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**DECARBONISATION OF THE SHIPPING
INDUSTRY BY 2050:
OPPORTUNITIES AND CHALLENGES IN
MARKET-BASED MEASURES**

VAISHAK ARAYAKEE

*A dissertation submitted to the World Maritime University in partial fulfilment
of the requirements for the award of the degree of Master of Science in Maritime Affairs*

2023

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.

A handwritten signature in black ink, appearing to read 'Aref Fakhry'. The signature is stylized with a large 'A' and 'F'.

(Signature):

(Date):25 September 2023.....

Supervised by: Dr. Aref Fakhry

Supervisor's affiliation: Assistant Professor, World Maritime University

NB The supervisor's signature is not required.

ACKNOWLEDGEMENTS

First and foremost, I express my profound gratitude to the **World Maritime University** for accepting my application for this Master's programme and nominating me for a donor fellowship. I wish to express my sincere thanks and gratitude to the **Maritime Training Trust**, a charitable trust in India, and their trustees "**Directorate General of Shipping, Government of India**", and "**Indian National Ship Owners Association (INSA)**," for granting me the fellowship for this course and making this research possible.

I would like to express my gratitude to my dissertation supervisor, Dr. Aref Fakhry, Assistant Professor, World Maritime University, for his unwavering guidance, patience, and invaluable insights throughout the course of this research. The guidance and mentoring you have given have played a crucial role in developing my work, and I am really grateful for the insight and support you have provided.

I also wish to thank all the respondents who participated in the survey questionnaire for their valuable time and contribution to this study. Further, I express my sincere thanks to all the interviewees who contributed to this study for their valuable feedback. Their perspectives greatly enriched the depth and quality of this research.

I am also thankful to the members of the research ethics committee at WMU and the librarian and team at the WMU library for their kind support and cooperation throughout my studies at the World Maritime University.

Special thanks to my friends and ex-colleagues across the globe for helping me with data gathering, finding the right professionals, and interviewing candidates for this study. I appreciate them for their assistance, which has been crucial.

To my family, thank you for your unwavering belief in me, your endless encouragement, and the sacrifices you have made to ensure my academic pursuits. Especially my wife, your love and faith have been my pillars of strength, without which this work would not have materialised.

Finally, I thank the creator of universe for being a strength throughout the journey of life.

Abstract

Title of Dissertation: **Decarbonisation of the Shipping Industry by 2050: Opportunities and Challenges in Market-Based Measure**

Degree: **Master of Science**

The dissertation is a study of the latest developments in the decarbonisation of the shipping industry, with a focus on the Market-Based Measures (MBMs) being discussed at the International Maritime Organisation (IMO).

A brief look is taken at the current trends and challenges in commercial shipping in view of decarbonisation, the IMO's commitments to climate change mitigation, and low-carbon shipping technologies.

The study explores the various aspects of MBMs, including the opportunities and challenges in their implementation. This research investigates the transitional potential of MBMs in guiding the maritime industry towards a substantial reduction in emissions, in accordance with the IMO strategies. The research is conducted by means of a meticulous systematic literature review and a comprehensive analysis of key stakeholders.

The investigation is based on two essential research issues. Initially, it investigates the primary challenges and opportunities of MBMs proposed at the IMO as transitional measures in the maritime industry, revealing the complexities and potentials of such approaches in the pursuit of industry-wide sustainability. Second, the research investigates the extent to which the maritime industry is responding to MBMs by assessing their level of awareness, preparedness, collaboration, and decision-making effectiveness for the achievement of the 2050 emission targets.

Literature synthesis and stakeholder perspectives converge to provide a comprehensive comprehension of the current scenario of MBMs in the maritime industry, highlighting their pivotal role and adaptive capacity in mitigating climate change impacts.

By identifying the opportunities and challenges inherent in the adoption of MBMs, this study contributes to the evolving discussions about shipping decarbonisation, moving it ahead and emphasising the need for collaborative efforts and informed decision-making in directing the shipping sector towards a sustainable and carbon-neutral future by 2050.

KEYWORDS: Market-Based Measures, Shipping Industry, Decarbonisation.

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LIST OF ABBREVIATION

AI	Artificial Intelligence
BV	Bureau Veritas
CBDR-RC	Common But Differential Responsibilities - Respective Capabilities
CII	Carbon Intensity Indicator
CO ₂	Carbon Dioxide
COP	Conference of Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
DNV	Det Norske Veritas
EEDI	Energy Efficiency Design Index
EEXI	Energy Efficiency Existing Index
EPA	Environmental Protection Agency
ETS	Emissions Trading System
EU	European Union
GL	Germanischer Lloyd
GHG	Green House Gas
IACS	International Association of Classification Societies
ICAO	International Civil Aviation Organization
ICVCM	Integrity Council for the Voluntary Carbon Market
IEA	International Energy Agency
IMO	International Maritime Organization
IMO DCS	International Maritime Organization Data Collection System
IMO Docs	International Maritime Organization Documents
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change

ITF	International Transport Forum
IUCN	International Union for Conservation of Nature
LDC	Least Developed Countries
LIS	Leveraged Incentive Scheme
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MBMs	Market Based Measures
MEPC	Marine Environment Protection Committee
NMFT	No More Favourable Treatment
OECD	Organization for Economic Cooperation and Development
Ph. D.	Doctor of Philosophy
R&D	Research and Development
REC	Research Ethics Committee
RM	Rebate Mechanism
SECT	Ship Efficiency and Credit Trading
SEEMP	Ship Energy Efficiency Management Plan
SEEMP II	Ship Energy Efficiency Management Plan Part II
SIDS	Small Island Developing States
SDGs	Sustainable Development Goals
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UN-DESA	United Nations-Department of Economic and Social Affairs
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
US	United States

USD	United States Dollar
VES	Vessel Efficiency System
WMO	World Meteorological Organization
WMU	World Maritime University
WSC	World Shipping Council
WTO	World Trade Organization

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1.0. INTRODUCTION

Climate change is a serious environmental and economic problem that humanity is facing in the twenty-first century (Steffen et al., 2018; Ripple et al., 2017; Stern, 2006). There has been a noticeable increase in the occurrence of frequent extreme climate events on a global scale on Earth (Coumou & Rahmstorf, 2012).

The energy balance of our planet is being altered by anthropogenic greenhouse gas (GHG) emissions, which give rise to a greenhouse effect and subsequently lead to global warming (Hansen et al., 1981; Shaftel, (n.d.)), the phenomenon of an overall rise in the atmospheric and oceanic temperatures of the planet (Merriam-Webster, (n.d.)). The primary anthropogenic GHG responsible for the greenhouse effect is carbon dioxide (CO₂), which is primarily released through the combustion of fossil fuels (Keoleian et al., 2005; Williamson, 2016).

Curbing GHG emissions at sea is challenging due to the non-availability of a zero-carbon emitting fuel (Gilbert et al., 2018; Balcombe et al., 2019; Deniz & Zincir, 2016). Presently, energy transition technologies encompass a diverse array of approaches to reduce GHG emissions from ships, such as renewable energy, energy efficiency systems, electrified transport, energy storage, alternate fuels, and carbon-capture-storage systems (Lindstad et al., 2021; Svanberg et al., 2018; Balcombe et al., 2019).

In order to secure the necessary research and development funding, it is projected that billions of USD per annum would be required over the course of the next two decades (Lloyd's Register [LR] & University Maritime Advisory Services [UMAS], 2020; Global Maritime Forum, 2020). As the current level of global investment in research falls short

for the energy transition towards zero carbon fuels (International Renewable Energy Agency [IRENA] & Climate Policy Initiative [CPI], 2023), IMO and member nations are considering the implementation of Market-Based Measures (MBMs) in the revised strategy to facilitate the achievement of GHG reduction objectives (International Maritime Organisation [IMO], (n.d.-a); International Transport Forum [ITF], 2022; Bennet, 2019).

MBMs have their roots firmly established in the discipline of economics, particularly in the realm of externalities and market uncertainties. The inception of this concept in the 1920s is attributed to Arthur Pigou, a renowned economist who advocated for the implementation of taxes as a means to rectify negative externalities (Pigou, 1920; Stabile, 1996; Britannica, n. d.).

Externalities arise whenever the actions of one economic agent directly affect another economic agent outside the market mechanism, and it refer to costs or benefits that impact individuals or entities who did not actively decide to bear or receive them, such as in the case of pollution (Smith, 2011).

During the latter half of the 20th century, the concept of MBMs gained prominence as economists delved into novel frameworks for organising markets in order to effectively and durably manage resources (Hoffman & Spitzer, 2011; Flaherty, 2014). However, it was in the twenty-first century that environmental economics became a widely studied subject due to growing environmental concerns (Henderson & Norris, 2012).

The shipping market is highly uncertain, and MBMs are characterised by their forward-looking aspects when externalities arise in the market (Stavins & Whitehead, 1996). Climate change creates economic uncertainty in shipping (Lopez et al., 2022), and the most urgent and complex externality is GHG emissions (International Monetary Fund [IMF], (n.d.)).

A prevailing viewpoint among economists is that MBMs are more successful and cost-efficient than command-and-control systems for pollution management (Hahn and Stavins, 2010; Montgomery, 1972; Tietenberg, 2003). This implies that economic incentives, rather than rigid regulations, should be prioritised to promote a more sustainable environment (Miola et al., 2011).

Even though several advanced scientific measures are introduced in shipping, the current global trend aligns with the implementation of MBMs, as the taxation of emissions makes emission mitigation technologies more effective (Cheaitou and Cariou, 2019; Schwartz et al., 2020). Further, in the past decade, there has been substantial growth in the scope and utilisation of MBMs, which have been employed to tackle pressing global issues such as climate change (Ellerman et al., 2016; Zhang et al., 2014; Cullenward, 2014).

This research paper is intended to study the MBMs under consideration at IMO and their opportunities and challenges in implementation in the shipping industry. As a new economic instrument in shipping, MBMs have the potential for techno-economic developments in the industry; however, under the purview of market uncertainty in shipping, MBMs can create adverse effects on the maritime industry as well. Accordingly, research on MBMs is of great significance in the current scenario of the maritime industry.

1.1. Background: The Global Agreement on Climate Change.

Our planet has experienced various manifestations of climate change, including the occurrence of severe temperature extremes, such as heat waves and droughts, as well as heavy precipitation that can result in floods (Sharma, H., & Sharma, A., 2014; Fry, 2008; Intergovernmental Panel on Climate Change [IPCC], 2018). There has been an observed

intensification of extra-tropical storms and tropical cyclones (Ulbrich et al., 2009). Further, the mid-latitude oceans have experienced an elevation in ocean wave height and the polar region has undergone extreme changes in sea ice and snow cover (World Meteorological Organisation [WMO], 2023; Meehl et al., 2007; Huber & Gullede, 2011). These examples highlight the discernible impacts of climate change on our planet.

In the year 1896, Svante Arrhenius, a Swedish physicist renowned for his contributions to the field of climate change research, disseminated his theories regarding the impact of GHG on atmospheric temperature. This seminal work played a crucial role in fostering global recognition and concern for the issue of GHG emissions (Arrhenius, 1896; Weart, 2003).

Later in 1979, a gathering of climate science experts from several nations and international organisations took place in Geneva, Switzerland. This was the world's first climate conference, which was dedicated to the examination of anthropogenic impacts on climate. The primary objective of this conference was to anticipate and mitigate potential climate variations that could have adverse consequences for the existence of human beings on this planet (Zillman, 2009; Fry, 2008; Bolin, 2008).

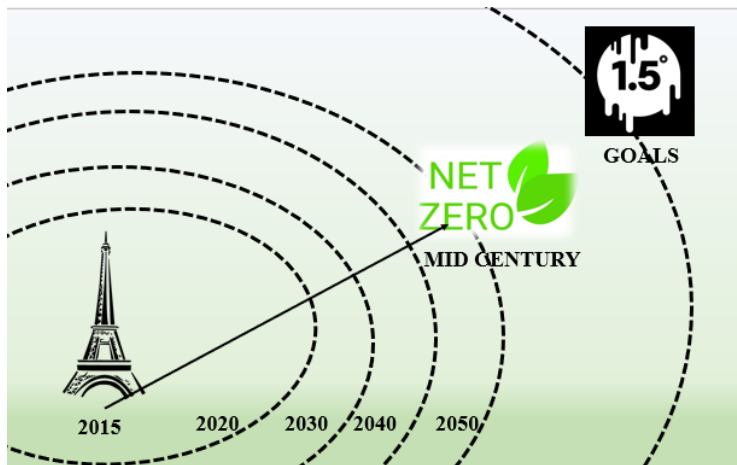
Over the course of subsequent decades, a series of international conferences and negotiations were held to address the issue of climate change. These efforts culminated in the establishment of the United Nations Framework Convention on Climate Change [UNFCCC] and the Conference of Parties [COP] on Climate Change (Bodansky, 2001).

However, it was not until the year 2015 that the international community reached a consensus and agreed on improving the international response to the danger of climate change. The key objective of the agreement is to hold the rise in average global temperature to a level significantly below 2°C above pre-industrial levels and strive to

limit the temperature increase to 1.5°C above pre-industrial levels. This agreement, called the Paris Agreement, is the treaty on climate change that currently binds 193 countries and the European Union under it (Paris Agreement, 2015; Burns, 2016).

The Paris Agreement represents a significant milestone in the global effort to address climate change and its impacts, as it marks the first instance in which all member nations have united under a legally binding commitment. This collective commitment signifies a pivotal moment in the ongoing multilateral process aimed at mitigating climate change and saving our planet for future generations (Rajamani, 2016; Falkner, 2016).

Figure 1 : Net-zero global commitments: Emissions needs to reach net zero by 2050.



Note. Based on (United Nations [UN], (n.d.)).

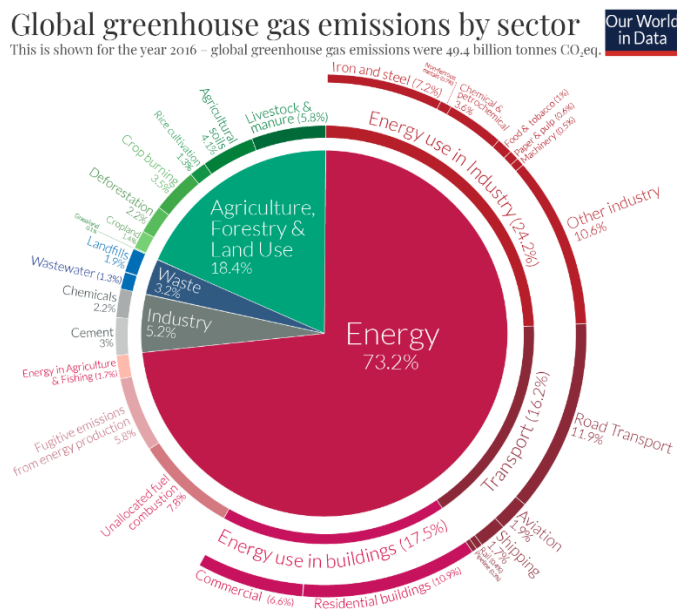
Although the shipping industry is not directly mentioned in the agreement (UNFCCC, 2016), the International Maritime Organisation [IMO], a specialised agency of the United Nations (UN) tasked with ensuring the safety and security of shipping and preventing marine and atmospheric pollution caused by ships, welcomed the Paris Agreement in 2016 and recognised the role of IMO in mitigating the impact of GHG emissions from international shipping (UNFCCC, 2018; IMO, 2018a; Doelle & Chircop, 2019).

1.2. Context: Role of the Maritime Transport Sector in Climate Change Mitigation

As the levels of GHG emissions continue to increase (WMO, 2022), it becomes crucial to reduce the current GHG emissions to meet the global emission targets. In the latest Emission Gap Report by the United Nations Environment Programme (UNEP), “To get on track to limiting global warming to 1.5°C, we would need to cut 45 percent off current greenhouse gas emissions by 2030” (United Nations Environment Programme [UNEP], 2022).

When we look at the total GHG emissions, approximately 75% of the total global emissions are attributed to the energy sector, which encompasses various activities such as electricity generation, heat production, and transport. Around 16% of the total emissions in the energy sector can be attributed to the transportation sector (Ge et al., 2020; Ritchie et al., (n.d.)).

Figure 2: Global Green house gas emissions by sector



Note. Adapted from "CO₂ and Greenhouse Gas Emissions". Hannah Ritchie, Max Roser and Pablo Rosado (2020) - Published online at OurWorldInData.org. Retrieved from:

[Online Resource] (<https://ourworldindata.org/emissions-by-sector#sector-by-sector-where-do-global-greenhouse-gas-emissions-come-from>).

The volume of maritime transportation has increased for a number of years, and this trend is anticipated to continue for the foreseeable future (Christiansen et al., 2007; United Nations Conference on Trade and Development [UNCTAD], 2022a). International trade relies heavily on maritime transportation, and more than 100 thousand world merchant fleets operate in our ocean, carrying roughly 1.5 million thousand tonnes of cargo (Equasis, 2021; Allen, 2023).

To mitigate climate change in the maritime transport sector, it is imperative to minimise CO₂ emissions to a level of net zero (Fay et al., 2015), thereby aligning with the objective of limiting atmospheric temperature thresholds below 1.5°C (Paris Agreement, 2015). According to the latest reports published by international organisations, maritime transport has been emitting hundreds of million tonnes of CO₂ per year for the past decade. This accounted for approximately 3% of the total global anthropogenic CO₂ emissions (IMO, 2018a; European Commission, 2022; UNCTAD, 2022; International Energy Agency [IEA], 2022).

Currently, only 0.1% of energy consumed in shipping comes from low-carbon fuels (Gardemal, 2022; IEA, 2021), and based on a set of long-term business-as-usual scenarios, this implies that the emissions from shipping in the year 2050 could range from 90% to 130% of the emissions recorded in 2008 (Faber et al., 2020; UNCTAD, 2022b).

These scientific studies show that maritime transport must remain abreast of global advancements in order to align with the objectives outlined in the Paris Agreement. In addition, it calls for an intervention in the shipping industry to reduce GHG emissions from maritime transportation. In order to avoid an irreversible change in the global

climate, the maritime transport system requires intense transformation. Decarbonisation of the shipping sector can effectively contribute to the issue of climate change (Levin et al., 2023; ITF, 2018b; Asariotis & Benamara, 2012).

The IMO has been working together with its member states and various stakeholders in the maritime industry for several years, focusing on formulating regulatory measures to facilitate the decarbonisation of shipping. IMO targets to decarbonise the shipping industry by 2050, which is criticised as ambitious in the shipping industry (Det Norske Veritas-Germanischer Lloyd [DNV-GL], 2019; Psaraftis & Kontovas, 2020). The maritime industry is currently considering MBMs as a transitional measure to phase out GHG emissions due to a lack of technological advancement in developing zero GHG emission fuels (Gardemal, 2022) and other economic factors.

1.3. Problem Statement

Climate change poses a distinct challenge for policymakers across the globe due to uncertainties in the realms of science, economics, and politics (Intergovernmental Panel on Climate Change [IPCC], 2018; United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2019; Miola et al., 2011). The readiness to meet the maritime industry's target of having zero-carbon fuels remains far from ideal. This lack of advancement in technology, combined with the huge cost incurred in transforming the entire shipping industry, leaves decarbonisation too ambitious. (Gilbert et al., 2018; Balcombe et al., 2019; Deniz & Zincir, 2016). Further, the lack of consensus among the member states at the IMO on finalising MBMs as a transitional measure (Psaraftis, 2021; Psaraftis & Zachariadis, 2019) creates concern among the stakeholders in the maritime industry.

The shipping industry is currently striving to adjust to the prevailing uncertainty in the market; however, the heightened GHG emissions stemming from shipping vessels pose an economic externality that hinders the attainment of the GHG targets. This is due to the fact that the financial consequences of GHG emissions were not previously taken into account in the economic evaluations by shipping owners, companies, and end users. (Wada et al., 2021; Stern, 2006). Several global and regional MBMs have been suggested to encourage the adoption of low-and zero-carbon fuel alternatives in maritime transport; however, shipping, being international in nature, needs international solutions.

As shipping progresses towards the 2050 objectives to phase out carbon from shipping, the IMO is considering MBMs as candidate mid-term GHG reduction measures (IMO, 2023a). The adoption and implementation of MBMs can cause substantial impact on the maritime industry; thus, the identification of challenges and opportunities associated with major MBMs in the current time and context holds great importance.

MBMs create high concerns for maritime stakeholders regarding its feasibility, efficacy, and potential consequences. Furthermore, maritime stakeholders play a key role in achieving decarbonisation and they need to be aware of and prepared for this transformation in the industry. Their collaborative efforts and decision making are critical in this maritime context, without which the IMO 2050 targets are difficult to achieve even if zero-carbon fuel technologies are readily available in the immediate future.

1.4 Aims and objectives of this research

The aim of this study is to study the decarbonisation efforts within the maritime sector on a global level. It aligns with the IMO World Maritime theme for 2023, “MARPOL at 50: Our commitment goes on”, linked to the UN 2030 Agenda for Sustainable Development (IMO, 2023b).

Further, this research paper aims to study the major MBMs that have been deliberated upon at the IMO. As an economic measure, MBMs in the foreseeable future of shipping are highly significant, and the research objective is to study the existing knowledge available and its implications in the shipping industry. The key objective is to ascertain the opportunities and challenges in the implementation of MBMs in maritime transport.

Further, this study evaluates the necessary awareness, preparedness, collaboration, and decision-making effectiveness on MBMs among maritime stakeholders. This study will provide a more holistic and well-informed understanding of MBMs and how they contribute effectively towards the sustainable development of the maritime industry.

1.5 Research Questions

The following research questions need to be answered in order to meet the set-out research objectives:

I) What are the key challenges and opportunities of MBMs discussed at IMO as a transitional measure in the shipping industry?

II) To what extent is the maritime industry responding to MBMs in terms of their level of awareness, preparedness, collaboration, and decision-making for the fulfilment of 2050 emission targets?

1.6 Scope and limitations

The scope of this research is to study and explore the opportunities and challenges of MBMs as a means of transitional measures in the maritime industry based on available literature and stakeholder analysis. The MBMs currently considered at IMO will be studied. This sets out the boundary of the research problem and limits the investigation

within the study time frame. The MBMs, as described in the below table, will be analysed in this research study.

Table 3: List of MBMs taken into consideration of the study.

List of MBMs
International Fund for GHG emissions from ships
Leveraged Incentive Scheme
Port State Levy
Ship Efficiency and Credit Trading
Vessel Efficiency System
Emissions Trading System
A penalty on trade and development
Rebate Mechanism

Note: Based on IMO Docs. MEPC 61/INF.2. (IMO, 2010a).

Another notable limitation of the study is the use of a limited sample size. The research was limited to a certain number of participants, which, while yielding useful insights, limits the extent to which the results may be applied to the broader population. Furthermore, this limitation has the potential to enhance the vulnerability of the findings to sampling error, which may have implications for the dependability and credibility of the study's conclusions. Subsequent research endeavours should aim to validate these findings by using a larger and more varied sample, so strengthening the reliability and generalizability of the outcomes to wider settings and populations.

This research paper will be useful to all readers who are interested in understanding the latest developments and future prospects of the decarbonisation of the maritime sector from a holistic perspective.

2.0. RESEARCH DESIGN

A postpositivist approach has been undertaken throughout this research (Creswell, 2009), where the critical realism is that MBMs are necessary in the current scenario of the shipping industry for driving maritime stakeholders to achieve global GHG emission targets; however, the opportunities and challenges in MBMs are to be studied prior to their implementation.

IMO's global efforts in climate mitigation are recognised in this study as a positive paradigm; however, the trends in social behaviour of maritime stakeholders towards the implementation of MBMs could be observed for a deeper understanding of the research topic.

2.1. Research Methodology

Research methodology encompasses the systematic procedures and techniques employed in the identification, selection, organisation, and analysis of information pertaining to a specific subject matter. These methodologies enable readers to comprehend and assess the dependability and overall soundness of the study (Marczyk et al., 2010).

This study employs a mixed-methods research technique. Mixed-methods research is characterised by its pragmatic approach, as it employs a combination of data collection methods. It utilises both structured and emergent designs in their research process. Furthermore, they employ statistical analysis as well as content analysis to analyse their data. By integrating the inferences derived from their qualitative and quantitative findings, mixed-methods researchers are able to provide meta-inferences as answers to their research questions (Tashakkori & Teddlie, 2010).

A combination of research methods, such as systematic literature review, qualitative and quantitative stakeholder analysis, and academic conferences, are used in this study (Lame, 2019; Creswell, 2009; Goundar, 2012; Bryson, 2004). As the dissertation title is of great socio-techno-economic importance in the current context of the maritime industry, a systematic literature review focused on relevant peer-reviewed primary sources and reliable secondary data sources was conducted initially. The aim of the systematic literature review is to ascertain, choose, and critically appraise appropriate literature addressing the research topic.

Further, since the shipping industry consists of several stakeholders, their perspectives on the implementation of MBMs are important, and accordingly, a stakeholder analysis will be undertaken secondarily. Decarbonisation is a major conference topic around the world in the maritime industry; accordingly, academic conferences attended during the course of this study are also used as research methodologies.

2.2. Systematic Literature Review

A systematic literature review is an essential research methodology that enables a thorough and impartial examination of existing academic literature pertaining to a specific study subject. The process involves the identification of a well-defined research question, the formulation of a precise protocol for conducting a literature search, the establishment

of criteria for the inclusion or exclusion of a study, and a critical evaluation of the study. This study aims to address the research questions through a systematic literature review. This approach facilitates the proper study of subject research areas available in the literature, thereby establishing a solid basis for this research (Lame, 2019).

After finalizing the research question, a qualitative systematic literature review was conducted for this study. Relevant sources were identified systematically, which include international conventions, international conference papers, textbooks, and peer-reviewed scholarly articles. IMO DOCS (document repository), including Marine Environment Protection Committee (MEPC) meeting documents, are taken as general reference works for this study.

The literature that has been identified will be subject to a systematic review. This is carried out by conducting a comprehensive study on subtopics such as carbon emissions from commercial shipping, current trends in the maritime industry and their 2050 targets, IMO's role in decarbonisation of the shipping industry, market barriers and enablers for low-carbon shipping technologies, and other challenges in decarbonisation of the industry. This facilitates a deeper comprehension of the study topic.

Secondly, the major MBMs under consideration of IMO and its global trends will be examined and analysed systematically. This analysis involves the identification of the challenges and opportunities of each MBM's, and finally, the MBMs will be analysed further to address the research question and generate qualitative findings.

2.3. Stakeholder Analysis

Stakeholder analysis is a highly effective research methodology that is extensively employed in diverse disciplines such as business, public policy, and project management.

Stakeholder theory says that we have a better chance of solving problems if we look at the ties between a business and the groups and people who can change it or are changed by it (Freeman et al., 2010).

Stakeholders can create positive impacts through modifications to their proposed actions and devise strategies to alleviate potential negative impacts (Babiuch & Farhar, 1994). The second research question will be answered by conducting a stakeholder analysis. Its primary purpose is to discern and comprehend the interests, influences, and interconnections of various stakeholders within the context of maritime decarbonisation (Bryson, 2004). Further, this stakeholder analysis can help comprehend the potential effects of IMO's proposed MBMs on shipping.

A qualitative and quantitative analysis will be conducted on the stakeholder research data (Goundar, 2012). This analysis consists of a survey questionnaire and interviews aimed at gathering information from the vantage points of various maritime industry stakeholders. It includes their perspectives, attributes, and actions towards IMO's 2050 ambition to decarbonise the shipping industry by using market-based measures as a transitional device.

A wide range of maritime stakeholders, representing classification societies, ship design and naval architecture firms, maritime administrations, the shipbuilding and repair industry, maritime education and training institutions, maritime technology providers, ship owners, international organisations, the port and terminal management sector, ship management companies, maritime students, and shipping customers, are considered as a representative sample of the maritime industry.

Through the questionnaire, the general demographics and background of the candidate will be collected to ensure the quality of the data. Further, it includes structured questions,

statements, parameters with a ranking scale, and open questions structured to describe the views of participants. These data will be analysed quantitatively and qualitatively.

In addition to the survey questionnaire, interviews based on semi-structured questions are used as a research tool to collect information from stakeholders. The data collected by interviews is systematically reviewed through quantitative and qualitative analysis to address the research questions.

2.4 Academic Conference

Academic conferences, often regarded as forums for the exchange of knowledge and professional connections, have the potential to function as effective instruments for research. They can inspire new research directions, offer methodological insights, and provide opportunities for data collection and collaboration. As a part of this study, conferences namely, the Nordic Maritime Transport and Energy Research Programme and the IMO, MEPC meeting 80th session, were attended. The information gathered during the conferences and networking sessions was utilized to add knowledge to this study.

2.5. Sampling Method

This study uses the purposive sampling approach in order to choose participants for stakeholder analysis. Purposive sampling entails a deliberate selection process that is not random but rather guided by specific logic or strategic considerations. Purposive sampling has many advantages, including the researcher's ability to ensure representativeness with respect to a certain element. The purposive sampling strategy is used in research when there is a requirement to get information from people who possess certain expertise (Isaac, 2023; Patton, 2002).

Given the study topic's connection to the marine industry, particular attention was directed towards individuals involved in various capacities within the maritime sector, including

professionals and students. Since member states have different viewpoints within the IMO towards decarbonisation and MBMs, a primary approach is to gather data from maritime experts who are actively engaged in the shipping industry from various countries. This includes individuals from developed nations, developing nations, least developed countries (LDCs), and small island developing states (SIDS). The underlying concept is to make a feasible sample that accurately represents the population of interest.

The data will be obtained via the collection of survey questionnaire responses and interview answers from marine professionals presently employed in several countries through purposive sampling. Experts who are actively involved in the decarbonisation of the shipping industry are targeted. In addition, the snowball sampling method (Noy, 2008) was also employed to gather survey results by survey questionnaire since the stakeholder analysis was remotely carried out.

Senior experts from the maritime industry are considered based on their experience, expertise in the research topic, and their current organisation role. The participants are selected based on purposive sampling, and criteria include a representation of various maritime stakeholders from leading shipping organisations and maritime professionals with expert knowledge on the research topic.

2.6. Ethical Considerations

This study is conducted in accordance with the recommended ethical guidelines for research involving human participants, encompassing activities such as surveys, data collection, and interviews. The World Maritime University (WMU) research ethics committee (REC) has approved the survey questionnaire and interview questions intended for the stakeholder analysis of this study. The research proposals involve surveys, questionnaires, and interviews to gather information about human subjects by online

means, and the participants are not paid. Further, this research is carried out by persons unconnected with the WMU, and only students from the WMU took part in the survey questionnaire of this study. In this study, informed consent is sought from each individual participant prior to their involvement, ensuring their voluntary participation.

3.0. LITERATURE REVIEW

This chapter will primarily review the available literature on the research topic through systematic research.

3.1. Commercial Shipping: Trends and Challenges

The maritime transport sector plays a significant role in facilitating global trade, as it serves as a vital mode of transport that connects global markets across the continents (Smith, 1776; Grammenos, 2013). Its role in promoting global commercial connectivity also brings environmental risks, primarily in the form of pollutants (Andersson et al., 2016), and it is essential to address the environmental impacts of this mode of transportation, particularly the emission of GHG (Mathez, 2009).

The predominant energy source utilised by the shipping industry has historically been fossil fuels, owing to their cost-efficiency. The combustion of fossil fuels in ship engines leads to the release of GHG emissions. This dependence on fossil fuels gives rise to environmental challenges in shipping, although shipping remains one of the most energy-efficient forms of transportation (Brynolf et al., 2014).

In light of the urgent global climate crisis, the maritime industry recognizes the need to reduce its carbon emissions and looks into cleaner technologies, alternative fuels, and stricter regulations to mitigate climate change (Vergara et al., 2012; Heitmann & Peterson, 2014). Developing a zero-carbon fuel viable for commercial shipping is the ideal solution for the industry as it faces several challenges in decarbonisation; however, the long lifespan of ships may slow down the rapid turnover to cleaner technologies (Serra & Fancello, 2020).

Increasing concerns about GHG emissions have led to research into alternative marine fuels like biofuels, hydrogen, and ammonia. Their potential to reduce carbon footprints is actively being investigated; however, the development of large-scale, long-haul alternative propulsion methods and fuels like electricity, hydrogen, ammonia, and biofuels is still in the pilot stage. Electrification, though in its nascent stages in shipping, holds promise however, feasible only for shorter sea routes where battery capacities can meet voyage requirements (Aakko-Saksa et al., 2023).

The rise of Artificial Intelligence (AI) and the Internet of Things (IoT) is optimising ship operations and attributes to sustainability in shipping. Furthermore, automated shipping and e-navigation represent the next frontier in maritime operations. Numerous vessels are currently designed with an emphasis on improving fuel economy, incorporating hydrodynamic configurations, air lubrication systems, and energy-efficient engines (Xing et al., 2020; Han et al., 2021). This shows the transition of shipping towards lower carbon emissions, but not to net zero carbon emissions.

Transitioning from such a deeply entrenched energy source requires not just new fuels but also changes in ship design, fuel transportation, storage, and refuelling infrastructure. At the same time, not just ships but also ports around the world will need to be significantly modified (Fenton, 2017). A big global port infrastructure revamp is on the horizon,

whether it's electric charging stations, hydrogen refuelling stations, or alternate fuel storage (Alamouh et al., 2022). Furthermore, training and educating current maritime professionals, especially current seafarers, for a decarbonised maritime environment is another significant issue.

In addition to these major technological hurdles, there are several other challenges arising due to the capital-intensive nature of the shipping industry and its international nature. The difficulties in ensuring global compliance, the high cost involved in decarbonizing, the lack of coordinated global regulations and policy frameworks play a critical role in the shipping industry. Market pressures due to stakeholders increasing demand for sustainable practices and balancing their expectations with on-ground realities also add to the challenges of decarbonising the maritime industry (Ayres & Ayres, 2014; Carlo et al., 2020; Rehmatulla & Smith, 2015; Halim, 2019).

The maritime sector finds itself at a critical crossroads as it grapples with the simultaneous issues of technological advancement and environmental preservation. The industry is exploring ways to implement circular economy principles, emphasising waste reduction, material recycling, and sustainable practices. Recognising its role in global carbon emissions, the marine industry has initiated a shift towards a more sustainable future. The industry is expected to drastically cut its carbon footprint in the coming decades through a combination of technical advancements, regulatory measures, economic tools, and industrial commitment (Bureau Veritas [BV], (n.d.); Det Norske Veritas [DNV], (n.d.)).

3.2. Pathway to Decarbonisation of Shipping Industry

The IMO, as a specialist agency of the United Nations, has acquired a pivotal role in spearheading endeavours aimed at achieving decarbonisation (Doelle & Chircop, 2019; Ampah et al., 2021; IMO, (n.d.-b)). In 1997, as an initial step to mitigate climate change caused by commercial shipping activity in our oceans, the IMO amended the International

Convention for the Prevention of Pollution from Ships (MARPOL) Convention by adding a new annex, ANNEX VI, that addresses air pollution from ocean-going ships (ClassNK, 2005; IMO, (n.d.-c)).

This resolution invited the MEPC to consider CO₂ reduction strategies. Recognising the significance of global CO₂ emissions originating from the maritime industry and their detrimental impact on the environment, the IMO has instituted a series of policies since the early 2000s with the objective of mitigating CO₂ emissions (Attard et al., 2018).

To support evidence-based decision-making on addressing GHG emissions from international shipping, IMO commissioned studies to estimate GHG emissions from the sector and project possible developments since 2000. The IMO GHG studies, namely the First GHG Study, Second, Third, and Fourth carried out respectively in 2000, 2009, 2014, and 2020 are a global reference in estimating GHG emissions from international shipping. These are prepared by reputable research organisations across the world, under the oversight of a panel of member governments and the IMO Secretariat (IMO, 2000; Buhaug et al., 2009; Smith et al., 2015; Faber et al., 2020).

IMO established a mandatory global energy efficiency standard in 2011, which was the first legally binding instrument for the international shipping sector in terms of GHG mitigation (IMO, 2011a). Further mandatory technical measures, instruments, standards, and data collection system such as EEDI, SEEMP, EEXI, CII, SEEMP II and IMO DCS respectively were enforced in the following years.

IMO and member states established a preliminary strategy in 2018 to mitigate GHG emissions from maritime vessels. This strategy was aiming to achieve a 50% decrease in emissions by the year 2050, relative to the levels recorded in 2008. Additionally, the IMO

plans for a 40% reduction in carbon intensity in shipping by 2030, aiming for a complete phase-out of CO₂ emissions by the end of this century (IMO, 2018b).

After research through GHG studies, and collaborative efforts with other maritime stakeholders and extensive discussions, ambition levels were revised in 2023 during their MEPC80 meeting. IMO has adopted the latest revised strategy called “2023 IMO Strategy on Reduction of GHG Emissions from Ships”, which sets out enhanced targets to tackle harmful emissions. The revised IMO GHG Strategy encompasses a shared aspiration to achieve a state of net-zero GHG emissions in the realm of international shipping by the vicinity of 2050 and a reduction in the carbon intensity of international shipping (to reduce CO₂ emissions per transport work) as an average across international shipping by at least 40% by 2030. As outlined in the IMO MEPC's 80th session, it also entails a pledge to guarantee the adoption of alternative fuels with zero or minimal GHG emissions by the year 2030 (IMO, 2023a).

The IMO aims to guide the sector towards a more sustainable future by implementing regulatory measures, conducting research and development activities, fostering international collaboration, promoting technical cooperation and the transfer of technology relating to the improvement of the energy efficiency of ships, and building capacity to least-developed countries (LDCs) and small island developing states (SIDS). To achieve and surpass the targets established, it will be imperative to implement continuous evaluation, enhance commitment, and foster greater involvement with stakeholders.

3.3. Low-Carbon Shipping Technologies: Market Barriers and Enablers

The shipping industry's transition towards low-carbon shipping technology is of utmost importance, but currently this transition is subject to the intricate interplay of several market variables. Numerous low-carbon technologies exhibit elevated initial

expenditures in contrast to conventional technologies. The perceived risk associated with investing in certain low-carbon technologies stems from their early stages of development. Shipowners may exhibit reluctance in embracing these technologies that lack empirical evidence of their effectiveness in actual marine environmental protection (Iyer et al., 2015; Rehmatulla & Smith, 2015).

Even though we currently have ships and prototypes operating on alternative fuels based on hydrogen, ammonia, methanol, and Liquefied Natural Gas (LNG). These alternate fuels require the establishment of novel refuelling infrastructure. The international seaports have not yet developed the necessary infrastructure on a large scale to support the use of these fuels, hence constraining the feasibility of these alternate fuels across the globe (Minutillo et al., 2021; Cardoso et al., 2021).

Enhanced allocation of resources towards research and development (R&D) endeavours has the potential to accelerate the advancement of novel technologies, hence diminishing their financial burdens and related uncertainties. Collaborative research initiatives, which may be supported by public-private partnerships, have the potential to consolidate resources and knowledge in order to enhance the efficiency of innovation processes (Organisation for Economic Co-operation and Development [OECD] Environment Directorate & IEA, 2003).

On a positive scale, the collaboration of stakeholders throughout the shipping value chain, including shipbuilders, owners, operators, fuel suppliers, and policymakers has the potential to harmonise objectives and expedite the advancement and acceptance of low-carbon solutions. Furthermore, this relationship has the potential to accelerate the advancement of essential infrastructure (UNCTAD, 2022c; IMO, 2018a; GreenVoyage2050, (n.d.); McKinsey & Company, 2021).

The adoption of low-carbon shipping technology in the market is a complex and multidimensional task, influenced by various obstacles and facilitators. To surmount these obstacles, it is imperative to adopt a collaborative strategy that combines legislative frameworks, technological advancements, public demand, and synergistic efforts. The identification and utilisation of these facilitators have the potential to lay the foundation for a transition towards zero-carbon fuels and a viable marine future.

3.4. CBDR-RC and NMFT principles: Role in Decarbonisation of Shipping Industry.

The worldwide dedication to reducing carbon emissions has grown stronger, with particular emphasis placed on the maritime sector. The principles of CBDR-RC and NMFT have emerged as influential foundations, exerting significant influence on the legislative framework of decarbonisation efforts in the maritime sector (Pieter et al., 2014; Chen, 2021; Buhaug et al, 2009).

The concept of CBDR-RC is grounded in the principles of international environmental law (Josephson, 2017). It acknowledges that although all states have a collective duty to combat environmental degradation, the specific responsibilities assigned to each state differ depending on their level of development and capacities (United Nations Conference on Environment and Development [UNCED], 1992; UN, 1997). In the context of the shipping industry, the principle of CBDR-RC recognises that although all nations should participate in endeavours to reduce carbon emissions, developed countries, given their historical role in carbon emissions and superior technological capacities, may assume a heavier burden of duty (Maguire, 2014; Rajamani, 2016).

The principle of NMFT in international maritime law is predicated on the idea that ships should be subject to equal treatment, regardless of their country of origin. The granting of preferential treatment to a vessel with regard to environmental rules should not be entirely

determined by its flag (Attard et al., 2018; Tsimplis, 2021). NMFT places significant emphasis on the principle of equal treatment for all ships, whereas the concept of CBDR-RC proposes a differentiated approach to responsibility, taking into account varying capabilities.

Achieving a harmonious equilibrium between these principles is crucial for the implementation of fair and efficient decarbonisation strategies. In the pursuit of international collaboration, IMO exemplifies the relationship between the principles of CBDR-RC and NMFT (Chen, 2021). The diverse capacities and obstacles encountered by individual countries are recognized in combating climate change.

The principle of CBDR-RC could potentially impede progress in global initiatives, and the NMFT may be excessively inflexible, disregarding the unique obstacles encountered by developing countries. These principles will continue to be of utmost importance in deliberations concerning the decarbonisation of the shipping sector.

3.5 Exploring the Significance of MBMS in Shipping Industry.

In order to achieve 2050 objectives and phase out carbon from shipping, IMO has devised several short, medium, and long-term measures. These measures can be simplified into three interconnected categories: technological, operational, and MBMs (IMO, 2018a; Linda, 2022).

Traditionally, for the past decade, the spectrum of measures aimed at mitigating GHG emissions from ships has been categorised into the following principal domains: Technological measures and Operational measures.

Technological measures encompass a range of advancements aimed at enhancing the efficiency and sustainability of maritime operations. These measures encompass the implementation of energy-saving engines, improved ship hulls and designs, enhanced propellers, the utilisation of cleaner fuels with low carbon content, the exploration of alternative fuels, and the adoption of exhaust emission trapping devices like scrubbers, etc.

Operational measures encompass various strategies such as speed optimisation, optimised weather routing, optimal fleet management and deployment, efficient supply chain management, and other factors that have an impact on the logistical operation. The shipping industry is currently adopting these technological and operational measures, though it can't achieve net-zero GHG emissions (Wan et al., 2018; Mallouppas & Yfantis, 2021).

However, MBMs function by incentivizing the reduction or elimination of emissions. Primarily, there are pricing mechanisms and offsetting mechanisms. Pricing mechanisms establish a monetary value for emissions, and non-pricing mechanisms include the compensation of emissions by investing in activities that reduce emissions in other locations (Peace & Ye, 2020).

MBMs provide organisations with increased flexibility in identifying the most cost-effective approaches to climate change mitigation, thereby potentially fostering technological advancements. MBMs possess numerous appealing characteristics. Primarily, they exhibit adaptability in formulating tactics to optimise resource usage and promote environmental conservation. In addition, incentives are offered by MBMs to encourage the minimisation of expenses associated with climate change mitigation (Hahn et al., 1992).

Furthermore, organisations and individuals are able to internalise externalities, by assuming responsibility for the environmental costs associated with their actions rather than shifting them onto others. This practice contributes to the enhancement of market efficiency. They facilitate the development of innovative solutions, thereby generating dynamic incentives that can drive down the costs associated with decarbonisation. MBMs have the potential to improve the decision-making processes of individuals by providing consumers and producers with valuable information about market dynamics and the environmental consequences of their actions. (Coria et al., 2019; Cornes & Sandler, 1996).

MBMs are designed to achieve environmental goals at a lower cost and in a more flexible manner than traditional measures. The pressing nature of the climate emergency has led global markets to consider MBMs and International Civil Aviation Organisation (ICAO) has established MBMs related to the aviation industry called the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in 2023 (International Civil Aviation Organisation [ICAO], 2023).

There are currently several regional MBMs established in the shipping industry. Certain jurisdictions are currently considering the implementation of carbon pricing methods that are tailored specifically to the shipping industry. (Kachi et al., 2019; Wu et al., 2022). Further, a number of maritime businesses are proactively engaged in the concept of carbon offsetting, wherein they mitigate their emissions by financially supporting renewable energy or reforestation activities. Although not obligatory, the adoption of these practices is more prevalent due to the influence of corporate social responsibility (Greene & Façanha, 2019).

IMO and its member states have come up with a wide range of MBMs, which will be studied in detail in subsequent chapters (Psaraftis, 2012; Ghaforian Masodzadeh et al., 2022), however no MBMs are currently mandatory in International Shipping.

MBMs present a promising approach to accelerate the process of reducing carbon emissions in the maritime industry. The potential effectiveness of these measures is contingent upon the establishment of robust global cooperation, transparent execution of these measures, and the development of adaptable strategies that take into account the intricate dynamics of the maritime transport sector (Psaraftis, 2012).

In order to adhere to the IMO Initial GHG Strategy, it would be necessary for zero-emission fuels to assume a predominant role in international shipping by the 2040s, thereby gradually displacing existing fossil fuel sources. Nevertheless, a substantial disparity in competitiveness can be observed between traditional fossil fuels and alternative zero-emission alternatives.

MBMs have the potential to facilitate the decarbonisation of the shipping industry by addressing the disparity in competitiveness between fossil fuels and zero-emission fuels. This can be achieved by implementing mechanisms that raise the costs associated with using fossil fuels, such as the imposition of a carbon price. Additionally, the costs of zero-emission alternatives can be reduced through various means, including tax incentives, and R&D funds. Furthermore, the implementation of MBMs can contribute to the alleviation of certain market failures and barriers that impede the progress of decarbonisation future endeavours (Baresic et al., 2021).

3.6. MBMs: International Maritime Organisation discussions.

A significant consensus was reached among the majority of participants in the IMO, indicating the necessity of implementing MBMs as a crucial element in international shipping. Among a range of options, MBMs have been suggested as effective instruments

for encouraging the reduction of emissions. In 2010, during MEPC's 60th session, the IMO's Secretary General appointed an expert group to assess multiple MBMs. These MBMs were proposed by different member states and international organisations (IMO, 2010 i).

All the proposals put forth by the member states outline initiatives and protocols aimed at achieving GHG reductions. These reductions would be achieved either through direct emissions reductions within the shipping sector or through the collection of funds to support mitigation activities in other sectors, thereby contributing to the overall global reduction of GHG emissions (IMO, 2010a; Buhaug et al., 2009). This viewpoint was particularly emphasised during the MEPC 62 meeting, where the committee collectively approved a new work plan to facilitate further examination and evaluation of MBMs (IMO, 2011a).

There are several potential approaches that might be taken that are under the consideration of IMO as per the proposals submitted by member states. This includes the International Fund for GHG emissions from ships (GHG Fund), Leveraged Incentive Scheme (LIS), Port State Levy, Ship Efficiency and Credit Trading (SECT), Vessel Efficiency System (VES), Emissions Trading System (ETS), Market-Based Instruments: a penalty on trade and development, and Rebate Mechanism (RM) (IMO, 2010a; Lagouvardou et al., 2020; Stochniol, 2011).

Further, the IMO has established a set of criteria for the assessment of measures aimed at reducing GHG emissions, which encompasses MBMs. It includes the efficacy of environmental measures, economic efficiency and potential consequences for trade and sustainable development, capacity to stimulate technological advancements and innovation, feasibility of implementing MBMs in practice, facilitating the transfer of

technology, and enhancing the capabilities of developing nations, specifically the LDCs and SIDS.

IMO had made revisions to its system for evaluating the effects of proposed measures on states at their latest MEPC meeting in the 80th session. This assessment will evaluate the effects on states resulting from the implementation of a specific MBM or a combination of MBMs. The evaluation will consider the consequences prior to adopting the measure, giving careful consideration to the requirements of developing nations, with a particular focus on SIDS and LDCs (IMO, 2023c).

The interplay with other pertinent conventions and organisations, such as the UNFCCC, the Kyoto Protocol, and the World Trade Organisation (WTO), as well as the alignment with established principles of customary international law and international maritime law, are taken into consideration at IMO. However, compatibility of the existing enforcement and control provisions within the IMO legal framework is a major concern (Psaraftis, 2012).

3.7. MBM's at IMO: Opportunities and challenges.

MBMs are economic tools that leverage market signals in order to accomplish environmental goals (Stavins, 2003). Various industries, such as energy, transportation, and agriculture, are implementing MBMs as a means of addressing environmental concerns, ranging from carbon pricing to emission trading systems (Kroeger & Casey, 2007). In this sub-chapter, the eight MBMs being discussed at IMO will be studied based on the available literature. The primary focus is given on their opportunities and challenges in implementation to address the research questions. IMO DOCS and submissions by member states are primarily taken as appropriate general reference works

for this study.

3.7.1. International Fund for GHG emissions from ships (GHG Fund)

The GHG Fund, also known as the International Fund for GHG emissions from ships, is a planned initiative aimed at facilitating and promoting decarbonisation endeavours within the marine industry. The primary objective of this MBM is to offer financial assistance to facilitate the study, development, and implementation of low-carbon technology within the maritime industry (Buhaug et al., 2009; IMO, 2019; Psaraftis, 2012).

The fund has the potential to generate substantial profits, which are essential for supporting research and innovation in sustainable maritime technologies. The provision of financial support can expedite the process of the maritime industry's transformation and adoption of environmentally sustainable technologies and practices. The establishment of a consolidated fund facilitates intergovernmental cooperation, and leads to the development of a comprehensive approach aimed at addressing GHG emissions within the maritime industry (Buhaug et al., 2009; Kågeson, 2011).

Although the GHG Fund may initially result in higher operational costs, it has the potential to reduce future expenses by encouraging the use of efficient technologies. The sector may experience a notable increase in innovative developments, encompassing a wide range of advancements such as alternative fuels and energy-efficient ship designs (Christodoulou et al., 2021).

The GHG Fund has the potential to achieve significant reductions in emissions due to the direct nature of levies. Moreover, it ensures that the funds are accessible to all stakeholders, especially from the developing countries, in a fair and just manner. This measure exhibits transparency and simplicity. One potential drawback of the GHG Fund

is the possibility of heightened operating expenses, with the need for meticulous management in the distribution and effective use of money. Robust monitoring and verification systems are also necessary for the effective implementation of this measure (IMO, 2010a; IMO, 2010B).

The International Fund for GHG Emissions from Ships presents a potentially effective approach to steering the marine industry towards a sustainable trajectory. Despite the presence of hurdles, the GHG fund has the potential to facilitate the decarbonisation of global maritime industry through the establishment of a cohesive international partnership (IMO, 2010b).

3.7.2. Leveraged Incentive Scheme (LIS)

The LIS is an innovative approach designed to provide incentives for people and organisations to adopt favourable behaviours and attain certain objectives. The proposed method aims to attain tangible results across several sectors via the enhancement of incentive mechanisms to maximize their efficacy. In contemporary discourse, market incentive schemes have garnered significant recognition as efficacious techniques for exerting influence on behaviours and attaining desired outcomes (Bower et al., 2002; Blyth, 1969; Guernsey et al., 2021).

Within the maritime sector, the concept of a LIS mechanism has been put forward as a means to encourage environmentally sustainable practices by providing financial incentives for cleaner operations. In this particular framework, vessels are granted incentives or subjected to penalties contingent upon their environmental performance, particularly with regard to their CO₂ emissions. Vessels that operate below a certain emissions level are eligible for incentives, while those over the barrier may face fines. The primary objective of this framework is to incentivize ship owners and operators to allocate

resources towards the adoption of environmentally friendly technology and the implementation of more efficient operational practices (IMO, 2011b; IMO, 2010c).

LIS has the potential to facilitate expedited adherence and foster innovative behaviour. It fosters technology innovation similar to other MBMs and provides incentives for proactive organisations. Nevertheless, the implementation of a successful global shipping incentive scheme itself may be difficult. Moreover, there is a potential for an uneven distribution of advantages, which may disproportionately favour vessels that are already efficient in terms of GHG emissions. The identification of a suitable global standard and the establishment of fairness will be a significant challenge (IMO, 2010a; IMO, 2010c).

Although the main objective of LIS is to foster sustainability, its implementation is anticipated to have economic consequences. Ships that are already running with great efficiency may acquire competitive advantages, but those that fail to satisfy the established requirements may encounter elevated operational expenses. The proposed program is expected to stimulate innovation within the industry. In order to mitigate fines and secure rewards, corporations may see an upswing in their investments towards greener technology such as alternative fuels, enhanced engine efficiency, and carbon capture systems (IMO, 2011b).

The LIS, as deliberated upon at the IMO conference, presents a compelling mechanism for propelling the maritime sector towards a more sustainable trajectory. LIS encourages greener sustainability initiatives (Olubunmi et al., 2016). As the specifics of the LIS are further developed, it will be essential for parties to engage in collaboration and assure the continued functioning of maritime transport as a crucial conduit for global commerce while also upholding the ecological limits of the planet.

3.7.3. Port State Levy

The Port State Levy is a prospective mechanism designed to ensure adherence to sustainability and regulatory requirements by vessels when they make port calls. In the current epoch, characterised by increased consciousness towards the environment, ports assume a pivotal function as entry points for global commerce and logistics. Port states occupy a distinctive position as key control locations, enabling them to effectively enforce maritime legislation. The implementation of the Port State Levy serves as a mechanism to effectively utilise this potential (IMO, 2012).

In simple terms, it is a financial charge that is enforced on commercial vessels when they make a stop at a port. The amount of this levy is determined by considering several criteria, including the size of the vessel, its emissions, and its adherence to international maritime regulations. The main objectives encompass promoting the adoption of environmentally sustainable practices within the shipping industry. Securing financial resources for initiatives pertaining to environmental projects or the development of port infrastructure. The objective of this endeavour is to guarantee adherence to international regulations pertaining to maritime activities (IMO, 2010a; IMO, 2010d).

The implementation of the Port State Levy provides port states with a certain degree of autonomy and effectively incentivizes the use of environmentally conscious technology in ships. Additionally, it offers a direct economic incentive. There is a possibility of encountering inconsistencies in the execution of procedures and protocols across several ports. One significant limitation of this technique is its potential to result in the avoidance of certain ports. This might potentially give rise to challenges in implementation and enforcement (IMO, 2010d).

The implementation of the Port State Levy presents a potentially effective instrument for facilitating the transition of the marine sector towards sustainable operational practices. Nevertheless, the achievement of its goals relies on the implementation of collaborative international endeavours, the establishment of strong administrative frameworks, and the consistent evaluation of its performance to guarantee the fulfilment of its environmental and regulatory aims while avoiding any negative impact on global trade.

3.7.4. Ship Efficiency and Credit Trading (SECT)

The emergence of the SECT system is a response to increasing environmental concerns and the demand for sustainable practices within the maritime sector. SECT offers a means for ships to mitigate their emissions and foster sustainable practices by integrating energy efficiency measures with a market-oriented framework. Solutions such as SECT offer prospects for harmonising operational requirements with ecological accountability (IMO, 2010e).

SECT is designed to achieve relative GHG reductions. As per the Ship Energy Efficiency Management Plan (SEEMP), vessels undergo evaluations to determine their efficiency ratings, which are determined by many criteria such as fuel usage, operating practices, and the extent of technological integration. Vessels that adhere to predetermined efficiency requirements are capable of generating credits. The aforementioned credits have the capacity to be exchanged for ships that fall below the established standard, enabling them to successfully counterbalance their emissions. This creates a market in which efficiency can be exchanged as a tradable commodity (IMO, 2009M, IMO, 2010e).

The potential to acquire credits serves as a financial motivation for the shipping businesses to allocate resources towards the adoption of energy-efficient technologies and the implementation of sustainable practices. Instead of incurring penalties, operators have the

option to mitigate their inefficiencies by acquiring credits, which grants them a period to gradually change and adjust. The utilisation of the trading platform has the potential to enhance economic activity, hence establishing efficiency as a novel market segment within the maritime industry (IMO, 2010a).

Variations in the demand for credit and its value can introduce uncertainty into operations and the strategic planning of shipping. Further, the establishment of a transparent and globally acknowledged framework for the evaluation, distribution, and exchange of credits necessitates stringent supervision and international cooperation.

The SECT framework integrates efficiency indexing with a credit mechanism, thereby enabling a more adaptable approach. The introduction of SECT facilitates a competitive market dynamic and cultivates an environment conducive to innovation. The practice of permitting the sale of additional credits fosters a culture of excessive performance. Nevertheless, the effectiveness of this approach is contingent upon the robustness of monitoring, reporting, and verification mechanisms. Another major concern is the manipulation of the credit market (IMO, 2010a; IMO, 2010e).

Despite the existence of these hurdles, the potential of SECT to significantly transform marine operations and its wider ramifications for other industries have garnered significant attention from stakeholders on a global scale. In addition, the promotion of international collaboration in the field of SECT has the potential to cultivate greater interconnections and shared goals across nations.

3.7.5. Vessel Efficiency System (VES)

The VES has emerged as a prospective alternative, aimed at improving the sustainability of ship operations. In order to effectively tackle carbon emissions, it is crucial to establish a harmonious equilibrium between operational efficiency and environmental stewardship.

The VES presents a novel methodology that combines market dynamics and sustainability goals (IMO, 2010a).

The operating efficiency of vessels is the guiding principle behind the functioning of VES, which involves the process of benchmarking. Various factors, including fuel usage, design, and the adoption of technology, are taken into consideration. Efficiency scores are assigned to ships based on the provided metrics. Vessels that attain and sustain elevated efficiency ratings can reap advantages from MBMs. Potential incentives that could be offered include the reduction of port fees, granting preferential berthing rights, or the introduction of tradable efficiency credits (World Shipping Council [WSC], 2010).

Ship owners are incentivized to invest in environmentally friendly technologies and sustainable operational practices by establishing concrete market advantages for efficiency. Efficient operations are intrinsically associated with decreased fuel usage and maintenance expenses. This economic incentive serves as a supplementary factor to market advantages, resulting in a dual motive.

VES serves as a catalyst for operators to enhance and optimise the efficiency of their fleet. This system operates in a transparent manner, coinciding with the growing consumer desire for sustainable practices. The VES establishes explicit criteria and advocates for exemplary methodologies. However, this strategy does not provide a certain assurance of an absolute limit on emissions. Furthermore, it is possible that aged ships might have some disadvantages. One of the challenges that arises in the context of global ports is the presence of discrepancies in their implementation (WSC, 2010). Smaller maritime enterprises may encounter difficulties in promptly embracing contemporary technologies. Unless appropriate steps are implemented to address this issue, it has the potential to result in competitive disadvantages (IMO, 2010a).

By integrating market incentives with efficiency indicators, the implementation of VES holds the promise of fundamentally transforming the shipping industry, propelling it towards a future that places equal emphasis on operational excellence and environmental stewardship. In order for the VES to achieve its intended outcomes, it is imperative to ensure widespread acceptance and cooperation across nations and ports, thereby mitigating any potential disparities in its implementation.

3.7.6. Emissions Trading System (ETS) for the International Shipping

The implementation of an ETS that is specifically designed for the international shipping industry offers a groundbreaking strategy to tackle the growing international apprehension regarding climate change. By utilising market processes, an ETS with a specific focus on the maritime industry has the potential to expedite the shift towards sustainable practices in maritime operations (Wu et al., 2022; Stavins, 2003).

The ETS is frequently advocated as an effective MBM for addressing climate change by creating economic incentives for the adoption of carbon-free or low-carbon technology (European Union (EU), 2015; EU, 2019). At its essence, ETS entails the establishment of a limit on permissible emissions. Ships or maritime enterprises acquire or procure emission allowances. Individuals who are able to decrease their emissions below the allocated limits have the opportunity to trade their surplus credits with entities that surpass their own emission allowances (Lam, 2022).

In the context of international shipping, the implementation of an ETS would include the consideration of many parameters, including the duration of voyages, the volume of cargo transported, and the kind of vessels utilised. These considerations would be taken into account in the allocation of allowances within the ETS framework (Lam, 2022).

Entities are granted the freedom to select the most economically efficient approach for mitigating their emissions, whether it involves technological innovations, operational modifications, or the procurement of allowances. Organisations that allocate resources towards environmentally sustainable technologies have the potential to reap benefits not only through decreased operational expenses but also by engaging in the trade of surplus allowances. Over the course of time, it could be possible to progressively reduce the aggregate limit on emissions, thereby compelling the entire industry to adopt more environmentally friendly practices (Wang et al., 2015).

Global standardisation and regulation are of utmost importance in ETS. It encompasses the establishment and implementation of uniform standards and regulations on a global scale. The successful implementation of a universally recognised ETS requires collaboration among governments, shipping authorities, and industry players (Integrity Council for Voluntary Carbon Markets [ICVCM], (n.d.)).

ETS for International Shipping establishes a predetermined limit on emissions and fosters a competitive market for the mitigation of emissions. This mechanism facilitates the trading of emission permits among ships, while the limitations on emissions are established by regulatory entities. This measure offers the opportunity for enhanced financial rewards and more flexibility for vessels that demonstrate efficiency. One significant limitation pertains to the possibility of price fluctuations and the intricate nature of creating a worldwide emissions market. Major issues include increased exposure to market swings and the potential for carbon leakage (IMO, 2010f).

Similar to other trading systems, there exists a potential for market manipulations or speculative trading activities that may lead to the distortion of allowance pricing (Roques et al., 2022). Smaller shipping businesses, lacking the financial means to invest in innovative technologies or purchase allowances, may have competitive disadvantages.

Despite the existence of ongoing problems, the implementation of the ETS for international shipping demonstrates a significant advancement in integrating economic mechanisms with environmental objectives (Psaraftis, 2012). By implementing an appropriate framework, fostering collaborative global initiatives, and continuously improving through iterative adjustments, the adoption of ETS has the potential to usher in a sustainable era for international maritime operations (IMO, 2010f).

3.7.7. Market-Based Instruments: a penalty on trade and development

"Penalty on Trade and Development" functions based on a simple principle where levies or fines are imposed on shipping activities that surpass a pre-established carbon emissions limit. The purpose of this penalty extends beyond punishment, as it is intended to be allocated towards the maritime sector with a specific focus on facilitating research, development, and adoption of more environmentally sustainable shipping technologies (IMO, 2010g; Psaraftis, 2012).

The funds derived from penalties would be allocated towards innovative research endeavours aimed at advancing cleaner maritime technologies. Recognising the potential ramifications of trade for developing nations, a segment of the fund could be designated to provide assistance for trade infrastructure in these nations, thereby ensuring fair and balanced development. The proposed scheme presents a resilient governance framework that guarantees equitable execution, surveillance, and utilisation of the accumulated funds (IMO, 2010a; IMO, 2010g).

While the primary objective of the penalty is to encourage sustainability, its implementation may introduce additional economic factors. Organisations may be required to evaluate the financial advantages of adopting environmentally friendly

technologies in comparison to the expenses associated with incurring penalties. Like any newly implemented regulation, shipping companies may be required to reassess their operational strategies in order to ensure compliance and maintain profitability (IMO, 2010g).

The reallocation of funds has the potential to significantly enhance research and development efforts within the maritime sector, thereby expediting the adoption of sustainable practices. There exists a possibility for trade dynamics to undergo a shift, particularly in the event that the penalties exert a substantial impact on the costs associated with shipping (IMO, 2010g).

The imposition of a penalty on trade and development may result in a direct financial disincentive, thereby facilitating a prompt decrease in emissions. This approach has a transparent and uncomplicated technique that yields quick effects. Non-compliant ships will face evident repercussions. Nevertheless, this particular approach might potentially be seen as punitive and may encounter resistance. The MBM in question has the potential to disproportionately impact low-income countries or smaller operators. Moreover, this strategy has the potential to discourage maritime trade, raising questions about its global scalability (IMO, 2010a; IMO, 2010g).

It will be of utmost importance to ensure that penalties do not exhibit a disproportionate impact on specific countries or smaller entities within the shipping industry. The tasks of monitoring emissions, verifying reports, imposing penalties, and managing reinvestment funds may necessitate substantial administrative endeavours. There exists a potentiality wherein the introduction of additional expenses, despite being driven by good intentions, may impede the pace of international trade or result in augmented financial burdens for ultimate consumers.

3.7.8. Rebate Mechanism (RM): MBM for International Shipping

The rebate mechanism emerges as a highly intriguing instrument that offers potential benefits in terms of both sustainability and equity. The core concept of the RM entails the implementation of fees on vessels or their activities, which are determined by certain factors like pollution or fuel composition. Climate change actions are funded by revenues from developed countries. Any country eligible for a rebate may, based on its circumstances, choose to forego its rebate or a portion of it in favour of global cooperation.

A fraction of the expenses that have been accumulated is afterwards reimbursed or returned, specifically to vessels originating from developing countries or those that fulfil special environmentally friendly requirements. The main goals of RM are twofold: to provide incentives for the adoption of environmentally friendly practices in the marine sector and to address the competitive apprehensions of emerging countries in the global maritime trade (Psaraftis, 2012; Psaraftis et al., 2021; International Maritime Emission Reduction Scheme [IMERS], (n.d.)).

The provision of refunds by the RM to ships that adopt cleaner technologies or practices serves as a distinct financial incentive to promote environmentally sustainable practices. The provision of rebates, particularly for ships originating from developing nations, serves to prevent these nations from experiencing an inequitable imposition of green levies, preserving their trade competitiveness. The surplus funds derived from the unrebated share of the collected charges might be allocated towards the advancement of research and development endeavours pertaining to sustainable maritime technology or infrastructure (Stochniol, 2011; IMERS, (n.d.)).

The implementation of a RM within the context of international shipping serves the purpose of mitigating possible imbalances and promoting equity. The primary benefits of this program are the provision of financial incentives and the development of green

technology. The surplus cash might be allocated to operators or countries that exhibit exceptional performance. The primary limitations are the intricacy involved in computing and disseminating rebates, possible disputes arising from rebate criteria, and the possibility of misappropriation (IMO, 2010a; International Union for Conservation of Nature [IUCN], 2010).

The management and allocation of rebates might present intricate challenges, necessitating the implementation of comprehensive systems for supervision and monitoring. Achieving an optimal equilibrium between environmental charges and rebates, particularly with regard to the equitable treatment of developing nations, continues to pose a significant issue (Benamara & Asariotis, 2012).

It may be impossible to agree on an efficient MBM for international shipping without integrating the principle of CBDR-RC in its design. The implementation of the RM signifies a notable advancement for the marine industry as it seeks to integrate sustainability and fair international trade practices. Despite the existence of ongoing hurdles, the implementation of iterative modifications and global collaboration has the potential to usher in a new era of responsible and inclusive maritime operations through the use of the RM.

3.8 MBMs: A Cohesive Compilation

Based on the above study conducted on the available literature, each MBM currently being discussed at IMO demonstrates unique advantages and challenges. The implementation of MBMs has the potential to signify a paradigm shift in the realm of sustainable maritime transportation, thereby bringing the industry in line with international carbon emission targets (Lagouvardou et al., 2020).

They have the potential to incentivize emission reductions and create financial resources that can be subsequently allocated towards the advancement of research and development in sustainable maritime technologies (Stavins, 2003). This cost-effectiveness through the utilisation of shipping market forces and progressive GHG reductions at the most economical cost makes MBMs attractive in the maritime transport sector.

MBMs can exert influence on consumer behaviour, thereby facilitating the development of a consumption pattern that is more sustainable in nature. However, the primary aim is to guarantee that any MBM or combination of MBMs applied to the shipping industry is effective in reducing emissions and fair for all parties concerned.

4.0. STAKEHOLDER ANALYSIS

This chapter will study the data available from the stakeholder analysis that is conducted as a part of this study. This study acknowledges expert opinions, views, and knowledge from various stakeholders currently working in the industry on Decarbonisation and MBMs.

A stakeholder analysis comprises a set of techniques based on qualitative data to assess the interest of each stakeholder in the intervention's success or failure and stakeholder's influence to support or obstruct the intervention. From a postpositivist approach, apart from the literature available on decarbonisation and MBMs, it is necessary to understand and observe the maritime stakeholders' perspectives for a realistic view of the shipping industry. The following analysis provides information from various maritime stakeholders, and the results will address the research questions.

4.1. Quantitative stakeholder analysis results.

A quantitative stakeholder analysis was conducted as part of this research. In total, 131 complete responses were received for the survey questionnaire prepared for this study, which was conducted remotely by purposive sampling and snow ball method. The consent form was accepted by 96.2% of the participants, and accordingly, results from 127 participants were taken into consideration of this study. Survey responses were received from 28 different countries, including developed nations, LDCs and SIDS. The below table shows the geospatial distribution of survey respondents spread across several continents as a representative sample.

Table 4: List participants current work place or country.

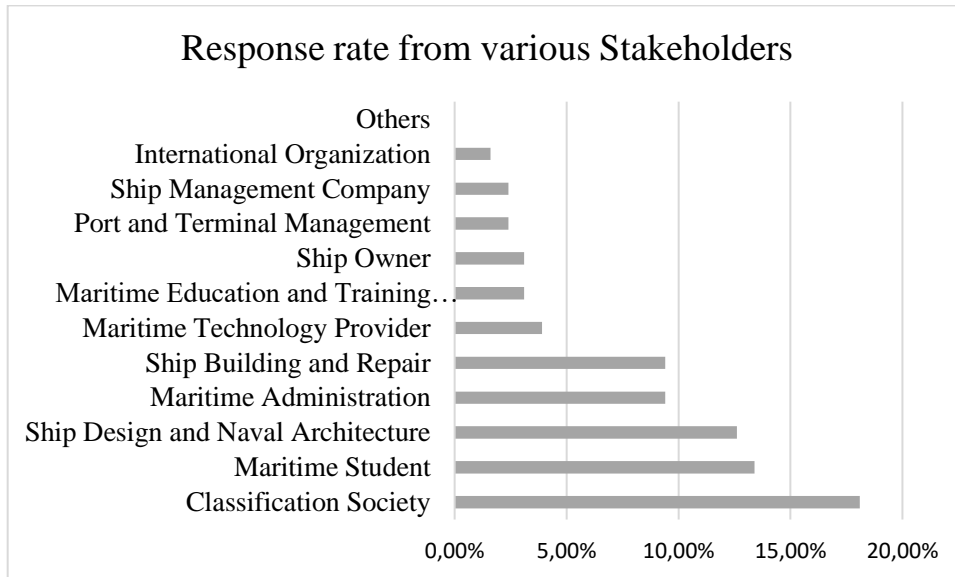
Geographical spread of responses
Antigua and Barbuda
Australia
Bangladesh
Britain
Canada
China
Denmark
Gambia
Germany
India
Indonesia
Japan
Liberia

Maldives
Namibia
Nigeria
Norway
Pakistan
Philippines
South Korea
Saudi Arabia
Singapore
Sri Lanka
Sweden
Tanzania
United Arab Emirates
Ukraine
Vietnam

4.1.1. General Demographics of the study

The various maritime stakeholders involved in this study and their response rates to the survey questionnaire are shown in the matrix below.

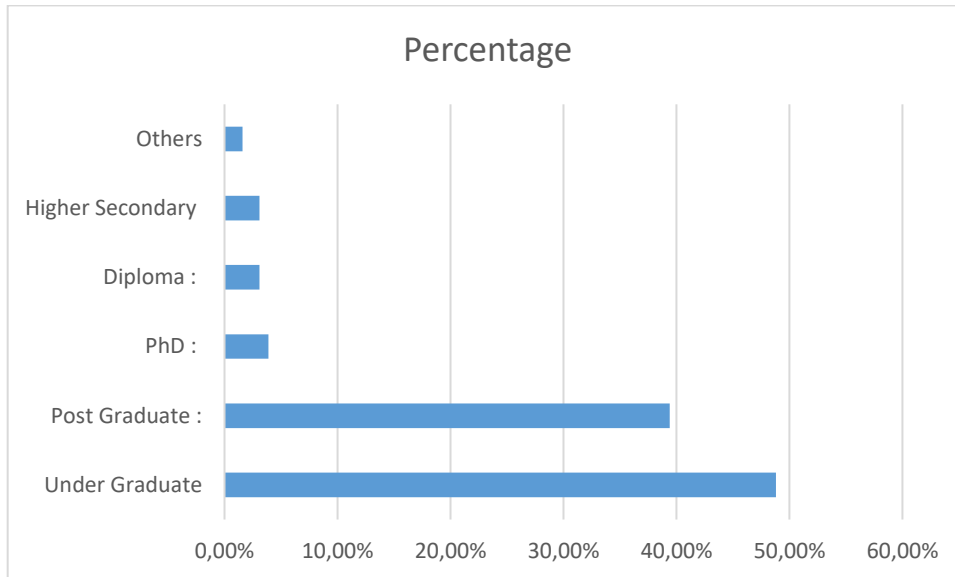
Figure 3: Stakeholder response matrix



The study consists of 18.1%, responses from the classification society, 13.4% maritime students, 12.6% ship design and naval architecture firms, 9.4% maritime administrations, 9.4%, ship building and repair yards, 3.9% maritime technology providers, 3.1% maritime education and training institutions, 3.1% ship owners, 2.4% port and terminal management firms, 2.4% ship management companies, 1.6% international organisations and 1.6% shipping customers.

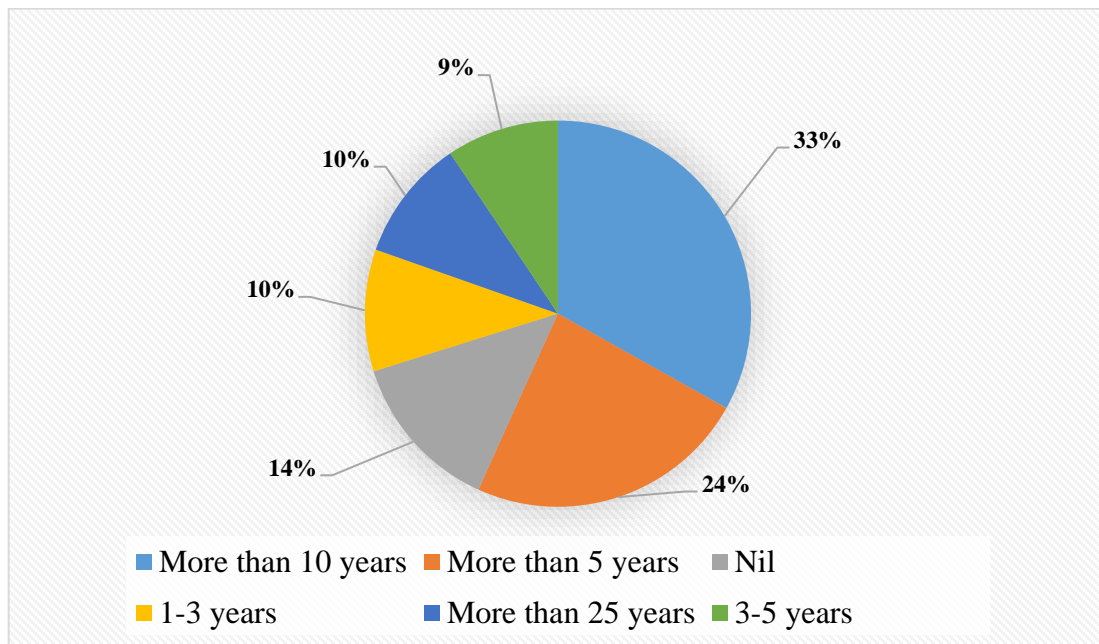
The below graph shows that more than 88 % of the participants involved in this study are maritime professionals with a minimum education level of bachelor's degree or master's degree in maritime field. Participants with Ph.D., diploma, higher secondary and others contribute to 10 % of the survey responses.

Figure 4: Academic Background of Participants



The below pie diagram shows the professional experience of participants in this study.

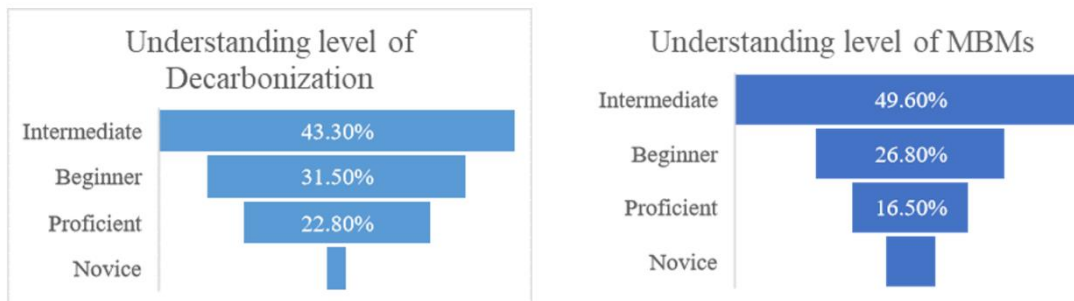
Figure 5: Participants professional experience



The participants with more than 10 years of experience contribute to more than 30% of the responses, and another 24% fall into the category of those with more than 5 years of experience. Senior professionals with more than 25 years of work experience in the maritime industry is more than 10%. 13% of the responses are from students at universities with no prior professional experience.

Special attention has been given to generating qualitative data by screening the level of understanding of participants on the research topic. The below diagrams describe the current level of understanding of participants about decarbonisation and MBMs in the shipping industry.

Figure 6: Understanding levels of Decarbonisation and MBMs among stakeholders



40-50% of the participants have an intermediate level of understanding about decarbonisation and MBMs, while approximately 25-30% are at the beginner stage. The mean responses from proficient participants were around 19 percent of the total responses. And an average of 4.7 % participants are novices in decarbonisation and MBMs, which will be excluded from further qualitative study.

4.1.2. Stakeholders' perspective

Below graphs and diagrams show the results generated from analysing the survey response data using manual calculations and software applications (Type form and Microsoft Excel). Structured questions and statements on a rating scale were used to study stakeholder’s perspectives on the significance of decarbonisation of shipping in combating climate change and global warming, the importance of MBMs as a transitional measure to decarbonize the maritime industry, and its effectiveness in achieving significant decarbonisation in the shipping industry by 2050. The results are represented as pie diagrams below.

Figure 7: Significance of the Decarbonisation of Shipping in Combating Climate Change and Global Warming

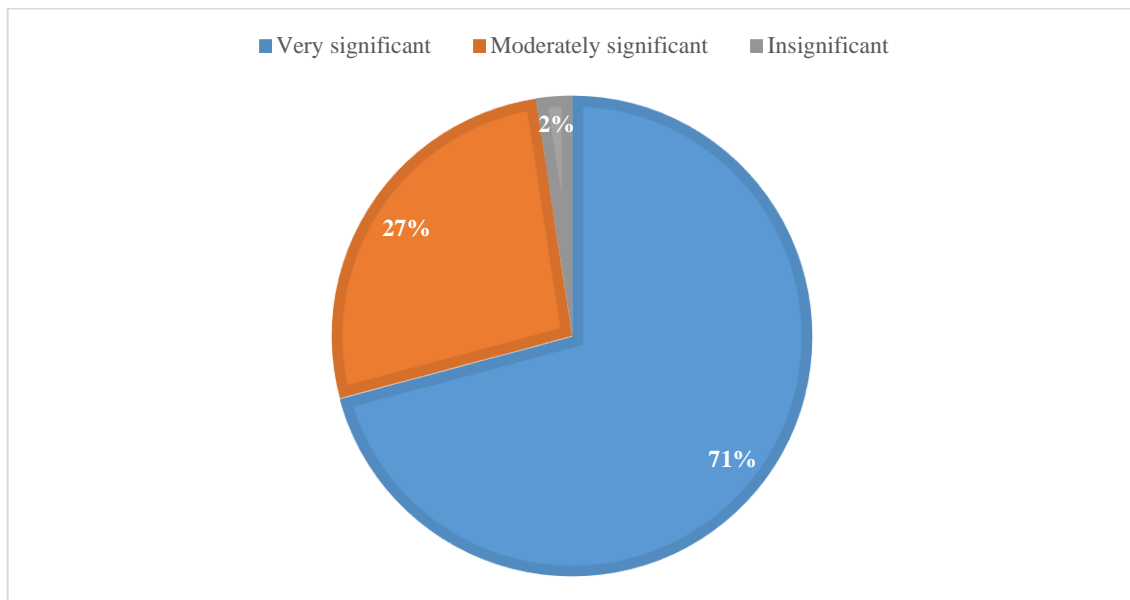


Figure 8: Importance of MBMs as a transitional measure to decarbonise the maritime industry

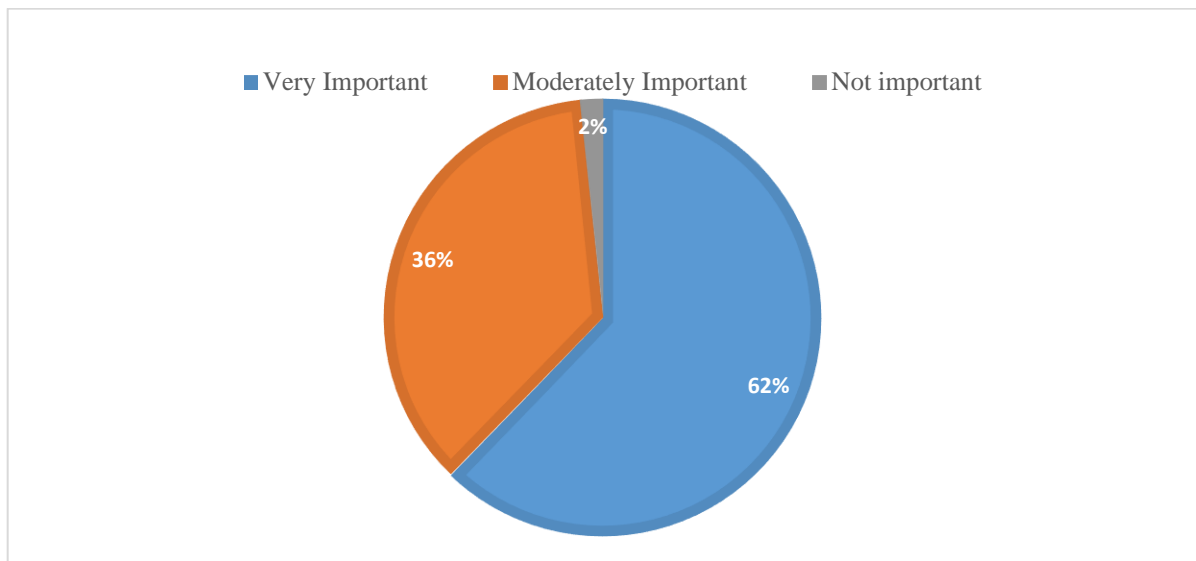
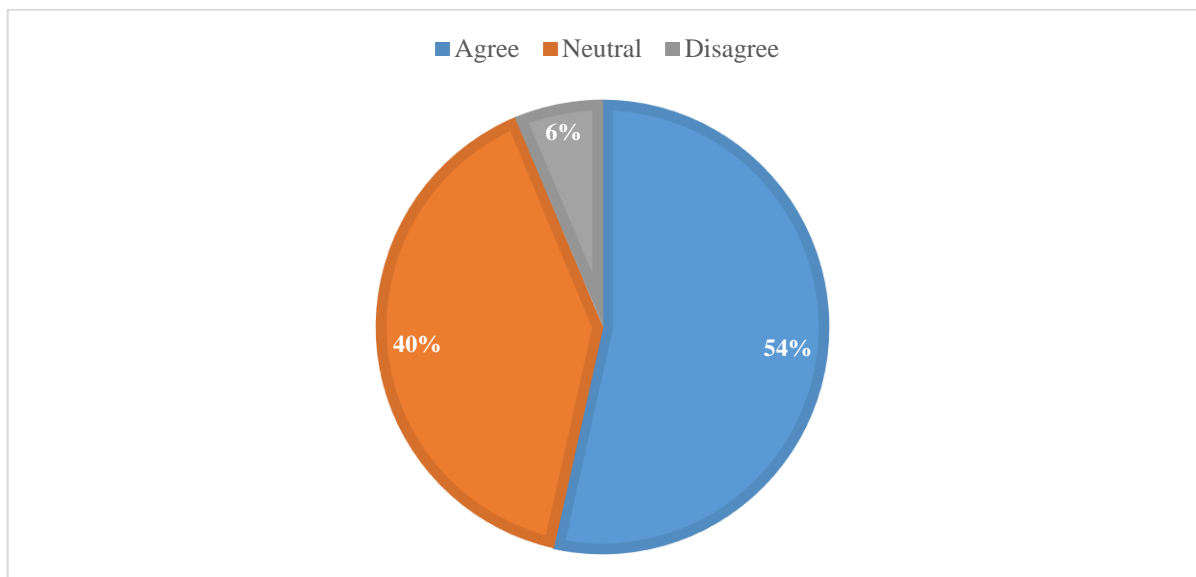


Figure 9: Effectiveness of MBMs in achieving significant decarbonisation in the shipping industry by 2050



Further, the study shows that currently more than 50% of maritime organisations stay updated on the latest developments in MBMs for the decarbonisation of shipping, while more than 30% stay updated sometimes and approximately 16% stay updated rarely. The analysis shows that around 50% participants understand that their organisations are moderately prepared to respond to the decarbonisation of shipping industry, while 30 % of the organisations are completely prepared and around 20% are unprepared. Similar results were shown for their preparedness level for MBMs as a transitional measure to combat climate change.

In terms of preference for carbon pricing mechanisms as MBMs in the shipping industry, around 48% are moderately preferred, 25% strongly prefer and 21% equally prefer other measures, and 5% do not prefer carbon pricing as a transitional measure to decarbonise the shipping industry.

Further, 55% participants understand that MBMs have a positive impact on the financial health of the shipping industry, while 33% believe MBMs will cause negative impact and 11% believe that, MBMs can have no impact on the financial health of the shipping industry.

84% agree that international cooperation among various stakeholders in the maritime industry is the key way to move forward with MBMs, while 1.6 % disagree and 14% have neutral responses. In addition, 57% of the stakeholders are willing to share best practices and lessons learned about implementing MBMs with other stakeholders in the shipping industry, while 36% prefer it sometimes and around 5% prefer it rarely. Only 1.5% responded that they would not share the best practices with the other stakeholders.

This study also ranked the challenges in decarbonisation of the shipping industry, results are shown below, along with their individual average ranking:

Figure 10: Ranking of the challenges in decarbonisation of the shipping industry

#1	High Capital Costs	#2.93 average
#2	Infrastructure Requirements	#3.98 average
#3	Energy Density and Safety Issues	#4.78 average
#4	Operational Challenges	#4.87 average
#5	Market Uncertainty	#4.97 average
#6	R&D Investment	#5.37 average
#7	Technological Innovation and Availability	#5.62 average
#8	Regulatory Alignment	#6.75 average
#9	Time Scale	#7.72 average
#10	Training and Education	#8.02 average

High capital costs, infrastructure requirements, energy density and safety issues, operational challenges, and market uncertainty are the major challenges ranked by the participants, with an average ranking value less than 5 out of the 10 listed challenges in decarbonisation of shipping.

A further list of challenges in implementing MBMs in the shipping industry is ranked below by the participants.

Figure 11: Ranking of the challenges in implementing MBMs

#1	Cost Implications	#2.67 average
#2	Administrative Complexity	#3.48 average
#3	Data Accuracy and Verification	#3.81 average
#4	Global Coordination	#4.92 average
#5	Evasion Risk	#5.37 average
#6	Fairness and Equity	#5.68 average
#7	Market Uncertainty	#6.92 average
#8	Leakage to other transport system	#7.4 average
#9	Technical Challenges	#7.8 average
#10	Reducing physical impact on corals and marine life	#8.85 average
#11	Reinvestment of Proceeds	#9.09 average

Cost implications, administrative complexity, data accuracy and verification, and global coordination are the major challenges ranked by the participants with an average ranking value of less than 5.

The below diagram illustrates the preference for 8 MBMs being discussed at IMO on a ranking scale as responded by the participants.

Figure 12: Participants preference for MBMs

#1	International Fund for GHG emissions from ships (GHG Fund)	#2.31 average
#2	Leveraged Incentive Scheme (LIS)	#3.6 average
#3	Ship Efficiency and Credit Trading (SECT)	#3.81 average
#4	Port State Levy	#4.14 average
#5	Vessel Efficiency System (VES)	#4.37 average
#6	Emissions Trading System (ETS) for International Shipping	#4.71 average
#7	Market-Based Instruments: a penalty on trade and development	#6.26 average
#8	Rebate Mechanism (RM) for a market-based instrument for international shipping	#6.8 average

Within the representative sample, the GHG Fund, LIS, and SECT are the most preferred MBMs, while rebate mechanism and a penalty on trade are the least preferred. While others are moderately preferred by the respondents.

4.2. Qualitative stakeholder analysis results.

The qualitative analysis was carried out through thematic coding. Primary keywords such as “Challenges”, “Opportunities”, “Awareness”, “Preparedness”, “Decision Making” and “Collaboration” are used to qualitatively analyse the literature to address the research questions. These keywords will establish a framework of thematic ideas (Gibbs, 2007) to answer the research questions.

Data collected through survey questionnaire responses, interviews, and academic conferences are analysed qualitatively. Five experts were interviewed as part of this study. They are senior maritime professionals possessing expert knowledge about the transition of the shipping industry towards carbon neutral, MBMs and Decarbonisation of shipping industry. The interview participants belong to the following organisations.

- a. International Organisation with full consultative status at the International Maritime Organisation (IMO).
- b. IACS recognized leading classification society.
- c. Leading global dry bulk operator.
- d. Global shipping logistics organisation.
- e. Leading global ship management company.

4.2.1 Major Opportunities in Implementing Market-Based Measures.

MBMs bring several opportunities to various maritime stakeholders. MBMs will result in significant innovation, research, and development, which will create new commercial opportunities for maritime industry stakeholders. It provides maritime stakeholders with the opportunity to collaborate on attaining zero-emission objectives.

The development and construction of environmentally sustainable ships to improve shipping competitiveness will have an effect on the industry's technical competitiveness. The cost implications of MBMs will encourage the adoption of innovative technologies that promote decarbonisation.

The development and deployment of technological solutions in the maritime industry are influenced by MBMs. MBMs will generate funding for research and development and investments in novel technologies. The approval of new technologies and the assessment of the entire decarbonisation process will create a number of socioeconomic opportunities.

In addition to employment opportunities for mariners, certification, approvals, trading carbon, verification of compliance, and research and development will create new business opportunities.

The development of rules and guidance to incorporate MBMs into the international shipping regulations brings equal opportunity to everyone in shipping. This can be achieved through international organisations, maritime administration, and other recognized organisations in the maritime industry. MBMs can create a paradigm shift in international shipping.

4.2.2. Key Challenges of MBMs in Maritime Industry

The challenges identified during the qualitative analysis are listed into mainly 12 categories as below.

4.2.2.1 Challenges in adoption of MBMs

It can be difficult to overcome resistance to change and encourage widespread adoption of MBMs. Creating and implementing new technologies, such as eco-friendly propulsion systems or alternative fuels, can be both expensive and difficult. Incorporating these technologies into ship designs and ensuring their efficacy can present obstacles. The adoption and acceptance of new standards based on MBMs is contingent upon the industry's willingness to accept these changes.

4.2.2.2. Challenges related to cost implications

The affordability and impact of MBMs on transportation costs are the primary challenges in MBMs and decarbonisation of the industry. Investments in research for alternative fuels, the retrofitting of existing vessels, and the acquisition of eco-friendly ships are crucial and will accrue tremendous costs for decarbonisation. The cost-effectiveness of

MBMs will have an impact on ship proprietors and will shape future regulations. Costs for other maritime stakeholders, including ports, terminals, and shippers, will increase as a result of shipping's high operating expenses.

4.2.2.3. Challenges related to administrative complexity

MBMs will impose administrative burdens on stakeholders. Regulating the innovative ideas implemented for the optimisation of design and operations will be difficult and will require R&D with various stakeholders. The current regulatory framework is insufficient to address decarbonisation in shipping and the domestication of MBMs in accordance with national legislation or any national policy framework. This will complicate the administration of shipping, particularly for several LDCs and SIDS.

4.2.2.4. Challenges related to regulatory compliance

Uniform regulations for MBMs are required. It can be difficult for MBMs to conform with regional emission regulations, particularly when various regulations apply in different regions where ships operate. Several candidate measures are already working across the globe. Future fuels will necessitate a new set of safety rules and manuals due to the risks associated with the handling of new fuels. New regulations and standards will need to be created, or existing rules will need to be modified, which will be quite difficult on a global scale.

4.2.2.5. Challenges related to Global Coordination and Collaborative Efforts

Effective collaboration among all maritime stakeholders is required to ensure that vessels are designed, constructed, operated, and scrapped in accordance with emission reduction objectives. The complexity of MBMs necessitates cautious planning, innovation, collaboration, and a proactive approach. The importance of bridging the divide between maritime stakeholders cannot be overstated, and only collaboration will ensure the successful implementation of the adopted measures.

4.2.2.6. Challenges related to market acceptance and uncertainty

Lack of clarity in MBM's international policy and the shipping industries' acceptability play a crucial role. Rapid advancements in emission-reduction technologies can lead to decisional uncertainty. Investing in a specific solution may become obsolete sooner than anticipated.

4.2.2.7. Challenges related to time frame

In the planning and implementation of technological solutions for market-based measures, stakeholders face time constraints. Critical is the availability of time for the transformation of the complete fleet of ships. Due to the lengthy lifetime of ships, the transformation of the transportation industry may be a gradual process. In addition, the return on investment in transportation takes longer, and the timeline for regulatory enforcement is currently uncertain. Creating awareness and the required technology within the specified timeframe is also essential.

4.2.2.8. Challenges related to economic and political factors

In the shipping industry, balancing the cost of compliance with prospective benefits and market demand is a delicate endeavour. The economic viability of future shipbuilding ventures can be affected by MBMs. Maritime nations continue to negotiate the MBMs based on their respective national interests. In a political context, fairness and equity are of the utmost importance, and any disparity with MBMs will complicate international negotiations.

4.2.2.9. Challenges related to implementation

The implementation of MBMs in shipping is hindered by cross-jurisdictional enforcement, competitive equity, cost disparities, and revenue sharing. For effective decarbonisation, international cooperation, transparent frameworks, and industry unity are required for establishing credible emission pricing, preventing market manipulation,

ensuring accurate data, and balancing stakeholder burdens. It will be difficult to implement because of the method for ensuring consistency and comparability of MBMs across various jurisdictions.

4.2.2.10. Operational challenges

The operational challenges associated with alternative fuels are a major concern for ship owners, operators, and managers. Fuels can be expensive and complicated. Integrating new technologies into ship designs and ensuring their efficacy can present challenging obstacles. Initial strategies involve a number of modifications to vessel operation and optimisation, notably in relation to IMO regulations. Currently, ship owners are pursuing retrofits, alternative fuels, and other options to acclimatise to the rapidly changing shipping industry.

4.2.2.11. Challenges related to infrastructure developments

The non-availability of green fuels is challenging in shipping. Transitioning to alternative fuels may necessitate the construction of new infrastructure for fuelling and storage, which can be an expensive and difficult logistical undertaking. While the objective of MBMs is to reduce emissions, any changes or modifications to vessels or operations must not compromise safety or environmental hazards.

4.2.2.12. Challenges related to training and capacity building

For the MBMs to be implemented, maritime stakeholders dispersed across multiple countries require adequate training and capacity building. Competent personnel are required to implement new technologies and procedures. Training is also required for maritime professionals involved in the processing and transportation of alternative fuels. Further, training and upskilling may be required to ensure that individuals in future shipping are equipped to work with innovative solutions.

4.3. Awareness among maritime stakeholders.

Several stakeholders are aware of MBMs as the global community pursues more aggressive measures to reduce greenhouse gas (GHG) emissions. Understanding and implementing MBMs is about future-proofing operations and investments for some stakeholders.

Cultivating awareness is both a responsibility and a strategic imperative for a sustainable shipping future. Several stakeholders are highly aware of the MBMs, while other are not fully aware. Some stakeholders consider MBMs to be an evolving measure in the maritime sector. They consider that regulatory measures are not taking any initiative towards the review of the MBMs according to the upcoming challenges in shipping.

4.4. Preparedness among maritime stakeholders.

Sustainability is being included in the operating plans of major shipping corporations and industry groups as a result of regulatory requirements and commercial incentives. There are several stakeholders not fully prepared for the MBMs. Several maritime stakeholders are proactively adapting to upcoming shipping industry changes. Several ship operators and managers are actively engaged in rigorous fleet assessment, technology scouting, and strategic partnerships that underpin readiness in the adoption of MBMs.

Some organisations are prepared for MBMs and they understand that rules and regulations could be efficiently implemented based on the readiness of the market and the availability of MBMs for implementation. Several stakeholders understand the needs and expectations of the interested parties. On the contrary, several stakeholders are not preparing for potential future business changes in the shipping industry in relation to MBMs being implemented globally. As the IMO focuses more on environmental regulations, ongoing stakeholder engagement will be critical to closing preparedness gaps.

4.5. Decision-making among maritime stakeholders.

The marine stakeholders' decision-making method for implementing MBMs in the shipping sector is now characterized by a mix of collaborative conversation and risk assessment. There are stakeholders who consider the impact of MBM's on their decision-making processes. Few organisations are already complying with established regional MBMs and they make data-driven solutions and decisions. However, several stakeholders are giving low priority to MBMs as they are awaiting technological advancements related to new dual fuel systems and infrastructure development primarily.

IMO's efforts are crucial to foster these conversations and guiding them towards internationally unified norms. Stakeholders are also engaging in studies to analyse the possible economic and operational consequences of MBMs, evaluating the advantages of long-term sustainability against the expense of short-term costs. Since decarbonisation is an immediate requirement to meet climate goals, ship designers and builders are already implementing novel design concepts offering future emission compliance; however, there are organisations that are not oriented towards MBMs and decarbonisation.

4.6. Collaboration among maritime stakeholders.

Recognising the shared responsibility and global character of shipping, key industry participants, regulators, and interest groups are actively participating in official and informal forums to build a consensus-driven strategy. Various maritime forums and dialogues are taking place around the globe. Currently for all new building projects decarbonisation is a major discussion point; therefore, collaborations allow stakeholders to fill the knowledge gaps and achieve the emission goals together as a team by utilising every stakeholder's expertise.

Certain stakeholders are collaborating with innovative suppliers to adopt digital solutions

for optimal route planning and energy management for ships. While these adjustments present initial challenges, they position the world fleet for long-term sustainability, operational efficiency, and enhanced competitiveness. Collaborations among stakeholders create an open platform for fast-flowing ideas, concerns, and development that can be achieved at greater pace. Knowledge and lessons learned should be shared among stakeholders for the fulfilment of decarbonisation.

5.0. DISCUSSION

This section discusses the qualitative research data that integrates the literature review and results from stakeholder analysis.

There are significant challenges in the implementation of MBMs, while the opportunities in MBMs as a transition measure are undeniably towards the decarbonisation of shipping. Lack of adequate awareness of the decarbonisation of the shipping industry as well as MBMs exists within the shipping fraternity. Several stakeholders are highly aware about the MBMs, while several stakeholders aren't. Certain stakeholders are not affected by the implementation of MBMs, since impact is not significant, as most of the outcome of the MBMs will be towards optimising fuel consumption, the availability of alternatives, and infrastructure for the supply of fuel to the available tonnages.

The marine industry's preparedness in the implementation of MBMs to meet GHG emission objectives is varied. While there is an increasing agreement on the need to address emissions in the maritime industry. For several organisations, MBMs impact their

strategies, investments, and operational practices to align with environmental goals and comply with regulations. Additional cost consideration, training requirements, voyage data and bunker management, energy efficiency, low-carbon energy fuel, and zero-carbon emissions solutions are key considerations in decision-making for several organisations.

Collective effort with input from stakeholders will help achieve goals more efficiently, and the future of decarbonisation can be achieved through cooperation and coordination among all stakeholders. Stakeholder engagement is vital in MBMs as it will be beneficial in terms of experience and financial support. Further, knowledge sharing is highly critical to the technological advancement and development of the shipping industry.

Through the integration and collaboration of various maritime stakeholders, MBMs can be enforced as a transitional measure. The opportunities for collaboration and cooperation are already present. However, whether they are effectively utilised or not is another question altogether.

6.0. CONCLUSION

The decarbonisation of the maritime industry is necessary for climate change mitigation and the achievement of GHG emission targets. MBM is an economic instrument that can be adopted by the maritime industry, thereby encouraging technological advancements related to zero-carbon fuels. There is a pressing necessity for MBMs in the shipping industry, and the lack of clarity in the implementation methodology of MBMs in time is likely to have adverse effects on the decarbonisation initiatives in the shipping industry.

This study shows that MBMs create several opportunities for stakeholders in shipping; however, severe challenges exist in their implementation. International cooperation and collaborative efforts hold great importance in addressing these challenges and achieving common IMO targets. Stakeholders need to be more aware and prepared for the introduction of MBMs in the shipping industry, and MBMs are likely to be a major decision-making factor in several shipping organisations.

The decisions on MBMs are not finalized at IMO, as they are being impacted by a lack of advancement in technology related to zero-GHG fuels, economic constraints, and international negotiations based on the principle of CBDR-RC in line with the UNFCCC and NMFT. The diverse interests and priorities of different countries make it difficult to establish a unified approach towards the adoption and implementation of MBMs. The maritime industry anticipates that the IMO will come up with more concrete measures during their future MEPC sessions. However, a lack of consensus among the member states on enforcing specific MBMs is obstructing the pathway to decarbonize the shipping industry.

The future of the shipping industry is very much dependent on whether the industry can catch up with the decarbonisation measures and regulations taken at IMO. The trajectory of the marine industry into the year 2050 is characterized by the influence of technical advancements and the pursuit of sustainability objectives, presenting a combination of opportunities and challenges. The industry's capacity for adaptation, combined with a proactive stance among stakeholders towards achieving the IMO objectives, will ultimately shape its position within the future of the 2050 climate scenario.

7.0. REFERENCES

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8.0. APPENDICES

Appendix A:

Survey Questionnaire

Dissertation Topic: IMO's 2050 AMBITIONS: CHALLENGES AND OPPORTUNITIES IN MARKET-BASED-MEASURES.

Dear Respondents,

Let me briefly introduce myself. My name is **Vaishak Arayakee**, presently pursuing postgraduation at **World Maritime University, Malmo, Sweden**, undertaking a **Master of Science in Maritime Affairs**, specializing in **Maritime Law and Policy**. I am currently undertaking a research project entitled "**IMO's 2050 AMBITIONS: CHALLENGES AND OPPORTUNITIES IN MARKET-BASED-MEASURES**", aimed at examining the major **Market Based Measures (MBMs)** being discussed currently at the **International Maritime Organization (IMO)**. Further, this study also involves stakeholder analysis specific to the maritime industry to assimilate the opportunities and challenges that underlie the MBMs for sustainable development of the maritime industry. This analysis consists of a survey questionnaire and interviews aimed at gathering information from the vantage point of various maritime industry stakeholders about their perspectives, attributes, and actions toward IMO's 2050 ambition to decarbonize the shipping industry by using market-based measures as a transitional device.

Summary of the Dissertation Topic

Climate change and decarbonization are deemed to constitute one of the most serious environmental and economic problems that humanity faces in the twenty-first century. The maritime industry, under the umbrella of the International Maritime Organization (IMO), is working towards reducing total annual greenhouse gas (GHG) emissions from global shipping by driving the GHG emissions to peak as soon as practicable and to achieve net-zero GHG emissions by or around 2050. Presently, due to the lack of technological advancement in developing fuels that have zero GHG emissions and the

cost involved in decarbonizing shipping, market-based-measures (MBMs) are expected to be adopted as a transitional measure to achieve the emissions targets. This research includes an analysis of IMO's 2050 objectives, the latest developments in regulating shipping decarbonization, global trends in the implementation of MBMs, and an examination of the challenges and opportunities in major MBMs.

I kindly request your valuable time and cooperation in completing this survey and greatly appreciate your participation.

Thank you.

Note: Part 1A is focused on general demographics and background, and Part 1B includes structured questions and statements with a rating scale. Part 1C consists of structured statements and parameters with a ranking scale, and Part 1D includes open questions structured to describe the views of participants. Part 2 consists of questions developed for semi-structured interview.

Part 1A: General Background

1. Age:
2. Current Place of Work:
3. Level of education:
 - Higher Secondary
 - Diploma
 - Under Graduate
 - Post Graduate
 - PhD
 -Other (Specify)
4. Duration of professional experience in maritime industry?
 - Nil
 - 1-3 years
 - 3-5 years

- More than 5 years
- More than 10 years
- More than 25 years

5. Current domain of occupation (Listed in alphabetical order):

- Classification Society
- International Organization
- Marine Conservation and related NGO's
- Marine Insurance and P& I
- Maritime Administration
- Maritime Education and Training Institutions
- Maritime Student
- Maritime Technology Provider
- Port and Terminal Management
- Ship Building and Repair
- Ship Design and Naval Architecture
- Ship Management Company
- Ship Owner
- Shipping Customers
- Shipping Logistics and Freight Forwarders
- Others..... (Please Specify)

Part 1B: Please rate the following questions on specified scales based on your knowledge, experience, and views.

6. How would you describe your current level of understanding of the **Decarbonization** of the **Shipping industry**?

Proficient	Intermediate	Beginner	Novice
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7. In your opinion, how significant is the **Decarbonization of Shipping** in combating **Climate Change and Global Warming**?

Very significant	Moderately significant	Insignificant

8. How would you describe your current level of understanding of **market-based-measures** in the **shipping industry**?

Proficient	Intermediate	Beginner	Novice

9. How important are **market-based-measures** as a transitional measure to decarbonize the maritime industry?

Very Important	Moderately Important	Not important

10. Do you agree that **market-based-measures** are effective in achieving significant decarbonization in the shipping industry by 2050?

Agree	Neutral	Disagree

11. How frequent does your current organization stays updated on the latest developments in **market-based-measures** for the decarbonization of shipping?

Always	Sometimes	Rarely

12. How would you describe your current organization's level of preparedness to respond to the **Decarbonization of Shipping Industry**?

Completely prepared	Moderately Prepared	Unprepared

13. How would you describe your current organization's level of preparedness to respond to the **market-based-measures in Shipping**?

Completely prepared	Moderately Prepared	Unprepared

14. How do you describe your level of preference for **carbon pricing** (e.g., carbon taxes, emissions trading) over other **market-based measures** being discussed in the Shipping industry?

Strongly Preferred	Moderately Preferred	Equally Preferred	Not Preferred

15. What kind of impact do market-based initiatives have on the financial health of the shipping industry?

Positive Impact	No Impact	Negative impact

16. Do you agree that international cooperation among various stakeholders in the maritime industry is the key way to move forward with market-based-measures?

Agree	Neutral	Disagree
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17. How frequent would you be willing to share best practices and lessons learned about implementing **market-based-measures** with other stakeholders in the shipping industry?

Always	Sometimes	Rarely	Not at all

Part 1C: Please rank the available options under each question based on its significance in an order in which the most desired option comes first.

18. Please rank the listed challenges in **Decarbonization of Shipping Industry** based on your knowledge and experience (“1” being the most challenging and “10” being the least. Please use each number only once):

- Energy Density and Safety Issues
- High Capital Costs
- Infrastructure Requirements
- Market Uncertainty
- Operational Challenges
- R&D Investment
- Regulatory Alignment
- Technological Innovation and Availability
- Time Scale
- Training and Education

19. Please rank the listed challenges in implementing **market-based-measures** in shipping industry. (“1” being the most challenging and “11” being the least. Please use each number only once):

- Administrative Complexity
- Cost Implications
- Data Accuracy and Verification
- Evasion Risk
- Fairness and Equity
- Global Coordination
- Leakage to other transport system
- Market Uncertainty
- Reducing physical impact on corals and marine life
- Reinvestment of Proceeds

- Technical Challenges

20. Please rank the listed available MBMs being discussed at IMO based on your most preference. (“1” being the most preferred and “8” being the least. Please use each number only once):

- International Fund for GHG emissions from ships (GHG Fund)
- Leveraged Incentive Scheme (LIS)
- Port State Levy
- Ship Efficiency and Credit Trading (SECT)
- Vessel Efficiency System (VES)
- Emissions Trading System (ETS) for International Shipping
- Market-Based Instruments: a penalty on trade and development
- Rebate Mechanism (RM) for a market-based instrument for international shipping

Part 1D: Based on your current domain of occupation as selected in the question no 6 in Part 1A, please describe your views in a paragraph for each question. (Please choose your current domain of occupation from a-o as stated below).

a. Classification Society

- ❖ What opportunities will market-based measures bring to the ship classification societies?
- ❖ Whether the market-based-measures will have significant impact on the rules and guidance set forth by the ship classification society?
- ❖ While incorporating new classification standards based on market-based measures, what challenges do you anticipate or have you experienced so far?
- ❖ In order to further support the decarbonization of the shipping industry, what changes do you anticipate in the regulatory landscape?

b. International Regulatory Bodies

- ❖ How do you envision the future of market-based measures in the decarbonization process of the shipping industry?
- ❖ In order to further support the decarbonization of the shipping industry, what changes do you anticipate in the international regulatory framework?
- ❖ What are the key opportunities for collaboration and cooperation with other maritime stakeholders in implementing market-based measures?
- ❖ How are you communicating about market-based measures to various stakeholders in order to build understanding and gain support?

c. Marine Conservation and NGO's

Whether your conservation goals and activities are being influenced by market-based measures, particularly related to marine biodiversity and ecosystems?

Whether your organisation is influencing the implementation of market-based measures to ensure they contribute effectively to global climate goals?

How are you monitoring the impacts of market-based measures on marine ecosystems and their contribution to broader climate goals?

What impact do you anticipate that market-based measures will have on your conservation goals and activities?

d. Marine Insurance and P& I

- ❖ To what extent are market-based measures being taken into account in your risk management strategies?
- ❖ While aligning your organisational services to market-based measures, what challenges do you anticipate or have you experienced so far?

- ❖ When it comes to offering marine insurance or P&I coverage, how do market-based measures affect your day-to-day work?
- ❖ In what ways do you think stakeholder collaborations would be beneficial to your business in relation to emerging market-based measures in the shipping industry?

e. Maritime Administration

- ❖ Within your jurisdiction, what role do you see for market-based measures in the decarbonization process of the maritime industry?
- ❖ How does the current regulatory framework in your administration affect the development of market-based measures?
- ❖ When putting market-based measures into place, what are the most important factors that your administration takes into account?
- ❖ To what extent do you foresee market-based-measures playing a role in your region's efforts to decarbonize the shipping industry?

f. Maritime Education and Training Institutions

- ❖ In the wake of potential future changes in the decarbonization of shipping and market-based measures, how are you preparing your curriculum and training programmes?
- ❖ What expertise do you think maritime professionals need to manage and deploy market-based measures successfully?
- ❖ In what ways are your students and disciples being provided with these opportunities?
- ❖ In what ways do you think it would be beneficial to work together with other maritime stakeholders concerned with this matter?

g. Maritime Student

- ❖ How familiar are you with the term 'market-based measures' in the context of the shipping industry's decarbonization efforts? Please describe.
- ❖ How do you normally keep updated with developments in the shipping industry, such as the introduction of market-based measures and decarbonization strategies?
- ❖ How interested are you in working for businesses that have adopted market-based measures and are making strides towards decarbonization? And why?
- ❖ How do you think market-based measures can help the maritime industry become decarbonized?

h. Maritime Technology Provider

- ❖ How do market-based measures influence your research and development initiatives?
- ❖ How are market-based measures shaping the development and deployment of your technological solutions in the shipping industry?
- ❖ When planning or implementing technological solutions for market-based measures, what difficulties do you foresee or have you already encountered?
- ❖ In what ways do you think it would be beneficial to work together with other stakeholders concerned with this matter?

i. Port and Terminal Management

- ❖ In what ways have you modified or intend to modify your port infrastructure to welcome ships that meet future GHG emission regulations and requirements?

- ❖ What do you think market-based measures will be like in the future of shipping, and how will this affect the way ports and terminal's function?
- ❖ What kinds of support do you need from other stakeholders to implement these measures effectively?
- ❖ In what ways do you think it would be beneficial to work together with other parties concerned with this matter?

j. Ship Building and Repair

- ❖ How are decarbonization and market-based measures influencing your decisions and processes in your organization?
- ❖ What difficulties have you found or anticipate in shipbuilding to meet the market-based measures?
- ❖ In what ways have you upgraded or are you revamping your organization to accommodate market-based measures and the decarbonization of the shipping industry?
- ❖ What opportunities do you see for collaboration or partnership with other stakeholders on this issue?

k. Ship Design and Naval Architecture

How does the decarbonization of the shipping industry influence your decisions and choices in the design of ships?

When designing ships that adhere to the decarbonization and market-based measures, what difficulties have you found or do you anticipate?

How do cutting-edge technologies and creative methods of design help market-based measures and decarbonization targets?

What opportunities do you see for collaboration or partnership with other stakeholders on this issue?

l. Ship Management Company

- ❖ In what ways are decarbonization and market-based measures changing your organization's perspective on handling vessels?
- ❖ What difficulties have you faced or do you foresee in introducing market-based measures aboard the ships you oversee?
- ❖ What steps have you taken to prepare your business for any shifts in market-based measures down the road?
- ❖ In what ways do you think it would be beneficial to work together with other parties concerned with this matter?

m. Ship Owner

- ❖ How does the decarbonization of the shipping industry impact your decisions regarding ship operations and investments?
- ❖ What are the biggest challenges you face in implementing market-based measures?
- ❖ How are you preparing your business for potential future changes in the shipping industry in relation to the market-based measures being implemented globally?
- ❖ What opportunities do you see for collaboration or partnership with other stakeholders on this issue?

n. Shipping Customers

- ❖ How well do you know the term 'market-based measures' in relation to the decarbonization initiatives in the shipping industry?
- ❖ Would you pay more for shipping services that can prove they are less harmful to the environment because of the use of market-based measures and other green initiatives?
- ❖ If the shipping sector starts using market-based measures, what effects do you think you'll feel as a consumer down the road?

- ❖ In what ways do you think you could be more actively involved in the shipping industry's efforts to reduce carbon emissions?

o. Shipping Logistics and Freight Forwarding

- ❖ How are you planning to adapt your supply chain management strategies to account for the decarbonization of shipping and market-based measures?
- ❖ What effect are market-based measures having on your logistics and shipping processes?
- ❖ What challenges do you foresee or have encountered in adapting your operations to accommodate market-based-measures?
- ❖ What effect do market-based-measures have on your interactions with consumers, carriers, and shippers?

Appendix B

Semi-structured interview questions.

1. From your vantage point as a senior professional, how do you conceive the maritime transport sector as a whole responding to the latest trend in adoption of regulations related to decarbonization and market-based-measures at a global level?
2. How do you foresee the future of your organization in light of the widespread use of market-based-measures in the maritime transportation sector?
3. To what extent have market-based-measures impacting your organizations s long-term strategy, decision-making processes and daily operations?
4. What challenges and opportunities have you observed in the implementation of MBMs in the industry?
5. What changes has your organization had to make, if any, in response to the adoption of MBMs in the shipping industry?
6. When it comes to market-based-measures, how does your organisation collaborate with other maritime stakeholders, regulatory agencies, or non-traditional partners (e.g., technology providers, NGOs), if at all?
7. What guidance would you offer to other marine organisations those are attempting to implement market-based-measures?

Appendix C

Survey Questionnaire report generated by Type Form

QUESTIONNAIRE

<https://14gp90mg3fm.typeform.com/report/OAnZ04kF/DG73Mi1och...>

QUESTIONNAIRE

127 responses

Consent Form

126 out of 127 answered

I accept	126 resp.	100%
I do not accept	0 resp.	0%

Level of education:

127 out of 127 answered

Under Graduate	62 resp.	48.8%
Post Graduate	50 resp.	39.4%
PhD	5 resp.	3.9%
Diploma	4 resp.	3.1%

Higher Secondary	4 resp. 3.1%
Others	2 resp. 1.6%

Duration of professional experience in maritime industry?

127 out of 127 answered

More than 10 years	42 resp. 33.1%
More than 5 years	30 resp. 23.6%
Nil	17 resp. 13.4%
1-3 years	13 resp. 10.2%
More than 25 years	13 resp. 10.2%
3-5 years	12 resp. 9.4%

How would you describe your current level of understanding of the Decarbonization of the Shipping industry?

127 out of 127 answered

QUESTIONNAIRE

<https://14gp90mg3fm.typeform.com/report/OAnZ04kF/DG73Mi1och...>

Intermediate	55 resp. 43.3%
Beginner	40 resp. 31.5%
Proficient	29 resp. 22.8%
Novice	3 resp. 2.4%

In your opinion, how significant is the Decarbonization of Shipping in combating Climate Change and Global Warming?

127 out of 127 answered

Very significant	90 resp. 70.9%
Moderately significant	34 resp. 26.8%
Insignificant	3 resp. 2.4%

How would you describe your current level of understanding of market-based-measures in the shipping industry?

127 out of 127 answered

Intermediate	63 resp. 49.6%
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Beginner	34 resp. 26.8%
Proficient	21 resp. 16.5%
Novice	9 resp. 7.1%

How important are market-based-measures as a transitional measure to decarbonize the maritime industry?
127 out of 127 answered

Very Important	79 resp. 62.2%
Moderately Important	46 resp. 36.2%
Not important	2 resp. 1.6%

Do you agree that market-based-measures are effective in achieving significant decarbonization in the shipping industry by 2050?
127 out of 127 answered

Agree	68 resp. 53.5%
Neutral	51 resp. 40.2%

Disagree 8 resp. 6.3%

How frequent does your current organization stays updated on the latest developments in market-based-measures for the decarbonization of shipping?

127 out of 127 answered

Always 67 resp. 52.8%

Sometimes 39 resp. 30.7%

Rarely 21 resp. 16.5%

How would you describe your current organization's level of preparedness to respond to the Decarbonization of Shipping Industry?

127 out of 127 answered

Moderately Prepared 62 resp. 48.8%

Completely prepared 39 resp. 30.7%

Unprepared 26 resp. 20.5%

How would you describe your current organization's level of preparedness to respond to the market-based-measures in Shipping?

127 out of 127 answered

Moderately Prepared	65 resp. 51.2%
Completely prepared	35 resp. 27.6%
Unprepared	27 resp. 21.3%

How do you describe your level of preference for carbon pricing (e.g., carbon taxes, emissions trading) over other market-based measures being discussed in the Shipping industry?

127 out of 127 answered

Moderately Preferred	62 resp. 48.8%
Strongly Preferred	31 resp. 24.4%
Equally Preferred	27 resp. 21.3%
Not Preferred	7 resp. 5.5%

What kind of impact do market-based initiatives have on the financial health of the shipping industry?

127 out of 127 answered

Positive Impact	70 resp. 55.1%
Negative impact	43 resp. 33.9%
No Impact	14 resp. 11%

Do you agree that international cooperation among various stakeholders in the maritime industry is the key way to move forward with market-based-measures?

127 out of 127 answered

Agree	107 resp. 84.3%
Neutral	18 resp. 14.2%
Disagree	2 resp. 1.6%

How frequent would you be willing to share best practices and lessons learned about implementing market-based-measures with other stakeholders in the shipping industry?

126 out of 127 answered

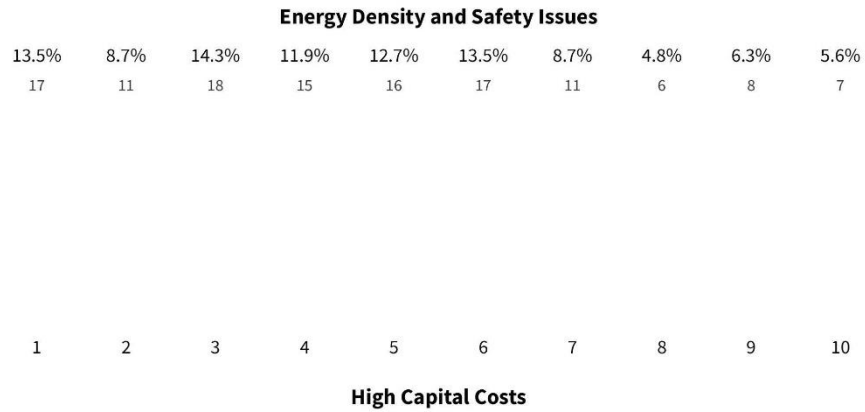
QUESTIONNAIRE

<https://14gp90mg3fm.typeform.com/report/OAnZ04kF/DG73Mi1och...>

Always	72 resp. 57.1%
Sometimes	46 resp. 36.5%
Rarely	6 resp. 4.8%
Not at all	2 resp. 1.6%

Please rank the listed challenges in Decarbonization of Shipping Industry based on your knowledge and experience.

126 out of 127 answered



34.9%	20.6%	15.1%	8.7%	5.6%	5.6%	4.8%	1.6%	2.4%	0.8%
44	26	19	11	7	7	6	2	3	1

1 2 3 4 5 6 7 8 9 10

Infrastructure Requirements

8.7%	20.6%	16.7%	17.5%	13.5%	9.5%	7.1%	4.8%	0%	1.6%
11	26	21	22	17	12	9	6	0	2

1 2 3 4 5 6 7 8 9 10

Market Uncertainty

7.1%	9.5%	16.7%	15.1%	9.5%	12.7%	13.5%	6.3%	4%	5.6%
9	12	21	19	12	16	17	8	5	7

1 2 3 4 5 6 7 8 9 10

Operational Challenges

5.6%	9.5%	8.7%	18.3%	24.6%	9.5%	12.7%	6.3%	4%	0.8%
7	12	11	23	31	12	16	8	5	1

1	2	3	4	5	6	7	8	9	10
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R&D Investment

9.5%	11.1%	6.3%	9.5%	6.3%	26.2%	5.6%	12.7%	8.7%	4%
12	14	8	12	8	33	7	16	11	5

1	2	3	4	5	6	7	8	9	10
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Regulatory Alignment

4.8%	1.6%	7.9%	3.2%	8.7%	5.6%	29.4%	11.9%	17.5%	9.5%
6	2	10	4	11	7	37	15	22	12

1	2	3	4	5	6	7	8	9	10
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Technological Innovation and Availability

QUESTIONNAIRE

<https://14gp90mg3fm.typeform.com/report/OAnZ04kF/DG73Mi1och...>

12.7%	13.5%	7.9%	2.4%	7.1%	5.6%	7.1%	29.4%	7.9%	6.3%
16	17	10	3	9	7	9	37	10	8

1	2	3	4	5	6	7	8	9	10
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Time Scale

0.8%	2.4%	2.4%	7.1%	7.1%	4.8%	7.9%	11.1%	41.3%	15.1%
1	3	3	9	9	6	10	14	52	19

1	2	3	4	5	6	7	8	9	10
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Training and Education

2.4%	2.4%	4%	6.3%	4.8%	7.1%	3.2%	11.1%	7.9%	50.8%
3	3	5	8	6	9	4	14	10	64

1	2	3	4	5	6	7	8	9	10
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Please rank the listed challenges in implementing market-based-measures in shipping industry.

126 out of 127 answered

Administrative Complexity

27%	21.4%	10.3%	14.3%	6.3%	7.1%	5.6%	0.8%	2.4%	3.2%	1.6%
34	27	13	18	8	9	7	1	3	4	2

1	2	3	4	5	6	7	8	9	10	11
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Cost Implications

29.4%	28.6%	19%	7.9%	5.6%	4.8%	2.4%	2.4%	0%	0%	0%
37	36	24	10	7	6	3	3	0	0	0

1	2	3	4	5	6	7	8	9	10	11
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Data Accuracy and Verification

14.3%	10.3%	28.6%	13.5%	13.5%	11.1%	4%	2.4%	0%	0.8%	1.6%
18	13	36	17	17	14	5	3	0	1	2

1	2	3	4	5	6	7	8	9	10	11
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Evasion Risk

3.2%	5.6%	8.7%	19%	16.7%	20.6%	10.3%	5.6%	7.1%	2.4%	0.8%
4	7	11	24	21	26	13	7	9	3	1

1	2	3	4	5	6	7	8	9	10	11
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Fairness and Equity

3.2%	7.1%	5.6%	11.1%	23%	13.5%	13.5%	12.7%	7.1%	1.6%	1.6%
4	9	7	14	29	17	17	16	9	2	2

1	2	3	4	5	6	7	8	9	10	11
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Global Coordination

11.9%	8.7%	11.1%	10.3%	7.9%	23.8%	11.9%	7.9%	4.8%	1.6%	0%
15	11	14	13	10	30	15	10	6	2	0

1	2	3	4	5	6	7	8	9	10	11
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Leakage to other transport system

1.6%	0.8%	2.4%	7.1%	4.8%	6.3%	30.2%	17.5%	12.7%	9.5%	7.1%
2	1	3	9	6	8	38	22	16	12	9

1	2	3	4	5	6	7	8	9	10	11
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Market Uncertainty

4%	7.1%	4%	5.6%	7.9%	2.4%	10.3%	33.3%	11.9%	8.7%	4.8%
5	9	5	7	10	3	13	42	15	11	6

1	2	3	4	5	6	7	8	9	10	11
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Reducing physical impact on corals and marine life

0.8%	0.8%	0%	3.2%	3.2%	4.8%	3.2%	7.1%	38.9%	23%	15.1%
1	1	0	4	4	6	4	9	49	29	19

1	2	3	4	5	6	7	8	9	10	11
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Reinvestment of Proceeds

QUESTIONNAIRE

<https://l4gp90mg3fm.typeform.com/report/OAnZ04kF/DG73Mi1och...>

1.6%	1.6%	1.6%	3.2%	1.6%	2.4%	5.6%	7.1%	8.7%	43.7%	23%
2	2	2	4	2	3	7	9	11	55	29

1	2	3	4	5	6	7	8	9	10	11
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Technical Challenges

3.2%	7.9%	8.7%	4.8%	9.5%	3.2%	3.2%	3.2%	6.3%	5.6%	44.4%
4	10	11	6	12	4	4	4	8	7	56

1	2	3	4	5	6	7	8	9	10	11
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. Please rank the listed available MBMs being discussed at IMO based on your most preference.

126 out of 127 answered

International Fund for GHG emissions from ships (GHG Fund)

47.6%	19.8%	12.7%	7.1%	4%	6.3%	0%	2.4%
60	25	16	9	5	8	0	3

1	2	3	4	5	6	7	8
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Leveraged Incentive Scheme (LIS)

6.3%	31.7%	19%	11.1%	11.9%	11.1%	7.1%	1.6%
8	40	24	14	15	14	9	2

1	2	3	4	5	6	7	8
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Port State Levy

8.7%	10.3%	24.6%	21.4%	10.3%	7.9%	7.1%	9.5%
11	13	31	27	13	10	9	12

1	2	3	4	5	6	7	8
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Ship Efficiency and Credit Trading (SECT)

9.5%	12.7%	20.6%	24.6%	18.3%	7.9%	4%	2.4%
12	16	26	31	23	10	5	3

1	2	3	4	5	6	7	8
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Vessel Efficiency System (VES)

11.1%	11.1%	7.9%	12.7%	28.6%	18.3%	6.3%	4%
14	14	10	16	36	23	8	5

1	2	3	4	5	6	7	8
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Emissions Trading System (ETS) for International Shipping

13.5%	7.1%	8.7%	9.5%	8.7%	36.5%	11.1%	4.8%
17	9	11	12	11	46	14	6

1	2	3	4	5	6	7	8
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Market-Based Instruments: a penalty on trade and development

1.6%	4.8%	2.4%	6.3%	11.1%	8.7%	46%	19%
2	6	3	8	14	11	58	24

1	2	3	4	5	6	7	8
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Rebate Mechanism (RM) for a market-based instrument for international shipping

QUESTIONNAIRE

<https://14gp90mg3fm.typeform.com/report/OAnZ04kF/DG73Mi1och...>

1.6%	2.4%	4%	7.1%	7.1%	3.2%	18.3%	56.3%
2	3	5	9	9	4	23	71

1	2	3	4	5	6	7	8
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Current domain of occupation (Listed in alphabetical order):

127 out of 127 answered

Classification Society 23 resp. 18.1%

Others 22 resp. 17.3%

Maritime Student 17 resp. 13.4%

Ship Design and Naval Architecture 16 resp. 12.6%

Maritime Administration 12 resp. 9.4%

Ship Building and Repair 12 resp. 9.4%

Maritime Technology Provider 5 resp. 3.9%

Maritime Education and Training Institutions 4 resp. 3.1%

Ship Owner	4 resp.	3.1%
Port and Terminal Management	3 resp.	2.4%
Ship Management Company	3 resp.	2.4%
International Organization	2 resp.	1.6%
Shipping Customers	2 resp.	1.6%
Marine Conservation and related NGO's	1 resp.	0.8%
Shipping Logistics and Freight Forwarders	1 resp.	0.8%
Marine Insurance and P&I	0 resp.	0%

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