Maritime Economics & Logistics (2024) 26:168–184
https://doi.org/10.1057/s41278-023-00261-1

POLICY PERSPECTIVES

# The prospects for, and implications of, emissions trading in shipping

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Accepted: 17 March 2023 / Published online: 5 April 2023


## Abstract

The decarbonisation of shipping has become a high priority on the environmental and political agenda. The prospect of implementing an Emissions Trading System (ETS) for shipping has come to prominence as a proposed mechanism for speeding up the decarbonisation of the industry, with the EU taking proactive action to include shipping within the EU ETS by 2023. This paper analyses and provides a qualitative review of the historical development of the discussions and actions taken at both global level (by the International Maritime Organization (IMO)) and at regional level within the EU. A SWOT analysis of the potential implementation of an ETS for shipping is then presented. The paper concludes that an ETS for shipping can incentivise greater investment in, and deployment of, green technologies that will have the effect of reducing the carbon footprint of the shipping industry. However, the speed and significance of this effect will depend upon the specific shipping market segment and the relative stage in shipping market cycles over time. It is further concluded that despite the imminent unilateral introduction of shipping into the EU ETS, it is important that the IMO continues its work to develop a global ETS that promotes a 'level playing field' for competition within the sector and eliminates the risk of carbon leakage.

**Keywords** Emission trading · Shipping · GHG emissions · Market-based measures · Decarbonisation

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## 1 Introduction

Despite the fact that climate change is one of the greatest challenges facing the world today, maritime transportation not only still depends on fossil fuels as the main energy source for vessels, but the sector is also responsible for an increasing proportion of global $CO_2$ emissions year on year (IMO 2020). In order to tackle this significant external cost from shipping, a number of initiatives and regulations have been adopted and implemented at a global and regional level.

The International Maritime Organisation (IMO)—the inter-governmental organisation responsible for the regulation of maritime affairs, including safety and environmental protection—has introduced technical and operational measures for the improvement of energy efficiency and the reduction of the GHG emissions of the global fleet. These include the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) that have become mandatory for all vessels over 400 GT since January 2013 (IMO 2011). Subsequent to the adoption of the global data collection system for $CO_2$ emissions from shipping in 2016, all vessels equal to or above 5000 GT are also now required to monitor and report data on their fuel consumption and amount of transport work undertaken on a yearly basis. The most recent regulations encompass additional technical measures (IMO 2021)—the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII)—which came into force on January 1st 2023.

Apart from the range of technical and operational measures that have already been introduced or planned for, the potential introduction of market-based measures (MBMs) has also been discussed, both within the IMO, the EU and individual countries such as China, Japan and Australia (Cullinane and Yang 2022). MBMs have been successfully and cost-effectively implemented in other industrial sectors for the reduction of the GHGs from operations (Meckling and Hepburn 2013; Mendes and Santos 2008). In contrast to the regulatory "command and control" approaches that require compliance with absolute targets for the reduction of GHG emissions through the introduction of specific actions, MBMs are more flexible mechanisms that seek to incentivise the internalisation of the external costs of GHG emissions into the production cost of industry players. Companies can then choose the way they address this increased cost from carbon pricing, but the expectation is that the additional $CO_2$ cost provides incentives for actions and investments that would reduce the carbon footprint of company operations.

By far the most discussed MBMs for potential implementation within the maritime industry are a global carbon tax (or levy) on fuel use and $CO_2$ emissions trading (Psaraftis et al. 2021; Christodoulou et al. 2021a, b). This paper focuses on analysing the prospects and implications of the introduction of $CO_2$ emissions trading within the maritime industry. In principle, emissions Trading Systems (ETS) are MBMs that involve the setting of an annual cap on the total GHG or $CO_2$ emissions of the industry sectors that are mandated to participate within the system.[1] Participant companies can then buy or sell rights to emit (as incorporated within the emissions allowances which are granted to each industry player), depending on their industrial output and their ability to improve their energy efficiency and reduce their carbon footprint. In this way, 'cleaner' operations are rewarded with these companies having the ability to sell their surplus emissions allowances to industry counterparts that find it more cost-efficient to buy allowances than to invest in reducing their emissions.

Although the potential of emissions trading for the abatement of shipping GHG emissions has received some treatment within the existing green shipping literature, the synergies and contradictions among global and regional policy proposals for the adoption of such a system have not yet been adequately analysed. Recent academic articles focus on the impact (and implications) that regional emissions trading systems would have on the shipping industry or analyse recent relevant developments within the IMO and the EU (e.g., Lagouvardou et al. 2020; Psaraftis et al. 2021; Wu et al. 2022). There is a literature gap, though, when considering the historical developments that have led to the current state of play in the potential introduction of both a global and a regional (EU) ETS for the maritime sector that the current study aims to fill. It is not a coincidence that the inclusion of shipping in the EU ETS forms part of the European Green Deal and is adopted prior to any developments or advances at global level have taken place. The processes and directions behind global and regional policy proposals present substantial differentiations that are underlined and comprehensively analysed in this research work. In this way, current inefficiencies and drawbacks in shipping policy-making procedures can be revealed. We attempt to offer a comprehensive understanding of the prospects for, and implications of, emissions trading for shipping through a SWOT analysis. Another novelty of this work lies in the fact that, in contrast to existing academic works that analyse the outcomes and results from the implementation of emissions trading in various industrial sectors, our study focuses on the suitability of such a system for the shipping industry, taking into account its particular characteristics and market conditions.

The suitability of an MBM is not uniform among different industrial sectors, but depends on the distinct characteristics of each sector and the structure of each market (Winebrake and Corbett 2010). In the shipping industry, the adoption of GHG or, more specifically, $CO_2$ emissions trading could supplement the already implemented and planned technical and operational measures for the decarbonisation of the sector by providing an incentive for investments in innovative technologies, or a shift to alternative fuels and energy sources. Nevertheless, the introduction of such a system for shipping at a global level presupposes that IMO members—both developing and developed countries—can reach agreement on the design of the system and reconcile their different interests and approaches, in line with the underlying principle of 'common, but differentiated, responsibilities' in international environmental law

[1] Emissions trading systems are not limited in their application solely to $CO_2$; they have been developed for the wider range of GHGs and for emissions of pollutants such as SOx and NOx (see Nikopoulou et al. 2013).

(Stone 2004). Given the existing challenges in reaching a consensus on the adoption of an IMO-led global emissions trading system (ETS) for shipping, recent developments within the EU have come to the forefront; with a commitment made to the introduction of shipping emissions into the existing EU Emissions Trading System (EU-ETS) for the reduction of GHG emissions from shipping (European Commission 2019).

Historical developments that have led to the current state of play in the potential introduction of both a global and a regional (EU) ETS for the maritime sector are presented in the ensuing section. The identified strengths, weaknesses, opportunities and threats from its implementation are analysed in Sect. 3, with conclusions drawn in Sect. 4.

## 2 Historical developments in the implementation of an ETS for shipping

### 2.1 Discussions within the IMO

The main rationale for the adoption of a global GHG ETS for the maritime industry is to design an MBM where the quantity of global shipping emissions would be determined through the setting of: (a) a global cap on GHG emissions which would be reduced year-on-year and (b) the purchase price of emissions allowances that all vessels above a certain deadweight tonnage would need to surrender to cover their emissions. Another important priority is that the system should be global in application and, thereby, facilitate a 'level playing field' for competition within the sector (Mellqvist et al. 2014; Artuso et al. 2016). Such a mechanism would effectively involve setting a carbon price that shipping companies would need to bear in correspondence with their carbon footprint. It would be the intention that the price paid for the allowance to emit would effectively incentivise investments and promote the decarbonisation of the sector. Additionally, a fund would be developed from the revenues accruing from the auctioned emissions allowances that would be designated to promote research and development of green technologies and to provide the necessary technical support to least developed and developing countries for the introduction and deployment of these technologies.

The First IMO GHG Study in 2000 recommended the further investigation of the potential for introducing a global maritime ETS as an additional tool for the reduction of GHG emissions from shipping. The possibility was immediately included in the agenda of the Marine Environment Protection Committee (MEPC) of the IMO. However, it was not until 2010 that IMO Member States were asked to propose MBMs that they deemed suitable for the maritime sector, so that suggested alternatives could proceed to assessment and evaluation. The proposals submitted to the MEPC came from a range of individual countries, organisations and groups of both. The proposals received could be broadly divided between the imposition of global levies on marine bunker fuels and shipping emissions and various forms of ETS (Lagouvardou et al. 2020).

The countries that were vociferously in favour of an ETS for shipping were Norway, the United Kingdom, France and Denmark, though both Japan and the US were supportive of the general principle of developing a global ETS for shipping. Norway proposed the introduction of the 'Global Emission Trading System for international shipping': an ETS in which a cap on global shipping emissions is set on a yearly basis and the emissions allowances corresponding to this cap are auctioned and traded within the system, with their price also set annually. The 'Global Emissions Trading System for international shipping' proposed by the United Kingdom was similar to the Norwegian proposal, with the main differences related to the determination of the emissions cap and the method by which allowances should be allocated. The French proposal—'Further elements for the development of an Emissions Trading System for International Shipping'—is also similar to the Norwegian proposal but provided greater detail in the exposition of the auctioning mechanism to be used within the system. The 'Design and implementation of a worldwide Maritime Emission Trading Scheme (METS)' was proposed by Germany as a cost-efficient mechanism for the reduction of shipping GHG emissions, in accordance with the proposals of Norway and France (IMO 2010a, b; Nikolakaki 2013).

The different MBMs proposed by IMO Member States were then evaluated by the Expert Group on the Feasibility Study and Impact Assessment of possible Market-based Measures, as commissioned by the MEPC (Psaraftis 2019). The remit for the group was to provide adequate information on the cost-effectiveness and the suitability of the proposed MBMs and to lead the way towards the implementation of the most appropriate measures. Despite the progress made at that time, with discussions on the implementation of MBMs at the IMO MEPC lasting well beyond the original deadline of 2011 that had been set for the work plan, in May 2013 the MEPC agreed to (indefinitely) suspend discussions on MBMs and related issues to a future session (Lagouvardou et al. 2020).

MBMs have recently returned to prominence in IMO discussions as a consequence of the 'Initial IMO strategy for the reduction of GHG emissions from ships', adopted in December 2018. The IMO GHG Strategy sets the target of reducing GHG emissions from shipping by 50% by 2050 compared to a baseline of 2008, with the ultimate aim being zero GHG emissions by the end of the century. The IMO strategy proposes a number of potential measures/tools that could be implemented to reach this target. The measures are categorised on the basis of the timeframe of their adoption into short-term (to be adopted between 2020 and 2023), mid-term (between 2023 and 2030) and long-term (after 2030) (IMO 2018). MBMs form part of the strategy's mid-term measures as they are not expected to be implemented or agreed upon by the MEPC before 2030, mainly due to the difficulties faced in reconciling the different interests of the IMO Member States.

The International Chamber of Shipping (ICS) proposed an "IMO Climate Fund" in 2021; a fund comprising revenues raised from a global carbon levy that would apply to all ships over 5,000 GT to accelerate the energy transition of shipping and the uptake of alternative fuels and infrastructure (ICS 2021). The ICS proposal urges the imposition of a bunker fuel levy of $2 per tonne of fuel that could lead to raising $5 billion each year to be channelled through the IMO Climate Fund. Additionally, in 2021, more than 150 industry stakeholders and organisations signed the

Call to Action for Shipping Decarbonisation asking, among others, governments to "adopt policy measures, including meaningful market-based measures, taking effect by 2025, that will support the commercial deployment of zero emission vessels and fuels in international shipping and make ordering zero emission vessels the default choice no later than 2030" (Global Maritime Forum 2021). Finally, at the IMO ISWG GHG12 meeting that took place in May 2022, it was the first time that there was an overall consensus on the need to introduce MBMs and set a carbon price on the GHG emissions of shipping, to accelerate the energy transition of the sector (ISWG GHG12, 2022). The main MBMs to be considered in the next meeting (ISWG GHG13) include, among others, the introduction of a global bunker fuel levy and a "Cap and Trade" system.

### 2.2 EU processes and directives[2]

The extensive negotiations required and the challenges faced in reconciling different interests in deciding upon and implementing a maritime ETS at a global level, in addition to the continued urgent need to reduce GHG emissions from shipping, has meant that various initiatives have emerged at regional level, with the actions taken by the EU clearly standing out.

The EU-ETS entered into force in 2005 and has been periodically revised and updated since that time, particularly with the controversial inclusion of the airline sector in 2012 (Nava et al. 2018). The European Commission (EC) initiated discussions on the potential for including shipping in the EU ETS as far back as 2007. These were postponed, however, because of the identified practical challenges in progressing such a development (Kågeson 2008). In contrast to the other industrial sectors included in the EU ETS (i.e., steel and metal industry, cement and stone, forestry, energy sector, refineries and aviation), the GHG emissions from the maritime sector cannot be easily allocated to a country. In addition, the geographical coverage of shipping emissions included in the EU ETS is also unclear; for example, it could include only emissions from intra-European voyages, from voyages departing or arriving from/to EU ports or all voyages; between two non-EEA nations but by vessels registered within the EEA (Bäuerle et al. 2010).

A cap on total GHG emissions from the sectors included in the EU ETS is determined on an annual basis and companies (entities) involved in the included sectors need to surrender the necessary allowances to cover their emissions. Depending on their ability to reduce their emissions, they may buy or sell allowances in the market, with the most energy-efficient companies being rewarded through the access which is gained to this additional source of revenue. Discussions on the potential inclusion of shipping in the EU ETS re-emerged in February 2017, with the European Parliament (EP) voting in favour of including shipping in the EU ETS as from 2023, unless the IMO has created a comparable scheme of its own by 2021. In 2019, the

[2] An interesting analysis of the politics involved in the decision to include shipping in the EU ETS is provided in Wettestad and Gulbrandsen (2022).

EU Green Deal commits to bringing shipping within the EU ETS (European Commission 2019).

These new policies have emerged on the back of the adoption of the EU Regulation 2015/757 introducing the monitoring, reporting and verification (MRV) of emissions from shipping (European Commission 2015). The MRV regulation requires all vessels of 5000 GT and above operating within the EEA or calling at EU ports to monitor and report their emissions on a yearly basis, along with information on the distance travelled and the transport work involved. The regulation entered into force in 2018 and provided a necessary and decisive first step in the process of including shipping in the EU ETS The MRV data collected on fuel consumption and CO2 emissions of vessels operating with the European Economic Area (EEA) is intended as the basis for setting emissions reduction targets for the maritime sector.

The proposal to extend the EU ETS to cover $CO_2$ emissions from maritime transport was recently included in the European Green Deal, released in December 2019, as an additional measure for the achievement of climate neutrality in Europe by 2050 (European Commission 2019). This development comes after the adoption of the EU Directive 2018/410 (European Commission, 2018) that calls for immediate action to address shipping GHG emissions. This discussion for the extension of the EU ETS to include shipping emissions was originally planned for July 2021, as part of a general review of the EU-ETS (Egenhofer et al. 2012; Perino and Willner 2017).

In July 2021, the 'Fit for 55' package was presented by the EC (European Commission 2021a), as a continuation and further development of the European Green Deal, setting the intermediate target of reducing GHG emissions by at least 55% by 2030 compared to 1990. In relation to the abatement of maritime emissions, the package includes three legislative proposals of fundamental importance, among which is the revision of the EU ETS and the inclusion of shipping emissions in it. The relevant legislative proposal includes detailed information on the design features of the upcoming system. For example, auctioning is proposed as the most effective method for allocating emissions allowances, while the emissions from all intra-European voyages and 50% of voyages departing from, and arriving at, EU ports are to be included in the system.

## 3 SWOT analysis

Following on from the previous presentation on the historical developments with respect to the use of an ETS for the reduction of GHG emissions from the maritime sector, an analysis of the various strengths, weaknesses, opportunities and threats associated with such an MBM is presented below.

### 3.1 Strengths

Based on the existing literature, MBMs can be characterised as either 'price' or 'quantity' measures (Weitzman 1974). An ETS is by nature a quantity measure as it sets the emissions cap and the associated emissions allowances to be allocated (quantity), while the price of the allowances is determined by market forces.

Assuming that the emissions cap will become stricter over the years and the price of emissions allowances will probably increase (as the limit on available emissions allowances tightens over time), shipping companies will act rationally by seeking to decrease the ever-increasing cost of emitting GHGs through investments in innovative technologies and clean fuels. In theory, the abatement costs incurred by the introduction of the energy efficiency measures and the employment of alternative fuels or energy sources will, at most, equal the cost of surrendering the required emissions allowances as shipping companies rationally seek to minimise their overall compliance cost (Vogt-Schilb and Hallegatte 2014). In this way, the companies will at the same time increase their competitiveness and promote their sustainable development (Eide et al. 2013). Participation in an ETS will allow shipping companies to choose the way they will cope with the additional cost of acquiring the most appropriate quantity of emissions allowances, either through improvements in their energy efficiency or buying these allowances from 'cleaner' companies in the sector or the wider market, depending upon the rules of the ETS.[3]

Another strength of implementing an ETS for the reduction of GHG emissions from shipping comes from the fact that such a system could reconcile two seemingly contradictory relevant principles. Firstly, the UNFCCC principle of 'common but differentiated responsibilities' among countries is based on the understanding that not all countries make the same contribution to global GHG emissions and their responsibilities in their alleviation should, therefore, be proportional to their contribution. Secondly, the IMO has traditionally applied the principle of 'equal and no more favourable treatment' amongst its Member States. This presupposes that no Member State should receive differentiated treatment on any matter and derives primarily from the fact that the vast majority of the world fleet is registered under the flags of developing and least developed countries. (Shi 2016; Miola et al. 2011). The adoption of an ETS for shipping is consistent with both these principles as, on the one hand, all vessels engaged in international voyages will have the obligation to acquire the quantity of allowances commensurate with their emissions ('equal and no more favourable treatment') and, on the other hand, the overall revenues from the allowances will be used for the creation of a fund that will promote research and development in the sector and provide technical assistance to developing and least developed countries ('common but differentiated responsibilities') to promote the introduction of innovative technologies and the shift to alternative fuels and energy sources.

[3] Specific industry sectors within an ETS can be treated as any other form of industry emitter and be free to trade allowances between sectors or even across national borders in an'open' system where the cap is set across all industry participants. Alternatively, while the general rules of the ETS apply to all, one or more specific sectors may be ring-fenced in a 'closed' system so that they have their own sectoral cap, a separate allocation of allowances to accord with this cap (and possibly a different method of allocation from the rest of the ETS) and are limited to trading allowances only between sectoral players. Obviously, this also implies a unique sectoral price for GHG emissions (Kopsch 2012).

Finally, there are already examples of successful ETSs implemented worldwide for the abatement of GHG emissions from other industrial sectors, with the largest ones being the EU ETS and the China National ETS. Currently, the most relevant ETSs for the maritime sector are the China National ETS for the $CO_2$ emissions of China-flagged vessels and the Regional Clean Air Incentives Market (RECLAIM) programme, which has been applied in California for the reduction of SOx emissions and which includes the SOx emissions from marine engines. The latter has resulted in significant reductions of SOx emissions in the region (Christodoulou et al. 2019; Nikopoulou et al. 2013).

### 3.2 Weaknesses

In contrast to a global levy on bunkers, an ETS allows the price of emissions allowances to be determined by market forces. This creates some level of uncertainty for participants, especially in industrial sectors that face uncertain supply and demand conditions, such as the shipping industry (Cullinane 2011), where the highly volatile market conditions (particularly in the bulk sector) imply significant differences in the price of emissions allowances from year to year. This can lead to increased uncertainty in that the industry will constantly need to adjust to changes in the price of emissions allowances. However, the urgent need to reduce the GHG emissions from shipping and decarbonise the sector can probably be best met by implementing a quantity MBM that determines the emissions cap for the maritime sector on an annual basis, so that the ongoing demand and supply context can be taken into account.

Although there are definite emissions reductions to be reaped through the workings of an ETS, the 'correct' setting of the emissions cap each year is crucial in providing incentives for the decarbonisation of the maritime sector and the reduction of its energy consumption. An overly high emissions cap with a correspondingly large volume of emissions allowances allocated to shipping companies would result in low allowance unit prices, as many would sell but few would buy, the companies being in a relatively easy position to cover their emissions. The incentives for investments in this case would also be minimal, as the companies would probably choose to buy the necessary allowances in the market rather than proceed to any energy efficiency improvements, since this would minimise their compliance costs. A similar experience emerged with the introduction of aviation into the EU ETS, where the allowances initially allocated to the airline companies were so high that the companies basically did not need to proceed with any modifications or improvements to meet their emissions reduction targets (Boon et al. 2007).

Another weakness with respect to the establishment of a global ETS for the maritime sector is associated with the high administrative costs and the complexity of such a mechanism. In contrast to a global levy on bunkers that, in principle, might be relatively straightforward to implement on the basis of previous energy levies that have been extensively applied in other industries, a global ETS for shipping would require a new administrative infrastructure and set of administrative processes, initially for establishing the emissions cap and the allocation of allowances and then for the monitoring and verification of the use of allowances, revenue collection and their disbursement in support of the decarbonisation of the maritime sector. All these processes imply high start-up and transaction costs for both the shipping companies and the regulatory entity involved, most likely the IMO.

The challenges involved in allocating emissions allowances to each of the relevant segments that comprise the shipping industry has also been underlined in the existing literature (Chai et al. 2019; Christodoulou et al. 2021a, b). The large differentiation in the technical and operational characteristics can cause additional allocation difficulties (Wang et al. 2015), with certain segments (primarily bulk shipping) being rewarded rather more than Ro-Ro and Ro-Pax segments that would probably receive lesser allowances due to their higher fuel consumption per unit of transport work performed.

In contrast to what would happen under any implemented global system regulated by the IMO, in the case of the inclusion of shipping in a regional ETS (such as in the case of the California RECLAIM programme, the China National ETS (see Pizer and Zhang 2018) and the proposal for the EU ETS), carbon leakage is another factor that needs to be considered as a potential weakness of such a system; shipping companies may have greater motivation to register all or some of their vessels elsewhere or even engage in maritime trades in other geographical regions in preference to the EU, to avoid compliance with the regional ETS system or, alternatively, decide to use neighbouring ports outside of the geographical coverage of the ETS (Miola et al. 2011; Wang et al. 2015, 2021). To address this challenge, Transport & Environment (2020) analysed the additional costs for re-routing vessels away from EU ports. They concluded that ships would only deviate if it is in a ship's financial interest to avoid the ETS and that this would only happen if compliance costs were more expensive than the sum of all the extra costs involved in the deviation to an alternative port. Based on their calculation for a representative model vessel, in order for such a deviation to be economically justified in practice, the price of each emissions allowance unit would have to be much higher than either the then current or historical price of emissions allowances within the EU ETS.

The geographical coverage of a regional ETS for maritime transport is another challenging factor that needs to be tackled to achieve optimal environmental outcomes and reduce the risk of carbon leakage (Hermeling et al. 2015). In the case of including shipping in the EU ETS, constraining system coverage exclusively to intra-European voyages would limit its environmental effectiveness, while the inclusion of emissions from all voyages—incoming and outgoing to/from EU ports—would significantly contribute to the reduction of shipping $CO_2$ emissions (Faber et al. 2009). According to Christodoulou et al. (2021a, b), the geographical scope of a regional ETS has a differentiated impact on the various segments. The significant deep-sea elements of voyages undertaken by certain market segments (containerships, oil tankers, bulkers, chemical tankers, general cargo carriers) would mean that companies would be largely unaffected, as the CO2 emissions from these voyage elements would only partially be included in the ETS (50% of emissions from voyages departing from, and arriving at, EU ports are to be included in the system). At the other extreme, shipping market segments that are exclusively short-sea in nature

(Ro-Ro and Ro-Pax vessels) would be equally affected irrespective of the geographical scope of the system, as all voyages take place within the EEA.

One final, but rather important, potential weakness in the case of applying an 'open' ETS for shipping is that although shipping companies will have the choice of buying or selling allowances from or to other sectors and will have increased flexibility, therefore, the environmental outcome for the maritime sector might not be the desired as the reduced CO2 emissions might come from other sectors (Faber et al. 2009).

### 3.3 Opportunities

The primary and most obvious opportunity from the implementation of an ETS for shipping is the decarbonisation of the sector through investments in carbon neutral technology, improvements in the operational energy efficiency of the fleet and a switch to alternative fuels and energy sources (Gu et al. 2019). As shipping companies will face increased operational costs from having to pay for CO2 emissions allowances, they will seek to reduce their costs, either by adjusting their operational practices (e.g., utilizing slow steaming) in the short term or by retrofitting new technologies on their vessels or renewing their fleet in the longer-term (Wan et al. 2018; Zhu et al. 2018).

The adoption of an ETS for maritime transport would also reward the 'first movers'—the companies that have been proactive and have already reduced their carbon footprint—by offering them the opportunity to sell their surplus emissions allowances to those companies with lesser environmental credentials and this will contribute to generating additional revenues. From a theoretical perspective, in the short-term, the abatement costs of the measures that shipping companies will implement for the reduction of $CO_2$ emissions from their operations will tend to be equal to the companies' additional $CO_2$ costs, as the companies will be incentivised to proceed with investments that would minimise their overall compliance costs in the most cost-effective way. In the long run, though, an ETS might stimulate further investments in energy-efficient new buildings and this potentially higher demand for cleaner vessels will also lead to their increased supply from shipyards that will, at the same time, reduce the marginal costs of their production. This should filter through into the market, leading to lower prices payable for new buildings and lower capital costs for shipowners. Shipping companies will then have stronger incentives to proceed with these more radical investments that are essential for the decarbonisation of the maritime industry.

Coming to the revenues that will be raised from the auctioning of the emissions allowances under an ETS, additional environmental and climate benefits can occur if these revenues are used for the creation of a fund designated to promote research and development into green technologies and to provide the necessary technical support to least developed and developing countries for the introduction of these technologies. In the case of an 'open' ETS for shipping (like the prospective inclusion of $CO_2$ emissions from maritime transport in the EU ETS), it is essential that a sector-dedicated fund be created to ensure that the revenues generated from the auctioning of emissions allowances return to the sector and finance its decarbonisation. The use of these revenues could to some extent, for example, compensate the ongoing current investments in cleaner fuels (e.g., hydrogen and ammonia) that are not only more expensive per unit of energy than conventional alternatives, but also require some initial investment for their deployment (e.g., engine conversion). In this way, a regional ETS for shipping would be combined with, and provide support for, the effective implementation of the forthcoming FuelEU Maritime Directive of the European Commission that proposes a requirement for all vessels of 5000 GT and above to gradually reduce the carbon content of their marine fuel starting from 2025 (European Commission 2021b).

### 3.4 Threats

Despite the clear potential for an ETS to incentivise the investments necessary for the decarbonisation of maritime transport, many authors have strongly questioned its suitability for reducing the $CO_2$ emissions of the shipping industry (Wang et al. 2015). Although the emissions cap is determined yearly and definite emissions reductions are guaranteed, the effectiveness of an ETS to promote investments in energy efficiency measures and alternative fuels very much depends on the prevailing market conditions, especially in industrial sectors that experience high levels of volatility, such as shipping. Depending on fuel prices, charter rates and the unit price of emissions allowances, shipping companies may choose not to proceed with any investments or energy efficiency improvements and simply buy allowances to cover their emissions or, alternatively, even lower their emissions by decreasing their fleet and operations.

In the case where shipping companies merely attempt to pass on their additional $CO_2$ costs to shippers and passengers, the threat of a modal shift from shipping to land-based modes of transport due to the increased cost of maritime services is mainly relevant only to short-sea shipping. This is in contrast to deep-sea shipping that, in many cases, has no substitutes and is characterised by a highly inelastic demand; the high elasticity of demand that characterises short-sea shipping services means that their customers could easily turn to alternative modes of transport (Faber et al. 2009; Suárez-Alemán et al. 2014). Any resulting modal shift from shipping to road transport would lie in contradiction not only to the norms of transport policy, but also to the achievement of climate neutrality in Europe, notwithstanding the greater generation of other negative externalities of road transport related to safety and congestion (Kaack et al. 2018).

A major challenge to the adoption and implementation of a global ETS for shipping lies with the strong opposition that this system faces from various maritime stakeholders, especially from Member States of the IMO from the least developed and developing countries. In comparison to developed countries, they consider that the implementation of an ETS at global level would have a higher and disproportionate impact on them for a number of reasons, including their geographical remoteness and distance from major maritime corridors (in particular for liner shipping and containerised cargo) or the high level of dependency on international trade and inelastic demand for shipping services, especially for the Small Island Developing States (Shi 2016). Despite the evidence in favour of developing interim applications exclusively for the dry bulk and tanker sectors (Meng et al. 2023), given the current strong opposition to the adoption and implementation of a global ETS as a mechanism for the reduction of GHG emissions from shipping, it cannot be expected that the required decisions are even close to being taken or that such a system has any possibility of being implemented at any time soon.

## 4 Conclusion and policy implications

At both global and regional level, discussions (and, in a few cases, actions) began many years ago around the potential of MBMs and, in particular, an ETS as a complementary mechanism for the reduction of GHG emissions from the maritime sector. Although the progress towards the adoption of a global ETS for shipping under the auspices of the IMO has not progressed significantly, at regional and most specifically at European level, the inclusion of shipping in the EU ETS is closer than ever. The same applies at national level for the case of China that has not been analysed in this paper. The recent 'Fit-for-55' package presented by the EC on July 14th, 2021, includes, amongst other things, a detailed proposal on how $CO_2$ emissions from maritime transport could be included in the EU ETS and an environmental and economic impact assessment of this potential development.

The introduction of an ETS for shipping would provide two major stimuli for the acceleration of investments in green technologies and alternative fuels. Firstly, the increased operational costs due to the need to acquire emissions allowances would incentivise investments up to the cost of these allowances. As these investments are strongly interrelated and determined by the price of emissions allowances, it is crucial that the additional carbon costs are high enough to stimulate significant energy efficiency improvements through technical/operational measures and alternative fuels. It is not a coincidence that—besides a number of operational measures -, it is the most costly technical measures and fuels/energy sources that can lead to substantial emissions reductions (e.g. wind power). In this way, companies will be incentivised to minimise this additional cost and, at the same time, develop in a sustainable way while maintaining their competitive advantage in the market. In addition, the incentives to shipping companies for making these investments will be further strengthened by the establishment of a dedicated fund from the revenues of the auctioned emissions allowances that will promote research and development for the decarbonisation of the sector (thus reducing abatement costs), as well as providing subsidies for investments in innovative green technologies and alternative fuels.

The expected constant increase in the price of emissions allowances over the years due to the imposition of a progressively stricter emissions cap and the limited number of allowances will accelerate the adoption of a long-term sustainability strategy within shipping companies and eventually lead to significant reductions in the sector's $CO_2$ emissions. Such positive environmental outcomes from the introduction of an ETS for shipping are not guaranteed, however, as they depend largely on market conditions and the ability of shipping companies to pass on the additional

CO2 cost to their customers. In periods of high fuel prices, low charter rates or high prices for emissions allowances, the supply of maritime services may be reduced, as a response of shipping companies to meeting their $CO_2$ reduction targets without buying additional emissions allowances. In periods when the supply of shipping services exceeds the demand and charter rates are determined by the marginal operational costs of shipping companies, the additional $CO_2$ cost could potentially increase charter rates and be borne by the shippers. These increased charter rates might affect the demand for shipping services, especially the short- sea shipping segments that face competition from other transport modes and have a high elasticity of demand (Cullinane 2011).

Quite apart from the challenges associated with the introduction of an ETS for the reduction of GHG emissions from shipping (Psaraftis 2021), the extension of the EU ETS to cover $CO_2$ emissions from maritime transport could contribute significantly to the achievement of the EU's target for climate neutrality in Europe by 2050, especially through investments in alternative fuels and energy sources for the decarbonisation of the maritime sector. Along with the development of regional ETSs for the reduction of shipping emissions, deliberations within the IMO on the potential adoption of a global ETS should not be postponed, as the international nature of shipping implies that global regulatory measures are more suitable and more effective for the regulation of the sector (Eftestøl and Yliheljo 2022; Hughes 2020), particularly when maintaining a 'level playing field' for competition within the sector is a serious concern (Artuso et al. 2016; Zis and Cullinane 2020). Although MBMs—including a global ETS—have been categorised as mid-term measures in the IMO GHG Strategy to be considered for implementation between 2023 and 2030, the introduction of MBMs in parallel with other operational and technical measures should be urgently examined (Bows-Larkin 2015), as they can incentivise investments in innovative technologies and fuels and accelerate the decarbonisation of the maritime sector.

**Acknowledgements** The authors are grateful to the editor and two anonymous referees for very helpful feedback on an earlier version of the paper.

**Funding** Open access funding provided by University of Gothenburg.

**Data availability** No datasets were generated or analysed during the current study.

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