Can Market-based Measures Stimulate Investments in Green Technologies for the Abatement of GHG Emissions from Shipping? A Review of Proposed Market-based Measures

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In order for the maritime sector to align itself with the targets set by the Paris Agreement, it should reduce its GHG emissions by at least 50% by 2050 compared to 2008 with the ultimate aim to phase them out entirely. It is along these lines that in April 2018 the International Maritime Organisation (IMO) developed a strategy, consisting of a range of potential technical and operational measures to reduce GHG emissions from international shipping, ranking from improvements on ship design to the employment of alternative fuels. In order to stimulate the adoption of these policies, the IMO also considers the implementation of market-based measures (MBM) that will provide additional incentives to shipowners to invest in new technologies and uptake of cleaner fuels. The MBMs analysed in this paper include two different policies proposed by different countries and associations for the abatement of GHG emissions from shipping: a) the *International Fund for GHG emissions from ships* that includes the imposition of a global levy on marine bunker fuel for all vessels and b) the *Maritime Emission Trading System (METS)* that requires all maritime companies to buy/sell emission allowances to meet their annual emission reductions targets, setting a cap on global shipping emissions. This paper presents and analyses these two diverse MBMs, highlighting their main advantages and drawbacks. The scope of this paper is to investigate the potential of these MBMs to incentivise investments in new technologies and alternative fuels, both essential for the decarbonisation of the maritime sector.

KEY WORDS
~ Maritime sector
~ Decarbonisation
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1. INTRODUCTION

The environmental and energy efficiency performance of shipping is better than any other mode of freight transport, accounting for 2.2 % of total global greenhouse gas (GHG) emissions (Smith et al., 2014). Shipping's contribution to GHG emissions, though, is predicted to increase by 50-250 % by 2050, in case no energy efficiency measures are implemented or no shift to alternative fuels is realised. GHG emissions reduction targets from international shipping are not included in the Paris Agreement that seeks to achieve net zero emissions the soonest possible, and certainly well before the end of this century (UNCTAD, 2015; UNCTAD, 2016). In order for the maritime sector to align itself with the targets set by the Paris Agreement, it should reduce its GHG emissions by at least 50 % by 2050 compared to 2008 with the ultimate aim to phase them out entirely. It is along these lines that in April 2018 the International Maritime Organisation (IMO) developed a strategy, consisting of a range of potential technical and operational measures to reduce GHG emissions from international shipping, ranking from improvements on ship design to the employment of alternative fuels (IMO, 2018).

In order to stimulate the adoption of these policies, the IMO also considers the implementation of market-based measures (MBM) that will provide additional incentives to shipowners to invest in new technologies and uptake of cleaner fuels (Lagouvardou et al., 2020; Ölcer et al., 2018; Goulielmos et al., 2011; Nikolakaki, 2013; Psaraftis, 2012; IMO, 2003; Christodoulou, 2019; Miola et al., 2011). Evidence and literature clearly suggest that the implementation of technical or operational measures alone could not result in sufficient emissions reductions, given the expected growth of shipping, but innovative solutions and combinations need to be developed (Shi, 2016; Bouman et al., 2017; Christodoulou and Woxenius, 2019). In this sense MBMs can play a complementary role and accelerate the adoption of technical and operational solutions aiming at the reduction of GHG emissions from shipping (Kosmas and Acciaro, 2017).

This paper presents and analyses two diverse MBMs that have been proposed by different countries and associations to the Marine Environment Protection Committee (MEPC) for the abatement of GHG emissions from shipping. These MBM proposals include: a) the *International Fund for GHG emissions from ships* that includes the imposition of a global levy on marine bunker fuel for all vessels and b) the *Maritime Emission Trading System (METS)* that requires all maritime companies to buy/sell emissions allowances to meet their annual emission reductions targets, thereby setting a cap on global shipping emissions. Although the potential of these MBMs to reduce GHG emissions from shipping has been studied in recent academic articles, the main advantages and drawbacks of each MBM have not been clarified based on the existing academic literature and relevant MEPC resolutions and it is exactly this research gap that our paper aims at filling A comprehensive comparison of the two 'predominant' MBMs for the maritime sector is developed in this study considering the previous experience from the adoption of these MBMs in different industrial sectors for the abatement of GHG emissions from their operations.

The scope of this paper is to investigate the potential of these MBMs to incentivise investments in new technologies and alternative fuels, both essential for the decarbonisation of the maritime sector. To achieve this, a brief presentation of the economic theory of externalities is included in this paper, highlighting the way MBMs can contribute towards the internalisation of the external cost of GHG emissions from the maritime sector. Our results suggest that MBMs are beneficial as complementary to technical and operational initiatives and can be considered additional tools in the toolbox of solutions for the reduction of GHG emissions from the maritime sector.

The paper is structured in the following way: the methodology is presented in Section 2, consisting of a brief presentation of the economic theory of externalities and a short description of the MBMs under consideration (a global levy on marine fuel and a METS); Section 3 includes an analysis and comparison of the two MBMs, while our conclusions are drawn in Section 4.

2. METHODOLOGY

In order to identify the main advantages and drawbacks of a global levy on marine bunker fuel for all vessels and a METS for the abatement of GHG emissions from shipping, as well as their overall GHG emission reduction potential, the economic theory of externalities is analysed in this section in addition to the existing academic literature and relevant MEPC resolutions on proposed MBMs for the maritime sector.

Internalisation of the external cost from GHG emissions in the maritime sector

In general, GHG emissions can be considered as an 'external cost' from the industrial production and the use of fossil fuels that has a negative 'social' impact, a 'social cost' that is not borne by the producers and does not form part of their production costs (Baumol, 1972). The market failure to 'internalise' this cost is the main reason why GHG emissions and climate change are characterised as 'the greatest example of market failure we have ever seen' (Stern, 2006).

If we add an extra supply curve in a standard supply and demand figure, we obtain an illustration of the economic analysis of externalities. The initial supply curve represents the marginal private cost for the production of a product or service, while the extra supply curve includes the marginal social cost, the 'total' cost for the production of a product or service, including the cost from the associated GHG emissions (Figure 1).

As can be seen in Figure 1, the marginal social cost (MSC) of products or services is larger than the marginal private cost (MPC) by the amount of the external cost, which is in our case the cost of GHG emissions. The vertical distance between the two supply curves represents the 'pollution' cost, assuming there are no external benefits and social benefit equals individual benefit (with the demand curve remaining the same). If this

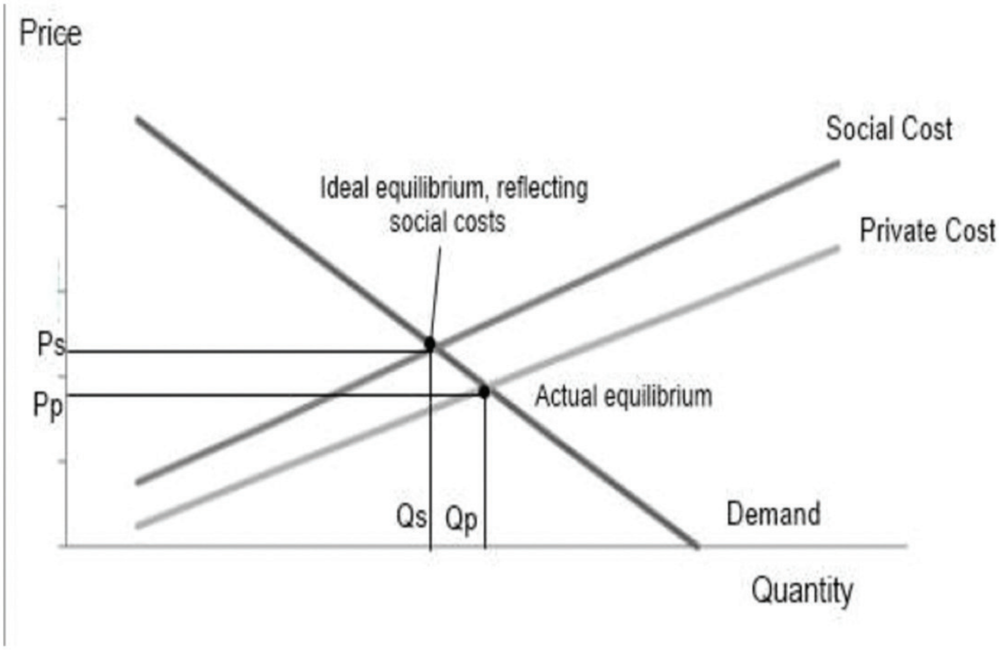

Figure 1.
Graphical representation of negative externalities Source: Adapted from Cornes and Sandler (1996).

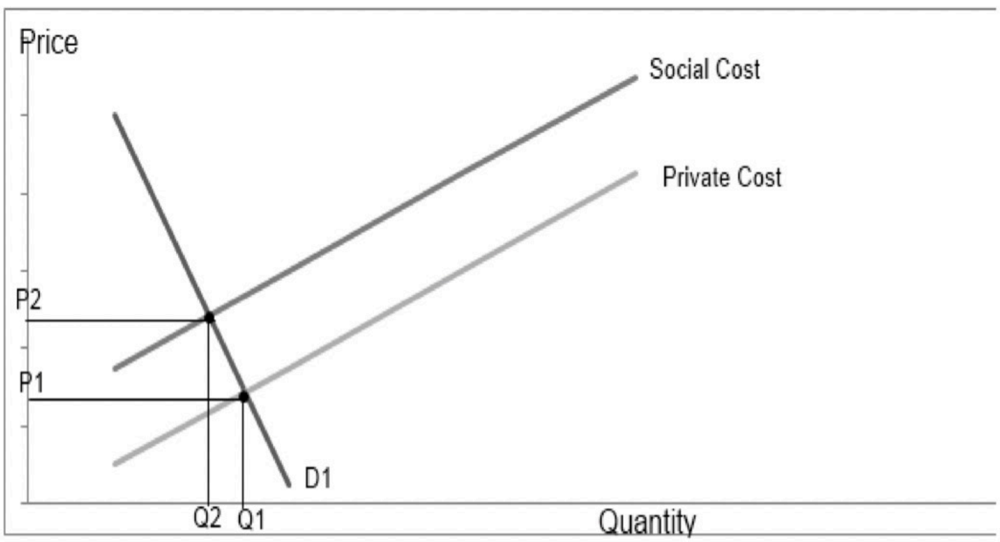

Figure 2.
Supply and demand curves of shipping with external costs Source: Adapted from Cornes and Sandler (1996).

environmental cost is not internalised, the producers will only take into account their own private cost and produce at a price Pp and quantity Qp, instead of the price Ps and quantity Qs, which corresponds to the 'social optimum' level of production. The 'ideal' social equilibrium can be found at Ps and quantity Qs, where the marginal social benefit (MSB) equals the marginal social cost (MSC).

When it comes to the maritime industry, the demand curve for international shipping services is almost vertical due to the inelastic demand of these services that do not face competition by any other mode of transport. Deep sea shipping services involved in transferring crude oil, oil products, dry bulk cargo, and containers at various destinations around the world, cannot be replaced by any other transport mode. The almost vertical demand curve of the shipping industry means that the demand for deep sea shipping services is inelastic and does not essentially follow freight rate changes. In this sense, the imposition of a global levy on marine bunkers or the need to purchase emission allowances within an emission trading scheme, would have an impact on ship owners and ship operators, who would need to supply their services adapting to increased operating costs. As illustrated in Figure 2, shipowners and ship operators would need to produce their services at Ps freight rate in order to include the social cost from their operations and achieve the 'ideal' equilibrium (Ps,Qs), accomplishing the "optimum" benefit for the society as a whole.

In order to overcome the market inefficiencies and equal social benefits to social costs for the production of maritime services, the internalisation of the associated external costs is essential. As regards the maritime sector, the international regulatory agency responsible for safety and environmental pollution issues for international shipping is the IMO that has made some progress towards the abatement of GHG emissions, including discussions and negotiations between involved parties on the MBMs that could internalise the total external costs of maritime services, making them equal to the external benefits. There are various MBMs that have been proposed by a number of countries, with most of them falling under the umbrella of a global levy scheme on marine bunker fuel or a METS.

3. PRESENTATION OF THE MBMs

During the last decade, the MEPC of the IMO has worked on the establishment of technical and operational measures to reduce GHG emissions from ships. Since January 2013, two of these measures – the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) – have been made mandatory for all vessels, irrespective of their registration flag or shipowner's nationality. Apart from this development, the IMO has started working on the development of MBMs that could supplement technical and operational measures and stimulate investments in more energy-efficient ships (IMO, 2007; Giziakis and Christodoulou, 2009). The need for the adoption of MBMs for the limitation of GHG emissions from shipping becomes more apparent today, as the growth of global seaborne trade during the last decade has faded out the energy efficiency improvements achieved from the introduction of the relevant mandatory regulations.

During MEPC 60 (2010) different MBMs were proposed by a number of countries and were discussed at the IMO. As summarised by Lagouvardou et al. (2020), Cyprus, Denmark, the Marshall Islands, Nigeria, Republic of Korea, and the International Parcel Tankers Association (IPTA) have proposed the introduction of a global levy on marine bunker fuel and the development of the International Fund for GHG emissions from ships. On the other hand, Norway, UK, France, and Germany have proposed the establishment of a global METS.

4. A GLOBAL LEVY SCHEME ON MARINE BUNKER FUEL

The development of an International Fund for GHG emissions from ships, based on a global levy on marine bunker fuel, was supported as an efficient MBM for the reduction of shipping GHG emissions by many involved parties (IMO, 2007b; IMO, 2008; IMO, 2010a). This scheme would require from all ships to pay a 'levy' on every ton of bunker fuel purchased. These 'levies' should not be uniform for all marine fuels, but should be set taking into account the different emission factors of each fuel. The funds from these 'levies' could either be collected through bunker fuel suppliers or paid directly by shipowners and would be used to establish an International Fund for GHG emissions from ships that would then finance the offsetting activities of GHG emissions from ships.

The International Fund for GHG emissions from ships would need to gather funds to offset the amount of current GHG emissions from international shipping that exceeds the global emissions reduction target, set by either UNFCCC or IMO. In order to achieve this target, the International Fund for GHG emissions from ships would need to adjust the 'levy' rate on marine fuel on a regular basis in order to secure the required funds to finance the necessary offsetting activities and achieve the agreed reduction target for maritime GHG emissions. Any additional funds remaining in the International Fund would be used for funding either Research & Development in shipping or the development of an IMO technical cooperation program to assist developing countries in improving the energy efficiency performance of their fleet.

The impact of a 'carbon levy' on marine fuel on the shipowners and ship operators' decisions will be significant, as fuel costs represent a substantial part of the vessels' operational costs, in many cases reaching one third of the voyage costs. The increase in fuels costs will depend largely both on the fuel consumption and the quality of the fuel purchased, as less 'polluting' fuels will be subject to lower 'levies'. In this way, shipowners and operators will be incentivised to reduce fuel use, shift to cleaner fuels and improve the overall energy performance of their fleet (Chupka, 2004). In general, marine fuel demand responds to changes in marine fuel price and can consequently have a significant impact on the associated GHG emissions.

The response of shipowners and ship operators to a marine fuel levy can differ widely, depending on the market conditions, technical advances, operational improvements, the existence and availability of alternative fuels. The marine fuel demand and the associated GHG emissions can alternatively be reduced by limiting maritime traffic, investing in ship engines and ship design modifications, improving operating practices such as weather routing and sailing speed, using alternative/renewable fuels, shifting to different vessel types (Rodrigue et al., 2009).

5. A MARITIME EMISSIONS TRADING SCHEME (METS)

Another MBM discussed in the IMO and supported by a number of countries – namely Norway, UK, France and Germany – as a complementary means of the abatement of GHG emissions from international shipping is the METS (IMO, 2010b; IMO, 2010c). The design of a METS is quite more complicated than a global levy on marine fuel. Under this scheme, a cap on GHG emissions from international shipping would need to be set in order for the maritime industry to contribute towards the global emissions reductions target set by the Paris Agreement, as well as the target set by the Initial IMO GHG emissions strategy on reducing GHG emissions from international shipping by at least 50 % by 2050 compared to 2008 (IMO, 2011; IMO, 2018). After setting this cap, an emission trading mechanism needs to be developed to assist shipping companies in meeting this cap and achieving the necessary emissions reductions in a cost-effective way (Faber et al., 2010). A shipping company that can reduce its emissions below the determined commitment for any reason (newer vessels, adoption of new technologies, use of alternative fuels, improved operational performance) can sell its surplus emission allowances to another company that cannot meet its emission reduction target. In this way, the overall abatement cost of meeting the emission reduction targets will be restricted to a bare minimum.

Under the METS, emission allowances would be attributed to each ship, correlating to the 'expected' CO_2 emissions from its operations. These emission allowances would be periodically submitted, and each ship would need to submit an annual emission report to the administration of the METS for approval, including their bunker consumption, to facilitate the relevant inspection from the port state controls. An international entity – probably the IMO – would administrate and regulate a METS that would provide easy access to the emission allowances for all ships. A METS could either be open for trade with other emission trading schemes and include out-of-sector allowances or closed, including only shipping emissions. The inclusion of shipping in an open METS would mean that the maritime industry could purchase emission allowances from other sectors and vice versa.

A recent development in this direction comes from the European Commission stating that there is an urgent need to also reduce GHG emissions from the maritime sector in order to meet EU's goal to become climate neutral by 2050 (European Commission, 2019). According to the EC, the inclusion of maritime emissions in the EU-Emission Trading System (EU-ETS) is one of the measures that could assist in the decarbonisation of the European transport sector and immediate action needs to be taken by relevant stakeholders at both European and international level (EU, 2018; EU, 2015).

6. ADVANTAGES – DISADVANTAGES OF THE DIFFERENT MBMs

MBMs are divided among 'price' and 'quantity' measures, according to the way they influence market forces, and proceed with the internalisation of externalities and, in this case, the abatement of GHG emissions from the maritime sector (Weitzman, 1974). Based on their nature – 'price' or 'quantity' measures - they present some pros and cons that are uniform across the various industrial sectors. A METS is a quantity measure that determines the cap of overall emissions (quantity) and allows prices to vary. Given the market volatility of the shipping industry, with unpredictable future supply and demand conditions, a quantity measure creates an increased uncertainty towards the future price of emission allowances, and it is the industry, not the regulatory body, that must bear the cost of adapting to these volatile market conditions (Giziakis et al., 2014). The pros of a quantity measure, like an ETS, is that the emissions cap is set in advance and there are no opportunities for corruption that might be the case under volatile market conditions.

On the other hand, a levy on marine fuels is a price measure that determines the price (levy) of emissions and allows the quantity of GHG emissions to vary according to economic activity (Hepburn, 2006). In this sense, a marine fuel levy might decrease maritime traffic, as the shipowners and operators will seek to retain their profits facing increased fuel and operational costs. Under this scheme, the uncertainty from the volatile market conditions will be borne by the regulatory agency, as the level of the levy is predetermined.

Given the high uncertainty in the compliance costs of shipping firms and the constant evolution of technological and operational trends, the optimum choice for the maritime industry seems to be a price scheme that eliminates the uncertainty from the volatile market conditions for the industry. If we take into consideration, though, that definite reductions in maritime GHG emissions are required for the shipping industry to align itself to the IPCC's goal that could prevent dangerous anthropogenic interference with the environment, a quantity measure that sets the emissions cap for international shipping might be a better choice that provides a higher degree of certainty.

If we assume that the regulatory body and the shipping sector can equally adapt to volatile market conditions, the suitability of the MBM depends on the potential of both the abatement costs and the environmental benefits to adjust to these changing market conditions. Given the long-term impact of GHG emissions, a levy on marine fuel seems to be more environmentally efficient than a METS, due to its better adjustment to cost fluctuations. By setting a cap on maritime emissions each year, the abatement cost of emission reductions is not taken into consideration under a METS. These abatement costs can vary widely over years, depending on many parameters, such as new emerging low carbon technologies and alternative fuels, different economic activity level and other factors. In the case of a global levy on marine fuel, the abatement cost of cutting emissions is predominant in the decision-making process of the shipping companies as they have an increased incentive to improve their carbon footprint when the associated abatement costs are relatively low compared to periods when these costs are particularly high.

Apart from their environmental effectiveness and the economic efficiency, parameters related to the practical implementation of the MBMs need to be examined, including the facility of their adoption and the height of the associated administrative costs. When it comes to the practical implementation of a global levy on marine fuels and a METS, the design of both schemes could follow either an 'upstream' or a 'downstream' approach. Under an 'upstream' approach of a levy scheme, the marine fuel suppliers would be taxed or regulated, whereas the users of these fuels – the shipping companies – would be involved in a 'downstream' design.

Comparing the adoption of an 'upstream' levy on marine fuels to an 'upstream' METS, the former seems much easier to implement given the existing previous experience and infrastructure from the adoption of energy levies in other industrial sectors. An ETS would need to build on a new administrative infrastructure, implying higher start-up costs compared to a levy on marine fuels to proceed with the initial allocation (grandfathering) of emission allowances to the participant parties.

Table 4.
Risk table representing probability of cyber incident upon survey results.

	A global levy on marine fuels	A METS
Strengths	- Better adjustment to cost fluctuations/ Achievement of a long-term target for GHG emissions - Easier to implement/ Existing structure	- No opportunities for corruption/ Emission cap set in advance - Definite reductions in maritime GHG emissions per year
Weaknesses	- Potential decrease in maritime traffic - Reductions in GHG emissions that vary according to the economic activity	- Increased uncertainty/ Need to adapt to volatile market conditions - Need for a new administrative infrastructure - High start-up costs

Source: Own elaboration based on the literature review conducted

7. CONCLUSIONS

Throughout this paper we have tried to evaluate the strengths and weaknesses of a global levy on marine bunker fuel and a METS as complementary measures that could stipulate investments in green technologies and use of alternative fuels for the abatement of GHG emissions from international shipping. Both MBMs seem promising as they provide flexibility about the way the external costs of GHG emissions could be internalised and the equation of social benefits to social costs for the production of maritime services could be achieved. MBMs set either the quantity of emissions that the maritime sector is allowed to generate (METS) or the price of these emissions (a global levy), thereby incentivising shipping companies to improve their energy performance and reduce their emissions.

According to our findings, the adoption of a global levy on marine bunker fuel seems to be more efficient for the reduction of maritime GHG emissions compared to a METS, mainly due to the volatile market conditions of the maritime industry. Although the setting of an emission cap under a METS would ensure definite reductions in GHG emissions per year, a global levy on marine bunkers would adjust better to cost fluctuations and the achievement of a long-term target for GHG emissions. Additionally, it would be much easier to implement in practice in contrast to a METS that would require a new administrative infrastructure and high start-up costs.

Both the IMO and the EU are currently focusing on the development of a global or regional MBM that could complement the technical and operational measures already adopted for the abatement of GHG emissions from the maritime sector. This paper sheds light on some aspects of the problem, highlighting fundamental differences among the predominant MBMs under discussion at the moment, and underlining their main advantages and drawbacks, while aiming at contributing towards the discussion for the adoption of an environmentally effective and economically efficient MBM for the abatement of GHG emissions from international shipping.

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