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A comparative evaluation of market based measures for shipping decarbonization

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ABSTRACT

The purpose of this paper is to provide an overview and discussion of potential Market Based Measures (MBMs) under the Initial IMO Strategy for the reduction of greenhouse gas (GHG) emissions from ships. In this context, some related developments are also seen as directly relevant, mainly in the context of the possible inclusion of shipping into the EU Emissions Trading System (ETS). A comparative evaluation of maritime MBMs is made using the following criteria: GHG reduction effectiveness, compatibility with existing legal framework, potential implementation timeline, potential impacts on States, administrative burden, practical feasibility, avoidance of split incentives between ship-owner and charterer, and commercial impacts. The paper breaks down potential MBMs into the following classes: Bunker levy/carbon levy MBMs, ETS (global and/or EU ETS) MBMs and other MBM proposals.

1. Introduction

The purpose of this paper is to provide an overview and discussion of potential Market Based Measures (MBMs) under the Initial IMO Strategy for the reduction of greenhouse gas (GHG) emissions from ships (IMO, 2018). In this context, some related developments are also seen as directly relevant, mainly in the context of the possible inclusion of shipping into the EU Emissions Trading System (ETS). The paper draws from a broader report that was prepared for this purpose, see Psaraftis et al. (2020). It also reflects the authors' broader experience in the MBM subject.

The main motivation for considering MBMs is that an MBM would implement the "polluter pays" principle and internalize the external cost of GHG emissions. An appropriate MBM would induce changes in ship owner behavior that would reduce GHG emissions. In the short run, an MBM could induce slow steaming or other operational/logistics based measures that would lead to reduced GHG emissions. In the long run, an MBM could incentivize the adoption of energy savings technologies or alternative, low carbon fuels whose use is not economically viable so long as the price of fossil fuels remains low. Such technologies or fuels would lead to GHG emissions reductions, and adopting them might be preferable to paying for the MBM.

In 2010 an Expert Group was appointed by the IMO's Secretary General after solicitation of member states and was tasked to evaluate as many as eleven (11) separate MBM proposals, submitted by various member states and other organizations.[1] All MBM proposals described programs and procedures that would target GHG reductions through either 'in-sector' emissions reductions from shipping, or 'out-of-sector' reductions via the collection of funds to be used for mitigation activities in other sectors that would contribute towards global reduction of GHG emissions. An 'in-sector' emissions reduction is defined as a reduction that occurs within the maritime sector, for instance by using (inter alia) an energy saving device on a ship, by reducing speed, or by using a low carbon

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[1] The first author of this paper was a member of this Expert Group.

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fuel. By contrast, an 'out-of-sector' emissions reduction is one that does not incur within the maritime sector, but is generated by the use of monies collected via an MBM to invest in energy savings technologies *outside* the maritime sector, for instance (inter alia) by establishing a wind farm in New Zealand or a solar farm in Indonesia. The use of such monies in this way is also called *offsetting*.

MBM proposals submitted to the IMO were the following:

(1) The International Fund for Greenhouse Gas emissions from ships (GHG Fund) originally proposed by Cyprus, Denmark, the Marshall Islands, Nigeria, and the International Parcel Tanker Association-IPTA (Denmark, 2010).
(2) The Leveraged Incentive Scheme (LIS) to improve the energy efficiency of ships based on the International GHG Fund proposed by Japan (Japan, 2010)
(3) Achieving reduction in greenhouse gas emissions from ships through Port State arrangements utilizing the ship traffic, energy and environment model, STEEM (PSL) proposal by Jamaica (Jamaica, 2010)
(4) The United States proposal to reduce greenhouse gas emissions from international shipping, the Ship Efficiency and Credit Trading (SECT) (USA, 2010)
(5) Vessel Efficiency System (VES) proposal by World Shipping Council (WSC, 2010)
(6) The Global Emission Trading System (ETS) for international shipping proposal by Norway (Norway, 2010)
(7) Global Emissions Trading System (ETS) for international shipping proposal by the United Kingdom (UK, 2010)
(8) Further elements for the development of an Emissions Trading System (ETS) for International Shipping proposal by France (France, 2010)
(9) Market-Based Instruments: a penalty on trade and development proposal by the Bahamas (Bahamas 2010)
(10) A Rebate Mechanism (RM) for a market-based instrument for international shipping proposal by the International Union for the Conservation of Nature (IUCN 2010)

The following developments took place after the above MBMs were submitted to the IMO:

- A German ETS proposal (Germany, 2010) that was not included in the original MBM list for administrative reasons was reinstated as part of the MBM roster. It was pretty similar to the other three ETS proposals.
- The Expert Group on MBMs produced a detailed report evaluating the MBM submissions (IMO, 2010), however the report expressed no preference or recommendation for an MBM.
- The LIS and VES proposals were combined into what was relabeled the Efficiency Incentive Scheme (EIS) (Japan and WSC, 2011).
- The Bahamian proposal was modified and then withdrawn altogether.
- Greece proposed that a short list of MBMs, consisting of only the GHG Fund and ETS proposals, be established, but this was turned down.
- A proposal by the Chairman of the Expert Group, who was also the Chairman of MEPC, to perform an impact assessment of the various MBMs was turned down.
- The MBM discussion at the IMO was suspended in 2013.

The suspension of the MBM discussion at the IMO in 2013 was probably the reflection of a rather political process and the highly divergent views across IMO member states on the subject of GHG emissions. This was demonstrated by, among other things, the non-consensus adoption of the Energy Efficiency Design Index (EEDI) in 2011, about one year after the initial IMO discussion on MBMs. EEDI still is the only mandatory GHG reduction measure for maritime transport. Developing countries such as China, Brazil, India, Saudi Arabia and others, were strongly opposed to the adoption of EEDI and they forced an IMO vote on the subject in 2011. After the highly divisive discussion on that vote, the subsequent discussion on further measures to curb GHG emissions became increasingly difficult and that led to the eventual suspension of the MBM discussion in 2013. The discussion was actually rechanneled to the subject of Monitoring, Reporting and Verification (MRV) of CO_2 emissions, a discussion that started at the IMO and the EU about the same time the MBM IMO discussion was suspended.

A few years later, and given that the IMO had moved to adopt an Initial Strategy in 2018 (IMO, 2018), much more can be said on MBMs. In fact MBMs have been included in the Initial IMO Strategy as a candidate *medium-term* measure (to be finalized and agreed to between 2023 and 2030), as follows: *"New/innovative emission reduction mechanism(s), possibly including Market-based Measures (MBMs), to incentivize GHG emission reduction."*

Note the word "possibly", which means that the fate of MBMs at the IMO is currently unclear. After the ill-fated discussion on MBMs in 2010–2013, visible interest on MBMs at the IMO seems currently limited, however this may change as some Member States have asked for the MBM discussion to reopen. These include submissions by France (2018), a number of Small Island Developing States (SIDS) plus Kenya (Antigua, 2018), the UK (2020) and the Marshall Islands and Solomon Islands (Marshall, 2020). However, other Member States seem opposed to the MBM idea, so at this point in time there is uncertainty on what the future may hold for MBMs at the IMO.

We note here that reducing maritime GHG emissions via offsetting is not included in the Initial IMO Strategy, at least explicitly. By this we mean that it is not clear if the IMO would allow discussion on an MBM that embeds carbon offsetting, if and when the MBM discussion resumes, and assuming that such an MBM is put forward. The use of monies collected under any MBM is anticipated to involve a serious discussion, and it would seem that such use in carbon offsetting activities cannot be a priori ruled out. Also it should be noted that offsetting was the intended main driver behind the GHG Fund MBM proposed by Denmark (2010).

In parallel, there have been MBM-related developments in Europe. In 2019 the new President of the European Commission (EC) revealed that in the context of the "European Green Deal" (EU, 2019) shipping would be included in the EU ETS. The ETS (which is an MBM) is a major instrument in EU energy policy, covering electricity production and several other major industries (but not

shipping, at least thus far). The position of the EC had been to align itself with the IMO process on decarbonization, and essentially refrain from acting on a possible inclusion of shipping into the EU ETS before seeing what the IMO intends to do on GHGs. To that effect, the EC has been closely monitoring the IMO process, starting from what is agreed on the initial strategy in 2018 and all the way to 2023. The EC had always refused to take the ETS option off the table or even to specify what would trigger action on its part. However, as of December 2019, this has changed, and the European Green Deal clearly points to the ETS path for shipping. It is still not clear how this will be implemented.

It should also be mentioned that even though no maritime MBM currently exists, the shipping industry may have missed, by a sheer twist of fate, the chance to witness first-hand a real-world "experiment" on the short-term effects of an MBM. Indeed, the anticipated fuel price increase due to the implementation of the global 0.5% sulfur cap as of 1.1.2020 would be in many respects tantamount to a bunker levy, as many ships would (and did) switch from 3.5% sulfur heavy fuel oil (HFO) to the more expensive 0.5% sulfur marine gas oil (MGO), marine diesel oil (MDO), or very low sulfur fuel oil (VLSFO). Under normal circumstances, these higher fuel prices might result in lower speeds and therefore lower GHG emissions. However, the outbreak of COVID-19 just after the start of the 0.5% sulfur regulation collapsed fuel prices across the board and the above "experiment" never happened. In fact, COVID-19 resulted in phenomena such as containerships on the Far East to Europe route sailing the longer route around Africa at increased speeds as it was cheaper to do so in lieu of paying the Suez canal tolls, and increasing per trip GHG emissions in the process. So to anybody who thought that the global sulfur cap would provide an opportunity to see what an MBM could do, that opportunity was missed.

The Technical University of Denmark (DTU) was commissioned by the Danish Maritime Authority (DMA) to undertake a study on MBMs. This study, whose full report can be found in Psaraftis et al. (2020), included a comparative evaluation of maritime MBMs. Per the terms of reference of the study, such a comparative evaluation included the following evaluation criteria:

- GHG reduction effectiveness
- Compatibility with existing legal framework
- Potential implementation timeline
- Potential impacts on States
- Administrative burden
- Practical feasibility
- Avoidance of split incentives between ship-owner and charterer
- Commercial impacts

In fact most of the above criteria draw from, and considerably resemble, the criteria set out by the IMO in 2010 to evaluate the set of MBM proposals. Criteria such as the avoidance of split incentives and commercial impacts were added as also relevant.

In order to undertake the analysis, this paper breaks down potential MBMs into the following classes:

- Bunker levy/carbon levy MBMs
- ETS (global and/or EU ETS) MBMs
- Other MBM proposals

For a comprehensive literature survey of maritime MBMs, see Lagouvardou et al. (2020). Also, Psaraftis (2012) included a discussion of the MBMs submitted to the IMO in 2010.

The rest of this paper is organized as follows. Section 2 looks at bunker levy/carbon levy variants according to the above criteria. Section 3 does the same for ETS variants. Section 4 examines other MBM proposals. Finally Section 5 presents the paper's conclusions including some very recent developments.

2. Bunker levy/carbon levy variants

2.1. General

There can be several variants of a bunker levy/ carbon levy MBM. These include:

A The International Fund for Greenhouse Gas emissions from ships (GHG Fund) originally proposed by Cyprus, Denmark, the Marshall Islands, Nigeria, and the International Parcel Tanker Association-IPTA, submitted to the IMO in 2010 (Denmark, 2010).
B A pure levy on bunker fuel.
C A pure levy on CO_2-equivalent (CO_{2e}) emissions.
D Variants that include restrictions on which ships would be subject to the levy or differentiation of the levy according to some criteria.
E Eliminating the tax-free status of marine fuels at a European level.

We clarify that variant E, proposed to be investigated under the European Green Deal (EU, 2019), will not be evaluated, as it is considered unlikely to occur. It is likely that its adoption would open a giant loophole, operators purchasing cheaper fuel from non EU sources, some of which could actually be geographically very close to the EU. This alternative would work only if marine fuels are taxed at a global level (variants A to D), and actually if this is so it would only be necessary so as to enforce the global tax by EU member states.

Table 1
Price levels of levy. Adapted from Psaraftis and Lagouvardou (2019).

Price level of levy	Range (USD/tonne of CO_{2e})	Range (USD/tonne of HFO/MGO/MDO)	Expected GHG reduction
Low	0.5 – 5	1.5 – 15	None or negligible
Medium	5 – 75	15 – 225	Moderate
High	>75	> 225	Significant

We also mention at the outset that variant A, together with all other MBM proposals submitted to the IMO in 2010, is *not* currently on the table at the IMO or elsewhere. However we mention it here for completeness purposes and in case something along these lines is proposed again in the future.

Variants B and C are simpler variants of A, imposing a prescribed surcharge on bunker fuel, or a prescribed price on CO_2 or CO_{2e} emissions. Variant C includes a sub-variant in which CO_2 or generally GHG emissions are directly monitored via a device in the ship's stack (Devanney, 2011a).

Psaraftis and Lagouvardou (2019) touched upon some of the key elements that need to be addressed assuming that a levy is contemplated. These include:

- which ships will be subject to the levy
- the levy as a function of type of fuel used
- the price level of the levy
- the timing of the levy
- who will be collecting the levy
- how and to whom the proceeds of the levy will be distributed

As argued in the above paper, the price level of the levy should be considered after an analysis that would recommend the level that would maximize the chances of compliance with the IMO GHG reduction target in 2050. Such an analysis would examine and analyze both the short-term and long-term effects of the levy. As regards the short-term effects, an analysis could be conducted for the world fleet, on what speed reductions (and hence CO_2 emissions reductions) could be achieved due to the levy. The long-term effects analysis would have to examine the levy in conjunction with the Marginal Abatement Costs (MACs) of potential energy saving devices and alternative fuels, again for the world fleet.

In general one would envision the following general options on the price level of the levy, together with their anticipated impacts as regards GHG emissions reduction.

The "low" option would mainly collect monies for R&D, with no discernible effect on GHG emissions. An example is the 5 billion USD R&D fund proposed by all major shipping associations to the IMO, which involves a 2 USD per tonne of fuel surcharge, which is equivalent to about 0.65 USD per tonne of CO_{2e} (ICS, 2019). In fact the proposers do not label this proposal as an MBM. The "medium" option would achieve some GHG reductions, mainly in the short-term, in the form of slow steaming. How much will be reduced is currently unclear. Finally the "high" option is a full blown MBM that would have both short-term and medium term effects, the medium-term effects being the provision of incentives to develop low/zero fossil carbon fuels and ship technologies that would reduce GHGs that are not currently viable (long-term objective/effects).

If the levy is assessed on CO_2 equivalent emissions, low carbon fuels, which are exactly the fuels that are desirable to reduce GHG emissions, would be levied less (on a per tonne of fuel basis) than conventional fossil fuels, because their carbon coefficient would be lower, and the levy on zero carbon fuels (should these be developed eventually) would be 0. So whenever zero carbon fuels are eventually used, there would be no levy on these fuels, and a levy would be confined only to fuels that have a carbon footprint, such as fossil fuels. The lower the carbon footprint, the lower the levy.

In a recent report by commodity trading company Trafigura (2020), a levy much higher than the highest levy of Table 1 was proposed. In a much publicized proposal, Trafigura argued that a levy between 250 and 300 USD per tonne of CO_{2e} should be imposed so as to make zero- and low-carbon fuels more economically viable and more competitive, and that this should be introduced at the IMO level. This translates into a levy between roughly 750 and 900 USD per tonne of fossil fuel. The proposed levy was calculated so that low carbon or zero carbon alternative fuels could become economically viable.

According to Psaraftis and Lagouvardou (2019) and in order to avoid distortions of competition and a level playing field, all ships should be subject to the levy, possibly excluding ships of very small size (eg, ships below 400 GRT).[2] According to that paper, schemes *to be avoided* include schemes that:

- exclude some ships from the levy, under some criteria
- differentiate the level of the levy among certain ships,
- provide a rebate on the amount of the levy.

On the other hand, policy makers may want to institute such exclusion/differentiation /rebate schemes, so as to selectively reward certain ships or penalize others. Criteria on the basis of which such schemes would apply may include any or all of the following:

[2] It is noted here that if shipping is included into the EU ETS, the size threshold will likely be 5000 GRT, as specified in the EU MRV Regulation.

- ship type, size, flag, age, ownership, route, ports visited
- other criteria, such as for instance an EEDI below a certain level, a speed below a certain level, the technical characteristics of the ship including waste heat recovery devices, hybrid propulsion, exhaust cleaning devices, or others.

Still, levy variant D may impose such restrictions or differentiations on which ships would be subject to the levy.

2.2. GHG reduction effectiveness

How much CO_2 can be reduced by a substantial global bunker levy? By "substantial" we mean at least two orders of magnitude higher than the USD 2 per tonne surcharge recommended to the IMO by the major shipping associations to establish an R&D fund to decarbonize shipping (ICS, 2019), i.e. at least USD 200 per tonne HFO. Such a levy would induce both technological changes in the long run and logistical measures in the short run. In the long run, it would lead to changes in the global fleet towards vessels and technologies that are more energy efficient, more economically viable and less dependent on fossil fuels than those today. In the short run, it would lead to slow steaming and hence reduced CO_2 emissions.

The IMO Expert Group on MBMs provided, in its report to the IMO (IMO, 2010), some estimates of CO_2 emissions reductions. For the baseline scenario, "in-sector" CO_2 emissions reductions of the GHG Fund were estimated to be very moderate, ranging from 1 to 31 million tonnes a year, whereas "out-of-sector" reductions were estimated to range from 152 to 584 million tonnes a year, confirming that the main intended effect of the GHG Fund MBM would be out of sector reductions realized by the issuance and application of offsets. However, it can be argued that there is enough evidence to the effect that the in-sector reductions that could be realized by the GHG Fund MBM could be significantly higher, and probably higher than the GHG Fund proposers themselves were willing to admit.

In fact, some prior estimates of CO_2 emissions reduction due to a levy do exist in the literature. Devanney (2010) estimated that with a base HFO price of USD 465 per tonne, a USD 50 per tonne bunker levy would achieve a 6% reduction in total Very Large Crude Carrier (VLCC) emissions over their life cycle and that for a USD 150 per tonne levy the reduction would be 11.5%. Some estimates of CO_2 emissions reductions for tankers and handymax bulk carriers, and for several bunker levy scenarios, were made in Gkonis and Psaraftis (2012) and in Kapetanis et al. (2014) respectively. These estimates showed CO_2 emissions reductions of more than 50% for a single VLCC if fuel price rises from 400 to 1000 USD per tonne, with similar reductions for bulk carriers. Psaraftis (2019) estimated for a rudimentary containership scenario that a doubling of bunker prices from 500 to 1000 USD per tonne would achieve a 50% reduction in CO_2 emissions, taking also into account the extra CO_2 emissions of the additional ships that would be deployed to account for loss of throughput.

At the strategic level, a substantial bunker levy would incentivize the development of alternative, low or zero carbon fuels and other energy saving technologies for which the Marginal Abatement Cost (MAC) is positive under current conditions. Such a levy could make such fuels and technologies obtain a MAC<0, which would make them win-win solutions. How much CO_2 emissions would be reduced would depend on the MAC curves (MACCs) that are established. However, unless MACCs are properly established estimates of CO_2 emissions reductions could not be reliable.

The 4th IMO GHG study (IMO, 2020), released in July of 2020, has produced, among other things, some MACCs, and based on these has projected some scenarios on how the shipping industry can move to meet the 2050 GHG reduction targets. Reviewing the 4th IMO GHG study is a major task which is not within the scope of this document, however we can state that MBMs are not explicitly mentioned in that study as possible measures to reduce GHG emissions.

A possible side-effect of a bunker levy that should also be looked at is shifts to other modes of transport, ultimately leading to more CO_2 emissions overall. These shifts could be due to (a) higher maritime transport costs due to the levy, and/or (b) the speed reduction that would ensue as a result of the levy. Both (a) and (b) would encourage some cargoes (and essentially the more expensive or perishable cargoes) to shift to rail, road or even to air transport, particularly if such other modes are spared a similar fuel price increase.

This situation is relevant to both deep-sea and short-sea shipping. Psaraftis and Kontovas (2010) developed a methodology to estimate modal shifts due to speed reduction in deep-sea routes and investigate, among other things, possible shifts to the railway mode in the Far East to Europe corridor as a result of speed reduction in the maritime mode. A binomial logit model was used, which can also account for freight rate changes. Zis and Psaraftis (2017) and Zis and Psaraftis (2019) performed a similar analysis for European short-sea (RoRo) routes. Finally the analysis of the Chilean cherry case in the impact assessment of the goal-based measure submitted by Denmark, France and Germany (Denmark, 2020) included a modal shift analysis of cherry exports shifting to the air mode in case ship speed is reduced. In all cases the methodology was based on the generalized cost concept which takes into account time and costs including freight rates, value of time and inventory costs.

The European modal shift analysis is also very relevant in the context of the EU ETS (see Section 3 later).

2.3. Compatibility with existing legal framework

The GHG Fund MBM proposal judiciously avoided the use of the words "levy" or "tax" to characterize the MBM measure, using the word "contribution" for that purpose, even though this would be a mandatory contribution, and therefore, for all practical purposes, a tax. This was done specifically so as to avoid legal obstacles in trying to institute an international tax. The same is the case for the R&D Fund recently proposed by a number of shipping associations (ICS, 2019), which is actually not considered an MBM even by its proposers. These associations have however stated that the architecture of that proposal could be borrowed should a bunker levy be instituted by the IMO.

It should be noted here that the IMO MBM Expert Group had established an "administrative and legal" task-group to examine legal issues. This task-group highlighted some of the policy sensitivities inherent when discussing compatibility with the UNFCCC and its Kyoto Protocol. The experts recognized that the principle of Common But Differentiated Responsibilities and Respective Capabilities (CBDR-RC) applied in the context of the UNFCCC and its Kyoto Protocol and the IMO Convention specifies non-discrimination in IMO instruments. However there were different views on application of these principles among the legal experts. One view was that the UNFCCC provides the central policy infrastructure for global climate change action and the proposed MBMs must take into account the principle of CBDR-RC. Another view was that the principles of the UNFCCC do not apply in the IMO and that all of the MBMs that aim to reduce emissions are therefore consistent with the UNFCCC. Division of opinion was also manifested regarding whether each of the MBM proposals would fit under MARPOL or would require a new convention.

It is therefore speculated that if and when the political will to institute a levy MBM is manifested, appropriate legal language could be drafted so as to avoid legal obstacles. However, differences of legal opinion may make this task non-trivial.

2.4. Potential implementation timeline

There is no specific timeline for a levy at the present time. MBMs are included in the set of medium-term candidate measures of the Initial IMO Strategy, that is, to be agreed upon and implemented between 2023 and 2030. Plus, their adoption is only a possibility ("possibly including MBMs"), meaning that MBMs may not be pursued by the IMO, after all. Even though the EU is pressing with the inclusion of shipping in the EU ETS (in the context of the European Green Deal- see Section 3 below), MBMs are currently almost invisible within the IMO agenda. To what extent and when this situation will change is not clear (see however Section 5 for more recent developments).

2.5. Potential impacts on states

We first clarify that to date, there has been no comprehensive impact assessment by the IMO (or by anybody else for that matter) of the potential impacts of MBMs on States. A proposal by Andreas Chryssostomou, the then chairman of MEPC, who was also the chairman of the IMO Expert Group on MBMs (2010–2013) for such an impact assessment study to be carried out was turned down. Most recently, the 5 billion USD R&D fund proposed to MEPC 75 by a consortium of shipping associations (ICS, 2019) encountered serious objections by many IMO Member States (developing countries and other), on the ground that a comprehensive impact assessment of the two (2) dollars per tonne surcharge on bunker fuel should be conducted before the discussion on the proposal continues. Note that such a proposal was not labelled an MBM even by its proposers, meaning that the issue of an impact assessment will be raised again, and whenever the MBM discussion reopens at the IMO. If an impact assessment was requested for a fuel surcharge that is well below the "noise" of daily fuel price fluctuations, one could imagine what would be requested if a full blown MBM is put forward at the IMO.

In the discussion at the IMO 7th intersessional meeting of the working group on GHG emissions from ships (October 2020), and on the subject of the detailed impact assessment studies associated with short-term measures, an independent evaluation by UNCTAD identified, among other things, many of the challenges of a comprehensive impact assessment (IMO, 2020). Even though the said impact assessment studies did not concern MBM measures, such challenges identified by UNCTAD are also very much relevant in any MBM impact assessment that is to be conducted in the future.

In the context of DTU's detailed impact assessment for the mandatory short-term operational measure proposed by Denmark, France and Germany (Denmark, 2020), several references that investigated the possible impacts of a carbon levy on states were reviewed. Among them, we note the Halim et al. (2019) study on potential impacts on Small Island Developing States (SIDS) and Least Developed Countries (LDCs), as well as the Krammer and Smith (2017) and NZIER (2018) studies on potential levy impacts on New Zealand including the territory of Tokelau. All indicate that the potential impacts of a bunker or carbon levy on states cannot be ignored. More recently, Psaraftis and Zis (2021) described the detailed impact assessment of the mandatory short-term operational measure proposed by Denmark, France and Germany as it applies to SIDS and LDCs.

We also note that a number of SIDS including Antigua and Barbuda, Marshall Islands, Palau, Solomon Islands, Tonga, and Tuvalu proposed that the MBM discussion should reopen (see Antigua (2018) and more recently Marshall (2020). The implicit assumption of these submissions is that SIDS believe they would incur significant (negative or disproportionately negative) impacts as a result of a carbon tax or levy (and of the resulting increase in freight rates), hence their suggestion to channel most of the revenues generated by such MBM to such states. A related implication is that these states believe that they would suffer negative impacts from freight rate increases due to other reasons as well, not just due to a carbon levy. However, in contrast to other (operational or technical measures) MBMs can generate income that can be used to compensate for such negative impacts.

How much of the MBM revenues would be channeled to such states is subject to discussion, whenever the MBM discussion reopens at the IMO.

2.6. Administrative burden

In the GHG Fund MBM by Denmark (2010) and, by extension, in a bunker levy MBM, there are several options: Option 1 collects the money at the bunker supplier level and Option 2 collects it at the ship level. At first glance it would seem that Option 1 has a lower administrative effort, as involving a lower number of transactions than Option 2. In fact one might consider yet another option, Option 3, to collect the money at the refinery level. Theoretically, the higher one goes up the fuel chain, the easier it would be to

administer it due to the reduced number of transactions. However, it is not yet clear how each of these options could work in practice, not only from an administrative burden viewpoint, but also in terms of enforcement and evasion avoidance. Some actually believe that none of the above options is viable, and instead propose the money to be collected via Option 4, by direct measurement of CO_2 or GHG emissions, via a suitable ultra-sound device within a ship's stack (Devanney, 2011a). However, ship owner circles have raised questions on the reliability of such systems.

2.7. Practical feasibility

A simple levy would be rather practical to implement, particularly if Options 1, 3 or 4 (see above) are exercised. If Option 2 is used, some additional administrative difficulty might be experienced in cases of time charters. A levy might act as an "invisible hand" that would affect user behavior towards reducing GHG emissions, both in the short term and in the long term. The scheme could be implemented by using, for instance, a scheme similar to the IOPCF (International Oil Pollution Compensation Fund), even though IOPCF also covers liability issues that may not be relevant for an emissions setting. The structure proposed by the ICS (2019) R&D Fund proposal could also be borrowed.

2.8. Avoidance of split incentives between ship-owner and charterer

What are split incentives? A split incentive situation occurs if the ship owner and the time charterer have different incentives in adopting energy saving devices or alternative fuels. The basic split incentive hypothesis is that for ships on time charter, in which the fuel is being paid for by the charterer, ship owners do not have any serious incentive to invest in energy savings technologies. This is so allegedly because fuel is being paid for by the charterer and not by the ship owner.

Advocates of the above hypothesis include organizations such as RightShip, Carbon War Room (CWR), and University College London (UCL). See for instance Rehmatulla and Smith (2015) for an exposition advocating such a hypothesis. We note here that RightShip and CWR have been funding some of the work of UCL, so it is not a surprise that they are on the same page on this issue (without implying of course a causal relationship).

These advocates argue that such split incentives constitute a serious "market imperfection" or "market barrier", and one which prohibits technologies or alternative fuels that have a negative MAC from being implemented. Recall that a MAC is defined as the marginal cost of a specific CO_2 abatement technology divided by the volume of CO_2 averted by that technology. A negative MAC would mean that the ship owner would want to adopt a specific GHG reduction measure as he would profit from such a measure and would not need the regulator to mandate it. In other words, these advocates argue that such technologies and/or fuels (that have a negative MAC) do exist today, but they are not implemented precisely because of these market barriers.

There are also skeptics of the split incentive hypothesis. In a Center for Tankship Excellence[3] paper, Devanney (2011b) argues that the above hypothesis is incorrect, and that ship owners and time charterers are not stupid. A former MIT Professor who went into the tanker business for several decades, he argues that in all chartering negotiations he has been engaged in, the fuel consumption vs. speed curve has been front and center, and that there is really no split incentive issue. In Kontovas and Psaraftis (2016), a more neutral approach is taken.

A central premise of the split incentive hypothesis is that owners of ships on time charter may have little or no incentive to adopt measures for the reduction of fuel consumption (and hence emissions) of their ships, since the fuel is paid for by the charterers and not by themselves. In such a case, a scheme such as EVDI, used by RightShip (EVDI for Existing Vessel Design Index), comes in and supposedly assists charterers in their selection of a fuel efficient ship.

The counter argument to the split incentive hypothesis is that when a ship is on time charter, the ship's consumption at various speeds is clearly described in the charter agreement. The ship's capacity and consumption are evaluated by the charterer before the contract is signed. A ship with a higher consumption at a given speed will receive a lower time charter rate than a similar ship with a better consumption curve. If during the charter the ship does not fulfill the agreement terms regarding fuel consumption, the charterer will lodge a claim on the ship and deduct monies accordingly as compensation for his contractual loss. 'Speed claims' are common and they may end in arbitration or in court. Thus the owner of a ship on time charter has every incentive to economize on fuel consumption while on time charter. This is corroborated by some studies. In a study of some 10,000 Panamax bulk carrier term charters, Wijnolst and Bartelds (1995) found a clear correlation between fuel consumption and charter rate. The sum of the fuel cost per day and the time charter rate was roughly equal for almost all the charters in the sample.

The rest of this section attempts to shed more light into the issue, via the Marginal Abatement Cost (MAC) concept, and also examines the impact of a bunker levy.

Recall again that the MAC of a specific technology is the ratio of the marginal cost of implementing this technology, divided by the CO_2 it can avert. It is expressed in USD/tonne of CO_2 averted.

In Psaraftis (2012) a formula for MAC was derived. Below we refer to the MAC of a specific energy savings technology. It can be shown that

$$MAC = \Delta GC/\Delta CO_2 - P/F \tag{1}$$

where

[3] www.c4tx.org

- ΔGC is the cost of the technology
- ΔCO_2 are the tonnes of CO_2 averted by that technology
- P is the fuel price
- F is the carbon coefficient of the fuel

If the ship owner pays for the fuel, a MAC<0 means that the ship owner would have an incentive to adopt such a technology. It would be a win-win situation for him.

Eq. (1) also means that any technology can be made to have MAC<0 if the price of fuel *P* is high enough. Hence the potential role of a bunker levy to make this happen.

What is not mentioned (at least we have not seen it) in any MAC discussion is that in formula (1), and *in the case of a time charter scenario*, the positive term $\Delta GC/\Delta CO_2$ is paid for by the ship owner, and the negative term - P/F is "paid for" by the charterer. More precisely, -P/F represents the charterer's *savings* (per tonne of CO_2 averted). In fact the charterer's savings (per tonne of fuel not used) are *P*, the price of fuel.

Let us assume, for the sake of the argument, the following scenario. The ship owner retrofits the ship with a hypothetical energy saving device (for instance, waste heat recovery) for which the following are true (all numbers are hypothetical):

$\Delta GC/\Delta CO_2$ = 200 USD/tonne (of CO_2 averted)

P = 350 USD/tonne

F = 3.11 (for HFO)

Then MAC = 200–112.54 = 87.46 USD/tonne (of CO_2 averted)

That is, for each tonne of CO_2 averted by this specific technology, the ship owner has to pay 200 dollars. The charterer will have an economic benefit of 112.54 dollars per tonne of CO_2 averted, or 350 dollars per tonne of fuel saved due to the lower fuel consumption that is due to the specific technology. The question then is, why should the ship owner pay for a benefit that will go to the charterer?

Before we address this question, assume that a levy *L* is imposed. Then *P* will increase to $P + L$, and the MAC will be reduced by L/F. The ship owner will still pay $\Delta GC/\Delta CO_2$, but the charterer's benefit will be $P + L$ (per tonne of fuel saved) and $(P + L)/F$ per tonne of CO_2 averted, i.e. the charterer will have an *additional* benefit of *L* (per tonne of fuel not used) and L/F (per tonne of CO_2 averted).

If for instance L = 300 USD/tonne, the new MAC will be

MAC new= 200- (350 + 300)/3.11 = - 9 USD/tonne <0.

In this case MAC is negative, however the question still is, in a time charter scenario, why should the ship owner invest in this technology, if all benefits go to the charterer? It clearly looks like a split incentive situation.

The answer to this question is, *the owner of a more fuel efficient ship will be able to negotiate a higher time charter (TC) rate with the charterer*, due to the fact that the energy savings device he has installed will reduce fuel consumption. This higher TC rate is a benefit to the ship owner and should be factored in the MAC equation in a time charter scenario.

If this is the case, it can be shown (see also Psaraftis et al. (2020)) that the MAC Eq. (1) is also valid for the time charter case. The upper bound on what the ship owner can charge for better fuel efficiency over and above the TC (monthly or daily) rate of the original, less energy efficient ship is the difference of (monthly or daily) fuel costs between the two ships.

In that sense, it can be argued that this supports the hypothesis that *a bunker levy is not likely to exhibit serious split incentive issues. What a bunker levy could do is to facilitate the adoption of technologies whose original MAC is positive, by making the MAC of such technologies negative.*

Such a hypothesis is reinforced by the fact that a major industry association representing charterers, Trafigura, has recently come out with a report endorsing a substantial bunker levy (Trafigura, 2020). By contrast, Trafigura is against including shipping in the EU ETS.

Less clear is what happens as regards split incentives when an ETS is imposed. In fact it can argued that in the ETS case, serious split incentives are likely to occur. This will be examined in Section 3.8.

2.9. Commercial impacts

Depending on the level of the levy, its commercial impacts are potentially very significant and may be manifested in a variety of ways. The exposition below is non-encyclopedic.

As regards the competitive position of shipping companies vis-à-vis other transport modes, if a bunker levy is not accompanied by an equivalent increase in the fuel prices of the other modes, then the potential shift of cargoes to these modes (either because of higher maritime transport costs, or because of increased sailing times, or because of both), as per Section 2.2, may result in loss of income to the shipping companies that are impacted by such modal shifts. Such shifts would be seen mainly in the more expensive and perishable products trades and are likely to be confined to liner shipping.

As regards competition within shipping, shipping companies that use ships that have slender designs that exhibit a lower resistance especially in non-calm weather conditions are likely to have a commercial advantage over shipping companies that do not.

Similarly in the long run, a levy is likely to favor companies that have the financial resources to invest in energy efficient technologies and alternative fuels, vis-à-vis those that do not.

It is also clear that if the price level of the levy is significant, in the long run it will boost the business prospects of a wide variety of companies, including alternative low/zero carbon fuel developers, manufacturers of engines that can use such fuels, manufacturers

of energy saving devices and other equipment (wind sails, Flettner rotors, air bubbles, energy recuperation devices, specialized propellers, etc.), shipyards that build energy efficient ships, and others. Conversely, enterprises such as fossil fuel producers and vendors, or companies that do not sell energy efficient technologies will be at a commercial disadvantage.

Should a scheme of direct taxation of GHG emissions be adopted at some point, manufacturers of emissions measuring equipment will reap significant commercial benefits.

Last but not least, commercial impacts would include the entire chain of stakeholders that are "downstream" after money is collected, and this depends on what is decided on the uses of this money and how the whole scheme is administered. This, in and of itself, is a subject of major discussion. The ICS (2019) R&D fund proposal describes one of the possible architectures that can be used, being run by the shipping industry, but as far as who will benefit from the collected funds it only concerns R&D. The potential beneficiaries of a full blown levy scheme are much wider and these include banks, fund administrators, emissions certifiers, shipyards, alternative fuel developers and vendors, ports, and others which actually may not be connected to the shipping industry at all (for instance, a wind farm in Indonesia that is funded by the proceeds of the levy and is used as an out-of-sector GHG emissions reduction mechanism). All these are expected to enjoy significant commercial benefits once a levy is established.

Situations to be avoided include the possible distortion of competition if, for instance, funds would be used in-sector, or if rebate schemes are used. If monies collected are to be given to developing states for capacity building and technical cooperation, it should be avoided that these funds are given to shipping companies of these countries that can enhance their competitive position vis-à-vis other companies that do not receive such funds. Care should be exercised if funds are given as subsidies to import-competing industries, as this might distort trade.

In all of the above cases, the precise degree of commercial impact is case-specific and cannot be pinpointed in advance.

3. ETS variants

3.1. General

There can be several variants of the Emissions Trading System (ETS) as applied to maritime GHG emissions. These include:

A Those that called for a *global* ETS, as submitted to the IMO in 2010 by Norway, UK, France and Germany. These four ETS proposals were submitted to the IMO independently but their main philosophies were very much similar. See Norway (2010), UK (2010), France (2010) and Germany (2010).

B Those that call for a *regional* ETS, as contemplated by the EU in the context of the European Green Deal (EU, 2019) and the intended inclusion of shipping into the EU ETS.

As regards variant A above, and after the suspension of the MBM discussion in 2013, there has not been any updated submission of these ETS proposals or of any variant. An example on variant A is Norway's ETS proposal in 2010 (Norway, 2010). The British (UK, 2010), French (France, 2010) and German (Germany, 2010) ETS proposals were very similar, but not completely identical to the Norwegian ETS. All had a global coverage basis.

As regards variant B, and other than the declared intent of including shipping into the EU ETS, and related action on the legislative and impact assessment front, neither of which is currently finalized, there is currently much uncertainty on the precise way that this would happen.

In contrast to the above *global* ETS proposals, which were pretty concrete and well defined and detailed, the inclusion of shipping into the EU ETS (variant B), as per the European Green Deal (EU, 2019), is substantially lacking in key elements at this point in time. The reason is that such elements are under investigation as regards impact and consequences and under negotiation among legislative stakeholders (European Parliament- EP, European Commission- EC, and the Council) and possibly industry and other stakeholders. One thing seems reasonably plausible: that the EU ETS proposal will be connected to the EU Regulation on the Monitoring, Reporting and Verification (MRV) of CO_2 emissions (EU, 2015) and that CO_2 emissions data collected via the THETIS MRV database would be used in the context of an EU ETS in shipping.

The European Maritime Safety Agency (EMSA) published in May of 2020 the first account of CO_2 emissions that are subject to the MRV Regulation, with results pertaining to 2019 (EMSA, 2020). According to it, in 2019 more than 138 million tonnes of CO_2 emissions were recorded via data from more than 11,000 ships. Other than (a) CO_2 emissions at berth, which are approximately 6% of total CO_2 emissions, the rest of the CO_2 emissions are about equally split among (b) intra- European Economic Area (EEA) trips, (c) EEA incoming trips and (d) EEA outgoing trips.

EU ETS prices are broadly fluctuating, but assuming an indicative price of €20 per tonne of CO_2, which was in the range of carbon prices within 2019, it would seem at first glance that a total of €2.75 billion could be raised had such an ETS price been applied to the 2019 CO_2 emissions. A recent report by the World Shipping Council (WSC, 2020) assumed a (very similar) carbon price of €25 per tonne of CO_2 as indicative for pre-COVID-19 2020 prices and came up with a figure of €3.45 billion as revenue raised.

Such crude calculations may give a first-glance indication of how much money could be collected. However, they have a basic flaw: they ignore changes in shipping operator behavior that would be triggered as a result of the inclusion of shipping in the EU ETS.

These changes could:

- Entail a reconfiguration of ship speeds, routes and networks.
- Potentially impact any or all four components (a), (b), (c) and (d) of the total CO_2 emissions, as stated above.
- Impact CO_2 emissions per ship sector in different ways.

If anything, one of the objectives of the European Green Deal is to incentivize a shift to greener technologies and energy saving practices, which would lead to CO_2 emissions reductions vis-à-vis Business As Usual (BAU). Precisely what such a shift would entail, or in fact whether there would be such a shift, or actually whether there might be side-effects that could lead to carbon leakage, remains to be seen. This would critically depend on the architecture of the EU ETS as applied to shipping. This architecture is at this point in time not very clear.

Elements of the EU ETS architecture that are not clear include the following (list may not be complete):

(i) whether the coverage of the EU ETS will be the same as that of the EU MRV or will only be limited to intra-EEA trips
(ii) what would be the mechanism of issuing, allocating, auctioning and redeeming carbon allowances
(iii) whether it will be an open or closed ETS
(iv) whether there would be any free allowances and if yes how many and how would they be allocated
(v) whether time charterers would be allowed to trade carbon allowances or that would be limited to ship owners

With respect to element (i), if only intra-EEA trips are covered, this would significantly limit the scope and the impact of the scheme. Note that this has been ultimately the case with the inclusion of aviation within the EU ETS, mainly due to the reaction of countries like the United States, China and Russia- and this might actually create a legal precedent- see also Section 3.3 below.

In mid- September 2020, the EP voted to include shipping into the EU ETS. This includes the creation of an "Ocean Fund" from 2023 to 2030, financed by revenues from auctioning allowances under the ETS, to make ships more energy-efficient. However, and as this report was being finalized, the way the scheme would work remained unclear. Discussions with the EC and the Council would determine the details of the scheme. We also understand that a study that would, among other things, investigate impacts and consequences of several variants of the scheme, is under preparation, and that this study would be released in the summer of 2021. Until then, the only justification for including shipping into the EU ETS is from a prior Impact Assessment (IA) conducted by the European Commission (EC) circa 2013 (EC, 2013), in which the EC examined several GHG reduction options and concluded that ETS was the best one. Supporting documentation for the IA came in a detailed Technical Report (TR) commissioned by the EC and prepared by a consortium of partners, see Ricardo et al. (2013).

As mentioned in Lagouvardou et al. (2020), both the IA and the TR were very comprehensive; however, neither contained information on the model that evaluated the various policies for reducing maritime GHG emissions. The model was based on the so-called TIMES energy model and was specifically developed for the IA. We were unable to access or find in the literature any specific information regarding the structure, methodology, or inputs and parameters of that model. We also note that even though the TR contained no recommendation on which of the GHG reduction measures was the best, the IA made its ETS choice based on the contents in the technical report.

So to the best of our knowledge, the major policy decision to include shipping in the EU ETS has been, at least thus far, based on models that are non-transparent or not open to scrutiny, and also entails other issues that are unclear or unresolved.

Another interesting fact is that the two processes, IMO and EU, appear to be completely disconnected. The IMO process currently focuses on short-term measures and the relevant discussion has been delayed due to COVID-19. There is no substantial mention of EU ETS in any of the current items on the IMO GHG agenda. There is nothing in the IMO current GHG agenda to discuss the potential repercussions of EU ETS to what is being discussed at the IMO, even though the implementation of the measure may render measures such as for instance the recent combined EEXI/SEEMP/CII proposal (China, 2020), a version of which was approved by MEPC 75, not fully relevant if implemented in parallel with the EU ETS, unless there is an attempt to link it somehow with the EU ETS in Europe (see also Section 4 below). In contrast, the EU process is very much up and running, as stated earlier. Moreover, the MBM discussion at the IMO is still under the horizon, as MBMs are under the medium-term measure category and only as a possibility.

In view of the uncertainties associated with the EU ETS proposal, it is clear that no complete cost benefit analysis on it can be conducted at the present time. At the same time, it can be argued that something can still be said on ETS, as regards the evaluation criteria. This is done in the sections that follow.

3.2. GHG reduction effectiveness

As argued among ETS advocates (see also Norway (2010)), the main selling point of the various *global* ETS proposals at the IMO was what was claimed as "full certainty on the emission reductions achieved by the mechanism". This means that if one sets a cap on emissions, that cap will absolutely be met. This stems from the fact that CO_2 emission allowances (or permits) will be auctioned (at a price that is established by the market) and if no more such allowances exist, a ship that does not have such allowances would not be able to legally emit CO_2. The cap would be adjusted downwards yearly so that at 2050 the 50% reduction target could be met, vis-à-vis 2008 levels.

The issuance of free allowances could potentially undermine the above full certainty and could potentially lead to carbon leakage. Also, and so as to limit its administrative complexity, a global ETS may entail other forms of exemptions, such as for instance applicability only to ships above a certain size, or geographical exemptions, for instance to SIDS/LDCs. Such exemptions may lead to carbon leakage as well.

But even if one is to assume that a way forward is found for a global ETS allowance cap to function with full reduction certainty, it is not yet clear how such a cap would be set and implemented *on a regional basis*, that is, for the EU ETS. It could be a cap concerning only CO_2 emissions on trips to and from EEA ports, including intra-EEA trips, but this is still not clear. For instance, if 2018 CO_2 emissions were 138 million tonnes, and the implementation of the EU ETS starts in 2022, a cap of 83 million tonnes could be set in 2030 (40% reduction vs. 2018), and intermediate caps could be set from 2023 to 2029. Then no one would be allowed to emit

over the respective annual cap, as far as the EEA is concerned. However, presumably no such restriction would exist outside the EEA geographical coverage if nothing similar is instituted by the IMO at the same time (which does not look likely at this point in time). In other words, even if ships meet the European cap, if no similar mechanism is set by the IMO on a global basis, it is not clear how the IMO 2050 targets would be met. There would have to be a global ETS to achieve that.

Whether global or regional ETS, another problem may be, even though one may reach the cap that is selected, the carbon price that would be established would be completely unknown, being a function of future supply and demand for carbon. Also, as soon as the cap would be approached and allowances would be in short supply, carbon prices may skyrocket. Market fears and expectations may skyrocket prices, which may in turn collapse as was the case with the EU ETS, where carbon prices dropped precipitously as a result of the 2008 economic crisis (and also as a result of COVID-19 in 2020).

If the EU ETS is to be compatible with the EU MRV, as it would seem the reasonable thing to do, it would be applicable to ships of 5000 GRT and above. This might lead to some carbon leakage for ships below that threshold. One may see side-effects like many ships of 4900 GRT being built so as to avoid being subject to the ETS. These would proportionally emit more CO_2.

An even more serious carbon leakage may occur if ships use non-EEA ports close to the EEA to transship cargoes to and from the EEA. These ports may be for instance Felixstowe, Kaliningrad, Izmir, Beirut, or ports in northern Africa. By transshipping in these ports just before or after an EEA port call, not only revenues collected via an EU ETS would be reduced, but CO_2 emissions reduction might be problematic as well. Psaraftis et al. (2020) develop a rudimentary hypothetical scenario of a containership using the (non-EEA) port of Felixstowe as a transshipment port on a container route from Shanghai to Antwerp, and show that an EU ETS would achieve much lower CO_2 emissions reductions than those achievable by a global levy. Also the funds collected by a global levy are shown to be much higher, even if the global levy is much lower than the ETS price.

We understand that the EP and/or the EC are very much aware of the above possibility of carbon leakage and may try to preempt it by an appropriate description of how a “port of call” is defined. How or if this could be achieved is not clear. If by a suitable definition of port of call all of the emissions of a ship going from (say) Shanghai to Piraeus are counted even if the last non-EEA port before Piraeus is (say) Izmir, then the loophole could be closed. However, doing something like this would likely entail similar changes in the EU MRV Regulation and might entail non-trivial legal issues brought about by non-EU Member States (or even by some EU Member States).

As with a levy, another possible side-effect of an ETS that should also be looked at is shifts to other modes of transport, ultimately leading to more CO_2 emissions overall. Similar considerations apply for the EU ETS case, and particularly in case the scheme involves only intra-EEA trips, where short sea shipping may compete with land-based modes. A main difference vis-à-vis the levy case is the inherent unpredictability of the ETS price. Any shifts to land-based modes would go against the EU policy to promote short-sea shipping and move cargoes from land to sea. The works of Zis and Psaraftis (2017) and Zis et al. (2019) are relevant here.

3.3. Compatibility with existing legal framework

At the regional level, both the EU MRV (which concerns shipping but has no pricing mechanism) and the EU ETS (which has a pricing mechanism but does not concern shipping) are already well-defined from a legal perspective. Thus it would seem, at least at first glance, that combining the two schemes so as to include shipping into the EU ETS would use well-established legal platforms and as a result would not encounter serious legal issues.

However, if aviation is any precedent, the inclusion of air transport into the EU ETS was marred by considerable reaction from non-EU countries such as the US, China and Russia, which banned their airlines from paying into the scheme and at the end the result was the scheme being applied only to intra-EEA flights. As mentioned in Evans (2016), the primary stated reason for this opposition was that it violated the Chicago Convention, which prohibits the taxation of jet fuel, and that such a scheme should be international in nature, and organized instead under the auspices of the International Civil Aviation Organization (ICAO). A similar reason may very well be valid and create a legal precedent for the maritime EU ETS as well. Already Japan, Korea, and some Chinese shipping groups have voiced their opposition to the inclusion of shipping into the EU ETS. One would imagine that countries such as Brazil, Argentina, India or Saudi Arabia would not be sympathetic either. The stance of the US under a Biden administration is likely to be more proactive on climate change and hence also on maritime GHGs than it was under the Trump administration, however its stance on MBMs (and in particular ETS) is likely to be similar to its stance on the inclusion of aviation in the EU ETS.

In fact, and as also mentioned in Lagouvardou et al. (2020), from a legal point of view, there are several authors that claim that a including shipping into the EU ETS is not compatible with international law (mainly UNCLOS), for various reasons (see for instance, Hermeling (2015) and Koesler et al. (2015)). A recent study commissioned by the International Chamber of Shipping (ICS) and the European Community Shipowners Associations (ECSA) on the inclusion of shipping into the EU ETS (Hughes, 2020) also identifies important legal issues. How all this will play out in the EU legislative process is not clear.

The recently released study by the World Shipping Council (WSC, 2020) identifies many problems (legal and other) should the EU proceed with an inclusion of shipping in the EU ETS in which the coverage is the same as the coverage as that of the EU MRV. The study recommends that if the EU goes ahead with such a scheme, coverage should be limited to intra-EEA trips only. Among other things the WSC examines what would happen if, perhaps as a retaliation, countries like the US, China or Brazil move to implement similar regional ETS measure as well.

So by and large the opposition of major shipping associations, including ICS, ECSA and WSC, plus various national shipping associations, to ETS in general (both global and regional) has been on record. Even when Germany and Norway were for ETS at the IMO, their national ship owners associations were against. To what extent and towards which direction such associations can influence the EU legislative process remains to be seen. Also it is not clear what the overall strategy of each of these stakeholders

would be, if in fact there is one: (a) give an all-out fight to prevent ETS from happening in the first place, or (b) accept that shipping would be eventually included into the EU ETS and negotiate the best (or least bad) scheme for this to implemented.

Option (a) appears to be the approach of ECSA and ICS (Hughes, 2020) and also of Trafigura (2020), however it is not clear which, if any, IMO stakeholder would bring forward the Trafigura idea to the IMO (see however Section 5 for some recent developments).

On the other hand, if (b) is the case, any form of EU ETS would be incompatible with non-ETS types of MBMs whenever the MBM discussion at the IMO resumes. In fact, the inclusion of shipping into the EU ETS would have another very serious ramification: it could pave the way for *a global ETS*, should the IMO eventually adopt an MBM on a global level. It would seem (at least at first glance) easier to choose *a global ETS path*, or see how various other regional ETS schemes can be interconnected, rather than mix an EU ETS with (say) a global levy. If this is the case, there could be additional legal issues associated with an extension of an ETS from a regional to a global scale and these could be considerable. The disagreement of legal experts on legislative compatibility of MBM proposals (see Section 2.3) is noted again. Compatibility with the principle of CBDR-RC is likely to be one and not necessarily the only one of the issues to be resolved.[4]

3.4. Potential implementation timeline

There is no timeline for a global ETS, because the IMO has not reopened the MBM discussion as of yet. As far as the EU ETS is concerned, and assuming that the updated impact assessment study will be completed in the summer of 2021, it all depends on the speed of the legislative process afterwards. Assuming no legal glitches (which may be a big assumption), a very crude guestimate is that the relevant process is completed in 2022 and the kickoff of the EU ETS will be in 2023, coinciding with the end of the 5-year phase after the adoption of the Initial IMO strategy in 2018. This would also coincide with the implementation start of the combined EEXI/SEEMP/CII short-term measures decided by MEPC 75. This would make this an interesting (but possibly messy) interface of two classes of GHG reduction measures, the preparation of which was carried out in parallel and with little or no consideration of the impact that one could have on the other. See however Section 4 about the possibility of a combined IMO/EU measure.

3.5. Potential impacts on states

To our knowledge, for an ETS there has been no work equivalent to that described in Section 2.5 for the carbon levy case. However, most of the relevant considerations relevant for a levy are also valid for ETS. Plus, and on top of whatever problems that a levy might create, the uncertainty of the ETS price would constitute an additional problem. In addition, if, in order to reduce the ETS administrative costs or potential negative impacts (see Section 3.6), exemptions are granted to some LDCs/SIDS, possible distortions and carbon leakage may occur. SIDS could establish themselves as mega hubs just to avoid the ETS. Note that SIDS include countries such as Singapore, even though that country is one of the best connected countries in the world.

On top of that, the LDCs/SIDS that asked for the MBM discussion to reopen at the IMO (Antigua, 2018) suggested a levy, not an ETS.

3.6. Administrative burden

The administrative costs for ETS include all those administrative costs associated with Option 2 of the GHG Fund proposal (the one which is ship based), plus, many more additional costs associated with issuing the allowances, trading, monitoring compliance, avoiding fraud, and others. Therefore among these two systems, ETS seems heavier administrative-wise.

Of course, the EU has already a well-defined administrative system to manage the EU ETS carbon market, and this could be conceivably adapted to shipping. The EU has also a well-defined procedure for the EU MRV. However, from a shipping company's perspective, the additional clerical burden of ETS and of combining the two systems could be substantial.

3.7. Practical feasibility

It is clear that the costs of ETS enforcement will be on the high side. The certified verifiers that engage in MRV verification could take up this task, at an additional cost obviously. For the reasons outlined in previous sections, and also in Section 3.8 that follows, the practical feasibility of a maritime ETS is considered to face substantial challenges, whether this is a global ETS or a regional ETS.

3.8. Avoidance of split incentives between ship-owner and charterer

In addition to the above, we think that a serious split incentive between ship owner and charterer may occur under an ETS. As argued in Psaraftis (2012), under an ETS it becomes difficult or impossible to link the price of a permit purchased by the ship owner at a certain time and the speed decision of the time charterer at a different time. We note again the opposition of a major chartering association (Trafigura), as well as the opposition of all shipping industry associations, to an ETS.

[4] In a recent Global Maritime Forum event (see https://www.globalmaritimeforum.org/virtual-high-level-meeting-2020/livestreams), some shipping companies came out in favor of an EU ETS as a parallel approach to a global carbon levy. This seems to be along the lines of case (b). However, it is not clear if this approach has any official industry association interest, either at the IMO or elsewhere.

Table 2
Summary evaluation of levy-based and ETS-based MBMs.

Criterion/ MBM	Levy-based	ETS-based
GHG reduction effectiveness	Considerable, depending on the level of the levy	Considerable for a global ETS Questionable for an EU ETS
Compatibility with existing legal framework	May encounter legal obstacles	May encounter legal obstacles.
Implementation timeline	Unclear at global level Industry R&D fund on the table at IMO	Unclear at global level EU ETS is forthcoming
Potential impacts on states	Potentially considerable	Potentially considerable
Administrative burden	Low	Considerable
Practical feasibility	High	Questionable
Avoidance of split incentives	No serious split incentives	Serious split incentives
Commercial impacts	Considerable and in many sectors	Considerable but uncertain due to uncertainty on carbon price

3.9. Commercial impacts

It would seem that the commercial impacts discussed in Section 2.9 for a levy scenario could also apply for the ETS case as well. In particular the "downstream" commercial impacts of an EU ETS, depending on how the proceeds of the fund are administered, would also be valid under such a scheme.

Again, a major difference vis-à-vis the levy is the inherent unpredictability of the carbon price under an ETS. Another difference is the high administrative burden and lower practical feasibility of an ETS. All this might significantly dampen incentives to invest in energy efficient technologies or alternative, low carbon fuels.

In another difference versus the levy scheme, which weighs in favor of an ETS, ETS would be an excellent business opportunity for whoever is tasked to administer ETS allowances and all clerical tasks associated with an ETS. As the administrative burden of the scheme would be substantial, substantial income would be generated for ETS administrators for their services. Obviously such income would come from the shipping companies who would hire such administrators, even though the shipping companies would pass on this cost to the charterers.

Table 2 below focuses on the two major classes of MBMs, the levy-based MBMs and the ETS-based MBMs and summarizes our evaluation of these MBMs according to the evaluation criteria, and as per Sections 2 and 3.

4. Other MBMs

In addition to the GHG Fund and the various ETS proposals, some additional MBM proposals were submitted to the IMO in 2010. Since at this point in time we have no reasonable indication that any of these proposals would be resurrected and resubmitted to the IMO, we shall only comment on each of the cost-benefit criteria *in summary form*.

It would also seem that the LIS scheme by Japan falls under the D variant of levy MBMs defined in Section 2, as it would provide a differentiated levy (or no levy) to ships with a good EEDI. To the same category also belongs the IUCN rebate MBM, to the extent it piggy-backs the GHG Fund MBM.

Table 3 below summarizes our evaluation of these MBMs according to the evaluation criteria. The table is adapted from a similar analysis in Psaraftis (2012).

We are not aware of other MBM proposals, however below we want to very briefly discuss the possibility of combining ship operational measures with MBMs. This might take one of the following forms (list below is not exhaustive):

(i) Use a global carbon levy but ships that have a "good" Carbon Intensity Indicator (CII) get a discount or rebate (with CII and "good" appropriately defined, for instance ships with climate rating A or B).
(ii) Same as i except levy is paid only if CII is above an appropriately defined threshold.
(iii) In the EU ETS, ships with a "good" CII can trade allowances with ships with a "bad" CII (again, "good" and "bad" are appropriately defined).
(iv) Same as iii except ETS is applied only if CII is above an appropriately defined threshold.
(v) Same as iii except a combination of the EU ETS and the new EEXI/SEEMP/CII combined short-term measure agreed upon at MEPC 75 is considered.

MBMs similar to some of the above cases have already been proposed, in the context of the prior IMO MBM discussion. For instance, case i looks similar to Japan's LIS or WSC's VES MBM proposals, and case iii resembles the USA's SECT proposal, all circa 2010.

Perhaps more interesting is case (v), the possible combination of an EU ETS with the recent EEXI/SEEMP/CII combined short-term measure, which looks like it will be IMO's way ahead as regards a short-term measure. To our knowledge no such combination has been proposed, and the analysis of such a combination is outside the scope of this paper. However, should both measures go ahead, one could foresee a scenario in which the two measures are combined instead of being applied in parallel and independently. Obviously the coverage of such a scenario would be limited to the coverage of the EU ETS, whatever that might be.

Table 3
Summary evaluation of other MBMs submitted to the IMO. Adapted from Psaraftis (2012).

Criterion/ MBM	Bahamas (do nothing)	IUCN (rebate)	STEEM (port based)	EIS (EEDI based)	SECT (EEDI based)
GHG reduction effectiveness	Some CO_2 reductions can be achieved even with no MBM.	Proposal piggybacks any MBM. Its environmental effectiveness is same as that of MBM implemented.	Carbon leakage risks exist as some port states may not implement scheme.	Lower than GHG Fund, as some ships will be exempted	Low. CO_2 reduction certainty does not exist, as scheme trades on EEDI. No attempt to compute CO_2 directly.
Compatibility with existing legal framework	Fully compatible	Same as that of MBM implemented	Likely to encounter legal obstacles		
Potential implementation timeline	None of these proposals is still alive. There is no indication of any attempt to reinstate.				
Potential impacts on states	None	Could be beneficial to LDCs and SIDS if levy is based on imports	Unclear. May create distortions by diverting traffic to port states that do not implement the scheme.	Unclear. SIDS served by older ships may be at a disadvantage	Unclear. SIDS served by older ships may be at a disadvantage
Administrative burden	Zero	Higher than that of MBM implemented (add costs of administering rebates)	High	Lower than SECT, but higher than GHG Fund.	Worse than ETS.
Practical feasibility	Highest	Lower than that of MBM implemented (add costs of administering rebates)	Low. Practically impossible to monitor emissions.	Higher than SECT but lower than GHG Fund, due to tracking of EEDI for existing ships.	Worse than ETS. Combines problems of ETS with tracking EEDI for existing ships and estimating activity levels.
Avoidance of split incentives	No split incentives	Same as that of MBM implemented.	Unclear	Unclear	Unclear
Commercial impacts	None	Same as that of MBM implemented.	Unclear	May favor countries with strong shipbuilding sector	May favor countries with strong shipbuilding sector

Under such a scheme, one could envision a "revenue neutral" scheme in which ships that fall in the "bad" ship categories of the EEXI/SEEMP/CII scheme (classes D and E) would be asked to pay the EU ETS carbon price, whereas classes A and B might conceivably get some revenue. Alternatively, class D and E ships could purchase carbon allowances that are held by high performing ships (classes A and B). Other combination schemes could also be considered.

Investigating such a combination would obviously be interesting from a research point of view. Also, such a combination might be attractive in the sense that it would combine the two processes, of the IMO and of the EU, which are running in parallel at this point in time. However, it would seem that combining two measures both of which entail a non-trivial degree of complexity would probably result in a more complex measure that would be difficult to enforce and whose benefits would be hard to document. Such a combination might also detract from the global MBM discussion, or even be an impediment to it, whenever that discussion resumes at the IMO.

5. Conclusions

This paper has presented a comparative evaluation of various maritime MBMs. On the basis of this evaluation, it is our opinion that a levy-based MBM exhibits several advantages over an ETS-based MBM.

As things stand, the closest approximation to an MBM proposal by the shipping industry before the IMO is one which is actually not considered an MBM by its proposers. It is the R&D Fund proposed by all shipping industry associations (ICS, 2019), which entails levying a 2 USD/tonne surcharge on bunker fuel, which is to be used for R&D. Such a charge would hardly do anything as regards GHGs, however it is expected to raise some 5 billion USD for R&D. The proposers have however stated that the architecture of that proposal could be borrowed should a bunker levy be instituted by the IMO in the future, thus implicitly indicating their preference as to which MBM they would support.

A parallel request, which was not an explicit MBM proposal but a request to reopen the MBM discussion as soon as possible, has been the one by the Marshall Islands and the Solomon Islands (Marshall, 2020). In a submission to MEPC 75 (November 2020) the proposers urged the IMO to revise the Initial Strategy so that MBMs are moved within the set of short-term measures, that is, agreed to and implemented before 2023. Due to divergence of views, MEPC 75 deferred decision on these matters to MEPC 76 (June 2021).

As this paper was being finalized (April 2021), IMO member states Denmark, Georgia, Greece, Japan, Liberia, Malta, Nigeria, Palau, Singapore, and Switzerland gave their support to the ICS (2019) R&D proposal (Denmark, 2021a). Moreover, the proposers also submitted a comprehensive impact assessment of the 2 USD/tonne surcharge, perhaps to counter the concerns of some devel-

oping countries that such a surcharge (which is actually well within the noise of daily fuel fluctuations) may entail negative or disproportionately negative impacts for their economies (Denmark, 2021b).

In addition, the Marshall Islands and the Solomon Islands submitted a new request to the IMO to impose a levy of 100 USD per tonne of CO_{2eq} (Marshall, 2021). Such a levy is below the levy requested by Trafigura (250 to 300 USD per tonne of CO_{2eq}). However, as the Trafigura proposal has not (at least as of yet) officially found its way into the IMO process, the Marshall Islands and Solomon Islands proposal is currently the official front runner among IMO proposals as far as the price level of levy is concerned.

All this also means that if the MBM discussion before the IMO would stand a chance to proceed and possibly preempt the problems associated with an EU ETS, the support and adoption of the above proposals could be an important first step.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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