Public Disclosure Authorized

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WPS8319

Policy Research Working Paper 8319

Regional Carbon Pricing for International Maritime Transport

Challenges and Opportunities for Global Geographical Coverage

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WORLD BANK GROUP
Climate Change Global Theme
&
Macroeconomics, Trade and Investment Global Practice Group
January 2018

Policy Research Working Paper 8319

Abstract

Although the existing literature identifies a fuel levy imposed by means of a global agreement as the most efficient policy for carbon pricing in the maritime sector, scholars and policy makers debate the possibility for regional measures to be introduced in case a global agreement cannot be achieved. This debate has highlighted several economic, legal, and political challenges that the implementation of an efficient and effective regional scheme would have to face. This paper compares the relative performance of various regional measures for carbon pricing based on the following criteria: jurisdictional basis, data availability, environmental effectiveness and avoidance strategies, impact on competitiveness, differentiation for developing countries, and incentives for reaching a global agreement. The main finding is that, if carefully designed, a cargo-based measure that covers the emissions released throughout the whole voyage to the cargo destination presents various advantages compared with other carbon pricing schemes. These advantages have been largely ignored in the literature.

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Produced by the Research Support Team

Regional Carbon Pricing for International Maritime Transport: Challenges and Opportunities for Global Geographical Coverage[1]

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Keywords: Carbon pricing; Maritime emissions; Regional measures, Jurisdiction; Data availability; Environmental effectiveness; CBDRRC.

[1] The findings, interpretations, and conclusions expressed in this work are entirely those of the authors and should not be attributed in any manner to the World Bank, its Board of Executive Directors, or the governments they represent. Whereas this knowledge product is a contribution to the Carbon Pricing Leadership Coalition's discussions on the appropriate role of carbon pricing in the maritime sector, its findings should not be interpreted as the views of the Coalition or its Partners.
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We are very grateful to Ben Milligan, Kelley Kizzier and Tristan Smith for very useful feedback and guidance, and to Susanne Gäde and Arne Pieters for useful discussion.
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1. Introduction

The maritime sector accounts for a non-trivial and growing share of global greenhouse gas (GHG) emissions.[5] Without adequate mitigation measures being in place, emissions from the maritime sector could prevent the goals established by the Paris Agreement from being achieved.[6] An economically efficient solution to mitigating these emissions would require carbon pricing to be part of the policy package.[7] The most efficient application of carbon pricing would be through a global measure that prices GHG emissions at the rate of the social cost of carbon.[8] However, given the urgency of action on climate change, there is an equal need to consider alternative solutions in case this preferred measure does not become available in time. One proposition in policy debates has been to introduce regional carbon pricing.[9] Such measures, however, face significant legal and economic challenges. This paper sheds light on these challenges, summarizes the relevant literature and explores ways forward for regional carbon pricing as a second-best policy back-up plan in case no global scheme of sufficient stringency can be implemented.

There is a consensus in the literature that a fuel levy imposed by means of a global agreement would be the most effective and efficient way forward for carbon pricing in the maritime sector.[10] Despite this consensus, scholars and policy makers have discussed the potential for sub-global action as a second-best solution if a global agreement cannot be reached.[11] Indeed, recent political developments highlight the fact that the absence of a global agreement could well trigger regional action in shipping.[12] Also, if shipping follows aviation, the adoption of the geographically limited Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) by the International Civil Aviation Organization (ICAO) indicates that shipping could equally have its own sub-global scheme. In this vein, regional action for shipping may have become more relevant since the Paris Agreement. First, although the Paris Agreement does not explicitly mention or clarify the status or regulatory pathway for GHG emissions from international maritime transport,[13] no sector of the economy is exempted from contributing to its goals.[14] In addition, the Paris Agreement establishes binding commitments by country parties to submit nationally determined contributions (NDCs) and to implement national measures to achieve them.[15] While the NDCs might not be the most suitable way to address international maritime transport emissions, domestic action pursuing mitigation policies for the sector could include the international part of the emissions.[16] At this point, two main issues

[5] Emissions from international maritime transport account for around 2.2% of global GHG emissions, and they are forecast to increase by 50-250% by 2050. See Smith et al. (2014).
[6] The Paris Agreement established the long-term goal of limiting the increase in global average temperatures to well below 2°C (with an aim to achieve 1.5°C) above pre-industrial levels (article 2). The agreement aims to reach a global peak of GHGs as soon as possible so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of the century (article 4). See ENVI (2017).
[7] IMF and World Bank (2011), Keen et al. (2013). Generally, on the advantages of combining environmental measures with carbon pricing, see Bowen (2011).
[8] Interagency Working Group on Social Cost of Carbon, United States Government, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (2016). For an estimate of the social cost of carbon emissions related to the maritime sector, see Heine et al. (2017), p. 1; Heine and Gäde (2018).
[9] For simplicity in the following, we will not distinguish between national schemes and schemes introduced by a coalition of states, unless otherwise specified.
[10] IMF and World Bank (2011), Keen et al. (2013); see also Bowen (2011).
[11] See, for instance, Faber et al. (2009); Bäuerle et al. (2010); Hemmings (2011); Kågeson (2011); Kollamthodi et al. (2013); Heine et al. (2017); Heine and Gäde (2018).
[12] European Parliament Amendment 36 Proposal for a directive Article 1 – point 2 a Directive 2003/87/EC Chapter II a.
[13] Emissions from international aviation and shipping were excluded from the Kyoto Protocol.
[14] The climate regime distinguishes between domestic and international maritime transport in addressing GHG emissions. Problems in attributing responsibility for these international emissions led to the exclusion of the sector from the Kyoto Protocol.
[15] Paris Agreement, article 4.
[16] Martinez Romera (2016).

are also relevant. First, the climate change regime emphasizes the role of developed countries in taking the lead in climate change mitigation,[17] including in the maritime sector.[18] Secondly, policies and measures aimed at climate change mitigation should be cost-effective so as to achieve global benefits at the lowest possible cost,[19] and carbon pricing is widely considered to be among the most efficient mitigation policies, including for the maritime sector.[20] Consequently, carbon pricing for the maritime transport sector initiated in developed countries seems like a relevant and timely subject of study for second-best policy action, with the caveat that a global measure that prices GHG emissions at the rate of the social cost of carbon would remain the first-best policy outcome.[21]

Existing studies of regional maritime carbon pricing have highlighted the fact that the implementation of effective and efficient sub-global schemes faces various economic, legal and political obstacles.[22] Among other challenges, it has been argued that regional measures may be incompatible with international law, face issues of emission data availability, have low environmental effectiveness, pose avoidance issues, generate low public revenues and affect the competitiveness of shipping companies. These concerns have given rise to a literature discussing whether and how some of these barriers can be overcome. Building on this literature, the present work compares the potential of different regional carbon-pricing schemes suggested in the literature in light of these economic and legal challenges. The analysis indicates that there are important differences between possible design choices for regional carbon pricing, as some would encounter much greater legal and economic problems than others. We stress that the present work does not advocate the introduction of a regional carbon-pricing scheme but argues neutrally that if countries do introduce such a scheme at the sub-global level, they should adopt one of the designs that raises the fewest economic and legal problems.

After this introductory section, the rest of this paper unfolds as follows. Section 2 introduces several regional measures that differ in terms of their geographical scope and accounting unit. Section 3 discusses the various problems that arise in implementing regional schemes and (when applicable) possible solutions. Section 4 then turns to the issue of country action within territorial or internal waters which also has a role to play in implementing a regional scheme with broader geographical coverage.

2. Type of Measure, Geographical Scope and Accounting Unit

The existing literature discusses a number of carbon-pricing schemes for emissions from the maritime transport sector.[23] The most efficient and effective option among these alternatives remains a fuel tax or levy applied through a global scheme,[24] with a tax rate set equal to the climate and public health costs of combusting bunker fuels.[25] Regional carbon pricing is a second-best option that might be considered if a globally adopted scheme became unattainable. With this qualification in mind, this paper considers various schemes for regional carbon pricing.

[17] UNFCCC, article 3.1.
[18] Kyoto Protocol, article 2.2.
[19] UNFCCC, article 3.3.
[20] e.g., IMF and World Bank (2011).
[21] Note that the analysis proposed here could inform also the adoption of sub-global schemes in pioneer regions under the IMO umbrella. ICAO has recently taken a similar approach in the adoption of CORSIA.
[22] Faber et al. (2009); Bäuerle et al. (2010); Hemmings (2011); Kågeson (2011); Kollamthodi et al. (2013); Keen et al. (2013); Heine et al. (2017); Heine and Gäde (2018).
[23] Faber et al. (2009); Bäuerle et al. (2010); Kågeson (2011); Kollamthodi et al. (2013); Heine et al. (2017); Heine and Gäde (2018).
[24] IMF and World Bank (2011); Keen et al. (2013).
[25] Parry et al. (2014).

Theoretically, carbon pricing in the maritime sector could take place through an emissions trading scheme (ETS) or a tax, levy or fee[26] on either the emissions or the fuel. Under a fuel tax, emissions are priced upstream, at the point of sale to the ship, based on the carbon content of the fuel. Crucially, for the maritime transport sector, a fuel tax would have to be applied globally to be effective.[27] The reason is that the effectiveness of a sub-global fuel tax depends on the cross-price elasticity of the demand between maritime fuel subject to the tax regime and fuel outside the regime. This elasticity is very high for the maritime sector, since vessels can avoid the tax by refueling either in jurisdictions that do not apply the tax or from tankers or platforms on the high seas. For this reason, the present report focuses mainly on other carbon-pricing measures, that is, non-fuel-based ones.[28] The arguments presented below apply equally to an ETS and to an emissions tax. Thus, if not otherwise specified in the text, our analysis treats these measures jointly under the heading of "carbon pricing".

Non-fuel-based regional measures for carbon pricing in the maritime sector that (also) cover emissions released outside the countries' territorial or internal waters can be distinguished along various dimensions.[29] This report classifies these measures based on their geographical scope and accounting unit.[30] As a result, Table 1 shows a wide variety of options that are theoretically available.

Table 1. Options for Regional Carbon Pricing by Geographical Scope and Accounting Unit, and Existing Proposals

	i. Emissions on First / Last Route	ii. Global Emissions Based on Time Period	iii. Emissions on Holistic Route
A. Accounting by ship	Option (i): Faber et al. (2009); Kågeson (2011); Kollamthodi et al. (2013);	Option (ii): Faber et al. (2009); Bäuerle et al. (2010); Kollamthodi et al. (2013);	Alternative option not considered
B. Accounting by cargo	Alternative option not considered	Alternative option not considered	Option (iii): Faber et al. (2009); Bäuerle et al. (2010); Kollamthodi et al. (2013); Heine et al. (2017); Heine and Gäde (2018);

As indicated in the table, most of the existing proposals cluster around the following three broad categories: i) carbon pricing for ships on the last/first leg of the cargo's voyage;[31] ii) carbon pricing for vessels over a certain period of time to/from a port;[32] and iii) carbon pricing for cargo on its whole voyage to/from a state's port.[33] In this report, we focus on these three measures.

In the case of the first measure, emissions are estimated per ship, and the emissions covered are those released by vessels that transport goods from or to the port of a state that is implementing the measure. Hereafter we will refer to this measure as the *first/last vessel measure* (i), since the emissions covered by this type of scheme are those that occur on the first/last leg of a vessel's

[26] Taxes and fees differ in the flexibility of their revenue uses, but can have similar incentive effects. The term "levy" has no precise economic definition and is only mentioned here due to its frequent use in policy discussions. Going forward this paper focuses on taxes, but the analysis applies more generally as similar incentive effects could be achieved with fees depending on the revenue usage and rate structure.
[27] Mishra and Yeh (2011); IMF and World Bank (2011).
[28] Note that there are possibilities of tax avoidance for non-fuel-based measures also (see Section 3.3). However, as explained below, for these types of measures tax avoidance is less likely to curtail the effectiveness of the measure to the extent of implementing it tout-court.
[29] See, for instance, Faber et al. (2009).
[30] Here the accounting unit is the level (vessel or cargo) at which carbon emissions are estimated.
[31] This type of measure is discussed, e.g., by Faber et al. (2009); Kågeson (2011); Kollamthodi et al. (2013).
[32] Faber et al. (2009); Bäuerle et al. (2010); Kollamthodi et al. (2013).
[33] See, for instance, Bäuerle et al. (2010); Kollamthodi et al. (2013); Heine et al. (2017); Heine and Gäde (2018).

outgoing/incoming voyage. Note that, for incoming voyages, this scheme also covers emissions released while transporting cargoes not destined for the state that is implementing the measure. In the case of the second measure, the accounting unit is still the vessel, but the emissions covered are those released during a certain period before/after a vessel has called at/left a port. Depending on the measure's design, the applicable period of time could vary considerably.[34] If the time covered is sufficiently long, the measure could cover emissions released in transporting cargoes going from/to other destinations than the port implementing the measure. In the following, we will refer to this measure as a *time-based measure* (ii). Emissions coverage is different in the case of the third carbon-pricing proposal. Here the geographical scope of carbon pricing includes all the emissions released by vessels that transport goods from/to the port of a state that is implementing the measure. Unlike the two previous options, emissions under this scheme are charged per unit of cargo instead of per ship. We refer to this option as a *holistic route cargo measure* (iii).

Among the other potential measures for regional carbon pricing that this report does not consider in detail, two deserve mentioning. The first are flag-based measures covering international emissions. Here, carbon pricing is limited to emissions released by vessels that are registered in the implementing state. Several authors have raised concerns about the effectiveness of this type of measure because it could be undermined if, in response to it, vessels were to register in another state.[35] We therefore do not offer a systematic analysis of flag-based regional carbon pricing measures. The second type of regional carbon pricing measure that we do not consider much further applies only to emissions released in internal and territorial waters.[36] Due to their limited environmental impact,[37] our analysis of these measures is restricted to issues connected to their complementary role in pricing international emissions.

3. Measure Design: Challenges and Opportunities

In this section, we discuss the problems that arise in implementing each of the three measures (i.e. *last/first vessel measure; time-based measure; holistic route cargo measure*). In particular, we focus on issues of jurisdiction (section 3.1), data availability (section 3.2), environmental effectiveness and robustness against tax avoidance (section 3.3), competitiveness effects (section 3.4), incentives to make the transition over time to the preferable global fuel tax or levy agreement (section 3.5) and the issue of differentiation in favor of developing countries (section 3.6). When applicable, we will also discuss potential solutions to the problems identified for each of the measures. Overall, the analysis provides an overview of the relative performance of each measure in light of the chosen criteria.

3.1 Jurisdiction and Extraterritoriality

A large share of the GHG emissions covered by the three measures considered here takes place beyond internal or territorial waters. Therefore, the issue arises of whether a state has the jurisdiction to price these emissions. In this section, we discuss the possible jurisdictional bases of each measure.

Jurisdiction refers to "the extent of each state's right to regulate conduct of the consequences of events"[38] and "the legal competence of a state (...) to make, apply and enforce rules of conduct upon

[34] For instance, theoretically the time covered could range from a few days to several months (Bäuerle et al., 2010; Kollamthodi et al., 2013).
[35] For example, Ringbom (2011, p. 618); Tanaka (2016, p. 334).
[36] See Section 4, for a more detailed discussion on a potential role of carbon pricing in territorial waters. In this report, we do not address the question of whether the three measures discussed here are applicable also to domestic shipping.
[37] Ceteris paribus, the environmental performance of a measure is positively correlated with its geographical scope; see below, Section 3.3.
[38] Jennings and Watts (1996, p. 456).

persons".[39] Two types of jurisdiction can be distinguished: prescriptive jurisdiction and enforcement jurisdiction. The former refers to whether a state has the authority to prescribe laws. Enforcement jurisdiction relates instead to the state's authority to enforce these laws.[40]

States have jurisdiction over activities that take place within their territory (territoriality principle). For activities that take place outside their territory, jurisdiction can be established on the basis of general international law or international treaties. Traditionally, under general international law, prescriptive jurisdiction can be based on the following principles:[41] i) the nationality principle, which implies that states can prescribe laws regarding those of their nationals who are abroad; ii) the protective principle, which permits states to legislate on conduct that threatens their primary interests (e.g. security); iii) the universality principle, which allows actions aimed to counter extremely serious crimes such as genocide and war crimes; and iv) the effects principle, which posits that a state has jurisdiction over acts that take place outside its territory that have an impact within the state.

It is commonly agreed that, based on the nationality principle, a state can price emissions released in the high seas by vessels which are registered in the state (nationality principle).[42] However, for the three measures considered here, finding a jurisdictional basis can be more challenging.

Some proposals in the literature suggest that jurisdiction over emissions released in international waters could be established via port-state jurisdiction: ports form part of the territory of a state, and as such they are subject to its authority.[43] The voluntary presence of a vessel in the port of a state gives the state prescriptive and enforcement jurisdiction over it. However, the scope of port-state jurisdiction with regard to activities that take place beyond the state's territorial waters is a debated issue.

The first point of controversy regards the question of when an activity should qualify as extraterritorial. Notably, Scott has put forward the idea that a conduct qualifies as non-extraterritorial when there is a territorial link between the regulator and the regulatee, even when this link is weak.[44] In particular, she argues that the presence of a person on the territory of a state triggers the jurisdiction of the state over conduct that has taken place abroad.[45] The opinion of Advocate General Kokott in the ATAA Case,[46] the CJEU ATAA decision and a decision of the WTO Appellate Body in the Shrimp Case[47] seem to support Scott's view. Scott's argument is also upheld by the fact that territorial measures having an extraterritorial effect are not uncommon.[48] From this perspective, the presence of a vessel at port could give rise to port-state jurisdiction over emissions released on the high seas. It is notable that, given that the jurisdictional link created here is due to the presence of a vessel in a port, this approach is unlikely to provide jurisdiction for a *holistic route cargo measure*. This is because the territorial link between the regulating state and the emissions released by vessels that do not call at its ports is absent here. Conversely, this link might be

[39] Jennings and Watts (1996, p. 456).
[40] Kopela (2016, p. 91).
[41] Dobson and Ringeyart (2016, p. 306); Ringbom (2011, p. 630); Ringbom (2008, pp. 360-366).
[42] Hermeling et al. (2015, p. 43). However, as mentioned in the previous section, due to the practice of flags of convenience, it is sometimes questioned whether flag states would be willing and/or able to effectively enforce measures that raise the costs of shipping companies. See, for instance, Tanaka (2016, p. 334); Rahim (2016, p. 161).
[43] Ringbom, (2011, p. 620).
[44] Scott (2014, p. 87).
[45] Scott (2014, p. 91).
[46] Case C-366/10, Opinion AG Kokott.
[47] Scott (2014, p. 115), referring to US-Import Restrictions on Shrimp and Shrimp Products (DS/58/AB/R). In this case, the AB found it compatible with WTO law measures that, with some qualification, limit imports on the basis of the content of a third-country law or policy. See also Case C-366/10, Decision CJEU. For a more nuanced view of the WTO Dispute Settlement Body on extraterritoriality issues, see Dobson and Ryngaert (2016, pp. 324 ff).
[48] Scott (2014, p. 114). Perez Rodriguez (2012, p. 40).

considered to exist with regard to measures that cover only emissions released by the ship that enters the port's waters, i.e. a *first/last vessel measure* and a *time-based measure*. However, Scott's approach has been contested by others, who consider this perspective to involve an over-extension of the scope of the territoriality principle.[49] Following this line of reasoning, the prescriptive jurisdiction of the port-state needs another basis. However, how to constitute an alternative basis is also controversial.[50]

Ringbom suggests an alternative way of extending port-state jurisdiction over emissions released outside the territorial waters of the state.[51] This stresses states' jurisdiction to regulate access to port waters and the type of sanction imposed on vessels that do not comply with the port-state's regulation. The authority of a state to impose conditions for accessing its port waters is recognized in general international law, as well as by articles 25(2)[52] and 211(3)[53] of UNCLOS.[54] Thus, generally, vessels do not have a right to access the port waters of a state, and a state could sanction vessels that do not comply with its regulations by withdrawing future access to its ports. Contrary to sanctions that are more punitive in nature (e.g. fines), the withdrawal of access to port waters falls more easily within the scope of port-state jurisdiction. This is especially so if the violation of port conditions on entry is framed in such a way that it occurs in port waters ("territorialization" of the offense):[55] for instance, if under an ETS the violation is identified as a failure to surrender allowances that take place in port waters. In this connection, port-state jurisdiction could be more easily established with regard to requirements that are more static (e.g. the age of the vessel) compared to those that can be changed when entering or leaving the territorial waters of the port state. Indeed, the static nature of the requirements implies that part of the violation will also occur in port waters.[56]

Ringbom's approach is contested on various grounds. The territorialization of the offence is seen as an over-formalistic approach that ignores the behavioral incentives that a price on carbon would place on the conduct of vessels on the high seas.[57] These incentives might infringe the freedom of vessels to navigate on the high seas[58] uninfluenced by port-state regulation that is incompatible with the UNCLOS regime.[59] In this connection, the fact that UNCLOS explicitly regulates exceptions to the general ban on port-state jurisdiction on the high seas[60] is seen as an indication that, generally,

[49] Dobson and Ryngaert (2016, pp. 307-308); Hermeling et al. (2014, p. 14).
[50] See below for a discussion of the effect principle.
[51] Ringbom (2011, pp. 626-628).
[52] Article 25(1) reads: "In the case of ships proceeding to internal waters or a call at a port facility outside internal waters, the coastal State also has the right to take the necessary steps to prevent any breach of the conditions to which admission of those ships to internal waters or such a call is subject."
[53] Article 211(3) reads: "States which establish particular requirements for the prevention, reduction and control of pollution of the marine environment as a condition for the entry of foreign vessels into their ports or internal waters or for a call at their off-shore terminals shall give due publicity to such requirements and shall communicate them to the competent international organization."
[54] See on this also: Kopela, (2016, p. 94).
[55] Kopela (2016, p. 94).
[56] Ringbom (2011, p. 622); Kopela (2016, p. 94).
[57] Hermeling et al. (2014, p. 14).
[58] Freedom of navigation on the high seas is recognized by article 87(1) lit. a of the UNCLOS, which reads: "The high seas are open to all States, whether coastal or land-locked. Freedom of the high seas is exercised under the conditions laid down by this Convention and by other rules of international law. It comprises, inter alia, both for coastal and land-locked States: (a) freedom of navigation".
[59] Hermeling et al. (2014, p. 14).
[60] Article 218(1) UNCLOS reads: "When a vessel is voluntarily within a port or at an off-shore terminal of a State, that State may undertake investigations and, where the evidence so warrants, institute proceedings in respect of any discharge from that vessel outside the internal waters, territorial sea or exclusive economic zone of that State in violation of applicable international rules and standards established through the competent international organization or general diplomatic conference".

a state cannot condition the imposition of an administrative sanction on activities that occur outside its territorial waters.[61]

Note also that the approach proposed by Ringbom requires the presence of a vessel in the port of the regulating state. For this reason, even if accepted as a legitimate basis for jurisdiction, it can apply only to carbon pricing related to the emissions released by the ship that enters port waters, not to a *holistic route cargo measure*.

Another issue related to port-state jurisdiction is the competing jurisdictional claim of the flag state. It is widely recognized in international law that vessels located in foreign ports are simultaneously subject to the concurrent jurisdiction of the port state and the flag state. A disputed issue is whether port-state jurisdiction over non-territorial conduct would infringe the jurisdiction of the flag state.[62] While some scholars answer this question affirmatively by referring to article 92(1)[63] of UNCLOS,[64] it has recently been argued that the flag state's jurisdiction is limited to enforcement.[65] As such, the prescriptive port-state jurisdiction over vessels at the port would not be limited by the jurisdiction of the flag state. Ringbom takes a more nuanced position on the matter, suggesting that the jurisdictional basis that prevails between the two depends on a balancing of interests, [66] which should be based on the criterion of reasonableness.[67]

Moving beyond port-state jurisdiction, an alternative way to establish jurisdiction is to identify the consignee/consignor as the entities on which carbon pricing is imposed and ordering/sending a good as the conduct that triggers the generation of emissions. When these entities are residents of the state implementing the measure, the jurisdictional basis of the state might lie on the territoriality principle. The stable residence of the consignee/consignor on the territory of the state might be seen as strengthening the territorial jurisdiction of the state that is imposing the measure in relation to the temporary presence of a foreign vessel at the port.[68] This is because it territorializes the conduct that is seen as generating the emissions (i.e. the act of sending/receiving cargoes).[69] In addition, to the extent that the consignee/consignor of the cargo has the nationality of the state imposing the measure, jurisdiction could also be imposed on the basis of the personality principle.[70] Lastly, imposing a liability on the consignee/consignor might make the potential interference of the flag state with the acting state's decision to levy the carbon price less legitimate compared to a situation in which the liability is imposed on the vessel at the port. Note that jurisdiction established in this way might be a viable option only with regard to measures that identify the accounting unit as the cargo (i.e. a *holistic route cargo measure*). This is because consignees/consignors can, at the most, be considered responsible for the emissions released in transporting the cargoes that they order/send, not for all the emissions released by vessels transporting goods that are also ordered/sent by others.

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[61] Hermeling et al. (2014, p. 14).
[62] The nationality of a vessel is determined by where it is registered (article 91(1) of UNCLOS: "Ships have the nationality of the State whose flag they are entitled to fly").
[63] Article 92(1) reads: "Ships shall sail under the flag of one State only and, save in exceptional cases expressly provided for in international treaties or in this Convention, shall be subject to its exclusive jurisdiction on the high seas."
[64] Hermeling et al. (2014, p. 13).
[65] Honniball (2016, p. 499).
[66] Ringbom (2011, p. 631).
[67] Ringbom (2011, p. 631). Ringbom suggests that the reasonableness criterion could be operationalized by referring to the eight criteria listed in the US Restatement of Foreign Relations Law subsection 403(2).
[68] Heine et al. (2017, pp. 38-39).
[69] Some authors discuss a jurisdictional principle that is relatively more widely accepted than, but closely associated with, the effect principle, namely the objective territorial principle. According to this principle, the jurisdiction of a state can be established "when any essential constituent element of a crime is consummated on state territory".
[70] For companies, a main criterion in establishing their nationality is the location where they are established.

Lastly, an alternative basis for establishing jurisdiction is sometimes found in the effect principle, according to which a state has jurisdiction over acts that, while taking place outside its territory, nevertheless have an impact on it.[71] In the context of carbon pricing in the maritime sector, the effect principle could provide a legitimate basis for jurisdiction because mitigating climate change is a primary interest of single states and the international community as a whole. Note that the effect principle could provide a legitimate basis for both port-state jurisdiction over vessels and jurisdiction over consignees/consignors, and thus potentially for all types of measures considered here, regardless of whether the accounting unit is the cargo or the vessel.

However, contrasting views exist on whether the effect principle could provide a legitimate basis for extraterritorial jurisdiction. Some authors argue that the interest of a state in regulating GHG emissions from shipping on the high seas is weak because the state would be acting as the procurator for a global interest.[72] However, this interest (or the appropriate way of protecting it) is not supported by other states, as testified by the absence of an international agreement on the matter.[73] In support of this conclusion, it has been pointed out that the effect principle has mainly been adopted in antitrust law and is not widely acknowledged in maritime law.[74] Kopela reaches a similar conclusion but on different grounds. In particular, she argues that the effect principle is not foreign to environmental and maritime law.[75] Yet, the application of the principle requires that an activity has a substantial ascertainable impact on the interests of the state. However, in the case of climate change, this impact might not be easily identified.[76] Ringbom sees the uneasy identification of the effect of carbon emissions from the maritime sector on the interests of a state as a potential constraint on the application of the effect principle, but not necessarily an insurmountable one.[77] In this respect, it has been argued that, if the price applied to the emissions reflects the share of the harm suffered by the state, the effect principle could become a more legitimate basis for extraterritorial jurisdiction.[78] The overall conclusion is that it remains a contested issue whether the effect principle could provide a basis for port-state jurisdiction over emissions released beyond territorial waters, but the limitation of the price of carbon to the harm suffered by the state that imposes the measure is likely to strengthen its jurisdictional claim.[79]

To conclude this section, the existing literature recognizes various ways of establishing jurisdiction over emissions released in international waters, but none of these options is uncontested and, apart from the effect principle, each of them could potentially apply only to a sub-set of the measures considered here. However, without taking a position on which (if any) of these approaches would be more legitimate, this paper highlights that, historically, regional action has served as a basis for the expansion of states' jurisdiction under maritime law.[80]

3.2 Availability of Data

A key issue related to the implementation of carbon pricing in the maritime sector is the limited amount of emissions data available to the public authorities. The data needed for carbon pricing, and the corresponding obstacles to obtaining it, are likely to vary depending on the design of the measure. The literature has identified several approaches to resolving this data problem.

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[71] E.g. Bäuerle et al. (2010, pp. 85-86).
[72] Hermeling et al. (2017, pp. 16-17). Against this conclusion, it has been argued that a state can legitimately act for the protection of a global interest when such interests are in line with the aims and obligations set out in international instruments; see Kopela (2016, p. 110).
[73] Hermeling et al. (2017, pp. 16-17).
[74] Hermeling et al. (2017, p. 16).
[75] Kopela (2016, p. 107).
[76] Kopela (2016, p. 107).
[77] Ringbom (2011, pp. 630-631).
[78] Heine et al. (2017, p. 39); Heine and Gäde (2018).
[79] Heine et al. (2017, p. 39); Heine and Gäde (2018).
[80] See, for instance, Boyle, (2006, p. 17). See also below, Section 5.

As mentioned above, the preferred solution for carbon pricing in the maritime sector is through an international agreement. If such agreements were to take the form of an upstream global fuel tax or levy, carbon pricing would occur upstream, with little need for data. Conversely, if the measure were to take the form of an ETS or a levy or tax on emissions, the measure would require data regarding the emissions released by single vessels or for transporting single cargoes. A monitoring, reporting and verification (MRV) system could be introduced by means of a global agreement enforced by the IMO. Recent developments at the IMO and the amendments to MARPOL Annex VI represent a move in this direction.[81] Indeed, a global data collection mechanism will provide flag states with data on fuel consumption, emissions and proxies for transport work (i.e. the product of the mass of cargo transported and the distance covered) per ship. IMO data could also be used to introduce a regional carbon-pricing measure. However, since the data are provided to flag states, a sub-global measure with large emissions coverage that relies on these data could only be introduced by states in which a non-trivial share of shipping companies are registered. In addition, a measure implemented on the basis of the flag of the vessel offers the potential for tax avoidance through re-registration in other jurisdictions that do not price carbon emissions from shipping. There are therefore doubts regarding the effectiveness of flag-based measures.[82]

For the *first/last vessel* and *time-based measures*, a main option is to institute a top-down MRV system that requires vessels calling at the port of a state that is implementing the measure to report data.[83] An example of this type of regulation that could be applicable to a *first/last vessel measure* is the EU's MRV,[84] which provides all the necessary data regarding emissions released by vessels in their first/last voyage to/from an EU port.[85] Alternatively, the distance covered could be obtained using the Automatic Identification System (AIS).[86]

In a *holistic route cargo measure*, emissions could be established based on the cargo weight, distance covered and fuel efficiency of the vessel(s) used to transport that cargo.[87] While data on cargo weight and distance are already available to the customs authorities, the fuel efficiency of vessels is sometimes not easily known.[88] There is, therefore, a risk that carbon pricing would charge an imprecise proxy measure of the actual emissions released by a vessel, potentially distorting the incentives.

An alternative solution that could partially obviate this problem is a voluntary MRV mechanism.[89] The basic features of the mechanism are the following:[90] i) carbon pricing is imposed via an emissions tax or levy; ii) the accounting unit used to calculate the tax is the cargo; iii) the tax liability is imposed on the consignee/consignor of the cargo; iv) the tax is imposed on the basis of default values that approximate to the social cost of the emissions; and v) emissions data are obtained by offering a rebate to the owners of ships that emit less than the estimated default value.

Under taxation based on default values, taxpayers are incentivized to provide data voluntarily, and these data are then used to improve the accuracy of the default values.[91] The incentive works as follows. Taxpayers that have released fewer emissions than assumed by the tax authorities are

[81] See the amendments to MARPOL Annex VI agreed at MPEC 70 (MEPC.278(70)).
[82] See, for instance, Ringbom (2011).
[83] See, for instance, Kågeson (2007); Bäuerle et al. (2010); Kollamthodi et al. (2013). For a discussion of various data sources on emissions released in the maritime sector, see Kollamthodi et al. (2013, pp. 42-46).
[84] Regulation 2015/757 (as amended by Delegated Regulation 2016/2071).
[85] Heine et al. (2017, p. 16); Heine and Gäde (2018).
[86] Smith et al. (2014).
[87] Bäuerle (2010, p. 60). Note that customs documents would allow to identify the port of origin of each cargo. Therefore, distinct cargoes loaded on a vessel in different ports would be taxed differently on the basis of the direct trade lane from that port of origin to the port of destination for the cargo.
[88] Bäuerle et al., (2010, p. 60); Smith et al. (2014).
[89] Heine et al., (2017, pp. 6 ff); Heine and Gäde (2018).
[90] Heine at al. (2017, p. 6); Heine and Gäde (2018).
[91] Heine at al. (2017, p 12); Heine and Gäde (2018).

entitled to obtain a rebate. To obtain the rebate, the taxpayer has to provide the tax authorities with data on its actual emissions.[92] At the margin, this incentive provides new data constantly to the tax authorities.

This tax could be calculated as follows.[93] Emissions can be estimated by multiplying fuel consumption in relation to the carbon content of the fuel. A proxy for this measure can be obtained by multiplying the assumed energy efficiency of the vessel used to transport the cargo by the weight of the cargo and the approximate distance of the voyage.[94] The tax rate is then calculated by multiplying the estimated emissions by the social price of carbon.

A major strength of this mechanism is that it limits jurisdictional concerns related to obtaining data on emissions released in international waters.[95] Under this measure, every vessel owner that can *voluntarily* prove to have transported the cargo in question from/to the consignor/consignee could claim a tax rebate,[96] subsidy[97] or tax credit[98] if it can show that its emissions were lower than the assumed default value. The voluntary nature of this action limits the necessity for states to exercise jurisdiction over vessels' information, especially for those vessels that transport a cargo for a segment of the voyage to the implementing state but that do not call at one of its ports. This mechanism could therefore be particularly useful in collecting data that top-down regional MRV systems might find more difficult to obtain.[99] Thus, the mechanism may allow a more empirically informed, and thus presumably more environmentally effective, *holistic route cargo measure* to be implemented.

A drawback of this mechanism is that, since it works at the margin, the data collected may be more incomplete than, for instance, the data the EU will collect through the implemented MRV. In this regard, default values could be made more precise by complementing data obtained by means of the mechanism using alternative data sources (e.g. EU and IMO MRV data).[100] In addition, when the authority has no data regarding the vessel used to transport the cargo, the type of vessel used can be assumed to be that typically used to transport cargo of the same type.

Generally, in our view, the voluntary MRV system described here could work as a useful *complement* to a top-down MRV system that covers first/last voyages from/to a destination. The two systems would provide the authorities with data that are only partially overlapping and that, when combined, would therefore yield more information than either of them considered separately.

3.3 Environmental Effectiveness and Avoidance Strategies

Tax avoidance and environmental effectiveness are commonly seen as two major, related issues to be considered in designing a regional maritime scheme. This section argues that a *holistic route cargo measure* offers the potential for tax avoidance that is limited in form compared to a *first/last vessel* or a *time-based measure.*

The environmental effectiveness and the revenue potential of a carbon-pricing mechanism depend on the scope of its coverage. A *first/last vessel measure* covers emissions on the first/last segment of the voyage from/to the implementing state. A *holistic route cargo measure* takes into account

[92] See also Fullerton and Wolverton (2005), Parry et al. (2014), Trachtman (2016).
[93] Heine et al. (2017, pp. 13-14); Heine and Gäde (2018).
[94] This calculation would take into account also the capacity usage of the vessel. This assumed capacity usage could be based on industry averages per route; see: Heine et al. (2017, p. 14) and Heine and Gäde (2018). As mentioned above, data on distance traveled and cargo weight are often already available to customs authorities; see Bäuerle et al. (2010, p. 60), or could be obtained via AIS.
[95] On a similar note, see Heine et al. (2017, pp. 38-39); Heine and Gäde (2018).
[96] Fullerton and Wolverton (2005); Parry et al. (2014).
[97] Heine et al. (2017, pp. 7 ff); Heine and Gäde (2018).
[98] Trachtman (2016).
[99] Notably, the current EU MRV system is limited to emissions released in first/last voyages from/to an EU port.
[100] Heine et al. (2017, p. 16); Heine and Gäde (2018).

emissions for the entire journey of an incoming or outgoing cargo. The coverage of a *time-based measure* is linked to the time taken by the voyage from/to a port to which carbon pricing applies. In principle, any of these measures could outperform the others in the scope of their respective coverage. A major difference between a *holistic route cargo measure* and the other two measures is that the scope of the emissions covered by the former is closely linked to the share of global maritime trade of the implementing state. This is because, under the other two regimes, coverage could be extended to emissions released while shipping cargoes not destined to the port of the implementing state, and a proportion of the emissions released in transporting cargoes to this port state would not be covered. The question concerning which of the three measures has the greater environmental effectiveness would therefore also depend on the share of the maritime trade of the implementing country. For countries whose market share is large, a *holistic cargo route measure* could have a substantial environmental impact.

The environmental effectiveness of a measure is also dependent on its potential for tax avoidance. In this regard, since it is based on cargo, a *holistic cargo route measure* is subject to a lower number of *forms* of tax avoidance than *first/last vessel* or *time-based measures*.[101]

A first/last vessel measure charged per ship leaves room for tax avoidance in various ways. One evasion strategy is to under-report the distance covered from/to ports that impose carbon pricing[102] through transshipment[103] or the falsification of documents.[104] The effectiveness of this evasion strategy will therefore depend on the distance between ports that impose carbon pricing and the closest available[105] port that does not. A *first/last vessel measure* thus creates incentives for non-participating ports to increase their capacity for transshipment and transit.[106] An alternative strategy to avoid carbon pricing is to make changes en route in port destinations for outbound voyages.[107] However, such changes of consignees are a viable strategy only if states that implement carbon pricing cannot obtain data regarding them. Thus, this evasion strategy could be made less effective if implementing states have access to AIS data to track the movements of outgoing vessels.[108] Note that this avoidance strategy could also be controlled by means of a top-down MRV system that requires vessels to report information about previous voyages. If such a system was effectively implemented, evasion could occur only after the cargo has been re-loaded (at sea) on to another vessel. In addition, carbon price avoidance could be put into practice by using the most fuel-efficient vessels to call at ports that implement carbon pricing and moving the less performing ones on to other routes.[109] However, this risk is limited because the fuel efficiency of vessels is linked to their size and capacity.[110] Lastly, another possibility for avoiding carbon pricing under a first/last vessel measure is to reduce speed in the period covered by the measure and increase it outside its scope.[111]

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[101] We stress that we do not have quantitative estimates of the size of the different types of avoidance strategy that would occur under any of these measures. Thus, our claim is not that tax avoidance is necessarily less problematic under a holistic cargo route measure. However, to the extent that the availability of more forms of tax avoidance yields greater avoidance, it is more plausible that a holistic cargo route measure would generate less avoidance than the other measures.

[102] Bäuerle et al. (2010, p. 61).

[103] Transshipment refers to the shipment of goods to an intermediate destination before reaching the final port of delivery. Note that tax avoidance through transshipment raises concerns that go beyond the environmental performance of the measure. This is because the costs of tax avoidance schemes in terms of potential extra transshipments would increase the cost of trade and, at the margin, distort trade patterns. See Heine et al., (2017, p 10); Heine and Gäde (2018).

[104] Bäuerle et al. (2010, p. 61).

[105] Availability refers to mere theoretical (and, maybe, credible) availability when avoidance is implemented by means of document falsification.

[106] Miola et al. (2010, p. 5494).

[107] Kollamthodi et al. (2013, p. 53).

[108] Kollamthodi et al. (2013, p. 53).

[109] Bäuerle et al. (2010, p. 59).

[110] Bäuerle et al. (2010, p. 59).

[111] Kollamthodi, (2013 p. 52). Notice that fuel consumption is strongly correlated with speed.

In this regard, while economic theory tells us that carbon pricing could provide incentives to implement this strategy, whether this will occur in a particular setting remains an empirical question. Existing empirical research on the effect of the introduction of more stringent sulfur regulation in Emission Control Areas (ECAs) on vessels' speed indicates that this avoidance strategy is not necessarily economically viable on a large scale.[112] These studies found that the introduction of ECAs did not trigger statistically significant behavioral changes in vessel speed.[113] This literature provides some hints that this avoidance strategy would not be widely implemented under a *first/last vessel measure* or a *time-based measure.*

Many of the strategies available under a first/last vessel measure would also be available under a time-based measure.[114] Under this scheme, carbon price avoidance could take place through: i) falsification of documents; ii) relocation of vessels such that the less polluting ships call at ports in the implementing state, while the overall stock of ships remains unchanged;[115] iii) changes in speed inside and outside the covered areas;[116] and iv) reduction of number of vessels calling at ports that impose the measure. Note that the economic feasibility of this last strategy depends on the costs of (re)loading cargoes.[117]

Most of the avoidance strategies described here would not be available under a *holistic route cargo measure.* For this type of measure, avoidance strategies are confined mainly to falsification of documents[118] and, for outbound voyages, making changes to cargo consignees en route. As above, possible ways to obtain data on changes in cargo consignees for vessels that repeatedly call at the ports of the implementing state are: i) AIS data; and ii) a top-down MRV system that requires vessels to report changes to cargo consignees on previous voyages. Alternatively, the voluntary MRV system described in the previous section could also provide the necessary data, at least in situations in which: i) the cargo is transported by three or more vessel owners that compete on some routes; and ii) non-reported en-route changes in consignee are punished and reported ones are rewarded. This is because a voluntary MRV designed in this way can create a 'prisoner dilemma'-type game.

In its simplest form, a prisoner dilemma game describes the situation in which two entities face the choice of whether to cooperate or defect. Cooperation yields a pay-off X if the other player cooperates or Y if the other player defects. Defection leads to a pay-off Z if the other player cooperates and Q in case of defection. Here, $Z > X > 0$ and $Q > Y$, therefore defection is a dominant strategy.

Imagine three vessels (A, B and C) that belong to three different vessel owners which compete on some trade routes. Vessel A transports a cargo from a port that implements carbon pricing. To avoid a higher price signal, it declares that the cargo will be delivered to a nearby port. Once having left the first port, the consignee of the cargo changes to a (previously determined) more distant one. To deliver the cargo to the new consignee after transporting the cargo for a longer distance than the one declared to the port authorities, A has to transfer possession of the cargo to B, which will subsequently transfer it to C, which will cover the last segment of the voyage.[119] In this situation, A,

[112] Schaumeier, et al. (2015); Adland et al. (2017).
[113] Schaumeier et al. (2015, p. 14); Adland et al. (2017, p. 45).
[114] Kollamthodi (2013, p. 52).
[115] Bäuerle et al. (2010, pp. 56-57).
[116] Kollamthodi, (2013, p. 52).
[117] To illustrate, imagine that, to reduce the costs of carbon pricing, a transport company decides to reload the cargoes transported from three different ports to the state that implements the measure on one vessel that covers only a small fraction of the overall distance from the three ports. Moving the cargoes from every vessel on to the one calling at the port that implements the measure will impose costs on the transport company, for instance, in terms of the opportunity costs related to the extra time needed to move the cargoes from one vessel to another.
[118] Bäuerle et al. (2010, p. 61).
[119] Note that the number of vessel owners involved in transporting a cargo can be larger than three, and may also unexpectedly increase en route if, for instance, the cargo is sold and re-sold multiple times throughout the voyage.

B and C earn a return if they do not declare to the state which imposes carbon pricing that they have transported the cargo to the new consignee. However, each of them will be better off if they can obtain the rebate from the state without having to pay the tax (the reward),[120] and therefore they have an incentive to provide data to the state. Since A, B and C are competitors, the incentive to provide information to the authorities goes beyond the rebate itself. By obtaining the rebate, each entity might be able to become more competitive on the routes on which it competes with the other entity. This advantage would be even greater if a ship-owner who has performed the undeclared en-route change in consignees is made non-eligible for the rebate (the punishment). Thus, as in a prisoner dilemma game, each entity is worse off if it is the only one not providing the information compared to a situation in which none of them provides data to the authority. In this theoretical scenario, the dominant strategy of each vessel owner is not to cooperate with the other vessel owners and to provide information to the authorities.

Whether the voluntary MRV mechanism creates a prisoner dilemma game and how vessel owners are likely to behave depends on various factors, such as their possibility to coordinate, retaliate or predict the number of players involved in the game, whether the game has a known or an unknown number of rounds, and the precision with which vessel owners and the consignee can identify vessel owners that have provided information to the authorities.[121] Different situations may arise on different routes at different points in time, which means that it is difficult to make abstract predictions about the reality that may emerge if a *holistic route cargo measure* is introduced by a state. However, to the extent that the voluntary MRV creates a prisoner dilemma game in which ship-owners will sometimes defect, at the margin the potential for evasion will be reduced.

Note also that, under the voluntary MRV system described above, the price signal received by the consignee/consignor and the vessel-owner is independent of who is made legally liable for remitting the emissions tax.[122] This is because both vessel-owner and consignee/consignor will pass on part of the price signal to their transaction partners. In this connection, the proportion of the burden borne by each transaction partner depends on the relative elasticities of demand and supply, as well as on the market structure.[123] Therefore, economically the incidence of the tax is independent of where the legal tax liability falls. Nonetheless, under this scheme, the higher the default values that are set, the greater the environmental effectiveness of the measure and the revenues generated.[124] However, there is also a positive relationship between the environmental effectiveness of the measure and the size of administration costs. This is because the latter are generally positively correlated with the number of taxpayers demanding a rebate. There is hence a trade-off between the environmental effectiveness of and the revenues collected by the measure on the one hand, and the administrative costs of its implementation on the other hand.[125]

3.4 Competitiveness Effects

A major concern related to regional carbon pricing pertains to its impact on the competitiveness of the shipping companies that operate under its scope. We suggest that, for companies whose market share increases the closer one gets to the region implementing the measure, competitiveness effects are likely to be smaller under a *holistic route carbon measure* than under a *first/last vessel measure*.[126]

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[120] Since this type of reward is costly for the implementing state, providing a reward might not always be feasible or desirable.
[121] On different types of prisoner dilemma games, see, for instance, Kreps et al. (1982); Bó and Fréchette, (2011); Camera, and Casari, (2009); Normann and Wallace, (2012) and references therein.
[122] Heine et al. (2017, p. 12); Heine and Gäde (2018).
[123] Logue and Slemrod (2010).
[124] Heine et al. (2017, p. 13); Heine and Gäde (2018).
[125] Heine et al. (2017, p. 13); Heine and Gäde (2018).
[126] Heine et al. (2017, pp. 58-60).

Among other determinants, the competitiveness effects of a regional carbon-pricing measure depend on the asymmetries in the tax incidence faced by competing companies. The competitiveness effects for shipping companies whose market share increases the closer one approaches a region that is imposing the measure would be less affected under a holistic route cargo measure than under a first/last vessel measure. Under a first/last vessel measure, emissions released before and after the first/last voyage are excluded. As a result, a measure on emissions from the first/last leg of voyages from/to the region would have its cost effects more concentrated on shipping companies that operate on these routes than a tax on the total voyages to the region.[127] This increase in costs may incentivize shipping companies to change their margins on routes not covered by the measure. This is where they may lose competitiveness as a result of the policy.

Note that if there is a positive correlation between ownership location and area of operation,[128] the introduction of a *first/last vessel measure* might attract more internal opposition from the industry than a *holistic route cargo measure.*

3.5 A Pathway for Achieving a Global Agreement

This section investigates the effect of introducing a regional measure to price carbon emissions in the maritime sector for the establishment of a global measure. The question is whether and to what extent the introduction of a regional measure could facilitate or constrain the achievement of a subsequent global pricing scheme. Again, we find that the answer to this question depends on the type of regional carbon pricing scheme adopted.

For negotiations that require unanimity, economic theory suggests that parties negotiating an agreement will prevent its achievement if their payoffs are lower under the agreement than in the status quo.[129] Yet, this reference point may change if at least one party introduces (or credibly threatens to introduce) an effective regional pricing scheme. In this scenario, countries that are blocking a global agreement will need to reevaluate their position in light of their new pay-off. As explained below, the existence of a feasible regional tax scheme may improve the situation of those who want to price shipping emissions, while simultaneously reducing the pay-offs for those that are against the measure.[130]

There are two main reasons for a country blocking a global agreement in this context:[131] first, preventing a decrease in the demand for oil (for oil-selling countries); and secondly, exploiting their position of power when unanimity is needed for the agreement (hold-up problem). A credible threat to introduce a regional measure reduces the expected benefits for oil-producing countries of not agreeing to a global solution. This reduction is usually the greater the decrease in the demand for fuel that is triggered by the introduction of the regional measure.[132] Similarly, the power of single countries to prevent carbon pricing would be significantly curtailed by the threat of regional action. This is because the party or parties that want to introduce the measure would be able to obtain benefits from pricing a fraction of carbon emissions without the consent of other states. This reduces the benefits that the non-agreeing party can withhold. If the non-cooperative payoffs are reduced sufficiently, unilateral action may raise the non-cooperative party's willingness to engage in a global agreement. Thus, economic contract theory suggests that the adoption of a regional carbon-pricing

[127] Note that to limit the effect of a holistic cargo measure on the competitiveness of ports that implement the measure, it is necessary to exempt transshipment and transit from the application of carbon pricing. This is because the price elasticity of demand for the services related to transshipment and transit is high. In addition, exempting these services would allow limiting the administrative complexities of implementation (Heine et al. 2017, p. 10); Heine and Gäde (2018).
[128] The correlation between ship ownership and market share might be stronger in some regions than in others.
[129] Heine et al. (2017, p. 3); Heine and Gäde (2018).
[130] Heine et al. (2017, pp. 45 ff); Heine and Gäde (2018).
[131] Heine et al. (2017, p. 44); Heine and Gäde (2018).
[132] Heine et al. (2017, p. 46); Heine and Gäde (2018).

scheme could contribute to a unanimous agreement on a carbon-pricing regime to replace the regional scheme being reached.[133]

The incentives to achieve an international agreement are greater the larger the emissions coverage of the measure. First, the decrease in the demand for fuel is likely to be positively correlated with the fraction of emissions covered by the measure. Secondly, the size of the benefits that each jurisdiction can obtain by acting on its own is also related to the size of the emissions coverage. As explained in Section 3.3, under a *holistic route cargo measure* the strength of the incentive is strictly linked to the size of the trading volume of the country that introduces the measure. If the country that implements the measure has a large share of international trade, a *holistic route cargo measure* can provide stronger incentives than the other two measures being considered here. This could also be due to the more restricted forms of avoidance strategies available under this measure. Note also that, if the main trading countries were to agree to introduce a *holistic route cargo measure*, a large proportion of the emissions would be priced.[134] In this situation, the marginal benefits that the non-cooperative parties would be able to withhold would be proportionate to their smaller trading volumes. [135]

Analogies can be drawn with recent developments in the aviation sector, which indicate that sub-global action can sometimes catalyze the achievement of global agreements. Indeed, the 2016 adoption of CORSIA by the ICAO seems to have been eased by the inclusion of the aviation sector in the EU's ETS. More generally, history teaches us that sub-global action can sometimes bring about global agreements in environmental regulation in the maritime sector. One example of a sub-global action that was significant in this respect is the Torrey Canyon disaster of 1967. On that occasion, the UK's bombing of the Torrey Canyon to reduce the environmental impact of oil spills in its coastal waters catalyzed the negotiation of the 1969 Intervention Convention.[136] Similarly, Canada's adoption of the Arctic Waters Pollution Act in 1970, according to which Canada's jurisdiction to regulate pollution was extended to a 50-mile zone in Arctic waters, led to a further expansion of the jurisdiction of coastal states over pollution in the 200-mile zone as currently regulated under UNCLOS.[137] Note that the political economy analysis offered above may not apply in these two last examples. A sub-global carbon-pricing scheme in the maritime sector might therefore play a role in achieving a global agreement that is partially unrelated to the economic incentives described above.

3.6. Differentiation in Favor of Developing Countries

This section argues that a regional measure would more easily satisfy the Common but Differentiated Responsibilities and Respective Capabilities (CBDRRC) principle if: i) differentiation takes place via revenue-sharing rather than the differentiation of tax rates reductions; and ii) carbon pricing is implemented through the voluntary MRV scheme described in Section 3.2.

CBDRRC is one of the guiding principles embraced by the UNFCCC in pursuing its objective [138] and its application in the development and implementation of climate change measures in international transport has been the subject of discussion in both ICAO and IMO in the context of their guiding principles of non-discrimination and no more favorable treatment. While the interpretation of this principle is subject to debate, in essence it entails that, while there is a common responsibility to address the climate problem, there is also a differentiation in favor of developing countries, which takes into account both responsibilities and capabilities. In the Kyoto Protocol the principle of CBDRRC was translated into a system with no binding limitation and reduction commitments for developing countries. In the Paris Agreement, however, this static approach to differentiation has

[133] Heine et al. (2017, p. 46); Heine and Gäde (2018).
[134] Heine et al. (2017, p. 46); Heine and Gäde (2018).
[135] Heine et al. (2017, p. 46); Heine and Gäde (2018).
[136] Bodansky (2000, p. 344).
[137] Boyle (2006), p. 17.
[138] UNFCCC Article 3.1 reads: "The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof".

been relaxed[139] with an agreement that has commitments for all parties but that takes a more nuanced approach to differentiation 'in the light of different national circumstances'.[140]

Although the specific content, reach and implications of the principle is still a contentious issue, CBDRRC plays an important role in negotiations related to carbon pricing in the maritime sector both in the international climate negotiations in the UNFCCC and the International Maritime Organization.[141] Furthermore, since the UNFCCC sets out that developed countries should take the lead in addressing causes and effects of climate change,[142] some have argued that the 'concept of CBDRRC retains relevance in the context of unilateral climate action'.[143] Politically, a regional measure with global geographical coverage would potentially be more broadly acceptable if the impact on developing countries is somehow addressed by the measure. Here, it is therefore important to analyze the relation of CBDRRC to any potential regional carbon pricing scheme.

Differential treatment in climate change law can be framed in a number of ways. First, the implementation of the CBDRC can cover the substantive and/or procedural aspects. Secondly, climate measures can differentiate in favor of developing countries in the central obligation, in implementation and/or by granting assistance and financing. Thirdly, the measure can grant differential treatment to developing states per se or contextual treatment, where applying the measure to countries can change when their situation changes.[144] The second and third possibilities represent the choices that a specific carbon measure would face. Examples of this can be found in the evolution of the EU's approach to differentiation with regard to international aviation.[145]

If carbon pricing is implemented regionally by means of a holistic route emissions tax based on cargoes, differential treatment between nations can be achieved in two different ways: i) by reducing tax rates for cargoes originating in or destined for developing countries (differentiation in the core of the obligation);[146] and ii) by granting developing countries a share of the revenue generated by the levy (differentiation through finance). In our view, ceteris paribus, a measure that grants developing countries a share of the revenue is likely to grant them greater benefits.[147] This is because reductions in the tax rate for containers from/to developing countries benefit not only the countries concerned with the reduction, but also their trade partners. As explained above, this benefit sharing will depend on the elasticities of supply and demand for the goods produced in developing countries. To the extent that satisfaction of the CBRDRC principle requires implementing a measure that grants favorable treatment to countries with lower levels of development, revenue sharing is a suitable way of addressing this question.[148] Still, the question arises regarding which specific developing countries will be granted the revenue. This could be done according to the different criteria of the World Bank classification, OECD membership, regional systems of preferential treatment, applicability only to the least developed countries, or include additional requirements, the impact on trade, etc.[149]

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[139] Bodansky (2016, p.6).
[140] Paris Agreement (2015, Preamble).
[141] Bodansky (2016, p.11).
[142] UNFCCC, article 3.1
[143] Scott & Rajamani (2012).
[144] Martinez Romera and van Asselt (2015).
[145] Martinez Romera and van Asselt (2015).
[146] Kågeson (2008) discusses the possibility of excluding developing countries from the scope of the measure for a certain period of time. In this report, we consider this possibility as a variant of the "reduced tax rate" option, in which the tax rate is reduced to zero for a certain period of time.
[147] Similarly, see World Bank and IMF (2011); Heine et al. (2017, p. 53); Heine and Gäde (2018).
[148] Revenue sharing is also likely to be superior to tax-rate reductions from a welfare and environmental standpoint. This is because the latter measure offers more possibilities of carbon leakage. See Heine et al. (2017, p. 53); Heine and Gäde (2018).
[149] See the different approaches to defining developing countries for international aviation measures in Martinez Romera and van Asselt (2015).

The problem of data collection complicates the issue of implementing CBDRRC. A lot of data are needed to gauge the extent to which countries are differently impacted by any carbon-pricing scheme. Those data are not yet available in sufficient detail, and collecting data is anyway complicated by the constraints mentioned above. This is a problem because the absence of reliable estimates of these costs may impair the achievement of a consensus among countries over how differentiation should take place. For instance, implementing a measure that has no net incidence on developing countries requires first establishing what the incidence would be in the absence of a rebate. It is then interesting to ascertain to what extent the different versions of a regional carbon-pricing scheme could contribute to resolving this data problem and thus to providing the basis for adequately addressing CBDRRC. We suggest that the data-generating features of the emissions tax scheme described in Section 3.2 may help to obtain additional information to estimate the incidence of the levy on the trade patterns between different countries. By contrast, the other options, which are less related to trade patterns between countries, are less informative in this respect.

4. The Role of Carbon Pricing in Internal and Territorial Waters

In this report, we have focused so far on regional carbon pricing for emissions that to a significant degree also take place beyond internal and territorial waters. In this last section, we shift our attention to carbon pricing in internal and territorial waters, showing that measures with this geographical scope can play a key role in implementing schemes with a broader coverage by: i) limiting legal feasibility concerns under the GATT; and ii) working as an incubator for technological development.

Starting with ii), carbon pricing in internal and territorial waters can facilitate the achievement of broader emissions coverage by acting as a booster of technological innovation. As mentioned in Section 3.4, research suggests that carbon pricing is a powerful,[150] if not essential[151] element in fostering green innovation. This is because the incentives to reduce the costs of decreasing emissions depend on how costly these emissions are to the polluter.[152] In this regard, carbon-pricing schemes limited to internal or territorial waters would provide lower incentives to innovate than measures with a broader geographical scope because market size is generally seen as a factor in driving green innovation.[153] Yet, since these measures are in some respects more easily implementable, they could work as an initial innovation booster. Indeed, some of the concerns discussed in the previous pages are less applicable to carbon pricing implemented in internal and territorial waters.

First, jurisdiction is less of a concern for carbon pricing in internal and territorial waters when compared to international waters. As discussed in Section 3.1, jurisdiction can be based on the territoriality principle. According to UNCLOS, territorial and internal waters are part of the of a state's territory.[154] There is, therefore, less controversy over the idea that a state has jurisdiction over price emissions released in these areas than emissions that take place further offshore.[155] UNCLOS poses some limitations on the exercise of this jurisdiction. One limitation that is often discussed in the literature is laid down by article 17 of UNCLOS, which gives the vessels of all states the right of innocent passage through the territorial seas of other states. Some authors warn that a measure covering emissions released into the territorial waters of a coastal state may not be in conformity with the principle of innocent passage.[156] Yet, to the extent that the measure is implemented only

[150] Fischer (2008); Aghion et al. (2016).
[151] Bowen (2011, pp. 28-30); Acemoglu et al. (2012, p. 133).
[152] Fischer (2008).
[153] Acemoglu et al. (2012).
[154] Article 3 UNCLOS reads: "Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles". Article 8 UNCLOS reads: "waters on the landward side of the baseline of the territorial sea form part of the internal waters of the State".
[155] Hermeling et al. (2015, p. 43).
[156] Faber and Rensema (2008, p. 8).

when a vessel enters port waters, regardless of whether it is a vessel-based or a cargo-based measure, these limitations do not apply.[157]

Secondly, the availability of data is a less compelling problem for carbon pricing in internal and territorial waters. A state would have a less contested jurisdictional basis for obtaining these data. In addition, for internal waters, data availability problems can sometimes be solved by means of a fuel tax. Indeed, under a fuel tax the price is imposed upstream without the need to gather and process data relative to emissions released in transporting a particular cargo a certain distance.

Related to this last point, carbon price evasions with a fuel tax are less of a concern for measures that are implemented in these areas than those that fall under geographically broader schemes. At the outset of this report, we argued that, since the cross-price elasticity of demand for fuel is very high, a fuel tax is generally not a viable option for sub-global carbon pricing. However, states can regulate fuel provision within their territory. Tax avoidance by bunkering elsewhere is therefore not a viable avoidance strategy for vessels that do not leave the territorial waters of the implementing state.[158] More generally, the regulation of bunkering within the territorial and internal waters of a state may reduce the cross-price elasticity of demand for fuel between the region subject to the tax and areas outside it by forcing vessels to cover longer distances to avoid the tax.[159]

Note that the implementation of carbon pricing in territorial and internal waters could take place under the umbrella of the IMO in the form of a national action plan. This could, therefore, be in line with China and India's recent proposal to develop an IMO strategy to reduce GHG emissions from ships with a bottom-up component.[160]

A second role of carbon pricing in internal and territorial waters for the achievement of broader coverage relates to legal compliance with the WTO. WTO law aims to ensure a level playing field by regulating trading activities at the international level. A measure to price carbon adopted regionally raises various concerns related to infringements of WTO law.[161] For instance, the measure is likely to increase the price of products imported into the region implementing the measure. This increase in the price of imports could be seen as infringing article III.2 of the General Agreement on Tariffs and Trade (GATT), which aims to guarantee equal conditions of competition between imported and non-imported products.[162]

Literature on the WTO compatibility of a regional measure on carbon pricing in the maritime and aviation sectors often suggests that infringements of GATT provisions might find justification under article XX of the same agreement, which provides various exceptions to the general obligations laid down by GATT.[163] The WTO Dispute Settlement Body has interpreted article XX as a two-tier test. The first part of the test consists in ascertaining whether a trade restrictive measure meets the requirements set out in one or more of the exceptions listed in article XX. The second part of the test

[157] Perez-Rodriguez (2012); Heine et al. (2017).
[158] Hemmings (2011, p. 3).
[159] On a related note, tax avoidance strategies that are available when a fuel tax is imposed alone might be reduced by the existence of the international mechanism. This may occur, for instance, if leaving territorial waters (e.g. to refuel at a floating platform) makes the vessel fall under the international scheme. See Heine et al. (2017, p. 19); Heine and Gäde (2018).
[160] MEPC 71/7 (China and India).
[161] See, for instance, Dobson and Ryngaert (2016, pp. 315-316). On a related issue, see also Trachtman (2016).
[162] Article III.2 reads: "The products of the territory of any contracting party imported into the territory of any other contracting party shall not be subject, directly or indirectly, to internal taxes or other internal charges of any kind in excess of those applied, directly or indirectly, to like domestic products".
[163] Bartels (2012); Perez-Rodriguez (2012).

focuses on the requirements laid down by the chapeau of the provision. Our focus here is on the first part of the test, and more particularly on a requirement laid down by article XX litera g.[164]

Article XX (g) justifies measures "relating to the conservation of exhaustible natural resources". This provision also requires that the introduction of the measure should be made "in conjunction with restrictions on domestic production and consumption". This requirement is less likely to be met by a measure that only imposes a price on emissions released when importing products in the region that imposes carbon pricing. Indeed, the Panel has found that US law that restricted imports of some types of tuna from Canada did not comply with WTO law because a restriction of this type had not been imposed on domestic tuna catches.[165] In this regard, a mechanism that covers global emissions in the international maritime sector might need to be complemented by a scheme that imposes a price on emissions from domestic shipping.

5. Conclusion

Tackling emissions from the international maritime sector remains a compelling priority in achieving the goals of the Paris Agreement, under which carbon pricing could play a fundamental role in mitigating emissions in the sector. While a global agreement to price these emissions, for example through a fuel levy set social cost of emissions,[166] is recognized as the preferable type of intervention, this first-best solution may not become available in time, so scholars and policy makers have discussed various back-up options for sub-global action. The discussion around these regional measures has highlighted various economic and legal challenges. This report has analyzed the three main regional measures available, namely *first/last vessel*, *time-based* and *holistic route cargo*, and compared their performance based on six main challenges identified in the literature.

The first challenge is the identification of a viable jurisdictional basis under international law for regional action. The analysis has highlighted that the identification of the most suitable jurisdictional basis depends on the specific design of the measure, although none of the possible jurisdictional bases analyzed here is likely to remain uncontested.

Regarding the challenge to the provision of emissions data, we found that, as testified by the EU MRV, a *first/last vessel measure* might be more readily implemented than the other measures. Yet, even a *holistic route cargo measure* and *time-based measure*, if carefully designed, may not present unsurmountable issues of data availability. A main difference between these two last measures is that the former, if implemented by means of a voluntary MRV, may present fewer concerns in respect of the jurisdiction to obtain data on emissions released beyond territorial and internal waters. This paper has described how such an MRV system can be designed through a tax-and-rebate scheme that can function legally even outside the jurisdiction of the acting state by providing strong commercial incentives for companies to supply the data voluntarily.

With regard to the environmental effectiveness of the various measures, this paper highlights that the coverage provided by a *holistic route cargo measure* is more strictly linked to the trade share of the implementing state than in the case of the other measure. If implemented by countries with a large market share of international trade, a *holistic route cargo measure* could have substantial environmental effectiveness. Also, a *holistic route cargo measure* restricts avoidance strategies more than a *first/last vessel measure* or a *time-based measure*. The paper shows that avoidance strategies for a *holistic route cargo measure* can be further reduced if the scheme is designed to produce a 'prisoner dilemma'-type game.

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[164] For a more extensive analysis of the legality of a regional carbon-pricing measure in the maritime sector, see, for instance, Perez Rodriguez (2012, pp. 27 ff).; Hermeling et al. (2015, pp. 46-48). For a debate on the application of article XX GATT to the EU ETS in the aviation sector, see Meltzer (2012); Bartels (2012).
[165] US - Canadian Tuna, para 4.6 ff.
[166] With the rate based on the social cost of the contained emissions of greenhouse gases and local pollutants.

Precisely due to these two main features, i.e. coverage strictly linked to trade share and limited opportunities for avoidance, a *holistic route cargo measure* implemented by a key player in international trade may also create larger incentives to achieve a global agreement than the other two measures. Empirical research on this aspect is still needed.

Another major issue related to the implementation of carbon pricing in the international maritime sector is its impact on the competitiveness of shipping companies. The study has highlighted that the tax incidence of carbon pricing would be more concentrated on shipping companies whose market share increases the closer one approaches a region that is implementing the measure under a *first/last vessel measure* than under a *holistic route cargo measure*. Depending on the strength of the correlation between the location of shipping company ownership and the market share in the region where the measure is implemented, a *first/last vessel measure* may have greater effects on the competitiveness of the implementing state's domestic shipping companies than a *holistic route cargo measure*.

The study has highlighted that revenue sharing is a more efficient way of reaching the distributional principle of Common but Differentiated Responsibilities and Respective Capabilities than cross-country differentiation of tax rates.

Connected to this distributional requirement, the achievement of no net incidence for developing countries would be more easily achievable if better data on the incidence of the measure on trade between different countries were available. This study argues that a *holistic cargo measure* implemented by means of a voluntary MRV system raises data on the incidence of carbon pricing on different trade routes more easily than the other two measures.

Lastly, the report has analyzed the role of carbon pricing in internal and territorial waters for the implementation of a measure of greater scope. In particular, due to the more limited economic and legal feasibility concerns linked to the implementation of measures of this type, carbon pricing in these areas can work as a technology incubator. In addition, pricing these emissions may reduce legal feasibility concerns under the GATT, suggesting that these measures could be used to complement carbon-pricing schemes that cover only emissions released further offshore.

Overall, the analysis shows that a *holistic cargo measure* has some positive features compared to the *first/last vessel measure* and *time-based measure*, features that in our view have so far been under-appreciated in the academic and policy debates on carbon pricing in the maritime sector. This is not to say that a *holistic cargo measure* is necessarily superior to other measures based on the criteria considered here. As highlighted throughout the text, the performance of each measure depends on its specific features, as well as on other factors (e.g. the state that is implementing the measure). It is therefore difficult to make a general claim regarding the relative performance of each measure in the abstract. Yet, we believe that, if a regional carbon-pricing scheme is to be implemented, a *holistic cargo measure* should be considered.

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