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Sharing under Different UNFCCC
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Scenarios**

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Accounting for CO₂ Emissions from International Shipping: Burden Sharing under Different UNFCCC Allocation Options and Regime Scenarios*

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CO₂ emissions from international shipping, which are currently unregulated, are predicted to rise from 2.7% today to 18% in 2050. International bunker fuel emissions have been excluded from any commitment in the Kyoto Protocol; the UNFCCC conference in Copenhagen also failed to bring about clear directions on how to proceed with these emissions.

In this paper we investigate the various options suggested by the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UNFCCC for allocating CO₂ emissions from international shipping to individual countries. We discuss economic and regulatory issues related to these options and the consequences of applying them. We evaluate the various options on the basis of environmental effectiveness, possibility of legal implementation, and fairness of burden sharing. We conclude that an allocation of international shipping emissions should be conducted on the basis of the operating company.

Keywords: climate change, international shipping, CO₂ emissions

JEL classification: Q52, Q54, Q56

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1 Introduction

In 2007, 3.3% of the world's total anthropogenic CO₂ emissions were caused by global shipping, with the international shipping sector accounting for the major share of 2.7% (Buhaug et al., 2009).¹ At first glance this is a small figure, but the International Maritime Organization (IMO) estimates that these emissions, if not curbed, could grow significantly until 2050 - amounting to 12% to 18% of the total allowable CO₂ emissions under the WRE² 450 ppm stabilization scenario (Buhaug et al., 2009).

To date, the major share of these global shipping emissions is unregulated, as neither the IMO nor the United Nations Framework Convention on Climate Change (UNFCCC) have set up a regulation scheme. International bunker fuel emissions have been excluded from any commitment in the Kyoto Protocol. In contrast to emissions from domestic shipping, which amount to less than 0.6%, emissions from international shipping, which make up the largest share of emissions, are not assigned to national emissions inventories. Therefore they remain unaffected by the Kyoto regulations. The UNFCCC conference in Copenhagen in 2009 also failed to give directions on how to proceed with emissions from international shipping. As a consequence, IMO and ICAO (International Civil Aviation Organisation) will continue to discuss the issue of regulating emissions in their respective sectors but without any formal guidance or deadline.

The present lack of regulation can be traced to the truly global nature of the shipping sector. In 2005, the world merchant fleet counted 90,662 million ships of 100 gross tonnes (gt) and more, transporting 7 billion tons of cargo between 160 countries (Shipping Statistics Yearbook, 2008; Stopford, 2009). A significant part of the emissions caused by international shipping therefore takes place on the high seas outside of the jurisdiction of any country. Here only the United Nations Convention on the Law of the Sea (UNCLOS) and those IMO conventions that have been ratified by member states apply. Moreover, regulation of shipping emissions is difficult due to the multiple nationalities of transporting ships. Often ships are registered in one country, their flag state, but their owners may be citizens of another country while the operating company is based in a third country. Regulating this global business

¹ In accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Buhaug et al. (2009) define international shipping as shipping activities with crossing of borders, whereas domestic shipping is defined as local shipping activities without any crossing of borders. Both shipping definitions exclude fishing and military vessels. The term global shipping includes international and domestic shipping as well as fishing vessels but excludes military vessels.

² Wigley et al. (1996).

therefore needs a global approach that includes as many countries as possible so as to limit the options for free-riders who seek to avoid emissions regulation.

However, abatement cost studies analysing potential technological and operational measures for reducing CO₂ emissions and their costs show that many cost-effective abatement measures are available to the shipping sector (Alvik et al., 2010; Buhaug et al., 2009; Eide et al.; Faber et al. 2009). They show that, even in the absence of a CO₂ regulation, most of the abatement measures have negative marginal abatement costs, i.e. their implementation is even beneficial. Moreover, they show that the total abatement potential in the shipping sector is considerable and that up to 75% of the projected emissions in 2050 can be avoided in this sector (Buhaug et al., 2009).³ Thus, integrating CO₂ emissions of the shipping sector into a UNFCCC climate regime or regulating these emissions within a sectoral approach based on IMO regulations could be economically beneficial. This makes a strong case for regulating shipping emissions because it is a cost-effective way of reducing emissions in general.

There are essentially two ways in which emissions from international shipping can be regulated: a UNFCCC-based versus a sectoral approach. If regulation by the UNFCCC framework is chosen, emissions would have to be allocated to individual countries, adding to their total national emissions. It would then be the choice of the individual countries how to reduce their total national emissions. They will probably opt for those sectors and methods that are most cost-effective. Hence, regulation of the shipping sector may or may not be the consequence, depending on what national policy makers consider the most efficient method. Alternatively, a sectoral approach could be aimed for, which would focus only on the shipping sector's emissions and allocate them within the shipping sector. It would set emission reduction targets specifically for that sector which would result in a regulation of the shipping industry. A global approach should be pursued to avoid free-riding. Otherwise shipping regulations introduced in some countries could easily be avoided if other non-committed countries provide safe havens for free-riders. From an economic perspective, an allocation to total national emissions combined with a global carbon price – e.g. within an international emissions trading system – would be most efficient. For this reason we focus on regulations based on the UNFCCC framework.

³ Only a few studies exist which estimate the total abatement potential in the world fleet. Buhaug et al. (2009) estimate that the total abatement potential of projected emissions in 2020 can be between 17% and 35% and of projected emissions in 2050 between 25% and 75%. Alvik et al. (2010) estimate that the total abatement potential of projected emissions in 2030 can be up to 56%, whereas Faber et al. (2009) estimate it to range from 25-43% if the world fleet is considered, and Eide et al. (2009) estimate it to be between 30% and 50%. Note that all studies are based on different assumptions concerning projected emissions, time horizon, fuel type and fuel costs, interest rate, and abatement measures, making a general comparison difficult.

For both options however, an allocation of emissions to individual countries is necessary - even if a global scheme is set up in the sectoral approach. Governments will want to know the quantitative and financial effects of regulations on their industries before they agree to an international scheme. Additionally, their support and policing is necessary for the effective implementation and enforcement of regulations. Hence, the question of how to allocate shipping emissions to individual countries is relevant for every option. So far, research on this matter has been mostly qualitative (Åhman, 2008; Kågeson, 2008; Zetterberg, 2008; Faber et al., 2006; Bode et al., 2002) and few quantitative assessments exist (Den Elzen et al., 2007; Faber et al., 2009).

Our analysis is a quantitative assessment, adding to the existing literature by analysing the UNFCCC options that have not yet been assessed by others. Moreover, to achieve an overall picture we compare them with those options that have already been researched by others, e.g. by den Elzen et al. (2007) and Faber et al. (2009). For example, den Elzen et al. (2007) investigate allocations based on both flag state registry and destination of goods, and compare the results with an allocation based on the sale of bunker fuels according to IEA statistics. Their analysis is conducted at the level of 17 country regions using historical trends and projections for the period 1980-2050. They conclude that on a regional scale the differences between the two allocation options are minor. Central America and Western Africa are exceptions because many ships are registered under a flag of convenience including e.g. Panama or Liberia. Faber et al. (2009) analyse an allocation based on departure or destination of vessels for CO₂ emissions from ships on voyages to or from certain regions. Their analysis is conducted at the level of 10 country regions using ship movement data from Llyod's Marine Intelligence Unit (for 6 months in 2006). Their findings suggest little difference in emissions from ships arriving in and departing from a region. Only in the case of the EU the amount of CO₂ emissions caused by ships departing from the EU is slightly higher than the amount caused by ships arriving there. Comparing the regions in the case of arrival shows that Europe has the lion share with 27%, therefore dominating over North East Asia (19%), North America (12%), and Far East Asia (12%). According to this study all other regions, like Central America or Africa, have a share of 7% or less.

Our quantitative assessment differs from the above because it is based on country-level data allowing a more detailed investigation into the effect of different allocation rules. Furthermore, we extend the literature by adding further allocation options proposed by the UNFCCC, such as a proportional allocation based on national emissions, based on nationality

of the ship owner as well as an allocation based on the nationality of the operator. Furthermore, we apply more recent and more detailed data and use a calculation approach which enables a more sophisticated allocation based on flag state registry. Also, we apply updated data for an allocation based on the sale of bunker fuels.

The paper is structured as follows: Section 2 presents background information on the shipping sector, and section 3 assesses the regulatory framework suggested by the Subsidiary Body for Scientific and Technological Advice (SBSTA 1996) of UNFCCC. This is followed by a quantification of the amount of emissions allocated to each country according to the different allocation options in section 4. Section 5 discusses the results on the basis of environmental and legal effectiveness, as well as fairness of burden sharing, followed by conclusions in section 6.

2 The shipping sector

2.1 Structure and emissions inventory of the shipping sector

The maritime transport industry carries over 80% of the world's merchandise trade by volume and exhibits an estimated annual growth rate of 3.1% on average over the last three decades (UNCTAD, 2008 and 2009), which has accelerated to 6.5% on average per year in the period 2004-2008 (Shipping Statistics Yearbook, 2008).⁴

In 2007, the world fleet⁵ consisted of slightly more than 100,000 ships of 100gt and above (Buhaug et al., 2009). Thereof, 44,971 ships belonged to the world merchant fleet (cargo ships) with over 1 billion deadweight tonnage (dwt), representing 89% of world total tonnage (Buhaug et al., 2009; Shipping Statistics Yearbook, 2008).

However, different commodities require different transport modes: Unpackaged liquids such as oil or chemicals are transported by tankers; dry unpackaged commodities such as coal and grain are transported by bulk carriers, while packaged commodities are increasingly transported in containers (UNCTAD, 2008). Tankers, bulk carriers, and container ships represent the largest share of total world fleet in terms of dwt (Shipping Statistics Yearbook, 2008), in terms of fuel consumption and consequently in terms of emissions (Buhaug et al., 2009). Moreover, the age of vessels is relevant to their efficiency and emission levels. Currently, about half of the ships are at least 20 years old, this fraction being considerably

⁴ In 2008, growth in international seaborne trade decreased and growth in world merchandise exports decreased by 4 percentage points from 6% in 2007 to 2% in 2008 due to the economic downturn (UNCTAD 2009).

⁵ The term "world fleet" includes all types of ships; from cargo shipping to fishing vessels.

smaller for container ships and cargo ships in general. Developed countries generally own and employ newer ships while older ships are more likely to be owned by developing countries.⁶

There is also a trend towards larger vessels. Recent additions in tonnage show that average dwt of newer ships has increased in all segments of the fleet; this is particularly pronounced for tankers and container ships (Shipping Statistics Yearbook, 2008). This reduces the cost per ton-mile (Stopford, 2009) but also fuel consumption and therefore the CO₂ emissions per ton-mile of shipping (Buhaug et al., 2009). Since efficiency (CO₂ per ton-mile) has improved over time, the fleet of developing and transition countries, such as China and Russia, is more emission-intensive than the fleet of developed countries.

The structure of the shipping sector is complex due to multiple ownership natures of vessels. A ship can be owned by a company based in one country, but its owners being citizens of another country, and it can be registered in another country (its flag state), and be operated by a company that is based in yet another country. Hence, multiple jurisdictions may apply in addition to the UNCLOS framework and IMO conventions. However, the country of registration, the flag state, is most relevant because it has the obligation to comply with international agreements.

The difference between registration and ownership (control) of fleets becomes evident when comparing tables 1 (registration of world fleet) and 2 (control of world fleet). They present the top five countries with the highest numbers of registration worldwide versus the top five countries according to ownership⁷.

Table 1: Registration of world fleet, ships of 300gt and more

country	number of ships	country	deadweight tonnage (in 1000)
Panama	6 380	Panama	250 287
Japan	2 528	Liberia	114 975
China	2 428	Greece	61 141
Liberia	2 067	Hong Kong	59 554
Indonesia	1 878	Marshall Islands	58 368

Source: Shipping Statistics Yearbook, 2008.

⁶ This analysis is limited to ships of 1000gt and more. Including smaller ships is likely to increase the average age as newer ships tend to be larger in size. For example, the fleets owned by Germany and Japan are very new with an average age of less than ten years; while China has a fleet that is older than 20 years on average; Russia’s average fleet age is even older than 23 years (Buhaug et al., 2009; Shipping Statistics Yearbook, 2008).

⁷ Note that due to availability of data table 1 refers to ships of 300 gt and more while table 2 refers to ships of 1000 gt and more. While the difference in total ships is substantial when comparing number of ships (44,553 versus 34,915), the difference in dwt is much smaller (1.0796 billion versus 1.0719 billion) (Shipping Statistics Yearbook, 2008).

Table 2: Control of world fleet, ships of 1000gt and more

country	number of ships	country	deadweight tonnage (in 1000)
Japan	3 433	Greece	175 711
Germany	3 189	Japan	160 722
Greece	3 087	Germany	94 513
China	2 975	China	83 064
Norway	1 400	Norway	45 118

Source: Shipping Statistics Yearbook, 2008.

It is clear that non-Annex I countries like Panama and Liberia are used as registration countries whereas actual control of the fleet mostly lies in developed countries like Greece, Japan, Germany and Norway, with the exception of China.

Establishing emission inventories⁸ for the shipping sector is a challenging task, inter alia due to limited data availability (Wang and Corbett, 2005; Wang et al., 2007). The main reason for limited data availability is that ships are neither obliged to report their route of navigation nor their consumption of fuel during their voyages. In addition, ships vary greatly in their emission intensities caused by different factors such as size, age, purpose, condition and operation - in particular speed. This makes a general analysis of average fuel consumption and emissions per ship type difficult (Buhaug et al., 2009).

In recent years different approaches to estimating overall global shipping emissions have been presented in the literature (Paxian et al., 2010, Buhaug et al., 2009, Eyring et al., 2005, Endresen et al., 2007, 2003; Corbett and Köhler, 2003). Top-down approaches either estimate emissions by summing up worldwide bunker fuel sales or by modelling global fleet activity based on specific ship characteristics and hours at sea.⁹ By contrast, bottom-up approaches additionally use route-specific simulations to determine the location of the estimated emissions (Paxian et al., 2010, Wang et al., 2008, 2007).

The latest studies concerning estimates of emissions were commissioned by the IMO and the European Commission (Buhaug et al., 2009; Faber et al., 2009). The IMO conducted two major studies to set up an emissions inventory for the global shipping sector - particularly for international shipping- to analyse potential reduction measures and policy instruments to regulate emissions (IMO 2000/ Buhaug et al., 2009). In the second IMO GHG study (Buhaug

⁸ Ships emit exhaust gases (like CO₂, nitrogen oxides) and particulate organic matter (Buhaug et al., 2009).

⁹ Both approaches have uncertainties in the estimated emissions totals. For an in-depth discussion see Buhaug et al. (2009) and Faber et al. (2009).

et al., 2009) emissions were estimated applying a top-down activity-based approach, since data on bunker fuel sales statistics, as used in the first IMO GHG study, were considered less reliable (Buhaug et al., 2009). Faber et al. (2009) conducted a study on CO₂ emissions for the EU region on behalf of the European Commission based on a bottom-up approach using ship movement data from 2006.

The results show that based on a CO₂ per ton-mile shipping is more efficient than other modes of transportation. However, the total emissions are quite large and are projected to increase substantially over the next decades (Buhaug et al., 2009). In 2007, international shipping amounted to 2.7% (870 Mt of CO₂ emissions) of the world's total anthropogenic CO₂ emissions. Predictions of future emissions show an increasing trend. According to the IMO base scenarios,¹⁰ emissions in 2020 are predicted to be between 6% and 22% (925 to 1,058 Mt of CO₂ emissions) higher. Without any policy measures in 2050, emissions are predicted to even lie between 119% and 204% (1,903 to 2,648 Mt of CO₂ emissions) higher than emissions in 2007 (Buhaug et al., 2009). With reference to Europe, Faber et al. (2009) find that ships operating in the EU area, i.e sailing to and from EU ports, contribute a major share of 31% (310 Mt CO₂ emissions) to global shipping emissions in 2006. Future predictions also show an increasing trend in emissions compared to emissions in 2006, ranging from 32% to 51% (409 to 469 Mt of CO₂ emissions) in 2020 and from 61% to 103% (499 to 630 Mt of CO₂ emissions) in 2050 (Faber et al., 2009).

2.2 Legal structures: IMO, UNCLOS and ownership of vessels

Ships are mobile emitters, and, if engaged in international trade, cross different jurisdictions. The United Nations Convention on the Law of the Sea (UNCLOS) applies in international waters, called the High Seas, but in the exclusive economic zone, i.e. the coastal area, the jurisdiction of that coastal state applies. UNCLOS provides ships with the right of “innocent passage” through national country's territorial waters and economic zones, meaning that national or regional laws and regulations do not apply to the design, construction or equipment of foreign ships wanting to pass through – “unless they are giving effect to generally accepted international rules or standards” (UNCLOS). Therefore, national or regional laws, e.g. within the EU, cannot affect ships registered in a foreign country.

¹⁰ This type of scenario is based on IPCC SRES scenarios with a special focus on shipping and seaborne trade (Buhaug et al., 2009).

Moreover, UNCLOS only regulates affairs between states; its regulations do not directly apply to ship owners or operators (Buhaug et al., 2009).

Ships are regulated by their country of registration, their flag state. Hence, they have to comply with their flag state's laws and regulations, such as labour laws and tax regulations. The process of "flagging out a ship", i.e. registering it in a country other than the owner's office location, is predominantly used to avoid regulation at home. From table 1 (see above) it becomes apparent that a large part of the fleet is registered in "open registry" countries such as Panama or Liberia, i.e. countries that have few or no restrictions on access to their flag. Under this system of "open flag" more than two thirds (68.3% in 2008) of ship tonnage are not registered in the country of the owner, but rather flying a "flag of convenience". This trend has continued in recent years, as 72% of total tonnage additions for which the country of domicile is known were attributable to open registry countries (Shipping Statistics Yearbook, 2008). This must be borne in mind when international regulation on shipping is discussed because compliance with international agreements is up to flag states (Buhaug et al., 2009). Flag states may choose not to be part of an international regulation and provide safe havens for those shipping owners and operators who wish to avoid regulation. However, the IMO provides a possible remedy.

The IMO has 168 Member States representing almost 99% of the world tonnage and provides the legislative framework for international shipping with 50 conventions and protocols. After a convention is agreed upon by IMO Member States, governments are asked to ratify the convention, thereby agreeing to implement it as part of their national legislation. Consequently, flag states must enforce this legislation upon their flag ships. Normally, governments negotiate certain provisions and conditions that must be met for a convention to enter into force, such as a certain number of countries representing a certain share of the world fleet (in gross tonnes) to ratify the agreement (Buhaug et al., 2009). This share can vary depending on the convention and the member states' negotiations. Once IMO legislation has entered into force, it is considered to be a generally accepted international rule and thereby overrides the UNCLOS right of innocent passage. Hence, when IMO legislation has entered into force, the countries that have ratified it can apply it to all ships regardless of their flag. As a result, port states have the power to enforce legislation not just on their own flag ships but, on any ship wishing to land in their port – also called the principle of "no more favourable treatment". Ships can only avoid this regulation if they operate outside the jurisdiction area of

any country that has ratified the relevant convention (Buhaug et al., 2009)¹¹. It follows that an IMO regulation that enters into force could apply to any ship that wishes to pass through waters of countries that have ratified the IMO convention. Of the current 50 IMO conventions, 41 are in force (Buhaug et al., 2009).

Until now, the IMO has adopted regulations on almost all aspects of shipping, such as design, construction, equipment, maintenance, crew and pollution prevention (on dumping, ballast water management, recycling etc). However, shipping emissions are yet to be regulated. The IMO started its discussion on the matter in the 1980s, and Annex VI to MARPOL (International Convention for the Prevention of Pollution from Ships, 1973) was adopted in 1997, entering into force in May 2005. It prohibits ozone depleting substances (ODS) according to the Montreal Protocol; it regulates exhaust gas emissions such as NO_x and SO_x, and cargo vapours (VOC). However, greenhouse gases are not covered (Vagslid, 2009; Buhaug et al., 2009). Further, the Air Pollution Conference in September 1997 Resolution 8 calls on IMO to study possible greenhouse gas emission reduction strategies and to co-operate with UNFCCC on that matter. In 2000, the IMO concluded that there is potential for emission reductions resulting from technical and operational measures such as ship design, propulsion advancements and vessel speed; that technical measures, particularly relating to new vessels, are best achieved by regulations; and, most importantly, that, if there is an increasing demand for ship transport, a growth in total shipping emissions will be difficult to limit (Vagslid, 2009; Buhaug et al., 2009).

In addition, the IMO principle of equal treatment of ships must be resolved with the UNFCCC principle of “common but differentiated responsibilities” that governs climate negotiations. It is enshrined in Article 3.1 of the UNFCCC Convention and has the purpose to differentiate between the contributions of developed and developing countries to the mitigation of climate change and other global environmental issues. This principle in particular, as well as the question whether it should be continued, was a matter of heated dispute at the Copenhagen conference 2009 and remained unresolved.

As mentioned above, the UNFCCC Kyoto Protocol Article 2.2 states that Annex I states should reduce emissions from international marine bunkers fuels by working through the IMO; no obligations were set in the Kyoto Protocol and, thus, are exempt from the national emissions regulated by the Kyoto Protocol. Moreover, non-Annex I states have no binding

¹¹ Some of IMO’s most important technical conventions contain provisions that allow ships to be inspected in foreign ports, also known as “Port State Control”.

obligations at all under the Kyoto Protocol and many of them have argued that any IMO convention on curbing shipping emissions should only be applicable to Annex I parties (mostly developed countries) to the Kyoto Protocol (Buhaug et al., 2009).¹² Yet, three quarters of all merchant vessels, by deadweight, engaged in international shipping are registered in countries that have no binding emission reduction targets under the Kyoto Protocol.¹³

The UNFCCC working group report of 2009 has also touched upon the regulation of shipping emissions by presenting several options in their negotiation text for the Cop15 in Copenhagen (UNFCCC, 2009). The options are not specified or laid out in any detail: The first option is that IMO should continue its policy making for reducing marine bunker fuels. Option 2 is about exempting developing countries from any obligations in this sector. Option 3 asserts that emissions from shipping cannot be allocated to just one economy and hence IMO measures to reduce these emissions must be agreed on by all Parties involved, and must not constitute any discrimination or restriction on international trade – hence a particular focus on WTO compatibility. Option 4 asks the IMO to set emission reduction targets for marine bunker fuels as equal to 20% below 2005 levels by 2020 – but competitive distortions or carbon leakages should be avoided (without specifying how). Option 5 focuses on reducing anthropogenic greenhouse gases not controlled by the Montreal protocol, asking for a sectoral global agreement by 2011 at the hands of the IMO. Option 6 suggests cooperation in technology transfer and research to reduce emissions, and option 7 is to leave international maritime transport out of the climate regime altogether. Unfortunately, this is the last stance on this matter and the Copenhagen meeting did not provide the UNFCCC input the IMO was hoping for.

Finally, international trade by way of shipping also falls under the laws of the World Trade Organisation (WTO). This could be relevant if emission reduction measures or an emission trading system discriminated against foreign products, i.e. discriminated against the trade of countries not party to the convention, or if it hinders market access. Any of these cases violate WTO rules (Voigt, 2008). However, this has not been an issue in any of the past IMO conventions on environmental and safety purposes.

¹² This argument was opposed by other IMO members who claim that IMO has made several international regulations for all ships regarding marine environment and ship pollution without reference to nationality. This line should therefore be continued and legislation should apply to all ships regardless of flag (Buhaug et al., 2009).

¹³ If ownership is considered, instead of registration, then, of the total merchant fleet, 68% of dwt is controlled by OECD countries and 95% of dwt is controlled by only 35 countries (Shipping Statistics Yearbook, 2008).

3. Options under the UNFCCC to allocate shipping emissions

In its 1996 National Communication by the Subsidiary Body for Scientific and Technological Advice (SBSTA, 1996a), the UNFCCC proposes eight possible allocation options for shipping emissions:

1. No allocation
2. Allocation to Parties in proportion to their national emissions
3. Allocation to Parties according to the country where the bunker fuel is sold
4. Allocation to Parties according to the nationality of the transporting company, or to the country where the vessel is registered, or to the country of the operator
5. Allocation to Parties according to the country of departure or destination of a vessel. Alternatively the emissions related to the journey of a vessel could be shared between the country of departure and the country of arrival
6. Allocation to Parties according to the country of departure or destination of passenger or cargo. Alternatively, the emissions related to the journey of passengers or cargo could be shared by the country of departure and the country of arrival
7. Allocation to Parties according to the country that owns the cargo or origin of the passengers
8. Allocation to the Party of emissions generated in its national space

Option 1 suggests no allocation and represents the status quo, i.e. shipping emissions would be treated separately from all other national emissions and would have to be controlled by an organisation other than the UNFCCC, such as IMO.

Option 2 is a pragmatic approach which would proportionally add marine bunker fuel emissions to the domestic emissions inventory of all countries, i.e. if shipping emissions make up 2% of global emissions, then each country would add 2% to its total national emissions. On a global scale this option distributes the burden equally, but, in doing so, disadvantages small countries and land-locked countries. It significantly advantages those with a large share of the international shipping fleet. Considering its oversimplification and the resulting unfairness of burden sharing, it was later dismissed by SBSTA (Faber/Rensma, 2008).

Option 3 suggests an allocation to Parties on the basis of where the marine fuel is sold. A major downside of this option is that national policies or reduction efforts would not be very effective as fuel can easily be bought elsewhere, avoiding taxes and regulations. Thus, it is difficult for a Party to influence its shipping emissions through national standards if this

allocation method is used (SBSTA, 1996b). Since fuel will become more expensive in countries who implement this option, fuel sales are likely to move to cheaper locations very quickly, thereby transferring emissions to either non-Annex I countries (Faber/Rensma, 2008, Faber et al., 2007) or non-parties of an IMO convention.

Option 4 advocates an “allocation according to the nationality of the transporting company, or to the country where the vessel is registered, or to the country of the operator”. These three cases must be disentangled because a ship may have owners and operators of different nationalities and be registered in a third country. The UNFCCC seems to imply that the ideal option is the allocation according to the nationality of the transporting company, i.e. the owner, because it offers better control options and incentives for national policies (SBSTA, 1996b). However, vessels are often owned by investment vehicles such as Limited Partnerships (UK), which are currently based mostly in OECD countries but can easily relocate to another country at little cost – thereby potentially evading obligations (Faber/Rensma, 2008).

Option 5 is the allocation to the vessel’s country of departure or arrival, or a burden sharing between both. This option is difficult to implement because it requires sharing of information between the countries of departure and arrival, which is complex for ships that have many short trips and frequent stops. Thus, the quantification of the emissions and its break-down to the country of departure and arrival is demanding (SBSTA, 1996b). It is also an option that is largely unaffected by national policies and therefore not ideally suited for a regulatory scheme. However, Faber and Rensma (2008) conclude that this option is manageable because port calls are registered in logs that can be verified by port authorities. Evasion would be unlikely because routes would have to be changed or other ports used, which is likely to add costs (Faber/Rensma, 2008).

Option 6 asks for allocation according to country of departure or the destination of passengers or cargo – again, information sharing on cargo and passengers would be necessary and, again, it would have to be correlated with fuel consumption. This option is complex because ships often carry cargo to multiple destinations (Faber/Rensma, 2008; Faber et al., 2007). Hence, emissions would have to be allocated to the various cargo items, making data gathering more demanding.

Option 7 requires allocation according to the country that owns the cargo or the country of origin of the passengers. This has all the downsides of option 5, yet is even more complex because the owners of the cargo might change frequently, also during transport. The higher

level of detail required for this allocation would add complexity and methodological difficulties in gathering the data, and, consequently, was dismissed by the SBSTA itself.

Option 8 has precedence in other sectors where emissions are also allocated to the party in whose territory they occur. This would be feasible for coastal areas but this option had to be dismissed by the SBSTA for international shipping because it leaves emissions on the high seas beyond the responsibility of any party (Faber/Rensma, 2008).

In summary, options 7 and 8 have already been dismissed. Den Elzen et al. (2007) and Faber et al. (2009) have assessed options 3 (IEA data from 2000), 5, 6 and parts of 4 (*flag state*). Our paper adds options 2 because its general approach can provide a benchmark for comparison with the other options, despite the fact that the SBSTA has dismissed this option. Further, we also add an updated version of 3 (IEA data from 2007) as well as a complete analysis of option 4 (*flag state/operator/owner*) with new data and a different calculation approach.

4. Calculation and results of emissions allocation to national inventories

4.1 Data set description and calculation approach of allocating CO₂ emissions

Our analysis is based on different statistical databases, which all refer to the year 2007. We use data from the International Energy Agency (IEA, 2009) on CO₂ emissions from fuel combustion, and the World Bank (World Bank, 2009) on country specific per capita CO₂ emissions as databases for determining a country's national CO₂ emissions inventory – in the following denoted as total national emissions.¹⁴ For attributing the share of emissions from international marine bunker fuel sold to a country (allocation option 3 (*fuel sold*)), we use data from the IEA on CO₂ emissions from international marine bunker fuel sold (IEA, 2009). For allocation options 2 (*proportional*) and 4 (*flag state/operator/owner*), additionally data from the second IMO GHG study (Buhaug et al., 2009) is employed. In this study, as mentioned in section 2.1, a CO₂ emissions inventory for the shipping sector is established for the year 2007 by estimating fuel consumption based on activity data.¹⁵ This data set covers all ships larger

¹⁴ For the year 2007 the data sets contain only data on a country's total CO₂ emissions from fuel combustion and not for a country's GHG emissions. The latter is only available in the IEA statistics for the year 2005. Nevertheless, we choose them as databases for determining a country's national emissions total because all datasets used on shipping emissions are based on the year 2007 too.

¹⁵ The applied activity-based model cannot differentiate between international and domestic shipping, since some types of ships can be used in both international and domestic shipping. To differentiate between them,

than 100gt (in total 100,243 ships), excluding military vessels, and contains information for different ship categories on size, number of ships, annual average fuel consumption, and used fuel type. Emissions per category are calculated based on conversion factors: $\varepsilon = 3.13$ for heavy fuel oil (HFO) or $\varepsilon = 3.19$ marine diesel oil (MDO).¹⁶

Information on the nationality of the transporting country (*ownership*)¹⁷, country of registration (*flag state*), and country of ship operator (*operator*) was provided by the Institute of Shipping Economics and Logistics for 2007 (ISL, 2008). By employing this data we restrict our analysis to ships of 1,000gt and more, which amounts to 32,292 for the two categories flag state and owner and 33,088 for the category operator.¹⁸ These ships are predominately cargo ships most often used on the high seas.

For allocation option 2 (*proportional*), the calculation of allocated emissions from international shipping is straightforward: this option merely proportionally adds marine bunker fuel emissions to the domestic emissions inventory of all countries, in the same proportion as the existing total national emissions. According to Buhaug et al. (2009), in 2007 international shipping emitted 870 Mt of CO₂ emissions and caused 2.7% of the world's CO₂ emissions. Consequently, 2.7% are added to all total national emissions, irrespective of whether a country is land-locked or has not sold any international marine bunker fuel (SBSTA 1996).¹⁹

For allocation option 3 (*fuel sold*) we allocate emissions from international marine bunker fuel to the countries which sold it in 2007.

To investigate allocation option 4 (*flag state/operator/owner*), emissions must be attributed to the individual countries' fleet. This can be done in terms of flag state registry (option 4a),

domestic fuel consumption based on fuel statistics is subtracted from the calculated global fuel consumption based on activity data (Buhaug et al., 2009). To date, emissions of domestic shipping are included in the national GHG emissions inventory reports of the UNFCCC Parties.

¹⁶ The emission factors employed in the second IMO GHG study are in line with the 2006 IPCC Guidelines on National Greenhouse Gas Inventories (IPCC 2006). Since some types of ships are able to use both types of bunker fuel, we assume a conversion factor of $\varepsilon = 3.16$ for those ships.

¹⁷ We follow Lloyd's Register by defining "ownership" as the "true nationality" of the controlling interest behind the fleet. In this case "true nationality" means where the benefits of the operation of the ships finally go to. So for example, if the owner of a ship is Greek and based in New York but remits the profits back to his home country Greece, then the "true nationality" would be Greece.

¹⁸ Information on ship ownership and flag state registration is based on July 2007 data and information on operator is based on January 2008 data. Although the ISL Bremen database includes only around 1/3 of the ships (mainly cargo ships) that are included in the second IMO GHG study we are able to cover more than 70% of the world fleet's total fuel consumption.

¹⁹ As we work with a different database compared to the second IMO GHG study (Buhaug et al., 2009) to determine a country's total national emissions, the relative share of international shipping of worldwide CO₂ emissions differs from the 2.7% mentioned in the second IMO GHG study. In the case of IEA data on CO₂ emissions from fuel combustion in 2007 (IEA, 2009) we obtain a share of around 3%.

operating company (option 4b), and ownership (option 4c). To gain insight on the country specific distribution of overall emissions, we combine data on annual average fuel consumption per ship type derived from the activity-based approach by Buhaug et al. (2009) with data on ship ownership, flag, and operator taken from the Institute of Shipping Economics and Logistics (ISL, 2008).

To calculate the total emissions for a country's fleet, we use information on annual average fuel consumption per ship type and multiply it by the corresponding emission factors. The resulting emissions per ship type are then multiplied by the number of ships that each country owns, operates, or has registered in that category. The emissions E for a country i 's fleet are thus given by

$$E_i = \varepsilon \sum_j q_{ij} c_j(d_{ij})$$

where ε represents the corresponding emissions factor, q the number of ships of country i in category j , $c_j(d_{ij})$ the specific fuel consumption value that gives yearly average fuel consumption depending on the ship size d .

Note that due to the unavailability of ship movement data, the above calculation assumes equal activity for ships in the same category and does not represent the actual miles that a country's fleet in a specific category travelled in one year. It merely represents the share of a country's fleet in a specific category compared to other countries. This assumption is made due to limited data availability.²⁰ Furthermore, 2007 was a good year for international seaborne trade in terms of ton-miles (UNCTAD, 2008). It can therefore be assumed that (almost) full employment of merchant ships existed, i.e. it can be reasoned that all registered ships were in use during the year 2007. This, in turn, supports our assumption of equal activity.

4.2 Results

The results of allocation options 2 (*proportional*), 3 (*fuel sold*), and 4a (*flag state*), 4b (*operator*), and 4c (*owner*) are presented in figure 1. It shows the relative shares of the respective top 10 countries in total international shipping emissions per allocation option in comparison to the rest of the world. Note that option 3 is based on 610 Mt of CO₂ emissions

²⁰ Llyod's Register maintains data on ship movements (Faber et al., 2009) but the authors have no access due to financial constraints.

instead of 870 Mt of CO₂ emissions. This is because IEA statistics use a different methodology than Buhaug et al. (2009) to account for international shipping emissions (Buhaug et al., 2009). Further, since we are going to analyse two different climate regime scenarios in section 5.1, we have marked countries that have agreed to emission reduction targets under the Kyoto Protocol with an asterisk.

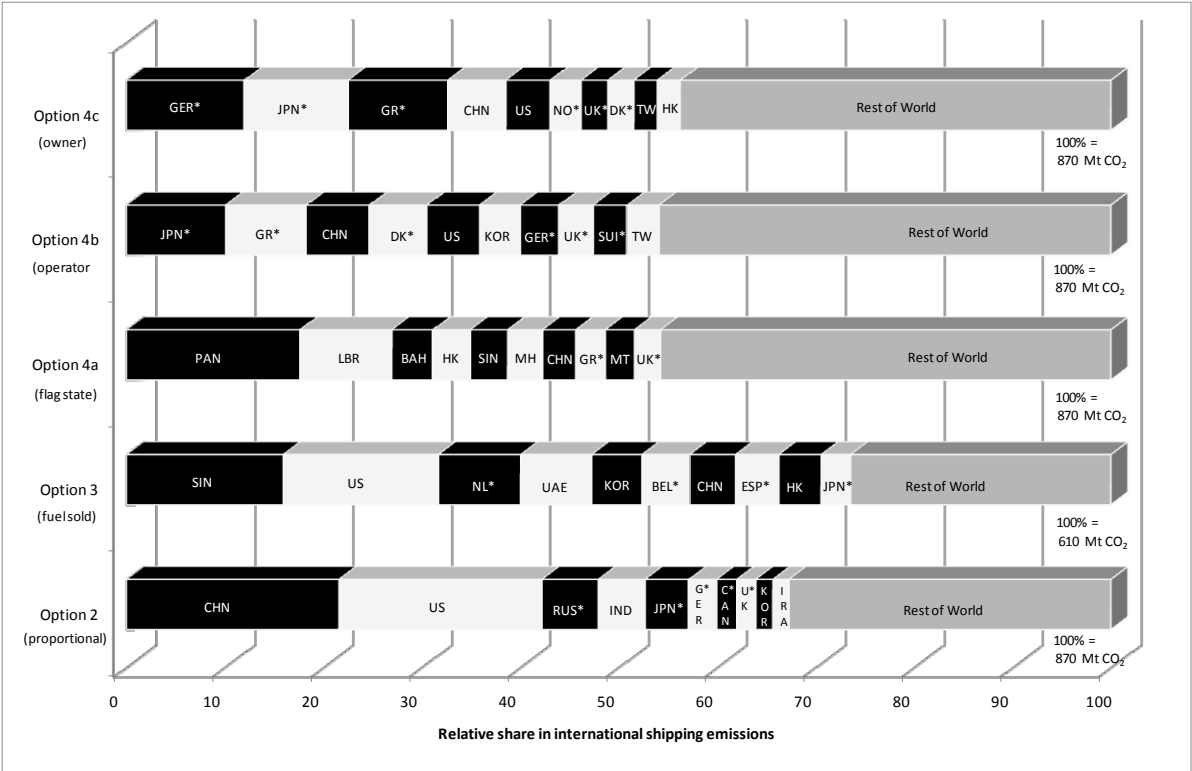


Figure 1: Top 10 countries according to relative share in total international shipping emissions per option in comparison to the rest of the world.

Source: Own calculations based on IEA (2009), Buhaug et al. (2009), and ISL (2008).

The results show that all option 4 cases would allocate roughly 50% of the emissions to the top ten countries and the other 50% to the rest of the world. This is considerably lower than allocation options 3 and 2 (70% and 65% respectively). However, the distribution of emissions varies significantly among options. Option 4c (*owner*) would allocate the highest CO₂ shares to Germany, Japan and Greece - all three have agreed to emission reduction targets under the Kyoto Protocol - followed by China and the US. Option 4b (*operator*) allocates the highest share to Japan, Greece and China, followed by Denmark and the US. Both options have a decent share of OECD countries amongst those most highly burdened, as well as countries that have signalled their willingness to reduce emissions. The third case of option 4, allocation according to *flag state*, is not as balanced because Panama and Liberia alone would have to account for roughly 25% of all emissions – whilst both countries have

small economies and a small amount of total national emissions overall. In this case, only two out of the top ten countries have agreed to emission reduction targets under Kyoto.

When taking into account not only the additional absolute emissions but also the relative increase in total national emissions, the following results emerge (see Appendix A, tables A1-4): If emissions are allocated according to option 4a (*flag states*), the highest relative increase in total national emissions would be burdened on the Marshall Islands, Liberia and other countries known for commonly “flagging out” ships (Appendix A, table. A1). Apart from being a popular registration location they have small economies with no large overall national emissions and are mainly non-Annex I countries.

In the case of option 4b (*operator*), the result is more diverse than in case 4a (*flag state*). Some popular flag states in developing countries with small economies are heavily affected, such as Bermuda, with a dramatic increase of 787% (Appendix A, table. A2). Bermuda is apparently a very popular location for ship operators. Other countries in the top ten list of allocation include some large European shipping nations such as Denmark, Greece or Norway, with increases up to 101% (Appendix A, table. A2). The operators are currently located in a diverse group of Annex I and Non-Annex I countries; in countries with fairly large economies; as well as very small island states.

The third case of allocating emissions according to the country of the *owner* (4c) is, on the whole, not too different from case 4b (*operator*), albeit with less dramatic differences. Bermuda is still the number one in terms of increase in percentage of its total national emissions after this allocation (Appendix A, table. A3), but the increase is smaller, with 267% compared to case 4b (*operator*). Bermuda is followed by Greece and Norway, and this list of top 10 affected countries, again, includes a variety of developed and developing countries, and Annex I, as well as small island states.

The result of allocation option 3 (*fuel sold*) shows that over 70 % of CO₂ emissions from international marine bunker fuel sold would be comprised of the top ten countries with the largest shares burdened on Singapore and the US, followed by the Netherlands.

This option has some distorting and surprising effects when looking at the relative increase in total national emissions by adding emissions from the sale of international marine bunker. For example, this would increase the total national emissions of Gibraltar in 2007 by over 800% (Appendix A, table. A4), although Gibraltar neither belongs to the top 10 international marine bunker fuel selling countries in absolute terms (Appendix A, figure. A1) nor to the countries with the highest emissions overall. However, Gibraltar’s amount of total national emissions is

extremely small (0,47 Mt of CO₂ emissions) in comparison to its emissions from international marine bunker fuel sold (3,84 Mt of CO₂ emissions). Other drastic relative increases would occur in Singapore and the Netherlands Antilles. In comparison, in 2007 the USA sold the second largest amount of international marine bunker fuel in terms of CO₂ emissions, but, adding these emissions to its total national emissions, would have increased them by only 1,7%.

Allocation option 2 (*proportional*) - proportional add-on of shipping emissions to existing total national emissions- gives a cross-sectoral balance of emission totals. Hence, the countries that would be burdened the most by this allocation are those that have the highest share of total national emissions to begin with, i.e. China and the US: they alone account for almost 40% of global emissions, whilst none of them have any Kyoto Protocol commitments.

4.3 Putting the results into perspective

The question now is how the different options analysed in section 4.2 compare to the options analysed in the studies of den Elzen et al. (2007) and Faber et al. (2009) in terms of absolute allocated shipping emissions. This comparison provides an overview of all investigated options and their allocation effects concerning different world regions. In order to make all of them comparable, we chose the regional aggregation of Faber et al. (2009). Their analysis is conducted at the level of 10 world regions, whereas the analysis of den Elzen et al. (2007) is conducted at the level of 17 world regions. The analysis in this paper is conducted at the level of countries.²¹ Also note that allocated emissions in option 5 (*departure/destination of ship*) are based on the year 2006 (Faber et al., 2009), option 6 (*destination of goods*) on the year 2000 (den Elzen et al., 2007), and options 2 to 4 on the year 2007.

Figure 2 shows the regional allocation effects of international shipping emissions according to the various options.

²¹ The aggregation of country level data to the level of the 10 world regions is straightforward, whereas the aggregation of the 17 world regions to the level of the 10 world regions is not. The reason is that the regions do not coincide in terms of geographical scope (assigned countries per region). For example, in den Elzen et al. Russia belongs to one region, whereas in Faber et al. it is split up and assigned to different regions. Thus the accuracy of option 6's indicated Mt of CO₂ emissions is limited.

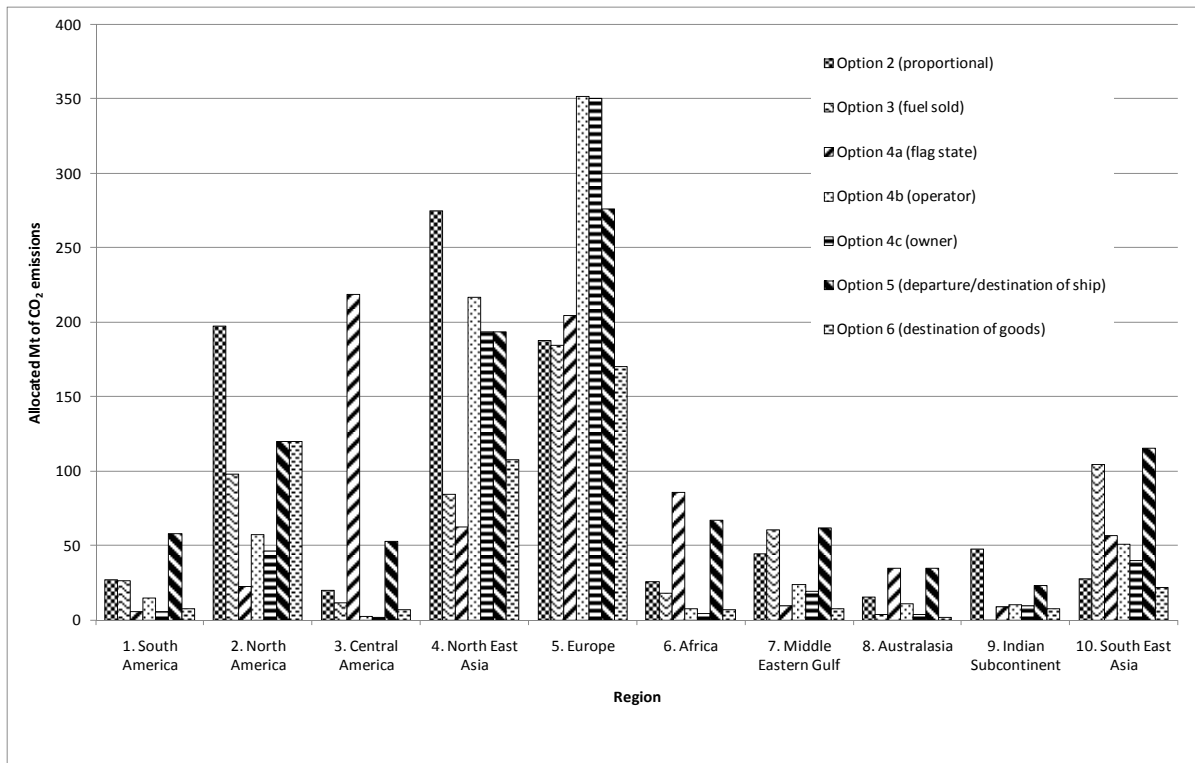


Figure 2: Comparison of allocation options on a regional scale.

Source: Faber et al. (2009) for option 5, den Elzen et al. (2007) for option 6, own calculations based on IEA (2009), Buhaug et al. (2009), and ISL (2008) for option 2, 4(a-c).

At first glance, the picture looks extremely heterogeneous. To gain a better understanding, we will first examine whether regions exist that score high in terms of allocated shipping emissions in all options. Then we will examine which region yields the highest absolute difference in allocated emissions across the range of options. Next, we will examine which option most equally distributes allocated shipping emissions across all regions. For this purpose we use the variation coefficient to illustrate the dispersion from the average within each option's distribution. Finally, we will relate options 3 to 6 to option 2 - proportional addition of shipping emissions to existing total national emissions. This delivers insight regarding to what extent the shipping-based allocation options 3 to 6 deviate from the country emissions-based allocation option 2 in each region. We associate the term "shipping-based allocation option" with an allocation based on general shipping activities, for example selling marine bunker fuel or owning a ship, whereas we associate the term "country emissions-based allocation option" with an allocation based on emissions within national territories.

In each option Europe is allocated at least 15% of total international shipping emissions, scoring higher than all other regions in options 3, 4b, 4c, 5, and 6. Thus, no matter which option is chosen, Europe is burdened with a large share of total international shipping emissions, followed by North East Asia and North America.

Concerning the absolute difference in allocated emissions between allocation options, Central America is exceptional as it yields the largest absolute difference between options 4a and 4c, followed by North East Asia (options 2 and 4a), and Europe (options 4b and 6).

Calculation of the variation coefficient shows that allocation in option 5 is less dispersed than in other options, i.e. the variation from the average within option 5 is less than in the other options. Thus, option 5 distributes allocated shipping emissions most equally across all regions, followed by options 3 and 2.

Regarding the distinction between shipping-based allocation options 3 to 6 and country emissions-based allocation option 2, the following observations can be made. Europe is allocated more emissions by shipping-based options than by the country emissions-based option, whereas the opposite is the case for North America and North East Asia. This implies that, if option 2 is chosen as an allocation rule, European shipping activities are underestimated. In contrast, if option 2 is chosen as an allocation rule, North American and North East Asian shipping activities are overestimated.

5. Discussion of allocation results

5.1 Scenario description and evaluation criteria

In the following we distinguish between two international climate regime scenarios and define three criteria for evaluation.

We define one climate regime scenario as the “Kyoto Accord” and the other as the “Copenhagen Accord”. To put both scenarios into perspective, we always relate them to the ideal case of a global climate regime, i.e. all countries are Parties to a climate regime and therefore all emissions are controlled. The first scenario “Kyoto Accord” is based on the countries presently taking action as they already have concrete emission reduction targets under the Kyoto regime (Annex B countries). The second scenario “Copenhagen Accord” includes all countries that have committed to plans for reducing their greenhouse gas emissions by 2020, despite varying commitment levels. This list is much longer than the Kyoto Protocol list of Annex B countries because it also includes large developing and transition countries such as China, India, Brazil and South Africa, since all of these have

made some emission reduction commitments;²² albeit not in internationally binding treaties. Nevertheless, they are more likely to agree to shipping emission reduction schemes than those countries with no emission reduction targets at all.

For evaluating the allocation results in the context of the two scenarios, we define three criteria: environmental effectiveness, legal effectiveness (possibility of evading regulation), and fairness of burden sharing.

The first evaluation criterion is that of environmental effectiveness, which asks what the allocation would entail in terms of potential emission reductions.

The second criterion is that of legal effectiveness which assesses the environmental effectiveness from a legal perspective, i.e. the potential for preventing regulation evasion. Two questions are linked to this: what ways of evading national regulation exist, for example, changing flag or relocating the owner's or the operator's company to another country, and what is their impact on allocated emissions according to each option. In this respect it is also relevant to assess the legal options committed countries have to enforce regulation or standards upon ships of other flag states. This is particularly relevant if allocation is made based on the owner or operator but the ship is registered elsewhere. As mentioned in section 2.2, countries that have implemented an IMO regulation may be allowed to impose it on all flag states that pass through the waters, but only once the IMO regulation is in force, which depends on the number of implementing countries.

The third criterion is that of fair burden sharing and should be based on the polluter pays principle. We distinguish between two groups of polluters. The first group of polluters to be examined is defined as countries that import and export goods. This implies that the more a country benefits from trade, the more it should be burdened with emissions from international shipping, because as mentioned in section 2.1 the shipping sector plays a large part in transporting these goods. The second group of polluters is defined as countries that employ ships. The term "employ ships", in this context, means having ships registered, owning or operating them. This for example implies that the more ships a country owns, the more it should be burdened with shipping emissions because ships are the entities that actually emit CO₂. This aspect is concerned with fairness within the shipping sector, i.e. are those burdened by the shipping emissions allocation those who profit most from employing ships?

²² A complete scenario description is in the Appendix B table B1, source for "Copenhagen Accord" list: <http://www.usclimatenetwork.org/policy/copenhagen-accord-commitments>. This list is updated regularly. Our scenario is based on the list's status in August 2010.

5.2 Discussion

5.2.1 Environmental effectiveness

The result of the first evaluation criterion, environmental effectiveness, is presented in figure 3. This figure shows the share of international shipping emissions in 2007 relative to the ideal case of a global climate regime (100% controlled emissions) according to the options 2, 3, and 4(a-c) which would be controlled in the two different scenarios described in section 5.1. Note that an analysis of this kind is not possible for the options discussed in den Elzen et al. (2007) and Faber et al. (2009) because they are based on a regional scale, making a distinction between Kyoto Annex B and non-Annex B countries difficult. The same applies to the second scenario “Copenhagen Accord” and in part to the third evaluation criteria “fair burden sharing”.

In the scenario “Kyoto Accord”, the highest share of international shipping emissions would be controlled by option 4c (*owner*) at 58%, followed by option 4b (*operator*) at 55%, option 3 (*fuel sold*) at 32%, and option 2 (*proportional*) at 29%. The lowest share would be controlled by option 4a (*flag state*) –at only 22%. This means that if option 4a is used as the allocation model, then most of the allocated shipping emissions will be added to the total national emissions of those countries that currently have no obligations to cut emissions under the Kyoto Protocol. Options 4c and 4b indicate higher levels of controlled emissions and therefore should be preferred over the other options. However, the commitments of the Kyoto Protocol are due to expire in 2012, thus, hopefully a new agreement can be found. If there is a breakthrough in negotiations, it is likely that commitments will be based on the scenario we called “Copenhagen Accord”. Here, the highest share of international shipping emissions would be controlled by option 2 at 84%, followed by option 4b at 80%, options 4c and option 3 at 78%, and the lowest share would be controlled by option 4a –at only 36%. The allocation according to flag state is again the least preferable option. However, all the other options indicate a similarly high level of coverage, around 80%, with no great disparities between the options.

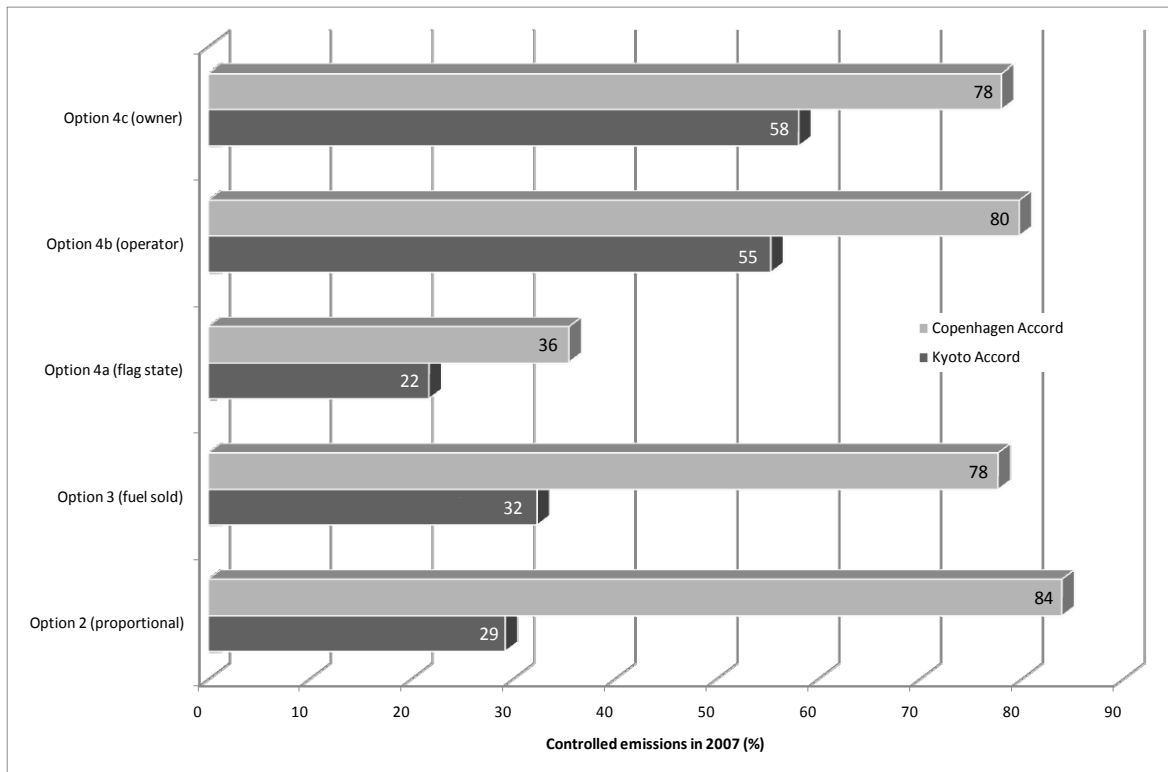


Figure 3: Environmental effectiveness of allocation options 2, 3, 4a, 4b, and 4c according to scenarios Copenhagen and Kyoto Accord.

Source: Own calculations based on IEA (2009), Buhaug et al. (2009), and ISL (2008).

It is evident that the registration of a ship as a basis for regulation (option 4a) would be environmentally ineffective both under the Kyoto and Copenhagen Accord scenarios because most shipping emissions would fall under flag states that have no commitments. Moreover, the process of “flagging out a ship” is easily done.

5.2.2 Legal effectiveness

The second criterion, legal effectiveness, must take into account the distinction between the UNFCCC approach and the sectoral approach laid out in the introduction. If a sectoral approach is desired, then only the IMO can introduce legislation – and so far, the obligations set out in IMO regulations affect the flag states who are obliged to enforce the regulations they agreed to under the IMO. However, in this paper we make the case for the UNFCCC approach because it leaves it up to individual countries to choose the most efficient way of reducing emissions. It also can be easily integrated into the existing Kyoto Protocol framework without having to initialise a new international treaty from scratch.

Hence we assume that the emission allocations we analysed would be used to add the respective emissions to total national emissions of the individual countries and it would be left to their discretion as to how to reduce their emissions. They may burden their shipping sector or they may resort to other means or other sectors. However, the global nature of the shipping sector entails the danger that, if only few countries burden their shipping sector with emission regulation, its stakeholders will search for ways of evading the regulation. These ways differ according to the different allocation options. Owners or operators will simply relocate their head offices to a country where no such regulations exist or where they would be exempt from emission reduction targets. The same is true for option 4a, as flagging out a ship is easily done. Evasion of regulation on a grand scale is also possible for option 3, as ships can be fuelled up in countries without regulation or emission reduction commitments. Evasion in the case of Option 5 (*departure/destination of ship*) and 6 (*destination of goods*) is only possible if ships call at or imports (cargo) are discharged at ports in countries without regulation or emission reduction commitments. All these options imply that allocated shipping emissions would be directed away from committed countries to countries with no commitments or regulations. Only in the case of option 2 - the one that indiscriminately adds the shipping emissions to the grand total of national emissions as a fixed percentage for all countries – does the evasion of regulation have no effect on allocated emissions. In summary, environmental effectiveness is heavily dependent on the legal effectiveness, and, for all options, a level of cooperative enforcement is potentially desirable.

Countries wishing to burden their shipping sector may resort to common enforcement. The number of countries willing to regulate their shipping emissions should be fairly considerable taking into account the cost-effectiveness of abatement measures and the abatement potential in this sector, as laid out in the introduction. The downside of course is the evasion of regulation and loss of competitiveness in this highly global and competitive sector. However, if enough countries are willing to cooperate, they could introduce IMO regulation affecting operators, owners, or flag states. Ideally, it should be the responsibility of operators because they have control over shipping routes, speed, and other operational details determining emission levels – and they have the opportunity to charge owners for their services as the two parties agree. Hence, if a certain number of countries – the exact number is agreed upon during the international treaty negotiations – implement the IMO regulation obliging operators to achieve certain targets, it comes into force. And, as explained in section 2.2, once an IMO regulation is in force, it may be imposed on all flag states that pass through the waters

of signatories, despite the ship being registered in a country not member to the international treaty. This would enable countries to impose regulation on their operators even though the ship is registered under another flag. The allocation option 4b – allocated emissions to operators - is also beneficial for this purpose because it includes countries with very busy ports such as EU countries, Singapore and Hong Kong, whose consent would be valuable for an effective implementation.

5.2.3 Burden sharing

The final evaluation criterion is that of fair burden sharing. We begin by examining the first group of polluters - countries importing and exporting goods. Then we proceed to do this for the second group of polluters - countries employing ships.

Tables 3a and 3b represent the top 10 trading countries defined by their relative share of world goods exports and imports in 2007. They also show whether these countries are under the top ten most burdened countries according to each option (figure 1 in section 4.2). The listed countries are the top polluters of international shipping emissions according to our fairness criterion and, consequently, the largest share of emissions should be allocated to them.

Table 3a: Top 10 countries in trading (export)

Country	Share of world goods exports in 2007 (%)	Country included in options				
		2	3	4a	4b	4c
Germany	9.84	x			x	x
China	8.89	x	x	x	x	x
United States	8.40	x	x		x	x
Japan	4.94	x	x		x	x
France	3.98					
Italy	3.66					
Netherlands	3.37		x			
United Kingdom	3.22	x		x	x	x
Canada	3.15	x				
South Korea	2.76	x	x		x	

Source: World Development Indicators 2009 (goods exports, BoP, current US\$).

Table 3b: Top 10 countries in trading (import)

Country	Share of world goods imports in 2007 (%)	Country included in options				
		2	3	4a	4b	4c
United States	14.55	x	x		x	x
Germany	7.98	x			x	x
China	6.69	x	x	x	x	x
United Kingdom	4.59	x		x	x	x
France	4.44					
Japan	4.24	x	x		x	x
Italy	3.69					
Netherlands	3.01		x			
Spain	2.88		x			
Canada	2.75	x				

Source: World Development Indicators 2009 (goods imports, BoP, current US\$).

A glance at the right column “Country included in options” highlights that no option perfectly mirrors this list of countries. The case which best accounts for the global distribution of trade and wealth is obviously option 2. This option is followed by option 4b as the second best case, followed by options 3 and 4c. And it is obvious that, with the exception of China and the United Kingdom, option 4c does not resemble the list of top 10 trading countries at all.

The first result for the second group of polluters is that options 2, 3, 5 and 6 can be discarded as fair allocation options since they are not based on owning or operating ships or having them registered. Only the three sub cases of option 4 would lead to a fair allocation within the shipping sector. The second result is that out of all three sub cases we prefer option 4b – allocation based on operator. The country where operators are based should be burdened with the emissions that are caused by their operations. This is because operators have the most control over their ship’s emission levels by regulating speed and routes. Furthermore, they are in a position to charge their clients or ship owners for their services.

6. Conclusion

Abatement cost studies that analyse the potential technological and operational measures for reducing CO₂ emissions within the shipping sector and their costs show a considerable total abatement potential and that, even in the absence of a CO₂ regulation, the implementation of most of these measures is economically beneficial. Due to this apparent cost-effectiveness, there is a strong case for regulating shipping emissions within a UNFCCC climate regime or regulating these emissions within a sectoral approach based on IMO regulations. In this paper

we focused on regulation within a UNFCCC climate regime and analysed various options for allocating CO₂ emissions from international shipping to individual countries proposed by the Subsidiary Body for Scientific and Technological Advice of the UNFCCC. We add to the existing literature by analysing the UNFCCC options that have not yet been assessed by others and by achieving an overall picture of allocation results by comparing them with those options that have already been researched by others.

Our analysis has shown that there is no allocation option that can be regarded as environmentally effective, legally effective, and allowing for fair burden sharing in all aspects. One could of course argue that the simplistic option 2 with the proportional add-on is, in some respects, the best scoring option in the scenario “Copenhagen Accord”, as it burdens the largest economies in terms of overall emissions and in terms of trade benefits. Thus, compared to other options, option 2 is environmentally effective and entails a fair burden sharing. On the other hand, however, it heavily disadvantages those large economies that are landlocked or do not significantly engage in shipping. It also gives massive advantages to those small island states that benefit from being used as registration or re-location destinations. Currently, due to the negotiations in Copenhagen 2009 failing to reach an agreement on quantified emission reductions, we should take the “Kyoto Accord” scenario as the most serious basis for discussion. From this perspective, it is clear that the most environmentally effective options are those of 4b (*operator*) and 4c (*owner*). As option 4b scores better than option 4c in terms of a fair burden sharing, it should be the preferred option. If, in addition, evasion of regulation is prevented by an IMO regulation - the possibility of evasion calls for a sector-wide regulation within the IMO regime -, then operators are the ones that have the most control over the emission levels of their ships by regulating speed and routes. Furthermore, they are in a position to charge their clients or the ship owners for their services. Consequently, we draw the conclusion that the best way to allocate international shipping emissions within a UNFCCC regime is on the basis of the operating company – option 4b.

However, we recognise that the political realisation will be difficult and it is not clear whether the international community will agree to any emission reductions in shipping, neither within the UNFCCC nor the IMO regime. As the BBC reported on 7th October 2010, China is against emissions regulations or standards in the shipping industry unless it is not accompanied by

financial aid to developing countries²³. Hence, we have sketched the most effective way to allocate shipping emissions within a UNFCCC regime – but implementation thereof depends on a political decision and currently development in this field is not likely.

A number of limitations apply. First, our conclusions are based on results derived from 2007 data. Since this reflects the situation of the shipping sector for only one year, future studies should try to extend the analysis to several years making results more robust. Nevertheless, we believe that 2007 was not an exceptional year for the shipping sector. Second, the use of ship movement data would be preferable to assess the actual miles that a country's fleet travelled in one year. However, at present such data is not affordable for researchers. In the future it would be interesting to achieve a more detailed evaluation of who would gain or lose from regulating CO₂ emissions from international shipping in a Post-Kyoto agreement and therefore oppose or support a specific allocation option.

²³ <http://www.bbc.co.uk/news/science-environment-11497829>

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Appendices

Appendix A

Tables A1 to A4 show the resulting top 10 countries according to allocation options 4a, 4b, 4c, and 3, if international shipping emissions would be allocated to total national emissions.

Table A1: TOP 10 countries according to relative increase in total national emissions (in %) Option 4a (flag state)

Country	Relative increase (in %)	Δ in 1000 t
Marshall Island	36 179	31 476
Liberia	21 874	80 935
Antigua & Barbuda	3 473	15 054
Saint Vincent	2 988	5 737
Panama	2 367	153 605
Bahamas	1 689	36 330
Bermuda	1 463	8 427
Comoro Islands	1 251	786
Vanuata	1 239	1 120
Malta	920	25 030

Table A2: TOP 10 countries according to relative increase in total national emissions (in %) Option 4b (operator)

Country	Relative increase (in %)	Δ in 1000 t
Bermuda	787	4 534
Marshall Island	189	165
Denmark*	101	51 069
Greece*	73	71 235
Gibraltar	72	341
Switzerland*	70	29 638
Norway*	66	24 253
Kiribati	64	18
Singapore	61	27 508
Hong Kong, China	57	24 735

Table A3: TOP 10 countries according to relative increase in total national emissions (in %)
Option 4c (owner)

Country	Relative increase (in %)	Δ in 1000 t
Bermuda	216	1 247
Greece*	89	87 505
Gibraltar	74	349
Norway*	74	27 171
Cyprus	66	4 815
Kiribati	64	18
Hong Kong, China	47	20 553
Denmark*	45	22 493
Singapore	40	17 931
Bahamas	19	415

Table A4: TOP 10 countries according to relative increase in total national emissions (in %)
Option 3 (fuel sold)

Country	Relative increase (%)	Δ in 1000 t
Gibraltar	817	3.84
Singapore	216	97.28
Netherlands Antilles	128	5.77
Malta	98	2.67
Hong Kong, China	60	25.95
United Arab Emirates	34	44.22
Netherlands*	28	50.92
Belgium*	28	29.54
Gabon	19	0.48
Uruguay	18	1.04

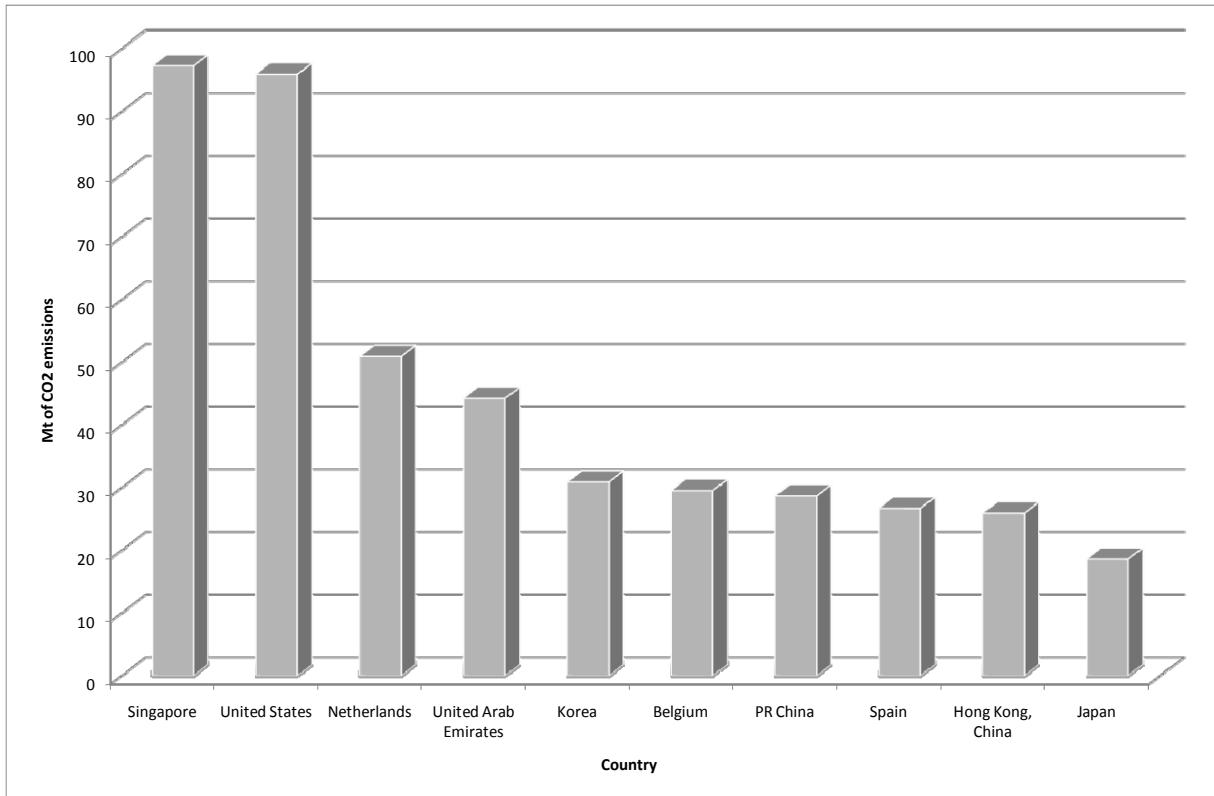


Figure A1: Top 10 countries in CO₂ emissions from IMB fuel sold in 2007.
Source: IEA statistics.

Appendix B

Table B1: Scenario description

Kyoto Accord	Kopenhagen Accord	Global Accord
Australia	Australia	all countries
Austria	Austria	
Belgium	Belarus ^o	
Bulgaria	Belgium	
Canada	Brazil ^o	
Croatia	Bulgaria	
Czech Republic	Canada	
Denmark	China ^o	
Estonia	Croatia	
Finland	Czech Republic	
France	Denmark	
Germany	Estonia	
Greece	Finland	
Hungary	France	
Iceland	Germany	
Ireland	Greece	
Italy	Hungary	
Japan	Iceland	
Latvia	India ^o	
Lithuania	Indonesia ^o	
Luxembourg	Ireland	
Netherlands	Italy	
New Zealand	Japan	
Norway	Kazakhstan ^o	
Poland	Latvia	
Portugal	Liechtenstein ^o	
Romania	Lithuania	
Russian Federation	Maldives ^o	
Slovak Republic	Mexico ^o	
Slovenia	Luxembourg	
Spain	Netherlands	
Sweden	New Zealand	
Switzerland	Norway	
Ukraine	Poland	
United Kingdom	Portugal	
	Romania	
	Russian Federation	
	Singapore ^o	
	Slovak Republic	
	Slovenia	
	South Africa ^o	
	South Korea ^o	
	Spain	
	Sweden	
	Switzerland	
	Ukraine	
	United Kingdom	
	United States ^o	

^o All countries that are not Party to the Kyoto Protocol but associated with action or targets in the Kopenhagen Accord

Source: USCAN

<http://www.usclimatenetwork.org/policy/copenhagen-accord-commitments>