What is an appropriate measurement and apportionment strategy for international shipping?

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Abstract

Much of international shipping's activity takes place outside national borders or a nation's EEZ – in "international waters". Consequently, conventional geographic definitions of nationality cannot fully encompass the sector's emissions. This led, in the Kyoto Protocol, to the IMO being given responsibility for developing international policy to control shipping's GHG emissions. Among other reasons, slow progress in that arena and a desire by countries and companies to develop metrics in order to evaluate their individual share of shipping's carbon emissions, has led to an aspiration to be able to apportion emissions at sub-international levels. To be an appropriate strategy, it is suggested that a measurement and apportionment strategy must be fair and feasible to implement. Therefore, this paper will first explore alternative approaches to apportionment and quantify the implications of these philosophies to different regions/countries. The approaches will then be discussed from the perspective of implementation, particularly with regards to monitoring, reporting and verification, and finally with respect to how the approaches can be incorporated in models/forecasts to explore future emissions scenarios.

Keywords: GHG emissions, apportionment, international shipping

1. Introduction

Ships are mobile emitters of GHGs. Many have documented their operation's consequences to the risk of dangerous climate change (Gilbert et al. (2010), Buhaug et al. (2009)). International shipping, involving travel between countries, produces emissions in multiple nation's EEZs, as well as international waters (the high seas), and travels through multiple jurisdictions.

With the exception of the EEDI and SEEMP regulations brought in as ammendments to the IMO's MARPOL Annex VI (IMO (2011)), GHG emissions from international shipping are unregulated. Three fundamental options for inclusion of international emissions exist:

- unilateral, by an individual nation or a region,
- multilaterally agreed at UNFCCC and allocated to national budgets, or
- multilaterally as a whole-sector policy by an international body (e.g. IMO)

For the first two, the nation or region must define its share of international shipping emissions. For the latter, it is not essential to be able to decompose total international emissions – they can be treated as a single entity. However, there are reasons why even for a whole-sector regulation, or process of developing and multilaterally agreeing to a whole-sector regulation, this may still be required. These reasons include:

- individual nations/regions wanting to understand their responsibilities for emissions and exposure to regulation
- individual nations estimating how much they should be compensated from economic impacts resulting from global regulation
- individual nations estimating their share of the costs (e.g. administration) or benefits (e.g. auction revenue) of a global regulation

In the UNFCCC's Kyoto Protocol Article 2.2, it is stated that Annex I states should reduce emissions from international marine bunker fuels through working with the IMO, however no firm obligations are set. No obligation at all was placed on non-Annex 1 states. So whilst discussion of various options for an IMO instigated sectoral regulation of shipping emissions, there remains ambiguity for its application, and there remain some significant complexities to be resolved around squaring the conflict between the UNFCCC's principle of Common But Differentiated Responsibilities and the IMO's principle of No More Favourable Treatment.

Therefore uncertainties remain in the national and international policy debates about how shipping's GHG will be regulated. However, because for all options, some decomposition appears to be inevitable, there is value in exploring the different options for measurement and apportionment and estimating what their consequences in application are.

2. Existing literature

SBSTA (1996) contains a number of options for possible allocation of shipping emissions. Some of the methods are simple and rely on smearing shipping's global emission across states according to a proxy for responsibility. Other methods are more complicated and rely on details about emissions associated with a specific voyage or the geographical location of a ship. The options include:

1. no allocation
2. in proportion to national emissions
3. according to where the bunker fuel is sold
4. according to the nationality of the transporting company, where the vessel is registered or to the country of the operator
5. according to the country of departure or destination of a vessel or some split between arriving and departing countries
6. according to the country of departure or destination of a vessel's cargo, or some split between arriving and departing countries
7. according to the country that owns the cargo or origin of the passengers (dismissed by SBSTA)
8. according to emissions generated in a country's national space (dismissed by SBSTA)

Besides option 1, which is to continue with the status quo and is therefore deemed unacceptable, these two overarching approaches (simple and complicated) can better be categorised as top down and bottom up methods.

2.1 top down methods

Top down methods rely on the calculation of the total emissions from shipping using a nationality-agnostic emissions calculation (e.g. sum of global bunker fuel sales e.g. Buhaug et al. (2009), or ship movements, e.g. Paxian et al. (2010). The total emission is then subdivided by an indicative metric. This includes SBSTA's options 2 and 4, and has been added to by the suggestions by Entec (2005), reported fuel consumption and freight tonnes loaded/unloaded, and by Gilbert et al. (2010) a nation's proportion of global GDP.

2.2 bottom-up methods

The SBSTA options also include a number of bottom-up methods, options 3,5,6,7 and 8. Options 7 and 8 were dismissed by SBSTA in the same report that they proposed them. Option 7, because of the data burden and method complexity, and Option 8 because it left emissions occurring in the high seas unallocated. This leaves three approaches: allocation according to fuel sales, ship movements and transport demand (freight and passenger).

2.3 Comparative analysis

A number of authors have conducted studies to calculate the emissions produced according to one or more of the different allocation options (Heitmann and Khalian (2010) and Gilbert et al. (2010)). Gilbert et al. compare estimates of the UK's share of emissions from different options. Heitmann and Khalian look at global emissions allocated to countries (and aggregated back up to regions) according to a number of the different SBSTA options. Figure 1 is taken from Heitmann and Khalian (2010) and presents the findings from a variety of sources including their own calculations using data from IEA, Buhaug et al. and ISL. All estimates are calculated for the year 2007.

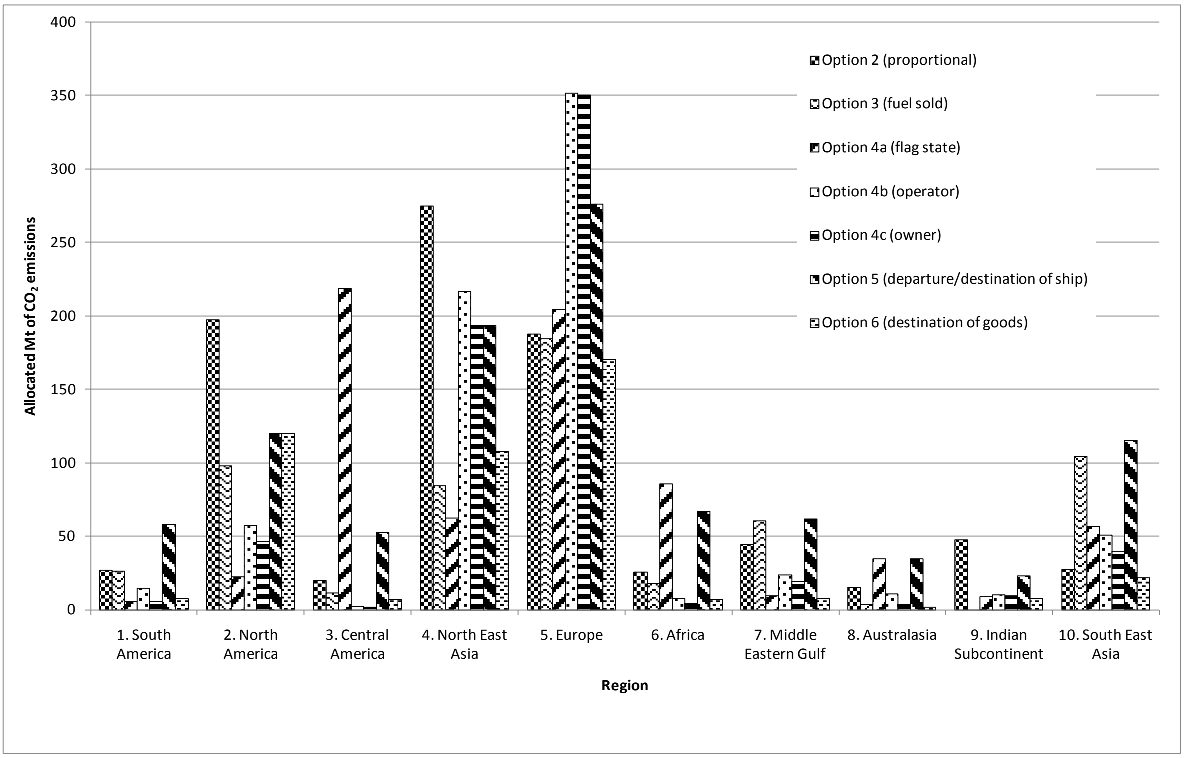

Figure 1. Emissions allocated for a number of the different SBSTA options, broken down by regions

Most notably, it can be seen that there is very little consistency between the options. Whilst for some regions (e.g. Europe), all options provide at least some degree of consistency, for others regions (e.g. Central America) the difference between options is frequently an order of magnitude or more.

3. Problem statement

A number of options have been proposed for national emissions allocation. It is clear from the existing literature that the allocation is highly sensitive to the option chosen. There is therefore a significant consequence to a nation and/or region's implied responsibility associated with the selection of an option and this makes the issue politically sensitive, a situation made more difficult because many of the assessment criteria (e.g. fairness) are subjective and hard to evaluate.

Alongside the politically contentious selection of an option is its feasibility from a method and data perspective. Data for top down calculations can be sourced from existing and long established internationally recognized sources (e.g. national GDP or emissions calculations). The methods are simple, involving little more than the calculation and application of percentage shares. Whereas bottom-up methods require a method or data collection programme, which can resolve detail on a per-ship and often per-voyage level. There is no existing international obligation for shipping data reporting that can be deployed to meet this level of detail.

The remaining sections of this paper are intended to:

- collate and discuss some of the recent discourse associated with the subjective selection criteria (fairness and effectiveness)
- discuss the details of method and data collection that might be required for the bottom-up methods to examine their feasibility
- bring both subjective assessment and implementation feasibility together in a discussion and highlight the challenges for further work in this subject

3.1 Fairness

Working on the assumption that regulation to control GHG will impose a burden, fairness is concerned with ensuring that the parties that bear that burden do so in proportion to the benefits they derive from the activity producing the emissions (shipping), also known as the 'polluter pays' principle. This can be described as internalisation of an externality (GHG emission) and is a common principle in the economics of efficiency (Friedman (2002)).

Heitmann and Khalian suggest two groups of parties who derive benefit from shipping:

- countries that import and export goods
- countries that own, operate or register ships

They also estimate a number of country's benefit from shipping according to their share of world goods exports and imports (by values of goods). Their study did not evaluate transport mode employed, so the figures are for total trade not shipping's contribution to that economic activity. The alignment between the benefit of trade and the burden from regulation is compared from different options. The option that most closely aligns benefit and burden in this comparison is owner ship of shipping (SBSTA Option 4). Even for this option, the alignment is poor: six out of ten of the most benefiting countries by imports and five out of ten of the top countries by exports would be burdened appropriately. No comparison is made with the data presented according to ship movement or trade.

In Gilbert et al. (2010), a different approach is taken, justified by the fact that shipping is a derived demand and, at least in the case of freight movement, only exists to facilitate a market exchange. The responsibility is attributed to the importers and exporters of goods, Unlike Heitmann and Khalian, no connection to the owners, operators and flag states is made. Starkey (2011) goes on to discuss how the trade responsibility can be broken down. There are two further classifications used: producers and consumers. Producers are those exporting goods and consumers are those demanding goods (goods purchased for consumption within its territory). Confusingly, others (CCC (2011)) have attributed producer responsibility to the nation (because the shipping activity associated with inbound ship movement is a production of emissions). Whilst there is nothing in the literature that conclusively defines fairness to either side, this discussion is an important component in the case of SBSTA Options 5 and 6: to distinguish where the definition of inbound vs. outbound or importer vs. exporter allocation is left ambiguous.

3.2 Effectiveness

The effectiveness of a regulation that at some level relies on national allocation of international emissions is dependent on whether the allocation will burden states that have the obligation to decarbonise (e.g. the Annex 1 states in the case of the Kyoto Protocol), and whether the allocation prompts evasion from responsibility.

Both of these components of effectiveness are discussed by Heitmann and Khalian. SBSTA Options 2,3 and 4 are compared for two policy scenarios and found to have a coverage of total sectoral emissions that vary significantly between options and policy scenarios.

A significant risk exists in the instance of any of the bottom up options, that the activity that the consequence of the regulation is that the shipping system reconfigures in order to avoid (or minimise) the burden that is being applied. There are two types of reconfiguration that can be considered:

- physical reconfiguration: movement of infrastructure, re-routing of ships (or additional port calls), re-routing of freight flows (land and sea), trans-shipment, relocation of fuelling facilities.
- paper reconfiguration: re-flagging of a ship, change of owner or operator nationality (movement of head quarters)

Each of these reconfigurations can be attributed a cost. If the cost of reconfiguration is lower than the burden experienced from a regulation, then it would be rational for the stakeholders in the shipping system to reconfigure with negative consequences to the regulation's effectiveness.

No cost analysis is conducted in this paper, but it is suggested that the costs of paper reconfiguration are normally significantly lower than the costs associated with physical reconfiguration. Within the physical reconfigurations, some may be comparatively 'low' cost (re-routing of ships or additional port calls, trans-shipment), whereas others may be very high cost (movement of infrastructure).

3.3 Summary position on the state of the art

There is good evidence in the literature that on assessment of both fairness and effectiveness all the top-down emissions allocation methods should be dismissed.

Option 3 (bunker fuel sales), has not only been shown by Heitmann and Khalian to be misaligned with the economic benefits of shipping, discredited as meaningless in terms of responsibility by Gilbert et al., but also requires a relatively simple reconfiguration of the existing shipping system for avoidance and so presents ease of evasion.

Heitmann and Khalian advocated Option 4b (bottom-up by ship operator nationality), and under the UNFCCC rather than a whole sector (IMO) approach. However, this seems naiive of the ease of the 'paper reconfiguration' required for evasion, particularly given the precedent of flags of convenience that shows that the shipping industry is adept at international mobility for the purposes of minimization of cost and regulatory burden.

This leaves Options 5 and 6, the most difficult to evaluate and potentially the most costly to execute because of their data and method requirements. To facilitate a greater discussion of Option 5 (movement) and 6 (trade), this paper will now explore a worked example and some data analysis.

4. A Worked Example

An issue significant to any mechanism for international shipping is the apportionment of emissions from a ballast leg (predominantly a feature in the bulk trades). Because some matches between trade flows and ship type are necessarily uni-directional, the consumer country's demand for transport can result in the requirement for a ship that arrives loaded to return empty – a ballast leg. This ballast leg generates emissions and raises the question about how they should be apportioned. The example below explains how this might differ depending on whether ship movement (Option 5) or trade (Option 6) is used for apportionment.

Imagine country A has two ships that call every year:

- ship 1 is a bulk carrier importing raw materials, (arrives full and leaves empty)
- ship 2 is a container ship exporting finished products (arrives empty and leaves full)

The two ships call at country B (and no other country) every year.

- ship 1 exports raw materials (arriving empty, leaving full)
- ship 2 imports products (arriving full, leaving empty)

The consequences of these ship movements in terms of emissions apportionment are shown broken down according to different implantations of Option 5 and 6 in Table 1.

Table 1. Emission apportionment details according to possible Option 5 and 6 philosophies

		Emission apportionment philosophy		
		incoming ship (Option 5)	50/50 (Option 5)	imported trade (Option 6)
Country A	Ship 1 – importer	100% of inbound/loaded leg	50% of inbound/loaded, 50% of outbound/ballast	100% ballast + 100% loaded legs
	Ship 2 – exporter	100% of inbound/ballast leg	50% of inbound/loaded, 50% of outbound/ballast	0
Country B	Ship 1 – exporter	100% of inbound/ballast leg	50% of inbound/loaded, 50% of outbound/ballast	0
	Ship 2 - importer	100% of inbound/loaded leg	50% of inbound/loaded, 50% of outbound/ballast	100% ballast + 100% loaded legs

Following the logic that a consumer-based allocation of emissions is fairest (Starkey (2011)), the imported trade apportionment might be the fairest mechanism. However, in reality, there are complexities that need to be taken into account - the ballast leg may be to a third country – country C.

The problem is further complicated when considering the operation of a ship that is part-loaded on a return leg. For example if ship 1 in the example above is fully loaded for the voyage from country A to B, and 50% loaded for the voyage from country B to A. The emissions for the voyage from B to A could be allocated according to the imported trade (Option 6) in three possible ways:

- country A and B are each apportioned 50% of the emissions (country B because its inbound demand has resulted in the need for a bigger ship, country A because it is importing)
- country A and B should negotiate what a fair split of emissions might be for the leg
- country B should be apportioned 0%, country A 100% of emissions– the demand for transport from B to A has come from A, otherwise the ship might have gone onto a third country C.

Under the ship movement apportionment philosophies (Option 5), the apportionment would be unchanged.

Another example is that of a multi-stop voyage, typical of the way a container ship might operate a liner service on a string (a sequence of ports). This is shown diagrammatically below for trade between three countries A, B and C, which results in 4 discrete voyages. At each country call, cargo may be loaded and off-loaded, for each discrete voyage the ship may be only part loaded, with cargo from multiple origins and bound for multiple destinations.

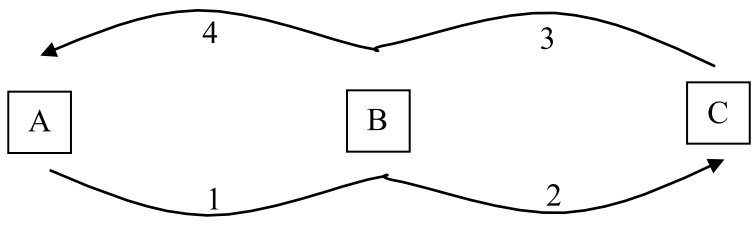

Figure 2. Representation of a round-trip voyage calling at three countries (A, B and C) with four legs (1,2,3 and 4)

A final example is that of a feeder ship operating from a hub port. Applying this to the three countries above, one ship (the feeder ship) might be used for the voyages between A and the hub B (voyage 1 and 4) and another ship for the voyages between the hub B and C (voyage 2 and 3). For cargo to move from A to C, it is transferred from ship-shore-ship at the hub in country B.

These examples perhaps highlight the difficulty for negotiation of a 'fair split' (bullet point 2 above) in emissions for every instance and therefore the need for a robust and simple apportionment mechanism. With robustness and simplicity may come a compromise on what is fair. However, it is clear that the simplest apportionment (vessel movement) may also be the least fair. For the multi-stop voyage and feeder example above, taking the scenario where B is a minor importer relative to A and C, apportionment on the basis of ship movements would be substantially misaligned with the moral responsibility for creating the demand for shipping activity.

Alignment of the apportionment with the moral responsibility for the demand for shipping activity could be achieved by applying the emissions of each of the four discrete voyages to each of the 3 countries in accordance with their share of the imported cargo carried on the ship for each voyage. By way of example, import shares are attributed to the three countries in Table 2, for the four voyages.

Table 2. Import shares for three countries associated with the voyage in Figure 2.

		Voyage			
		1	2	3	4
country	A	0	0	70%	100%
	B	40%	0	30%	0
	C	60%	100%	0	0

The compromise on fairness for such an apportionment regime would again be around the eventuality of a part-filled or ballast leg. On voyage 2, country C is apportioned 100% of the emission. But this may be argued as unfair if the ship is only part filled on this voyage because the transport demand is much greater for voyages 3 and 4 than for voyages 1 and 2 (fronthaul demand to A is greater than backhaul demand to C). Table 3 shows how the same import shares might be attributed but now as a percentage of the ship's total capacity not just the percentage split of the ship's cargo. The sum of the cargos for each voyage represent the ship's total capacity utilisation.

Table 3. Import shares as proportions of ship's total capacity for the voyage in Figure 2.

		Voyage			
		1	2	3	4
Country	A	0	0	70%	100%
	B	16%	0	30%	0
	C	24%	30%	0	0
Capacity utiliisation		40%	30%	100%	100%

In recognition of this shortcoming in the method, an alternative solution might be to calculate the total emission for all 4 voyages and then share it out in relation to the relative magnitude of each country's inbound transport demand. Taking the same cargo share and capacity utilisation, this same example is portrayed for the case that:

- voyage 2 and 3 are 1000 nm each
- voyage 1 and 4 are 100 nm each
- The ship has a capacity of 1000 TEU and emits 1 tonne of CO_2/nm (regardless of its capacity utilisation). The total emission of a round trip is therefore 2200 tonne CO_2.

Table 4 presents calculations of the emissions allocation share for this example using three different apportionment schemes – variants that have each been discussed above.

Table 4. Trade details and apportionments of emissions for three different implementations of Options 5 and 6.

		Importer		
		A	B	C
Export from / TEUnm	A	0	16,000	264,000
	B	30,000	0	60,000
	C	770,000	300,000	0
Total inbound transport demand/ TEUnm		800,000 (~56%)	316,000 (~22%)	324,000 (~22%)
Apportionment demand share per round trip (Option 6) / tonne CO_2		1222	483	495
Apportionment cargo share per voyage (Option 6) / tonne CO_2		800	340	1060
Apportionment per ship movement (50/50 or inbound, Option 5) / tonne CO_2		100	1100	1000

By comparison of the three apportionment results, it is clear that at least for this example the calculation is sensitive to method – A, C and B are each in turn apportioned the greatest share of emissions. And yet in terms of transport demand, country A has twice the demand of B and C individually.

Further complications arise with the inclusion of a land-locked country that exports or imports maritime cargo through a neighbouring country. Indeed, it would not necessarily have to be a land-locked country but would apply for all cargo that doesn't enter a country through a maritime route. Option 5 would apportion no emissions to the landlocked country but instead emissions would be apportioned to the country through which the cargo was transferred to/from a vessel. For option 6, there would be no change to the apportionment from the examples above as the landlocked country remains the country of origin or destination of the cargo. Neither approach is entirely satisfactory as the gateway country would have economic gain from the port activity associated with loading, unloading and storage. However, it could not be deemed fair for it to carry the full emissions apportionment associated with option 5. Conversely, option 6 would not apportion any emissions to the country.

5. Data and metnod

5.1. Data for option 5

Depending on the apportionment split, both last port of call and next port of call may have to be reported. There would be issues on some trades with reporting next port as some destinations can change mid-voyage. This is unlikely to be an issue for liner trades but it is often the case for vessels active on the voyage charter market in the dry or wet trades. The use of full voyage GPS location data would allow attribution of vessel activity to ports. AIS data (combined shorebased and satellite to avoid geographic gaps in the data) could also suitably fulfil this purpose. As well as vessel to port allocation, fuel consumption on voyage would be required. This could be determined using reported EEOI data for the vessel. EEOI could be reported either as voyage EEOI (IMO, 2009) or as annually reported EEOI. Reporting of the voyage EEOI would occur immediately on arrival and immediately before departure (to allow attribution of in port emissions), whilst annually reported EEOI would either be reported through the country of registration or directly to the IMO (or possibly to UNFCCC as per national emissions).

5.2. Data for option 6

The data required for this option would require the same as required for option 5 above, but any cargo loaded or unloaded would have to be recorded for each voyage in addition - to allow association of the cargo with each vessel voyage.

5.3. Implications for shipping's stakeholders

It is not the intention of this paper to comment definitively on how apportionment might then lead to action to reduce emissions. For some emissions allocation mechanisms (e.g. most, if not all the top-down options), the consequence of a policy measure aligned with the apportionment mechanism could be perverse e.g. the only way to reduce a nation's share if apportioned by GDP is to reduce GDP relative to other countries. The response that would reduce emissions apportioned according to Options 5 and 6 are respectively:

- Reduce inbound or outbound ship movements
- Reduce imports or exports
- Increase operating efficiency of vessel servicing the route.
- Change of vessel to a more efficient vessel servicing the route.

To a certain extent these are linked, but some physical reconfiguration could be used to maintain imports and exports but with minimisation of attribution of ship movements, depending on the exact details of the implementation of Option 5 used.

6. Conclusions

- The existing literature in the subject of emissions apportionment describes a variety of options and analyses their fairness and effectiveness
- The concept of top down emission's allocation for international shipping is shown by a variety of authors to lack credibility
- Nationally accounted fuel sales (normally described as a bottom-up apportionment philosophy) are found wanting with respect to fairness and openness to ease of evasion, and would do little to incentivise emissions reductions.
- This leaves variants of bottom-up options associated with ship movements and trade as the only credible mechanism for emissions allocation.
- The part utilisation of ship's cargo capacity, the multi-pick-up multi-drop-off nature of cargo movements and the ballast voyage are all operational details that deserve careful consideration in the design of an apportionment mechanism.
- Different details of Option 5 and 6 mechanisms can result in substantial differences in emissions allocated.
- Data is difficult to obtain and would also have to be enacted globally for some apportionment methods. For unilateral action, data (such as EEOI) would only be captured at the port of the country enacting the policy or reported by nationally registered vessels. Non-cooperating member state's ports would be under no obligation to capture this data and would be unlikely to adopt the administrative burden. If using a policy based on annually reported EEOI (e.g, reported to UNFCCC as is the case currently for bunker fuels), a global classification and verification system would be required. Verification of emissions has not being standardised (DfT, 2010) and therefore and internationally recognised approach would have to be agreed.
- The issue of the country that plays a role as a hub port remains unresolved.

7. Acknowledgements

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