

Exploring the scope for complementary sub-global policy to mitigate CO₂ from shipping

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HIGHLIGHTS

- Debate on sub-global CO₂ policies for shipping focuses on emission apportionment.
- Data limitations prevent apportionment regimes from monitoring policy success.
- Nations, regions and organisations directly influence shipping at sub-global levels.
- Sub-global policies influence demand and operations in ports/waters.
- Policy should focus on what can be influenced and consider how to monitor progress.

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ABSTRACT

For a high probability of avoiding dangerous interference with the climate system, all sectors must decarbonise over coming decades. Although shipping is an energy efficient transport mode, its emissions continue to grow. Compounding this, the sector's complexity, exclusion from emission inventories and slow progress towards a mitigation strategy, limit drivers towards meaningful change. Whilst there remains a preference within the industry for global mitigation policies, the urgency of required emission cuts necessitates exploration of complementary sub-global measures. The debate surrounding such measures tends to focus on apportioning global shipping emissions to nations. To explore the policy implications of apportionment, the UK is used in this paper to illustrate how available apportionment regimes produce a wide range of emission estimates. Moreover, in the absence of transparent fuel consumption and freight data, they have limited sensitivity, rendering them currently obsolete for monitoring purposes. Nations, regions and organisations influence shipping, particularly in relation to operations, yet debate surrounding apportionment has arguably delayed consideration of sub-global policies and indicators. This paper makes a case for putting the apportionment debate aside in the short-term to open out the full span of options, consider influence over aspects of the shipping system, and how to monitor success.

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1. Introduction

Treating climate change as a central environmental concern has come relatively late in the day for the shipping sector for a combination of reasons: more obvious local pollutants, its omission from national inventories under the Kyoto Protocol, its importance in globalisation and its reputation as the most energy efficient mode of freight transport. However, if governments take heed of the scientific evidence underpinning the global 2 °C temperature target recognised by the Copenhagen Accord (UNFCCC, 2009), all greenhouse gas emitting sectors need to decarbonise to a very high degree within only a few decades.

Sharing out the abatement effort through mechanisms such as emissions trading aim to mitigate greenhouse gases within sectors or nations where it is easiest and most cost effective to do so. Nevertheless, the scale of emission reductions necessary for a high chance of avoiding a 2 °C rise suggests complete energy system decarbonisation, particularly for Annex 1 nations, by 2050–2060 (Anderson and Bows, 2011; Bows and Barrett, 2011). With shipping's reliance on heavy fuel oil coupled with relatively high rates of growth that are projected to continue (IMO, 2009), shipping is securing its position as an important sector to urgently direct decarbonisation policies towards.

The body charged with addressing emission mitigation within shipping, the International Maritime Organisation (IMO), has completed two major studies of the sector's greenhouse gas emissions (IMO, 2000, 2009). Furthermore, the Marine Environment Protection Committee (MEPC) of the IMO has convened meetings to

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discuss measures for reducing emissions. However, the perceived slow pace of progress in policy implementation at a global scale led the European Commission to state that if no international agreement on the reduction of international shipping emissions is reached by the end of 2011, the Commission would propose policy measures of its own by 2013 (Faber et al., 2009). Whilst it may be productive to encourage a sense of urgency and develop policies at an EU level, there are many challenges in doing so that have been identified in the literature, including leakage, permit allocations, and different likely responses associated with the broad range of ship service, type and size (Miola et al., 2011). A further practical barrier concerns how to apportion the emissions associated with shipping to regions or even nations (Gilbert et al., 2010). The challenges surrounding this issue are also currently the focus of debate at a national scale in the UK (CCC, 2011). Nevertheless, the rate of CO₂ reduction required to be commensurate with the 2 °C target, together with the complex nature of the shipping system, suggests a need to review existing policy strategies aimed at shipping and consider alternative policies that could be urgently implemented.

Drawing from the results of a process of stakeholder engagement with shipping industry representatives, the aim of this paper is to question if ongoing efforts to develop mitigation policies through the IMO and the current focus of debate around apportionment at sub-global scales is preventing progress on limiting the CO₂ from shipping. The objectives of the paper are to:

- Describe the climate change challenge faced in the context of shipping, highlighting the importance of cumulative emissions and urgency (Section 2)
- Review the climate policy landscape surrounding shipping from a global to a national scale (Section 3)
- Assess the usefulness of emission apportionment in supporting strict and urgent shipping mitigation policy (Section 4)
- Illustrate the policy implications of emissions apportionment, using UK shipping as a case study (Section 4)
- Consider how direct and indirect influence over the shipping system at a sub-global scale may offer complementary policy levers to existing and potential future global-scale measures (Section 5)

2. Climate change context

Many nations are committed to policies aiming to avoid global mean temperatures rising by more than 2 °C above pre-industrial levels (UNFCCC, 2009). However, translating this target into emission budgets and associated pathways highlights the extremely challenging nature of achieving this goal with any reasonable degree of probability (> 50%) (Clark, 2009; Meinshausen et al., 2009; Bows and Barrett, 2011). Although some analyses suggest that politically feasible global pathways are achievable, they generally ignore the impracticality of an early peak in global emissions or the implications of tackling particularly intractable aspects, such as the emissions associated with agriculture (Anderson and Bows, 2008; CCC, 2008; Hedenus, 2010; Köne and Büke, 2010). If more realistic peaking dates are assessed for the same probability of reaching the 2 °C target, and there is a focus on CO₂ alone, significantly higher annual decarbonisation rates are necessary (Anderson and Bows, 2008).

To illustrate how shipping CO₂ emissions are situated within this context, a selection of global cross-sectoral CO₂ scenarios are presented in Fig. 1, chosen on the basis that they are recent analyses and broadly commensurate with 2 °C.¹ A shaded area

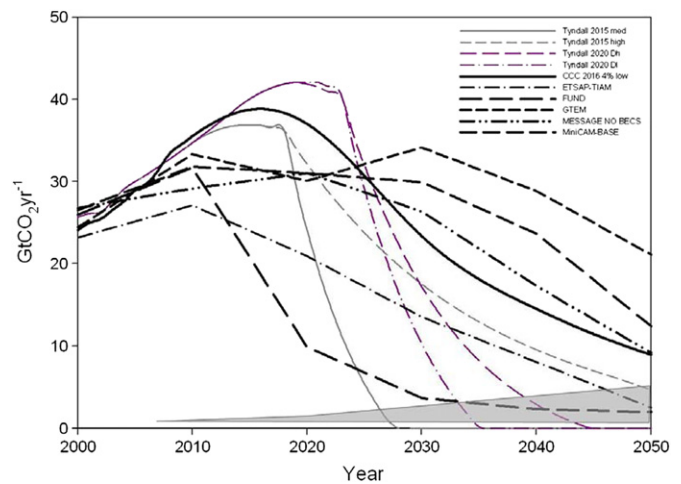


Fig. 1. CO₂ emission scenarios taken from the UK Committee on Climate Change (CCC 2016 4% low), Clarke (2009) (ETSAP-TIAM, FUND, GTEM, MESSAGE NO BECS, MiniCAM-BASE) and Anderson and Bows (2008) ('Tyndall...'), selected for their relatively low future climate impacts. The grey area represents the possibility space associated with the IMO's shipping emission scenarios (IMO, 2009).

representing CO₂ emission scenarios explicitly for shipping is taken from studies by Eyring (2005a) and IMO (2009) and is overlaid on the global cross-sectoral CO₂ scenarios.

As Fig. 1 illustrates, the more stringent the global cross-sectoral CO₂ scenario, the more untenable the available sector-specific scenarios for international shipping appear. Comparing the 'possibility space' (denoted by the shaded area in Fig. 1) for shipping emissions with global cross-sector scenarios, CO₂ emissions for all of the shipping scenarios exceed the budgets available for global scenarios that have realistic peaking dates and the highest probability of not exceeding 2 °C² (Tyndall 2020 DI). Moreover, all but the lower end of the shipping emission scenario range occupy a large share of the global emissions budget. This is particularly apparent in those scenarios with realistic peaking dates but higher probabilities of staying below 2 °C (CCC 4% low, Tyndall 2015 High, MESSAGE NO BECS). If it is to be accepted that avoiding the 2 °C threshold is paramount, and that the cumulative emissions framework holds, then the analysis points to a need for complete decarbonisation of the shipping sector by or soon after 2050. This would necessitate an urgent step-change in technological, operational and behavioural mitigation policy. Although emissions trading offers some scope for shipping to reduce emissions on aggregate, the more stringent global cross-sectoral CO₂ scenarios presented in Fig. 1 highlight that reductions in CO₂ made through trading will be limited. Therefore, the urgency with which policy measures are effectively adopted is crucial.

3. Shipping policy review

3.1. Global landscape

For greenhouse gas targets at a sub-global scale to be meaningful, all emitting sectors must be accounted for (Bows and Anderson, 2007). However, one legacy of the Kyoto Protocol is

(footnote continued)

probability of avoiding 2 °C are those with the smallest cumulative budgets, e.g. FUND. However, note that some of the scenarios (including FUND) require emissions to have peaked in the past to solve for 2 °C.

² Ignoring scenarios that needed to have reached a global peak in emissions by 2010.

¹ The spread within the scenarios is due to the peculiarities of the different models used, different probabilities of remaining below the 2 °C threshold, and differing assumptions relating to the energy system. Scenarios with the highest

that emissions produced within international airspace and waters are excluded from national targets. Instead, the International Civil Aviation Organization (ICAO) and the IMO were charged with addressing these ‘international’ emissions. The omission of shipping from national carbon-reduction efforts has meant that nations are relying on the IMO to deliver appropriate mitigation policies, with the IMO pursuing global-scale measures.

While the complex nature of shipping ideally requires a global solution, progress at the IMO has been delayed by the broader UNFCCC negotiating process. Difficulties that continue in seeking consensus over a global scale carbon target hinders the IMO taking a decision on the degree of mitigation aimed at shipping CO₂ emissions (ICTSD, 2010). Therefore, despite interest in developing measures to tackle emissions from within the shipping industry, through for instance, the creation of an international sectoral trading scheme (Australian Shipowners’ Association, Royal Belgian Shipowners’ Association et al., 2009), implementation will likely be some years away.

The political landscape has imposed a global approach to tackling shipping emissions, yet this is accompanied by many challenges, not least of which is reconciling ‘Common but Differentiated Responsibility’ (CBDR) – a way of fairly managing the mitigation effort with ‘No More Favourable Treatment’ – a maritime principal to ensure shipping standards apply to all nations (ICTSD, 2010; Kageson, 2011). Delays incurred whilst attempting to reconcile these principles compound problems in progressing policies, and inevitably lead to discussions around alternative approaches to break the deadlock.

Although agreement on global mitigation policies through the IMO does not require consensus, it does require a majority vote. As a high proportion of IMO member states are non-Annex 1³ nations and do not have Kyoto targets, many have concerns over being penalised by, for instance, a global market-based measure to curb shipping emissions. As a result, ongoing debate and discussions at the IMO regarding market-based measures to mitigate emissions have so far failed to reach an agreement. China and India in particular are using the CBDR principle to argue that policies aimed at shipping should apply only to Annex 1 nations through application to ships controlled by owners residing in those nations (Kageson, 2011). Directing mitigation policy at different spatial or governmental scales may lead to opportunities for overcoming opposition to decarbonisation measures applied globally that may disadvantage industrialising nations. However, the practicality of non-compliance or avoidance through, for instance, a change of ship owner residence or ship flag, would need to be overcome.

In terms of progress towards global-scale mitigation measures, the MEPC of the IMO is considering a range of measures and economic instruments to limit greenhouse gas emissions from shipping (IMO, 2009): (1) market-based instruments and (2) technical and operational measures. The four market-based mechanisms under consideration are: an international fund for greenhouse gas emissions from ships; an international fund with measures to improve ship efficiency; a global emissions trading scheme for shipping; and a trading scheme for energy efficiency credits. The technical and operational measures proposed are: an Energy Efficiency Design Index (EEDI) to set minimum energy efficiency for new builds; a Ship Energy Efficiency Management Plan (SEEMP) to improve the efficiency of ship operations; and an Energy Efficiency Operational Indicator (EEOI) to monitor the progress of the SEEMP. At MEPC 62, the Committee adopted

revisions to the MARPOL ANNEX VI to include the EEDI and SEEMP (Lloyd’s Register, 2011); the EEOI will take the form of guidance. The EEDI enters into force in January 2013. Although this is welcomed progress towards mitigating global CO₂ shipping emissions, it is regarded as a “soft measure” by many stakeholders; it only covers newly built ships and therefore excludes the vast majority of the international fleet, whose operational life can span 40 years. Its effectiveness therefore, depends on the rate of introduction of newbuilds and the specified rate of efficiency improvement. Additionally, by reducing the design speed of new builds, the EEDI target can be met with relative ease. This in turn reduces the incentives for more novel, step-change mitigation that is necessary if the sector is to make its fair contribution to the international community’s commitments under the Copenhagen Accord (Traut et al., 2011). Given the levels of cuts required by all sectors, the EEDI is unlikely to yield significant benefits, and therefore complementary policies are required that urgently tackle the sector’s emissions (Gilbert et al., 2011).

3.2. Regional landscape

Considering the EU as an important regional example, it takes the position that maritime emissions should be controlled at a global level. However, it also stated that if no international agreement is approved through the IMO, the UNFCCC and/or by the European Community by the 31st December 2011, then the EU will make a proposal for how to include international shipping emissions in its Community Reduction Commitment, entering into force by 2013 (European Parliament and Council, 2009). In CE Delft’s 2010 report for the EU (Faber et al., 2009) the four instruments identified for potential adoption are: a cap-and-trade system for maritime transport emissions; an emissions tax with hypothecated revenues; a mandatory efficiency standard for ships in EU ports; and a baseline and credit system based on an efficiency index.

3.3. National landscape (UK)

The UK is one of the forerunning nations in actively implementing measures and legislation to tackle its carbon emissions, and therefore an interesting nation to consider regarding mitigating shipping emissions from a national perspective. At present, the UK Government is working closely with other EU member states to ensure the UNFCCC reaches an agreement with the IMO to reduce shipping emissions (EAC, 2009b; CCC, 2011). If an agreement is not forthcoming, then the UK Government will support the EU in its intention to include international shipping emissions in one of the proposed market-based measures.

Meanwhile, the UK Government continues to debate whether the UK should (a) make unilateral adjustment of its national carbon budgets to account for its share of shipping emissions, and (b) whether unilateral action should be taken to reduce the UK share of global shipping emissions (CCC, 2008; EAC, 2009a, b). Recent developments include the UK Committee on Climate Change (CCC) presenting three options⁴ for the inclusion of UK-related international shipping emissions in its carbon budgets and 2050 target (CCC, 2011). However, in the absence of a clear

³ The nations which are Annex 1 parties to the United Nations Framework Convention on Climate Change (UNFCCC) which are the industrialised countries and ‘countries in transition’.

⁴ The three options presented by the CCC are: (1) International shipping emissions are included now in carbon budgets and the 2050 target; (2) International shipping emissions are included in carbon budgets and the 2050 target when progress has been made on developing internationally agreed methodologies for estimating emissions and; (3) International shipping emissions are included in the 2050 target now, but in carbon budgets at a later date. These options are to be discussed with relevant parties before a decision is made in Spring 2012.

methodology to estimate the UK's share of international shipping emissions, the CCC raised concerns over unilateral adjustment of its budget (CCC, 2008). It also argued that UK unilateral adjustment could lead to other EU member states relaxing their emission targets. Moreover, the UK Environmental Audit Committee (EAC), CCC and UK Chamber of Shipping previously advised against the UK taking unilateral action to reduce its international shipping emissions (CCC, 2008; EAC, 2009a).

One of the most significant developments within the CCC's latest report (CCC, 2011) is the attempt to address the inadequacy of the existing methodology using bunker fuel sales to estimate the UK's share of global shipping emissions. A concern is raised by Anderson et al. (2008), the EAC (EAC, 2009a), and more recently by Gilbert et al., 2010, 2011. However, difficulties surrounding the apportionment of international shipping emissions to nations are unresolved, both in relation to data quality and availability and how to define what is meant by the 'UK's international shipping emissions'. This issue will be explored in more detail in Section 4.

3.4. Wider policy landscape

While as of July 2012 there were no policy measures in place to tackle the climate-related impacts from shipping as a whole, other environmental policies have knock-on impacts. For instance, an IMO measure imposed globally to control local pollutants, MARPOL (marine pollution) Annex VI legislation, was adopted in 1997, stipulating a global cap on the sulphur content of marine fuels at 4.5% (MEPC, 2008). During its development, discussions were held to include CO₂ emissions in the legislation, however this option was subsequently dropped – and with it the opportunity for an international, sectoral policy mechanism to control the emission of CO₂ from ships (Gilbert et al., 2011). Nevertheless, in the issue of switching to lower sulphur fuels, conflicting environmental challenges are raised. If ships comply by switching to lighter, cleaner distillate fuels, then this contributes to the release of more greenhouse gases over the full “well-to-prop” lifecycle of the fuel, through additional emissions associated with extraction, processing and delivery, compared with heavy fuel oil (Corbett and Winebrake, 2008). Furthermore, in the short- to medium-term, a wholesale shift away from heavy fuel oil would likely prove too great a challenge for the shipping sector, because supply is not suitably geographically situated (Gilbert et al., 2010).

Assuming continued use of heavy fuel oil, incentivising fuel efficiency improvements is an attractive mitigation option. For example, reducing ship speed, through mandatory global regulations for existing ships and lower design speeds for new ships, is considered by some (Clean Shipping Coalition, 2010; Faber et al., 2010) to be the most readily available short-term measure. However, in addition to questions over enforcement, there are conflicting issues related to speed reduction with regard to the resultant increase in soot and fouling, absolute CO₂ savings, and the impacts on the supply and demand of trade (Corbett et al., 2009; IMO, 2010, 2010a). While soot and fouling can be avoided through improved engine control, as demonstrated by Maersk, the long-lived nature of CO₂ emissions arguably poses a greater societal threat compared with localised, short-lived environmental impacts. The overcapacity in the ship building market allows for demand to be met that incorporates slow steaming through the supply of more TEU capacity, but the impact on absolute CO₂ emissions of an increase in the number of journeys required, as opposed to fuel use per freight tonne-km, is what is relevant from the climate's perspective.

The debate is also complicated by assessments of radiative forcing that highlight the cooling impacts of short-lived sulphate aerosols currently released during the combustion of heavy fuel

oil, and which offset some of the historical warming impact of the CO₂ (Fuglestad et al., 2008). This cooling effect will diminish in future however, due to standards reducing SOx production, and the long-lived nature of CO₂ emissions.

The range of actors involved in the shipping system is a further complication that renders globally incentivising low-carbon technologies, operational practices and behaviours challenging. For instance, ship operators are not necessarily responsible for purchasing fuel, which also often represents a minimal cost compared with the cargo. Ship builders tend to be in parts of the world where climate change mitigation is not high on the political spectrum and certain chartering options mean that the operator has little interest in reducing fuel costs (Gilbert et al., 2010).

Yet it is the global extent of shipping that leads to both the shipping industry's importance and its preference for global policy measures. Transporting goods, resources and waste materials in a fuel efficient manner plays a central role in economic growth. A constraint on shipping, particularly when it has the potential to offer lower-carbon options for transporting goods than other modes, may not prove beneficial in terms of total transport emissions. Nevertheless, complete decarbonisation of all sectors, shipping included, is necessary for a high chance of avoiding a 2 °C rise. To address the challenge of decarbonisation within this global structure, it is hypothesized that shipping can be treated as a complex system with many interdependencies and emergent properties. Through this lens, which has been applied previously to the aviation system (Randles and Bows, 2009), the effectiveness of policies at sub-global scales that target and tackle specific aspects of the system, and any potential role of apportionment within these policies, are now explored.

4. To apportion or not to apportion?

Much of the debate surrounding shipping emissions at national and regional scales has focused on if and how to apportion global shipping emissions to nations. This section presents the range of apportionment methods available, assessing their limitations, including how the choice of apportionment can significantly alter the emissions estimate. The section goes on to explore the practical difficulties in linking apportionment methods to particular policies if wishing to influence and monitor levels of emissions.

4.1. Apportionment regimes

Apportionment regimes are used to ascribe responsibility to sub-global bodies for the emissions they produce. With regard to international shipping emissions, various apportionment regimes are outlined in the literature (UNFCCC, 1996a; UNFCCC, 1996b; Entec UK Ltd, 2005; Faber, 2007; Wright, 2008; Gilbert et al., 2010) and have been discussed with regard to environmental benefit, fairness and burden sharing, data availability and complexity and legal effectiveness (Entec UK Ltd, 2005; Gilbert et al., 2010; Heitmann and Khalilian, 2011). Within a given apportionment regime there are two ways of accounting for the emissions – top-down and bottom-up. In top-down emissions accounting, an annual global shipping emissions estimate is shared out using a relevant scalar to give a 'national shipping' emissions estimate. In bottom-up emissions accounting, 'national shipping' emissions are estimated using specific activity data on actual fuel consumption or alternatively, ship movements and characteristics. Apportionment regimes also vary in relation to the approach to allocate the emissions. They can be allocated either on a producer basis, where emissions are assumed to be the responsibility of the

Table 1

Apportionment regimes categorised according to the accounting method and allocation approach.

Emissions allocation approach	Emissions accounting method	
	Top-down Scaled from annual international shipping emissions estimate using national statistics of:	Bottom-up Emissions apportioned on the basis of:
Producer	(1) National GDP (2) National emissions	(3) Bunker fuel sold by the nation (4) Shipping activity within the nation's territorial waters (only) (5) Nations registered fleet, the nation's operating fleet or the nation's owned fleet
Consumer		(6) Amount of freight tonnes loaded or unloaded at the nation's ports (7) Port of departure or destination of the freight (8) Nation importing or exporting the freight (9) Owner of the freight

supplier (e.g. nation operating the ship), or on a consumer basis, where emissions are assumed to be the responsibility of the demand end of the supply chain (e.g. nation where goods are consumed that arrive by ship). Table 1 summarises apportionment regimes described in the literature according to the accounting method and allocation approach they adhere to.⁵ The apportionment regimes are discussed in greater detail by Gilbert et al. (2010).

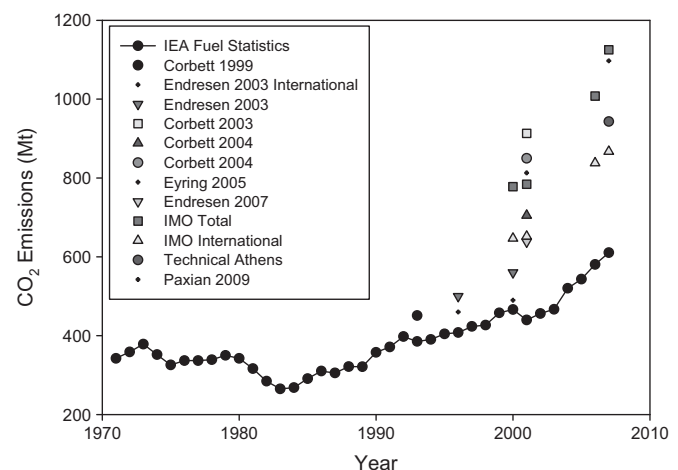
4.1.1. Challenge: wide range of global estimates

For the apportionment regimes requiring top-down emissions accounting, an estimate for international shipping emissions must be established. This estimate is then apportioned to a nation using scalars such as national GDP or population⁵. There are three main approaches for estimating global international shipping emissions:

1. Converting global bunker fuel sales figures into CO₂ using an emission factor. Such data are subject to limitations to coverage and underreporting, resulting in underestimates with a high degree of uncertainty (Olivier and Peters, 1999; Corbett and Koehler, 2003; Entec UK Ltd, 2005; Eyring et al., 2005a,b, 2010; Endresen et al., 2007).
2. Modelling global fleet activity aggregated by vessel type (IMO, 2009; Eyring et al., 2010).
3. Using data on individual ship movements on specific routes within a discrete geographical location to estimate fuel consumption and hence emissions (Faber et al., 2009).

Fig. 2 illustrates how estimates for global CO₂ emissions from international shipping vary substantially. The IEA fuel statistics use the first approach (bunker fuel sales) (IEA Statistics, 2009); all other estimates shown use the second (fleet activity-based models) (Corbett et al., 1999; Corbett and Koehler, 2003,2004; Endresen et al., 2003; Eyring et al., 2005b; Endresen et al., 2007; NTUA, 2008; IMO, 2009), apart from Paxian 2009, which uses the third (a geographically specific model) (Paxian et al., 2010). The variance between estimates made using the second approach is due to differing assumptions relating to parameters such as the average number of days spent at sea (Endresen et al., 2007), engine load factor, fuel consumption rate and emissions factors (Faber et al., 2009). At a global scale, modelling approach (3) can have a high degree of uncertainty due to assumptions made regarding engine workload, ship speed (Faber et al., 2009) and, more significantly, trajectories between ports (Eyring et al., 2010).

⁵ Several of the apportionment regimes that use bottom-up emissions accounting could also be calculated using top-down emission accounting, if detailed data is unavailable. The benefits and limitations of this is analysed and discussed in Section 4.1.2.

**Fig. 2.** Estimated CO₂ emissions for international shipping.

Inconsistency in global shipping emissions estimates leads to a wide range of potential values if used to apportion international shipping to nations using top-down emission accounting. This variance, along with the validity of assumptions that underpin these apportionment regimes, is an important issue for policy-makers to consider when determining the scale of a nation's international shipping emissions.

4.1.2. Challenge: data availability and quality

Referring to the regimes numbered in Table 1, the data required for apportionment regimes 4, 7, 8 and 9 would require actual reported fuel consumption, which is not publicly available. The CCC recommended that the UK Government collaborate with the EU and industry for improved access to fuel data for the benefit of underlying emission estimates (CCC, 2011). Despite this proposal, fuel data do exist. Vessel masters monitor fuel consumption in order to plan voyages and fuel uptakes, although ship operators are not at present obliged to disclose the amount of fuel consumed during journeys (Bäuerle et al., 2010). Furthermore, actual fuel consumption data are recorded in vessel logbooks, but reporting this information is not mandatory. The bunker fuel delivery note, mandated by the MEPC under MARPOL Annex VI to detail the quantities of fuel oil delivered to and used by vessels (MEPC, 2006), could provide a means to report fuel consumed. However, according to industry stakeholders, there are often discrepancies between recorded bunker fuel sales and actual consumption as stated on delivery notes. Potential schemes designed to capture actual fuel consumption data, such as the EEOI, could standardise reporting if set as mandatory by the IMO.

Table 2

Estimates for UK's share of international shipping emissions for 2006.

Apportionment regime		UK's international shipping emissions		Source
		Mt CO ₂	% of global	
1.	National GDP	41.64	4.97	(IMF, 2009)
2.	National emissions	16.37	1.95	(UNSTATS, 2009)
3.	Bunker fuel sold by the nation	7.05	1.25	(UNFCCC, 2010)
4.	Shipping activity within a nation's territorial waters	–	–	
5a.	Flag of a vessel	11.65	1.39	(UNCTAD, 2007)
5b.	Ship owner	22.91	2.73	
6a.	The amount of freight tonnes loaded at the nation's ports (only)	24.28	2.90	(UNCTAD, 2007; EUROSTAT, 2010)
6b.	The amount of freight tonnes unloaded at the nation's ports (only)	40.55	4.84	
7.	The port of departure or destination of the freight	–	–	
8a.	The nation exporting the freight	31.40	3.75	(UN Comtrade, 2010)
8b.	The nation importing the freight	42.05	5.02	
9.	The owner of the freight	–	–	

Before this becomes workable, an agreement would need to be reached amongst the parties concerned as to whom this data should be reported and how it would be used. One option is to place the responsibility with port authorities, thereby allowing national governments access to actual fuel consumption data.

A challenge to be overcome with both the bunker delivery note and the EEOI is that they are not voyage specific. Consequently, as regime 4 concerns voyages in national waters only and regimes 7, 8 and 9 are based on voyages between two or more nations, even if fuel data are reported, greater data granularity would be required. In addition, the EEOI is only reliable if time-averaged data are captured that account for multiple voyages and a range of operating conditions. A mandatory reporting scheme has been proposed by Bäuerle et al., 2010⁶ and includes: amount, location and date of fuel uptakes; carbon content of fuel uptake; a list of ports visited and the distances between them; and fuel consumed per distance travelled. The important aspect to consider here is that the reporting mechanism must be able to distinguish what level of fuel should be apportioned to a nation if a journey consists of multiple port callings, transporting freight to a range of both coastal and land-locked nations. The reporting should also account for transshipment, where freight is transferred between two or more vessels – or modes of transport – before reaching its final destination, again to ensure the correct level of emissions are apportioned to the nation in question. These aspects are especially important for container vessels, but less so for bulk and tankers etc, where the trade is generally between two nations.

If actual fuel reporting is not used, apportionment regimes 4, 7, 8 and 9 require detailed and time-intensive bottom-up accounting methods to estimate emissions using distance travelled. Such an accounting method could in principle be developed using the ship movement and engine characteristic data collected by Lloyd's List Intelligence, although these data are costly. Additional approaches for distance monitoring based on AIS and LRIT have been outlined by Bäuerle et al. (2010). However, according to some stakeholders, it is unlikely that sovereign nations will accept estimates of their share of international shipping emissions based on the outputs of computer models. On the other hand, models could be used to validate or even to encourage the reporting of fuel consumption data. This would also help to avoid false reporting when disclosing fuel consumed and distances travelled.

Regime 8, nation importing or exporting the freight, would require data to be reported on freight movement activities

between nations and the nature of the relationship between freight movements and CO₂ emissions to be established. In the EU, national customs officers already record data for imported and exported goods that transfer through their port facilities (Bäuerle et al., 2010). In theory, there is sufficient data to identify the distance the freight has travelled, its weight and the departing and arriving vessels. However, until legal issues relating to propriety are resolved, it is not possible to determine emissions using this regime.

4.1.3. Example: UK shipping emission estimates

An example of the variance resulting from apportioning responsibility for emissions from global international shipping activity using different regimes is presented in Table 2 for the UK.⁷ To compare regimes, the most recent, comprehensive estimate of international shipping emissions, the IMO's fleet activity estimate (IMO, 2009), is adopted for use in all apportionment regimes that require top-down accounting.

The 'national shipping' emissions estimates in Table 2 range from around 7 MtCO₂ for regime 3 (current reporting approach) to around 42 MtCO₂ for apportionment based on freight imported to the UK (regime 8b). A similar exercise undertaken recently by the CCC estimates the range to be 12 to 16 Mt⁸ CO₂ (CCC, 2011). This table highlights that relying on bunker sales to estimate international shipping emissions is a questionable basis for determining cross-sector emission budgets and mitigation targets commensurate with 2 °C.

Fig. 3 compares the total UK emissions inventory split by sector, depending on whether the proportion of total emissions from shipping is apportioned on the basis of bunker sales (on the left) or freight imported to the UK (on the right). If the UK were to unilaterally adjust its carbon budgets to include emissions from international shipping and aviation, as currently being debated by the CCC⁴, then the national emissions inventory would increase to 597.48 Mt CO₂ (7.7 % increase) UNFCCC (UNFCCC, 2010) using

⁷ Alternative top-down emission accounting methods with appropriate scalars are used for apportionment regimes 5, 6 and 8, as the data required for detailed bottom-up emission accounting is unavailable. It is not possible to use an alternative top-down accounting method for apportionment regimes 4, 7 and 9, therefore no emission estimates are calculated.

⁸ The lower estimate in the CCC's range is based on a bottom-up emissions accounting method for ships calling at UK ports (with adjustments for transshipment), the distance travelled by these ships and their carbon intensity – similar to apportionment regime 7 in Table 1. The upper estimate is based on a top-down emissions accounting method using freight unloaded is similar to apportionment regime 6 in Table 1. However, it is lower than the upper estimate in Table 2, as it is adjusted to account for the difference between average UK and global shipping distances.

⁶ Proposed in an outline for the integration of marine transport into the EU-ETS.

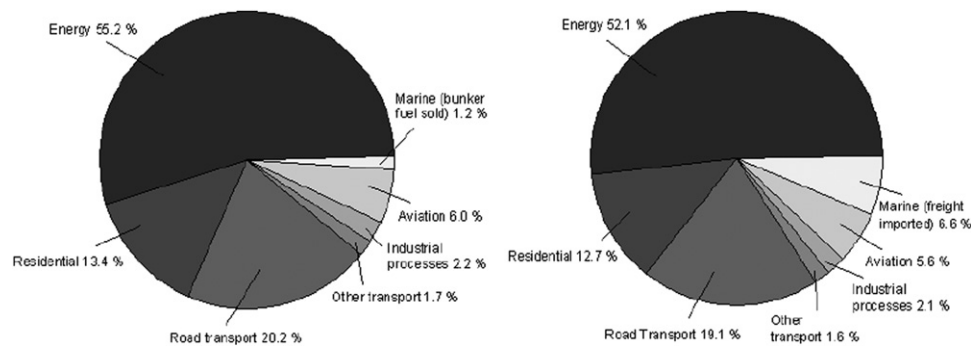


Fig. 3. UK sectoral split of CO₂ emissions, apportioning international shipping emissions using bunker fuel sold (left) and freight imported (right). Total national emissions are 597.48 Mt CO₂ and 632.48 Mt CO₂ respectively.

marine bunker fuel sales and to 632.48 Mt CO₂ (14 % increase) using the freight imported apportionment regime presented here.

4.1.4. Challenge: use in monitoring policy measures

Since there is a notable absence of transparency in the shipping data currently available, it is attractive to use top-down emission accounting to apportion international shipping emissions (Table 2). However, many do not encapsulate enough information for monitoring the success or otherwise of mitigation policy. For instance, a top-down emission accounting method based on value or weight of imports and exports could be used for regime 8, and provide an estimate for 'national shipping' to compare with other sectors, but it would not capture improvements in voyage optimisation, ship energy efficiency or port congestion over time. Furthermore, as profit is not necessarily proportional to shipping emissions, nor is it proportional to the value of the goods shipped, the value alternative also has limited use. To be useful for policymaking purposes, a viable regime must include a measure of the tonne-kilometres (tkm) moved between nations (or in a nation's waters) or actual fuel consumed and annually updated emission factors for vessels in gCO₂/tkm. The tonne-kilometres parameter can be derived either from tonnes of freight loaded/unloaded at ports and the distance between the ports (regime 6), or from the freight traded between nations, including landlocked nations, and the approximate seafaring distances between these nations (regime 8). This type of indicator could then be used to determine where improvements could be made to the efficiency of shipping routes, the distance travelled, congestion and so on.

Apportionment regimes may be a useful measure for providing an estimate for 'national shipping' emissions to compare with other sectors of the economy. However, specific methodological and practical limitations underpinning their inability to monitor change or being attuned to the relevant outcome in terms of technical or operational efficiency, highlights the importance of finding other suitable indicators that can be readily gauged. Arguably, if wishing to impose sub-global policy measures to urgently tackle shipping emissions, attention needs to be turned towards aspects of the shipping system that can be influenced.

5. Sub-global influence on shipping emissions

Apportionment regimes are likely to be inadequate for informing national policymaking aimed specifically at reducing shipping emissions if:

- (i) They do not capture those aspects of the shipping system over which a nation, region or even an organisation has influence;

Table 3

Aspects of the shipping system and gauge of influence of nations.

Aspect of shipping system	Potential for national policies to influence this aspect		
	Strong	Medium	Weak
Main engine fuel type		✓	
Auxiliary engine fuel type	✓		
Quantity of fuel sold			✓
New ship designs using alternative fuel sources or propulsion			✓
Fuel efficiency of main engine			✓
Fuel efficiency of auxiliary engine			✓
Efficient ship design		✓	✓
Efficient ship retrofit		✓	
Efficient ship building processes		✓	
Efficient ship routing/driving		✓	
Efficient operations in national waters	✓		
Efficient port operations	✓		
Efficient use of journey or ship (e.g. high load factor)		✓	
Flag of vessel			✓
Vessel owner			✓
Vessel operator			✓
Efficient crew management			✓
Number of journeys	✓		
Quantity of freight imported/exported	✓		
Value of freight imported/exported	✓		
Ultimate destination or origin of imports/exports	✓		
Freight owner		✓	

- (ii) They are insufficiently sensitive to the effects of mitigation measures, or do not permit tracking and monitoring of these effects on an ongoing basis.

This section identifies aspects of the shipping system that can be influenced at a sub-global scale and goes on to consider how this influence could be monitored or gauged.

5.1. Stakeholder assessment of policy influence

Table 3 lists various aspects of the shipping system and gives an indication of the extent to which they are amenable to influence from sub-global-level policies. While global measures are argued by stakeholders to be preferable for influencing some aspects of the shipping system such as ship design, here it is argued that in other areas down the supply chain the IMO has less influence over, and nations or regions are better positioned to intervene. Moreover, the challenges posed by the deadlock surrounding 'No More Favourable Treatment' and CBDR at the international level could be overcome. This assessment is based in

part on stakeholder workshops and engagement conducted under the EPSRC 'High Seas Project' (Gilbert et al., 2010).

Table 3 shows that some aspects of the shipping system lend themselves more readily to being influenced at a sub-global scale than others. These aspects over which nations or organisations within nations can have a strong and direct influence are generally related to the movement of freight, operations in national waters and ports and to a lesser extent, the type of fuel sold by a nation. They in general have a consumption-related or operational rather than a technological focus, although some technologies related to operations, such as developing renewable energy supply for cold ironing, would clearly require national intervention. This is not to say that technological development is outside the scope of influence of nations. For example, if stringent and consistent sub-global policies aimed at the consumption or operational level are adopted by multiple nations, then this could have an indirect influence on technological innovation.

5.2. Potential for policy intervention and monitoring

If it were accepted that in the short-term, individual nations or sub-global policies in many parts of the world have limited direct influence over technological developments within shipping, then policy measures at the sub-global scale would do well to focus on how to influence and improve the carbon intensity and absolute carbon emissions associated with shipping goods for national consumption. Policies aiming at reducing the carbon intensity would not generally require an apportionment regime, as indicators like the fuel consumed per tonne-km, if reported as ships dock, would be sufficient to monitor the success of mitigation measures put in place. Consequently, policies such as an efficiency standard per journey enforced at ports or borders⁹ could incentivise a reduction in port congestion, more efficient manoeuvring in ports, more efficient routing and slow steaming. Again, if stringent standards are adopted by multiple nations, this could also increase the indirect influence over technological development. However, care would need to be taken to ensure that perverse incentives do not occur. For example, ships off-loading goods onto higher carbon intensity forms of transport at ports without such standards would avoid being penalised but as a result likely increase the absolute level of emissions. A combination of regional (eg EU-wide) policies, coupled with the inclusion of road-freight within national carbon targets, as is the case within the UK, could overcome this avoidance problem. Furthermore, if set under national jurisdiction and enforced within ports, the measure would not necessarily need to abide by 'No More Favourable Treatment' and could potentially differentiate between goods traded with non-Annex 1 and Annex 1 nations.

Employing policies that tackle the carbon intensity or absolute emissions within national waters could influence improvements to the operational fuel efficiency of the vessels and the amount of fuel consumed by a ship operator. Policies could involve monitoring the efficiency of ships entering a nation's ports using something similar to the Environmental Ship Index (International Association of Ports and Harbours, 2010) and incentivise efficient ship choice by those with a significant proportion of operations in those national waters. In this case, apportionment regime 4 could be a useful indicator of success.

Influencing the absolute carbon emissions associated with imports and exports could, in addition to directly and indirectly addressing efficiency, involve policies that aim to change the

origin and destination of goods in order to reduce the length of journey. They may also involve policies to alter the type and level of consumption. Although there is no evidence to suggest that national legislation is exploring this route explicitly, organisations with international supply-chains could use their influence in this way to reduce overall supply-chain emissions. In these cases, apportionment regimes 6, 7, 8 and 9 could provide useful indicators of mitigation measures, if sufficient data were publicly available.

5.3. To apportion or not to apportion? – Revisited

The quantitative analysis and stakeholder viewpoints presented in this paper suggest that gathering detailed, accurate and annual greenhouse gas emissions data sufficient to support the apportionment regimes currently has significant limitations, particularly if wishing to monitor the success of mitigation policies. Thus a valuable first stage would be to explore what can be influenced at a national or regional scale and to develop indicators that can be used to monitor the progress of mitigation policies. For example, establishing mechanisms for the reporting of 'in-port' or 'national waters' fuel consumption, km travelled or time spent in port or national waters would start to provide a baseline from which to monitor changes in the carbon efficiency of operations. Beginning the process of policy development immediately through data gathering and emission monitoring would be highly desirable given the urgency with which emissions from all sectors need to be tackled, and the current barriers to agreeing stringent mitigation policies at an international level.

6. Conclusions

Mitigation policy commensurate with a high chance of avoiding 2 °C is absent from most sectors, and shipping is no exception. Despite being the most efficient mode of freight transport, shipping is projected to increase the amount of greenhouse gases it produces over the coming decades due to growth of the industry and incremental efficiency improvements. Given the size of emission cuts necessary across all sectors to avoid a high probability of dangerous interference with the climate system, the shipping sector, alongside others, needs to urgently adopt policies with an aim to fully decarbonise before 2050.

There is a strong preference for global-scale mitigation policy for shipping among industry stakeholders, typically premised on shipping's inherently international nature and the contention that sub-global policies will be ineffective compared with global equivalents. Although the IMO is exploring measures to tackle shipping emissions, slow progress to date has led the EU to announce its intention to introduce such sub-global policies by 2013. The global and complex nature of the shipping industry will likely require a range of global policy solutions, but this paper argues that this does not preclude complementary and more swiftly-implemented sub-global measures for reducing shipping emissions if a high chance of 2 °C is to be avoided. Indeed some aspects of the shipping system are more directly influenced at a national rather than global level; those most suited to national policy intervention include amount, source and destination of freight imported and exported, and the efficiency of operations and technologies used within national waters and at national ports. Nations could also indirectly influence technological innovation if sub-global policies are adopted across multiple nations.

Sub-global mitigation policies aimed at shipping are generally assumed to require apportionment regimes to allocate an appropriate share of global international shipping emissions to nations. The wide range of apportionment regimes available results in

⁹ Land-locked nations could also influence carbon-intensity associated with the transportation of goods if controls are set at borders in relation to imported goods. This would likely have World Trade Organisation or EU free trade implications.

significant variance in the estimates for national-level shipping emissions. Compounding this, poor data availability and a high data cost for making detailed bottom-up estimates of 'national shipping' emissions limit their applicability at present. Although simplified top-down methods can be used to estimate emissions, these are currently only useful for comparing shipping emissions to other sectors, as they do not enable any monitoring of mitigation policy success over time. Thus the aspects of the shipping system over which national or sub-global policy may have influence, are not sufficiently captured by existing regimes. Nevertheless, metrics out with the need for apportionment, such as 'in-port' or 'national waters' fuel consumption, km travelled or time spent in port or national waters could provide a data baseline.

The urgency with which emissions from all sectors need to be addressed to remain commensurate with a 2 °C goal requires the full span of policy options to be explored. Debate surrounding apportionment has arguably compounded ongoing disagreements between IMO member states diverting the attention of policy-makers away from in-depth consideration of sub-global mitigation policies aimed at shipping. But, if avoiding 2 °C is to remain high on the EU's and UK's agendas, a fresh approach to the debate is needed. For as long as meaningful global-scale policies remain in the wings, complimentary direct and indirect measures that can immediately send the right signals to the shipping sector require consideration at a sub-global scale. Whilst recognising the importance of the principal of 'No More Favourable Treatment' for shipping, drivers for change are needed urgently, and require actors from all aspects of the system, including retailers, to play a role. The analysis in this paper argues for policymakers and organisations to consider the influence they may have over aspects of the shipping system, the implications of measures that could be employed to control emissions, and how success could be monitored.

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