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The potential contribution of the shipping sector to an efficient reduction of global carbon dioxide emissions

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ABSTRACT

In this paper, we analyze how much the shipping sector could contribute to global CO_2 emission reductions from an efficiency point of view. To do this, a marginal abatement cost curve (MACC) for the shipping sector is generated that can be combined with a MACC for conventional CO_2 abatement in the production and consumption sectors around the world. These two MACCs are used to assess the following as regards the various global reduction targets: (a) what the maximum global cost savings would be that could be achieved by abating emissions in the shipping sector, (b) how much the shipping sector could contribute to abating emissions cost efficiently, and (c) what the potential additional costs of implementing a separate solution for the shipping sector would be. The focus is on the year 2020. We find that the shipping sector could always contribute to efficient global emission reductions and thus could always achieve global cost savings, but also that the size of the contribution and the size of cost savings depend heavily on the MACC case assumed, i.e., on how the existence of negative abatement costs is treated in a MACC, and on the reduction potentials and costs of measures assumed.

1. Introduction

The shipping sector contributed 3.3% to global GHG emissions in 2007 and its CO_2 emissions are projected to increase significantly in the coming decades (Buhaug et al., 2009). Discussions on how to regulate the shipping sector's CO_2 emissions center around the question whether this sector should be subject to an emission cap or whether it should be subject to some other means of reducing emissions (UNEP, 2011). Progress was made when the International Maritime Organization (IMO) agreed on two mandatory efficiency measures in July 2011 (MEPC, 2011): the Energy Efficiency Design Index (EEDI), which is exclusively for newly built ships, and the Ship Energy Efficiency Management Plan (SEEMP). Market-based policies for the shipping sector are also being discussed and investigated (MEPC, 2010).

While there is some literature on the pros and cons of different allocation options to allocate shipping emissions to countries and on their effects for specific country groups (den Elzen et al., 2007; Gilbert and Bows, 2012; Heitmann and Khalilian, 2011; Wang, 2010) and some literature on technical abatement potentials and the costs of different measures (Buhaug et al., 2009; Eide et al., 2011, 2009; Faber et al., 2011a; Wang et al., 2010; Faber et al., 2009; Longva et al., 2010; Miola et al., 2011, 2010), the literature on how much the shipping

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sector should contribute to global emission reductions from an efficiency point of view remains limited. Only Eide et al. (2009) derive a decision criterion that is in line with the 2 °C target. Yet, the importance of regulating CO_2 emissions in the shipping sector can only be assessed, when the potential cost savings are known. In this paper, we thus want to address this issue.

From a methodological point of view, the problem is that approaches like global top-down economy-climate models or integrated assessment models (IAMs) that are able to analyze the cost-efficient contributions of various sectors do not or do not explicitly include the shipping sector. Another approach, which is less sophisticated and simpler, to include the shipping sector is using marginal abatement cost curves (MACCs) (see Criqui et al., 1999; Ellerman and Decaux, 1998). Generally, MACCs show how many emissions a country or a sector can reduce confronted with a given price per emission. Put differently, they provide a mathematical relationship between the level of abatement and the associated costs. These relationships can be derived from different types of numerical models or alternatively from expert knowledge on the abatement potential and costs of different specific abatement options (see e.g., Kesicki and Stachan, 2011). MACCS are used in particular to analyze the impacts of international emission trading at the country level (see, e.g., Ellerman and Decaux, 1998; den Elzen et al., 2005; Löschel and Zhang, 2002; Rickels et al., 2012), but can also be used to calculate sectoral contributions to emission reductions. While using MACCs has some drawbacks and results have to be treated with care (Kesicki and Ekins, 2012; Kesicki and Stachan, 2011; Klepper and Peterson, 2006; Morris et al., 2012), MACCs can nevertheless provide an indication of the cost-efficient contributions of various nations/sectors to emission reductions.

Thus, we use information on abatement costs and potentials for the shipping sector that is available in the literature (Buhaug et al., 2009; Eide et al., 2011; Faber et al., 2011a; Wang et al., 2010; Faber et al., 2009) to generate a global MACC for the shipping sector. This MACC is than compared to a MACC for conventional CO_2 abatement in the production and consumption sectors around the world derived from a global CGE model following the same general approach as in Rickels et al. (2012). We then use these two MACCs to assess for various global reduction targets: (a) the maximum global cost savings that could be achieved by emission abatement in the shipping sector, (b) the cost efficient abatement contributions of the shipping sector to the global reduction targets, and (c) the potential additional costs that would be incurred by implementing a separate solution for the shipping sector. We focus on the year 2020.

This paper is structured as follows. Section 2 provides some background information on the shipping sector, gives an overview of existing MACC studies, and discusses the methodological challenges that arise when using an expert-based cost assessment in combination with MACCs generated by a top-down model. The main challenge is how to treat the negative abatement costs that are found in the MACC studies of the shipping sector. We discuss how these negative abatement costs can be interpreted and suggest two different approaches to deal with them in our context. Section 3 shows how the computable general equilibrium (CGE) model DART (Dynamic Applied Regional Trade) can be used to generate a global MACC, excluding the shipping sector, and a corresponding marginal abatement cost function. Section 4 describes two global emission reduction scenarios and presents the model results for these scenarios, in particular, the efficient contribution of the shipping sector and the global cost savings. Section 5 discusses the results and Section 6 summarizes and concludes.

2. Generating a marginal abatement cost curve (MACC) for the shipping sector

2.1. *Overview of existing studies*

There are four major expert-based studies on the marginal abatement costs and reduction potentials of the world fleet (Buhaug et al., 2009; Eide et al., 2011; Faber et al., 2011a; Wang et al., 2010,[1] and Faber et al., 2009), which are also reviewed by Faber et al. (2011b). Table 1 presents an overview of the assumptions and results of these studies for the year 2020, which is in the focus in our analysis.[2] It shows in particular that the maximum abatement potential of the world fleet is large (about 15–40% relative to business-as-usual (BAU) emissions) and that without any further regulation, between 255 Mt CO_2[3] and 340 Mt CO_2 or 20% and 26% of projected emissions can be abated at negative cost in 2020.

The studies include only measures for which costs and abatement potential estimates exist (e.g., Faber et al., 2011a; Wang et al., 2010), which is not always the case. They do account for the fact that some measures may be mutually exclusive (Faber et al., 2011a), which allows the generated curves to be interpreted as MACCs, which they are not in the narrower sense, since they only calculate the average cost per ton abated and not of the marginal (last) ton abated.

According to the literature (Eide et al., 2011; Faber et al., 2011a), abatement measures can be categorized into operational and technical measures, structural changes, and alternative fuels/power sources, differing, e.g., in terms of costs and implementation. Operational measures mainly concern the operation and maintenance of ships and are characterized by low investment and moderate operating costs, and low abatement potential. Technical measures mainly concern technical design features of ships and are characterized by high investment and moderate operating costs. Structural changes and alternative fuels/power sources are characterized by high abatement potential, but at the same time are limited in application, e.g., because there is a lack of mature infrastructure for liquefied natural gas, or are difficult to develop.

[1] Note that Faber et al. (2011a) is an updated version of Wang et al. (2010), but that only the later provides data that we make use of in this paper.

[2] Faber et al. (2009) present a MACC for the year 2030 that is not included in Table 1.

[3] This number represents the central estimate of cost-effective potential (<0$/t) in Buhaug et al. (2009).