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Adapting the shipping sector to stricter emissions regulations: Fuel switching or installing a scrubber?

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A R T I C L E I N F O

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A B S T R A C T

This paper examines how the existing fleet in the shipping industry can be adapted to the new emission regulations through the two main techniques that currently exist: (a) the use of low-sulphur marine diesels; and (b) the installation of scrubbers. A method is presented here for drawing up an economic assessment of both these techniques under uncertainty. It enables the best option to be selected at any given time taking into account fuel prices (spot and futures), scrubber installation costs, the time that the vessel operates in an Emission Control Area (ECA) and the remaining useful lifetime of the vessel. The paper also considers the possibility of an unexpected change from a non-ECA navigation area to an ECA. The assessment is carried out in a manner consistent with marine diesel and crude oil spot and futures market quotes. Our results show the net present value of investing in the installation of scrubbers and investing in changing fuel types for different assumptions on how vessels are operated. We also analyse increases in fuel consumption and CO_2 emissions as a consequence of using scrubbers and how they affects the financial analysis if such incremental emissions must be paid under a CO_2 pricing mechanism.

1. Introduction

Maritime transport has increased significantly over the past 40 years in terms of both volume and the number of ships operating. This growth has been driven by an increase in the demand for transportation in an ever-more globalised economy. In fact the shipping industry is responsible for carrying about 90 per cent of world trade (ICS, 2014).

According to the International Chamber of Shipping (ICS, 2014), the forecast is for around 17 billion tonnes to be carried in 2030, while Global Marine Trends 2030 forecasts that the volume of seaborne trade will double from nine billion tonnes to around 20 billion tonnes by the same year.

The trends denote a continued increase in both seaborne trade and the size of the worldwide fleet. This increase in demand affects the consumption, availability and price of marine fuel (UNCTAD, 2016).

Note that fuel consumption is a factor in the shipping industry mainly because it is the largest cost item in the operational expenses (OPEX) of a vessel. Up to 50 per cent of the cost of a voyage is accounted for by fuel costs (Bialystocki and Konovessis, 2016; Stopford, 2009; Ronen, 2011). Fuel consumption in this sector is also an important driver of air quality and greenhouse gas (GHG) emissions.

Fig. 1 shows the estimated fuel consumption of the world fleet resulting from different activity-based estimates and statistics

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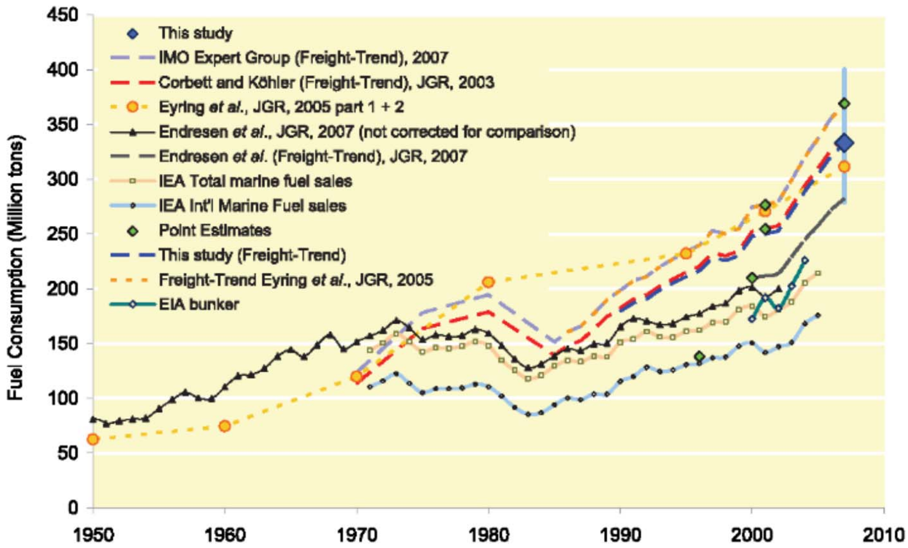

Fig. 1. Worldwide fleet fuel. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
Source: IMO, 2009, Second IMO GHG Study 2009, under IMO authorisation. "Symbols indicate the original estimates for individual years and the solid lines show the original estimates of trend. Dashed lines show the backcast and forecast, calculated from the time evolution of freight tonne-miles with the point estimates. The blue square shows the activity-based estimate from IMO (2009) and the blue range bar indicates the high and low bound estimates."

Table 1
CO_2 emissions from different modes of transport..
Source: own work based on the following data: http://www.worldshipping.org/industry-issues/environment/air-emissions/carbon-emissions and http://fluglaern.de/hamburg/klima.htm

Mode of Transport	CO_2 emissions
Aircraft	450–500 g
Truck	60–150 g
Train	30–100 g
Ship	10–40 g

(Corbett and Köhler, 2003; Eyring et al., 2005; Endresen et al., 2003; IMO, 2009). These estimates show a high degree of uncertainty depending on the source of the study and the methods used. Two main approaches are used: (1) based on activity data (bottom-up approach); and (2) based on fuel statistics (top-down approach).

Fuel consumption in the shipping industry is, as in other sectors, closely related to emissions into the atmosphere. Indeed, it has been suggested that the international fleet contributes significantly to global anthropogenic emissions (Endresen et al., 2003). Its key emissions are of carbon dioxide (CO_2), nitrogen oxides (NO_x), sulphur oxides (SO_x) and volatile organic compounds (Hydrocarbons). These pollutants are related to climate change and health problems, as well as to localised ocean acidification and fertilisation (Hassellöv et al., 2013; Fuglestvedt et al., 2009). The adverse health effects of air pollution include premature mortality due to cardiopulmonary diseases and lung cancer (Silva et al., 2016).

The shipping industry accounted for about 4 per cent of global CO_2 emissions in 2007 (Reynolds, 2009), 2.8 per cent of the world's total GHG emissions in 2007 and 2.2 per cent in 2012 (ICS, 2014). The 3rd IMO GHG study (IMO, 2014) recognises that maritime transport emits around 1000 million tonnes of CO_2 annually and is responsible for about 2.5% of GHG emissions. Maritime shipping is by far the most carbon-efficient form of trade (see Table 1).

Table 1 below shows the amount of CO_2 in grams emitted per metric tonne of freight and per kilometre of transportation.

The International Maritime Organisation (IMO) is a specialised agency of the United Nations in charge of the safety and security of shipping, and of preventing marine pollution by ships. One of its main roles is to implement and review international conventions for shipping. The most important international convention related to environmental quality in the shipping sector is the International Convention for the Prevention of Pollution from Ships (MARPOL).

As these regulations become stricter with respect to emissions, the shipping sector is considering all its fuelling options. These include changing to low sulphur marine fuels, LNGs or biofuels, or even retrofitting their vessels and installing scrubbers[1] (Boer and Hoen, 2015). Adopting scrubbing technology enables sulphur oxides (SOx) and particulate matter (PM) to be removed. In this paper

[1] Scrubbers are air pollution control devices that remove particulates and/or gases from exhaust streams.