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Effect of a speed reduction of containerships in response to higher energy costs in Sulphur Emission Control Areas

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ABSTRACT

The objective of this paper is to explore the possible consequences of the future low-sulphur fuel requirements in Sulphur Emission Control Areas (SECA) on vessel speed, from the standpoint of the container shipping industry. Rational energy use, speed reduction, and revenues are closely related in the container shipping sector because speed reductions may provide substantial energy and cost savings. The operators could consider reducing their speed in SECA in order to save on fuel that will become relatively expensive. However, to maintain a weekly frequency without adding new ships, such a behaviour implies that the required speed at sea outside the SECA area increases. This paper aims to investigate if such a difference in speed is cost-effective, and if the increase in speed outside SECA may result in an increase in CO_2 emissions of the total cycle. We propose a cost model that estimates the cost-minimising combination of speeds inside and outside SECA, and the resulting CO_2 emissions of the liner service. Applying this model to representative liner services serving North Europe, we find that differentiating speed accordingly slightly decreases total costs and increases CO_2 emissions in a similar way. The results are sensitive to the price of low-sulphur fuels, the part of the cycle in SECA and the number of ships deployed in the service.

1. Introduction

The speed of ships has been shown to be a major variable for both shipping costs and emissions. Energy costs, speed reductions, and revenues are closely related because energy is an important cost item to operators and because speed reductions may provide substantial energy savings (Corbett et al., 2009). With rising bunker costs and increased emphasis on environmental issues, the question of optimal speed has received a growing interest with a number of speed models developed in the literature (Psaraftis and Kontovas, 2013). Some of these models explore the relationship between fuel price and profit-maximising (or cost-minimising) speed (see e.g. Ronen, 2011; Corbett et al., 2009), or evaluate the effects of CO_2 reduction policies like mandated speed reductions and carbon taxes on speed, costs and emissions (see e.g. Corbett et al., 2009; Cariou and Cheaitou, 2012).

The objective of this paper is to examine the possible consequences of Sulphur Emissions Control Areas (SECA) on vessel speed, from the standpoint of the container shipping industry. The International Maritime Organisation (IMO) has

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established regulations in recent years to reduce emissions of sulphur oxides (SO_x) by lowering the sulphur content of marine fuels. Annex VI of Marpol sets a global limit of 3.5% of sulphur content for marine fuel oil, and defines Sulphur Emission Control Areas (SECA) where ships are required to use low-sulphur marine fuel oil not exceeding 1.0% of sulphur content. From 2015, the threshold in SECA will be lowered to 0.1% and this is expected to considerably increase bunker costs. The questions that this paper sets out to answer are the following: can speed reduction in SECA help mitigate the higher energy costs within these areas? What are the consequences of such a behaviour on: (i) speed in the non-SECA leg, (ii) emissions of the entire cycle?

The paper is organised as follows. Section 2 formulates the problem and presents the results of academic works in this field. Section 3 proposes a cost model for a shipping company operating a liner service that includes a SECA. This model determines the combination of cost-minimising speeds (speed in the SECA and speed outside the SECA) and the corresponding quantity of CO_2 emitted. The last section applies the model to some representative liner services serving North Europe and provides estimates of the total costs and CO_2 emissions resulting from speed reductions in SECA, then draws conclusions.

2. Formulation of the problem

2.1. Reducing SO_x emissions: a policy impacting on the price of energy in certain areas

Maritime transport is a heavy contributor to SO_x emissions due to the nature of fuel used by ship engines; that is, mainly Heavy Fuel Oil (HFO) with a high sulphur content. The substitution of fuels with maximum sulphur content of 0.1% within SECAs from 2015 implies that vessels will have to use primarily Marine Gas Oil (MGO), which is a distillate fuel. It is more expensive than HFO, depending on the method of production and the market supply and demand.

Annex VI also allows the use of alternative compliance methods with equivalent reduction effects. The SECA requirements could be met by continuing to use cheaper high-sulphur fuels with exhaust gas cleaning equipment or by using liquefied natural gas (LNG), an alternative fuel that has no sulphur content. The first option involves installing a scrubbing system on the ship that removes the sulphur oxide compounds from exhaust. The second option requires the installation of engines powered by natural gas, stored on board as LNG. The main drawbacks of the first option are the lack of data on the reliability of this technology to meet SECA requirements and the high capital costs. The mains concerns related to LNG-powered ships are the need for a LNG supply infrastructure in ports and the higher capital costs of this type of propulsion.

MARPOL Annex VI thus induces “the introduction of unilateral approaches and a relative distortion of the global maritime market” (Schinas and Stefanakos, 2012) since the SECA regime implies that environmental rules are not the same everywhere. Ship operators are faced with higher energy costs or the introduction of advanced technology in specific areas. Given the limitations of the alternative compliance methods (scrubbers and LNG propulsion), several studies highlight that using low-sulphur fuel is the most immediate compliance means (Sweco, 2012; AMEC, 2013). We assume in this paper that most ships in the short term will switch to MGO in the SECAs.

2.2. An incentive to differentiate speed?

Containerships are among the top fuel-consuming ships and hence air polluters, due to their high service speed. In 2007, they represented 4% of the total fleet while producing 22% of CO_2 emissions from international shipping (Corbett et al., 2009). Container vessels sail on closed routes and observe fixed schedules. As explained by Ronen (2011), “a route is a specified sequence of calling ports that each containership assigned to that route repeats on each voyage. [...] Due to customer service and competitive considerations most routes provide at least weekly service to each calling port, where a ship calls at a specific port on a given day of the week. Most containership routes take from a few weeks up to a few months to complete and in order to provide a weekly service they require multiple vessels to operate on the route with weekly phasing between them. Thus, a route that takes 6 weeks and provides a weekly service will require six vessels to operate it.”

Fuel consumption is very sensitive to the sailing speed, as the daily quantity of fuels consumed by a motor ship is approximately proportional to the third power of its sailing speed. In addition, bunker cost accounts for a significant proportion of the total costs. For these reasons, the sailing speed of containerships has a large impact on the total costs (Wang and Meng, 2012). The sailing speed also has an impact on the cycle time. When ships reduce their speed, the cycle time is obviously increased, and additional ships are required on the cycle as the liner shipping companies generally provide a weekly frequency. As a result, reducing speed implies lower bunker costs, whereas the additional containerships needed to provide weekly frequency generate additional costs.

In the literature, a number of papers have investigated the optimisation of speed for liner shipping services with different objectives and constraints. Psaraftis and Kontovas (2013) provide a comprehensive literature review of speed models in maritime transport and propose a taxonomy of these models according to a set of parameters. The trade-off between reducing speed and adding ships to maintain the service frequency and capacity has been explored by Ronen (2011), who proposes a procedure for determining the sailing speed and the associated fleet size that minimise the annual ship operating costs of a single containership route. Wang and Meng (2012) broaden this issue by taking into account the whole liner shipping network. Corbett et al. (2009) examine the policy impacts of a fuel tax and a speed reduction mandate on CO_2 emissions, considering a scenario with lower speed without additional vessels (and thus less frequent arrival) and a scenario assuming