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The effectiveness of a European speed limit versus an international bunker-levy to reduce CO_2 emissions from container shipping

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ABSTRACT

In the fight to reduce CO_2 emissions from international shipping, a bunker-levy is currently under consideration at the International Maritime Organization (IMO). Faced with the inability of the IMO to reach an agreement in the short term, the European Commission is now contemplating a unilateral measure of a speed limit for all ships entering European Union (EU) ports. This paper argues that this measure is counterproductive for two reasons. Firstly, because it may ultimately generate more emissions and incur a cost per ton of CO_2 which is more than society is willing to pay. Secondly, because it is sub-optimal compared to results obtained if an international bunker-levy was to be implemented. These elements are illustrated using two direct transatlantic services operated in 2010.

1. Introduction

The European Commission is beginning to think that technical measures such as the Energy Efficiency Design Index (EEDI) agreed upon at the International Maritime Organization in July 2011 will be insufficient to reach the target of a 30% reduction in Greenhouse Gas Emissions by 2030 based on the 1990 levels. It is in this general context that a new proposal for a speed limit is today finding an increasing echo. This proposal was presented by Shipping and EU Policy Adviser John Maggs who said, “a mandatory speed limit found for different ship types…can create a benefit to society without costing owners” (Lloyd’s List, 2011). In this paper, we challenge this view using the example of CO_2 emissions generated by container vessels.

Indeed, with the determination of an area within which a maximum speed is set, and given the weekly service requirements, the owner has no alternative other than to speed up vessels on the non-European leg, and therefore to increase emissions on the cycle. To illustrate this phenomenon, the paper is organized as follows. Section 2 develops a general profit maximization model for a shipping company operating an intercontinental liner service from which the corresponding quantity of CO_2 emitted can be retrieved. It also presents the anticipated impact of a bunker-levy versus a speed limit. Section 3 provides estimates on the optimal choice regarding the speed and fleet size using the example of two transatlantic liner services which operated in 2010. It also provides a comparison of the impact on the owner’s choice of these measures and on the corresponding amount of CO_2 emitted. The last section provides conclusions.

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2. Model

The model sets out to represent the impact that a European speed limit versus a bunker-levy will have on a liner shipping company's optimal choice of speed and fleet size. This choice is based on the total daily profit expected for a return service sailing between two ranges of ports, A and B. We assume a direct line-bundling service (Cariou and Notteboom, 2011) with a total intercontinental distance per cycle (in nautical miles) between the last and first ports of call, D, of twice the one-way distance ($D_{\mathrm{AB}} = D_{\mathrm{BA}}$). Furthermore, whatever the chosen speed, a weekly frequency at each port of call is required and the number of vessels should be adjusted accordingly (Ronen, 2011). Finally, three types of products are transported, dry (dr) products in dry containers and frozen (Z) and fresh (F) products in reefer (R) containers. The model parameters can be defined as follows.

2.1. Model Parameters

- Δ: set of product categories, indexed with j, with $\Delta = \{dr; Z; F\}$,
- N: number of ships in the service,
- V_i: vessel intercontinental speed $i = 0,\ldots,m$, [knots] defined within a range of feasible values (ranging from a minimum sailing speed to a maximum sailing speed),
- V^R, V^{DS}: vessel sailing speed within ranges A and B and vessel design speed respectively [knots],
- D: intercontinental distance per cycle [nautical miles],
- S: total intercontinental sailing time per cycle [hours],
- RT: total incompressible time per cycle spent in ranges A and B, including incompressible sailing time in the ranges (S^R) and incompressible port times (P) which are both constants [hours],
- T, W: total cycle time equal to $S + RT$ in [hours] and in [weeks] respectively,
- d^{jAB}, d^{jBA}: weekly demand from A to B and vice versa, with $j \in \Delta$ [Twenty-foot Equivalent Unit containers (TEU)/week],
- q^{jAB}, q^{jBA}: weekly transported quantity from A to B and vice versa, with $j \in \Delta$ [TEU/week],
- Q: total carrying capacity of the vessel [TEU],
- Q^R: total reefer (frozen and fresh) carrying capacity of the vessel [TEU],
- $Q–Q^R$: total dry carrying capacity of the vessel [TEU],
- ρ^{jAB}, ρ^{jBA}: revenue per TEU shipped from A to B and vice versa, with $j \in \Delta$ [$/TEU],
- CT_d: average daily total cost for all the vessels operating on the cycle [$/day],
- CB_d^M: average daily bunker cost for the main engine for all the vessels operating on the cycle [$/day],
- CB_d^A: average daily bunker cost for the auxiliary engine for all the vessels operating on the cycle [$/day],
- C_b^M: IFO 380cst (Intermediate Fuel Oil), used for the main engine, price [$/ton],
- C_b^A: MDO (Marine Diesel Oil), used for the auxiliary engine, price [$/ton],
- CV_d: average daily fixed cost for all the vessels operating on the cycle [$/day],
- C_v: fixed daily cost of a vessel excluding port dues [$/day],
- CD_d: average daily dry and reefer container depreciation cost for all the vessels operating on the cycle [$/day],
- dp^R: reefer container depreciation rate per day [$/day],
- dp^d: dry container depreciation rate per day [$/day],
- F^M: main engine average fuel consumption per intercontinental day at sea [tons/day],
- F^{MR}: main engine average fuel consumption per regional day at sea [tons/day],
- F^A: auxiliary engine average fuel consumption per day on the cycle [tons/day],
- $-ECO2_d^{M-AB}$ *and* $ECO2_d^{M-BA}$: average daily CO_2 emissions for the main engine for all the vessels operating from A to B and from B to A respectively [tons/day],
- $-ECO2_d^{A-AB}$ and $ECO2_d^{A-ba}$: average daily CO_2 emissions for the auxiliary engine for all the vessels operating from A to B and from B to A respectively [tons/day],
- $-ECO2_d^M$ and $ECO2_d^A$: average total daily CO_2 emissions, for the main and auxiliary engines respectively, for all the vessels operating on the cycle [tons/day],
- $-ECO2_d^T$: average total daily CO_2 emissions for the main and auxiliary engines for all the vessels operating on the cycle [tons/day].

2.2. Profit function calculation

2.2.1. Profit function

The operator aims to maximize the average daily profit of all the vessels operating on the cycle (Π) which is obtained by subtracting the total average daily cost CT_d from the average daily revenue ρ_{d}. CT_d includes the average daily bunker cost for the main and auxiliary engines (CB_d^M and CB_d^A), the average daily fixed cost of the vessels (CV_d) and the average daily depreciation cost of the containers (CD_d):

$$\Pi = \rho_d - CB_d^M - CB_d^A - CV_d - CD_d \tag{1}$$