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Views & Comments

# Implications of the EU's Inclusion of Maritime Transport in the Emissions Trading System for Shipping Companies

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## 1. Introduction

Maritime transport is the backbone of international trade. The amount of total international maritime trade in million tonnes loaded was 8408 in 2012 and had increased to 11 076 by 2019, for an average annual increase of 3.12%. In early 2020, the world fleet contained 98 140 ships of 100 gross tonnes and above with 2.06 million dead weight tonnage of capacity [1]. The greenhouse gas (GHG) emissions from shipping activities are not negligible. According to the fourth GHG study commissioned by the International Maritime Organization (IMO), in 2018, global shipping emitted a total of 1056 million tonnes of carbon dioxide ($CO_2$), accounting for around 2.89% of global anthropogenic $CO_2$ emissions [2]. Due to the international nature of shipping, efforts to control $CO_2$ emissions from ships are absent from the Kyoto Protocol and the Paris Agreement. In an attempt to phase out carbon emissions from shipping entirely, the IMO formulated a strategy to cut the total annual GHG emissions from shipping by at least 50% from their 2008 levels by 2050 [3]; however, no mandatory rules have been promulgated since the release of this strategy.

Given the insufficient progress made by the IMO, the European Union (EU) decided to take a leading role in promoting the reduction of $CO_2$ emissions from maritime transport. In 2015, the EU issued regulations on the monitoring, reporting, and verification (MRV) of $CO_2$ emissions from ships with a gross tonnage above 5000 arriving at, within, or departing from ports under the jurisdiction of an EU member state, to come into force at the beginning of 2018 [4]. It should be noted that, under the MRV regime, even if only one port on a voyage is within the European Economic Area (EEA) and the other is not (e.g., a voyage from Rotterdam directly to Singapore), the ship must still report the total $CO_2$ emissions of the whole voyage, rather than just the emissions of the part of the voyage within EU waters.

The MRV regime has been in operation for over two years, and the $CO_2$ emissions data for the 2018 and 2019 reporting periods have already been published. Based on the data collected, on 16 September 2020, the European Parliament [5] took the bold step of voting for the inclusion of maritime transport in the EU Emissions Trading System (ETS). This is a market-based system that uses economic tools such as a levy on bunker fuels and an emission trading system to provide monetary incentives for polluters to reduce emissions [6]. The European Commission is conducting an impact assessment of the ETS, the results of which are expected in 2021. At this time, it is unclear how the inclusion of shipping into the EU ETS will work. There are two possibilities. The first is that only intra-EU voyages will be included; that is, only voyages from one EEA port to another EEA port will have to pay $CO_2$ emission costs. The second is that both intra-EU voyages and voyages between an EEA port and a non-EEA port will have to pay $CO_2$ emission costs, with the cost of a voyage between an EEA port and a non-EEA port being based on the $CO_2$ emissions over the whole voyage, rather than the part of the voyage within EU waters. As the second possibility also covers the first possibility, we examine the implications of both possibilities but focus more on the second.

## 2. Current literature, implications, and academic research opportunities

### 2.1. Review of current related literature

This article mainly focuses on three areas that might be affected by imposing $CO_2$ emission costs on the maritime industry: green technology investment, transportation mode shift, and fleet deployment in the shipping network. A summary of relevant studies on these three areas is briefly presented as follows. In terms of green technology investment, state-of-the-art technologies and measures to reduce GHG emissions from shipping and their potential have been discussed by Bouman et al. [7], who proposed that there are six main groups of green technologies with investment potential: hull design, economies of scale, power and propulsion, speed, fuels and alternative energy sources, and weather routing and scheduling. Metzger and Schinas [8] introduced a novel, easy-to-use selection criterion for greening technologies in shipping by assessing the impact of financing concepts on the overall net present value of a technology. On transportation mode shift,

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Zis et al. [9] examined policy options that could mitigate or reverse the negative effects of the low-sulfur regulations imposed on maritime transport. Zis and Psaraftis [10] further modeled the modal shifts between sea and land-based transportation brought about by the low-sulfur regulations for shipping. Finally, regarding fleet deployment in the shipping network, Gu et al. [11] developed an optimization model to study the impact of the ETS on fleet composition and deployment. They concluded that, in the short term, the ETS would not lead to emissions reductions in most scenarios. Zhen et al. [12] proposed a mathematical model that incorporated green technology adoption to minimize the total operational costs of shipping by optimizing fleet deployment, sailing speeds, timetabling, cargo allocation, and berth allocation.

### *2.2. Effects of both possibilities of including shipping in the ETS on technology investment and transport mode shift*

Once the inclusion of shipping into the EU ETS is finalized (regardless of whether the first or second possibility is adopted) and comes into force, a given ship will have to pay high $CO_2$ emission costs. If the second possibility is implemented, the emission costs will be more significant. Consider a large container ship that sails from Singapore directly to Rotterdam in 21 days, burning 100 tonnes of fuel each day. Suppose that 1 tonne of fuel produces 3.17 tonnes of $CO_2$, and the carbon price is 30 USD per tonne. The $CO_2$ emission costs for the voyage will be as high as 200 000 USD. This amount is not trivial. For example, the average toll charge imposed by the Suez Canal per ship in 2019 was estimated to be 300 000 USD [13]. This high cost has led many shipping companies to choose the free Cape of Good Hope route instead, and it has been reported that the Suez Authority is set to lose over ten million USD as a result [14]. Analogously, the direct consequences of emission costs could be that ship owners and charterers choose to invest in new technologies that reduce fuel consumption, adopt cleaner fuels (e.g., methanol or hydrogen), and operate ships in more fuel-efficient ways (e.g., slow steaming).

This analysis can be mathematically presented as follows. Denote the unit carbon cost by $c$, and let $\Theta$ represent the set of technologies available, $d(\theta)$ represent the annualized fixed costs of using technology $\theta \in \Theta$, $f(\theta)$ represent the annual fuel costs of using technology $\theta$, and $m(\theta)$ represent the annual carbon emissions when using technology $\theta$. For ships sailing exclusively within the EEA, operators need to balance the tradeoff between $d(\theta)$ and $f(\theta)$ of using a technology. Once shipping is included in the EU ETS, operators will need to balance the tradeoff of three cost components. Note that a more expensive technology usually implies lower fuel costs and lower carbon emissions (otherwise, nobody would use it). Assume that only one type of fuel is consumed (with a fixed price) by a ship, and that the carbon emissions are derived from the fuel consumption. The relationship between annual carbon emissions and the total cost is therefore linear. Assume that no two technologies have the same fixed costs. For $\theta_1,\ \theta_2 \in \Theta,\ f(\theta_1) > f(\theta_2)$ and $m(\theta_1) > m(\theta_2)$ if $d(\theta_1) > d(\theta_2)$. The curves of annual carbon emissions and total costs for $\theta_1$ and $\theta_2$ can then be derived as follows (Fig. 1).

When the fuel and/or carbon price rises, the rate at which the total cost increases (including the fixed costs and the fuel and carbon costs) differs. The threshold of the annual carbon emissions of switching to a technology with a higher fixed cost but lower fuel and carbon costs decreases, which implies that more ship operators will be motived to adopt advanced technologies to reduce fuel consumption and $CO_2$ emissions. This analysis is a simplification of the reality. Further research that integrates long-term investment decisions with medium- and short-term operational decisions is required. These decision problems usually involve mixed-integer nonlinear stochastic optimization models, because investment in new technologies is a discrete decision variable, sailing speed is a continuous decision variable, the fuel consumption rate is a nonlinear function of the sailing speed, and the future unit carbon cost is random.

At the same time, it has been pointed out by researchers working on other regulatory schemes covering shipping emissions (e.g., Refs. [9,10]) that some coastal shipping services within the EEA will become less competitive as a result of the ETS, and will therefore be replaced by land-based transport modes (e.g., road or rail). As the total amount of cargo that needs to be transported is fixed and land-based transport modes produce much higher $CO_2$ emissions per unit of transport load [3], this transport mode shift would increase $CO_2$ emissions. Empirical data are therefore essential to formulate models that capture shippers' transport mode choice behavior, which will inform carriers' decisions on service design and government policy on the promotion of green transportation.

### *2.3. Influence of the second possibility of including shipping in the ETS on liner shipping service design*

If the second possibility of the ETS is implemented, we argue that, in addition to the two possible consequences of adoption of green technologies and mode shift discussed above, there are two other noteworthy potential effects on shipping companies, as illustrated in Fig. 2.

First, the Cape of Good Hope route will become less attractive to shipping companies than the Suez Canal route. Because of the high toll charges imposed by the Suez Canal, shipping companies at present often choose the free Cape of Good Hope route, as the shipping capacity is large and fuel prices are low due to the COVID-19 pandemic. However, the Cape of Good Hope route is much longer than the Suez Canal route. For instance, the distance between Rotterdam and Singapore is 8288 nautical miles (n mile; 1 n mile = 1.852 km) via the Suez Canal, and 11 755 n mile via the Cape of Good Hope. Therefore, using the Cape of Good Hope route leads to greater fuel consumption and thus to increased carbon emissions, and carries a higher cost. This scenario is illustrated by the blue and green lines in Fig. 2. In the absence of carbon emission costs, as shown by the solid lines in Fig. 2, the Cape of Good Hope route costs less than the Suez Canal route. However, when carbon emission costs are imposed on maritime transport through the ETS, the total cost of the Cape of Good Hope route is likely to be greater than the cost of the Suez Canal route, as shown by the green and blue dotted lines in Fig. 2. As a result, the Cape of Good Hope route becomes less advantageous for operators, which could lead to a reduction in $CO_2$ emissions. Therefore, shipping companies will need to re-evaluate whether the extra ships for operating shipping services via the Cape of Good Hope (as it takes much longer) are needed.

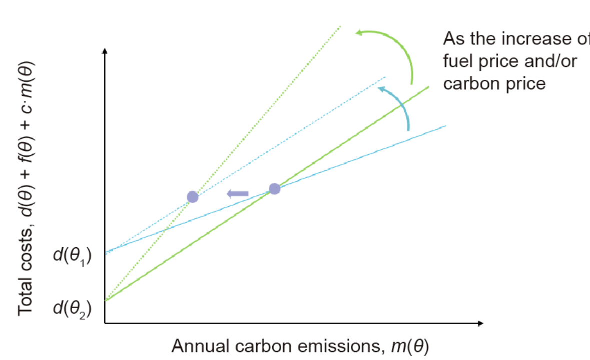


**Fig. 1.** Relationship between total costs and annual carbon emissions.

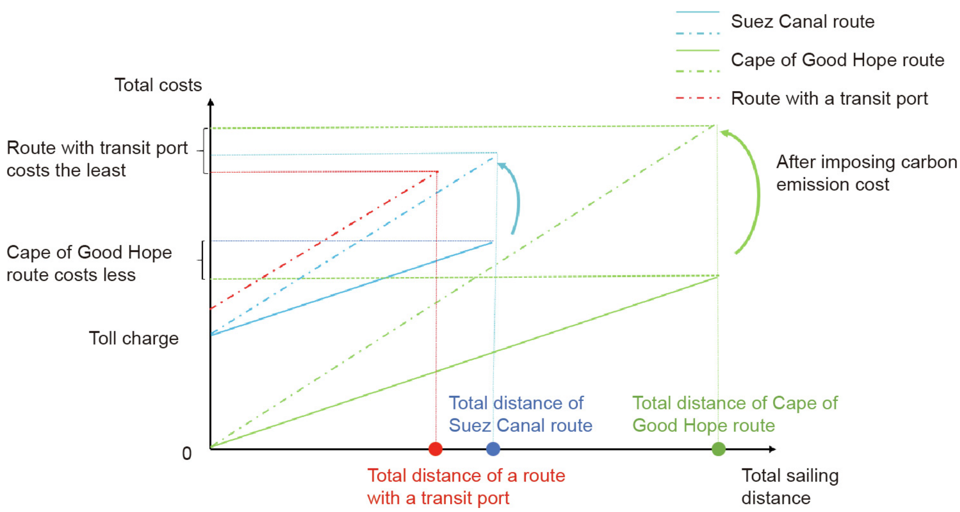


**Fig. 2.** Relationship between the total costs and the total sailing distance.

Second, container shipping companies that operate Asia–Europe services may choose to redesign their services to include ports in the Middle East, Turkey, or North Africa. For instance, the voyage from Singapore directly to Rotterdam is 8288 n mile (via the Suez Canal) and the carbon emission cost could be as high as 200 000 USD. If the ship does not directly sail from Singapore to Rotterdam but instead sails directly from Singapore to Port Said (Egypt) and from there to Rotterdam, it will only have to pay the carbon emission cost of the voyage from Port Said to Rotterdam. The distance from Port Said to Rotterdam is 3274 n mile, and the carbon emission cost would therefore be only 80 000 USD. The saving of 120 000 USD could justify the inclusion of an extra port of call on the service. Similarly, instead of visiting major ports in Western Europe (e.g., Le Havre, Antwerp, Rotterdam, Bremerhaven, and Hamburg) on Asia–Europe services, container shipping companies may choose to redesign some of their services by visiting ports closer to Asia instead, such as Piraeus (Greece) and Barcelona (Spain), to reduce carbon costs. This possibility is depicted by the red line in Fig. 2. When a transit port in the Middle East, Turkey, or North Africa is included on the route, the operational costs from the origin port to the transit port and the toll charge for the Suez Canal can be treated as fixed costs. The carbon emission costs are reduced, because the total sailing distance that attracts carbon emission costs is smaller. As a result, the total cost of the voyage is less than the cost of the Suez Canal route and the Cape of Good Hope route, as shown by the red dotted line in Fig. 2. Shipping companies are therefore advised to start contacting ports in the Middle East, Turkey, or North Africa that they have not previously considered so that they can quickly adjust their services once maritime transport is included in the EU ETS.

It should be noted that containers are often transshipped between ships deployed on different services (similar to the transfer of passengers between buses on different routes) during trips from the origin port to the destination port. The redesign of liner shipping services will therefore affect the whole shipping network of a container shipping company or shipping alliance, and the entire shipping network will need to be redesigned. The liner shipping network design problem has attracted much research effort [15]; however, due to its strongly non-deterministic polynomial-time (NP)-hard nature, no effective algorithms have been discovered. The inclusion of shipping into the EU ETS does not directly affect trans-Pacific services or intra-Asia services. This fact could be exploited to design efficient algorithms to generate high-quality liner shipping networks for shipping companies.

The foregoing analysis identifies two managerial insights. First, shipping companies that are negotiating to charter extra ships to operate shipping services via the Cape of Good Hope should carefully reexamine whether these ships will be needed once the EU's legislation comes into force[†]. Second, shipping companies are advised to start contacting ports in the Middle East, Turkey, and North Africa that they have not previously considered in order to enable them to quickly adjust their services once maritime transport is included in the EU ETS.

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[†] Note that, when making such decisions, shipping companies should not only compare the Cape of Good Hope route with the Suez Canal route, but should also take into account the fact that all ships running Asia–Europe services may need to slow down (e.g., by slow steaming) to reduce carbon emissions and carbon costs, and that slow steaming requires a greater number of ships to maintain the same service frequency.

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