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Modeling the impacts of alternative emission trading schemes on international shipping

Kun Wang [a], Xiaowen Fu [b], Meifeng Luo [c,*]

[a] Sauder School of Business, The University of British Columbia, Canada
[b] Institute of Transport and Logistics Studies, The University of Sydney, Australia
[c] Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hong Kong

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ABSTRACT

Various market-based measures have been proposed to reduce CO_2 emissions from international shipping. One promising mechanism under consideration is the Emission Trading Scheme (ETS). This study analyzes and benchmarks the economic implications of two alternative ETS mechanisms, namely, an open ETS compared to a Maritime only ETS (METS). The analytical solutions and model calibration results allow us to quantify the impacts of alternative ETS schemes on the container shipping sector and the dry bulk shipping sector. It is found that an ETS, whether open or maritime only, will decrease shipping speed, carrier outputs and fuel consumption for both the container and dry bulk sectors, even in the presence of a "wind-fall" profit to shipping companies. Under an open ETS, the dry bulk sector will suffer from a higher proportional reduction in output than the container sector, and will thus sell more emission permits or purchase fewer permits. Under an METS, container carriers will buy emission permits from the dry bulk side. In addition, under an METS the degree of competition within one sector will have spill-over effects on the other sector. Specifically, when the sector that sells (buys) permits is more collusive (competitive), the equilibrium permit price will rise. This study provides a framework for identifying the moderating effects of market structure and competition between firms on emission reduction schemes, and emphasizes the importance of understanding the differential impacts of ETS schemes on individual sectors within an industry when considering alternative policies.

1. Introduction and background

Transportation sector accounts for a significant share of global Greenhouse Gas Emission (GHG). In year 2007, transportation accounted for 27% of global CO_2 emission. The design of emission reduction mechanism for the transport sector thus has drawn significant attention from policy makers and academia (Schwanen et al., 2011). Market-based measures (MBM) are cost-effective policy instruments that can provide industrial organizations with strong incentives to use up-to-date technological, operational and managerial practices in emission reduction (Buhaug et al., 2009; European Commission, 2013a). One of the most promising alternatives in MBM is the Emission Trading Scheme (ETS) (Kageson, 2007; Miola et al., 2011). In the US, the trading programme of SO_2 has been very successful (Klaassen, 1996). Since its initial launch in 2005, the European Union (EU) ETS has become by far the largest ETS in the world, now having around 12,000 installations and representing 45%

* Corresponding author. Tel.: +852 27667414.
E-mail addresses: kun.wang@sauder.ubc.ca (K. Wang), xiaowen.fu@sydney.edu.au (X. Fu), meifeng.luo@polyu.edu.hk (M. Luo).

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of EU emissions of CO_2 (Grubb, 2006; Wrake et al., 2012). Although some MBMs have been proposed and implemented to control emissions from transport sectors such as motor vehicles (Hao et al., 2006; Poudenx, 2008; Beck et al., 2013), and the aviation sector (Vespermann, 2011; Sgouridis, 2011), there has been rather limited progress in emission reduction from international shipping (European Commission, 2013b). Whereas numerous political and institutional factors could be blamed for such a slow progress, certain important issues remain to be studied and evaluated concerning the ETS itself.

An ETS involving the shipping industry can be either "open" or "closed". In an open system, shipping companies can trade emission permits with other industries (e.g., electricity generation, manufacturing or agriculture), whereas in a closed ETS (or Maritime ETS, METS) shipping companies can only trade among themselves. In theory, the scale of an open/broader ETS is larger because it allows permits to be traded with other industries, which makes the ETS system more transparent and the allocation of permits among different industries more efficient. In METS, an appropriate emission cap is hard to set up, because international shipping is growing fast, and associated CO_2 emissions are estimated with a high degree of uncertainty (Kageson, 2007). The cap has to be generous, since an excessively tight cap is very hard to change at a later stage, which could bring excessive pressure and cost to the shipping industry and may even limit the possibility of international trade (Luo, 2013). Such considerations would favor the choice of an open ETS. However, an METS also has its own advantages. Comparing with a global ETS that includes all sectors, METS may be more feasible to implement from a policy, institutional and economic perspective (Schmidt et al., 2004; Bosi and Ellis, 2005). It is usually easier to target a given sector rather than the entire economy, and building technical capacity and data collecting are more manageable at a sectoral level. That said, the challenge of implementing an METS should never be underestimated, especially when an ETS system is already in place. In summary, both broad and sector-specific mechanisms are being considered by regulators and government agencies, and no definite decision has yet been made.[1] Therefore, it is important to benchmark the impacts to the shipping industry by an open ETS vs. an METS, thus that better decisions can be made for the design and implementation of emission reduction mechanisms.

In addition, these two types of ETS can have different impacts on the shipping industry. The shipping industry is not composed of homogeneous carriers. Different types of cargo are carried in specialized ships that run at different speeds and have differing operational costs and energy efficiency. In the implementation of Energy Efficiency Design Index (EEDI) for new ships, different ship types are given different reference lines – the energy efficiency to achieve (IMO, 2009; Hasan, 2011; Walsh and Bows, 2012; Zheng et al., 2013). IMO (2009) specifies the equation to calculate the EEDI baseline for each ship type and size. The full EEDI equation takes a range of factors into account including different ship type's engine size, load, and energy generation system. Different reference parameters are used for the container and dry bulk ship EEDI calculations (IMO, 2009; Walsh and Bows, 2012). Hasan (2011) also estimated how the IMO EEDI regulations can affect the ship design of container and dry bulk shipping differently, in terms of ship length, beam, draft and other parameters. In addition, the market structure and conduct of companies also differ among various shipping sectors. For example, it is generally perceived that, on average, in comparison with container ships, dry bulk ships are older, less expensive and less energy efficient. Bulk cargos tend to have a lower value per ton, and thus such ships generally sail slower compared to container ships. In terms of market structure, the container shipping market tends to be less competitive, due to high market concentration, and the existence of liner conferences and alliances (Cullinane and Khanna, 2000; Song and Panayides, 2002; Luo et al., 2014). These features will make each sector to respond to the ETS differently, resulting in different impacts on international trade (Song and Panayides, 2008, 2012a,b; Lam, 2011, 2013; Lam and Van de Voorde, 2011; Cristea et al., 2013). Despite this, few published studies have investigated such an important issue.

Apparently, any proposed mechanism needs to be endorsed or supported by major stake-holders. Therefore, without a good assessment and clear understanding of the possible consequences, the different sectors of the shipping industry may not be able to reach a consensus, which could well delay the implementation of the proposed emission reduction schemes. Bosi and Ellis (2005) emphasized the need to carry out *ex ante* studies prior to the formation of a mechanism, and *ex post* studies to monitor and evaluate subsequent progress. However, previous studies on emission reduction in international shipping have mostly focused on operations and technologies (Eyring et al., 2005; DNV, 2010), emission volume and cost simulation (Wang et al., 2007; Buhaug et al., 2009; Eide et al., 2009, 2011; Liao et al., 2010), or emission permit allocation mechanisms (Kling and Zhao, 2000; Haites, 2009; Hepburn et al., 2006). Although a few studies have provided comprehensive evaluations of alternative policy instruments on emission reduction (CE Delft, Germanischer Lloyd, MARINTEK and Det Norske Veritas, 2006; Kageson, 2007; Eide et al., 2011), they have not analyzed the economic implications for the international shipping industry as a result of the ETS, nor the differential impacts on the various shipping sectors. The inception of the EU ETS in 2005 motivated a number of economic studies, such as on the carbon cost pass-through ratio and its effects on end products' prices (Sijm et al., 2006; Chen et al., 2008; Kim et al., 2010), the effects on firms' profitability and stock prices (Smale et al., 2006; Oberndorfer, 2009; Demailly and Quirion, 2006; Veith et al., 2009; Mo et al., 2012), alternative emission permit allocation methods (Bode, 2006) and geographic and country differences (Knight, 2011; Viguier et al., 2006). Although these studies provide rich insights into the EU ETS, they have mostly focused on one single sector (e.g., the power generation industry) without investigating the implications of an open vs. a closed scheme. The implications of differences

[1] For detailed and updated information related to mechanism design and choice, see for example UNFCCC's reports at http://unfccc.int/bodies/awg-lca/items/4488.php and OECD/IRA's reports at http://www.oecd.org/env/cc/scaling-upmarketmechanisms.htm.