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Economy-wide impact analysis of a carbon tax on international container shipping

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ABSTRACT

International shipping is a vital channel linking the world economy, particularly from the perspective of international commodity trade. The recently proposed carbon regulation in international shipping will not only affect the competitiveness of shipping lines, but will also have implications for the global economy. This paper adopts an energy–environmental version of the Global Trade Analysis Project referred to as GTAP-E to analyze the quantitative effects of a maritime carbon tax on the global economy by placing a special focus on containerizable commodities given their significant role in international trade. The major advantage of the GTAP-E model is that it can capture the effects of asymmetric changes in freight costs on different routes caused by the maritime carbon tax. Based on our numerical results, imposing a maritime carbon tax on international container shipping will not lead to a significant economic impact unless the tax level is high. China will suffer the greatest real GDP loss among all countries. Under a high level of global maritime carbon tax ($90/tCO_2$), the real GDP loss to China will be around 0.02%. The negative economic impacts on the European countries will be greater if a maritime carbon tax is imposed only on the European container exporting/importing routes, compared to the situation where a global maritime carbon tax is imposed on container shipping. Finally, the imposition of a maritime carbon tax will discourage distant container trade on the routes (origin–destination) "China–USA", "Rest of Asia–USA", and "South America–China".

1. Introduction

Carbon dioxide emissions from international shipping are growing rapidly (Haites, 2009). According to the statistics, international shipping contributes about 3% of global carbon emissions (Buhaug et al., 2009). The emissions are estimated to range between 685 and 1039 million tons of CO_2 in 2007, and they are projected to grow at 1.9–2.7% per year to 2050 (Buhaug et al., 2008). Currently these large amounts of carbon dioxide emissions are not covered by the Kyoto Protocol.[1] However, their contribution to anthropogenic climate change is perceived to be an important issue that is expected to be addressed in the post-Kyoto climate pact because of the industrial dynamics and high growth rates of the associated carbon emissions.

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[1] Despite the exclusion from the national targets of the Annex-1 countries, Paragraph 2 in Article 2 of the Kyoto Protocol states: "The parties included in Annex-1 shall pursue the limitation or reduction of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively."

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To date, the International Maritime Organization (IMO) has studied options for maritime carbon mitigation in international shipping and has adopted some initiatives to set-up a legally binding regime to regulate these carbon emissions. Policy options considered to be feasible for reducing maritime carbon emissions include, among other things, emissions standards, environmental indexing, voluntary agreements, carbon tax, and emissions trading scheme (Buhaug et al., 2009; Faber et al., 2009; Bode et al., 2002). Among these policy options, the former three (emissions standards, environmental indexing, and voluntary agreements) follow the idea of a mandatory or voluntary approach; while the latter two (carbon tax and emissions trading scheme) are market-based instruments. At present, mandatory measures on energy efficiency (i.e., Energy Efficiency Design Index (EEDI) for new ships and Ship Energy Efficiency Management Plan (SEEMP) for all ships) have been adopted by Parties to MARPOL Annex VI as represented in the Marine Environment Protection Committee (MPEC 62) in July 2011. This is the first mandatory global greenhouse gas reduction regime for an international industry sector. On the other hand, market-based measures (MBMs), as policy instruments for cost-effective abatement, have drawn considerable attention in the IMO abatement initiative, and have been seriously considered by every single MPEC since MPEC 56 (July 2006). In MPEC 59, the overwhelming majority agrees that MBMs should be a part of a comprehensive package of measures to regulate greenhouse gas emissions from international shipping. Since then, MPEC 62 has agreed upon a new work plan and guidelines for further consideration of MBMs.

International shipping is a vital channel linking the world economy, particularly from the perspective of international commodity trade. Hence the regulation on maritime carbon emissions will not only affect the competitiveness of shipping lines, but will also have a significant impact on the world economy through increasing freight costs and changing individual countries' trade patterns (i.e., imports and exports). However, a survey on the current studies of carbon regulation for international transportation shows that most studies explore the implications for the aviation sector by concentrating attention on the mode of the initial permit allocation, the sectoral impacts such as tourism and airlines, and the macro-economy impacts (e.g., Anger, 2010; Mendes and Santos, 2008; Faber et al., 2007; Forsyth et al., 2007; Boon et al., 2007; Scheelhaase and Grimme, 2007; Swedish Energy Agency, 2007). A few studies also focus on the implications for international shipping (e.g., Michaelowa and Krause, 2000; UNCTAD, 2009). Moreover, in spite of many countries' concerns regarding the impact of introducing carbon taxation to international shipping in relation to both the shipping industry and the macro-economy (Cariou, 2011; Cariou and Cheaitou, 2012; Kim et al., 2012; Miola et al., 2011), none have attempted to explore the economic impact of the carbon regulation on international shipping under a general equilibrium framework that captures the economy-wide interactions.[2]

To fill this gap in the literature, this paper aims to explore the quantitative effects of a maritime carbon tax on the global economy. Here we place a special focus on containerizable commodities given their significance in international trade and maritime CO_2 emissions. At present, the global value of seaborne container trade accounts for around 60% of the global seaborne trade (Heiberg, 2012). This percentage is expected to continue to grow rapidly in the years that follow (Buhaug et al., 2009) given the specific advantages of container shipping such as shorter handling costs and time, as well as the assurance of cargo safety.

To perform the quantitative analysis, we adopt a global computable general equilibrium (CGE) model, which is an extended version of the Global Trade Analysis Project (GTAP) referred to as GTAP-E, where the latter letter E represents energy and environment. The GTAP model captures intricate linkages between all sectors and agents of the economy and worldwide bilateral trade flows, and is widely used in quantitative analysis of international policy issues such as free trade agreements (e.g., Kitwiwattanachai et al., 2010; Ariyasajjakorn et al., 2009). In addition, considering the fact that trade liberalization causes significant and asymmetric impacts on trade patterns and hence seaborne cargo volumes, Lee and Lee (2012) and Lee et al. (2011) respectively apply the GTAP model to estimate the impacts of ECFA and IBSA[3] free trade agreements on the derived demand for shipping services. The GTAP-E model follows the main GTAP model framework concerning economic activities, but further incorporates energy–economy–environment-trade linkages, such as energy substitution and carbon emissions. Both the GTAP and GTAP-E models disaggregate transportation services into air, sea and ground. This treatment allows for differences in transport margins in international trade, not only by commodity types and routes, but also by the modes of transport. The above important features justify the appropriateness of the GTAP-E model for our analysis.

Given the fact that container freight rates vary across commodity types and shipping routes worldwide, imposing a uniform maritime carbon tax will lead to asymmetric percentage increases in the average freight costs on different shipping routes,[4] which in turn alter the patterns of world trade and hence the production of traded goods. Because the percentage increases in the average freight costs depend on the levels of the carbon tax, this paper develops three simulation scenarios with different tax levels, and simulates the associated economy-wide impacts using the GTAP-E model. In existing studies, the CO_2 prices vary from $10 per ton of CO_2 (e.g., United Nations, 2010) to as much as $1,000 per ton of CO_2 (e.g., Anger et al., 2009). This paper follows Scheelhaase et al. (2010) and assumes a modest price of $30 per ton of CO_2 for our benchmark scenario (i.e., the

[2] In the current literature, there are few studies analyzing the carbon regulation of the transportation sector under a general equilibrium framework. One exception is Abrell (2010), who analyzes different market-based instruments for the carbon regulation of the road transportation sector in the EU27.

[3] The Economic Cooperation Framework Agreement (ECFA) between Taiwan and mainland China is aimed at closer trade relations and economic co-operation across the Taiwan Strait. IBSA is a free trade agreement among India, Brazil, and South Africa.

[4] This study simulates the scenarios concerning the impacts of a maritime carbon tax on the average container freight costs for different trade routes. Of course, the impacts will vary given different vessel sizes and speed, as well as the fuel price. However, these factors are beyond the scope of this paper and are not considered.