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# The contribution of China's bilateral trade to global carbon emissions in the context of globalization

Tao Ding, Yadong Ning*, Yan Zhang

*Key Laboratory of Ocean Energy Utilization and Energy Conservation of Ministry of Education, School of Energy and Power Engineering, Dalian University of Technology, Dalian 116024, China*

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ABSTRACT

Controlling and reducing carbon emissions for mitigation of climate change are a global common consensus. It is imperative for legitimately and effectively ascertaining responsibilities among countries to study $CO_2$ emissions embodied in the international trade. As the largest exporter and the second largest importer in the world, the large amount of $CO_2$ emissions embodied in China's bilateral trade have a significant impact on China's and global carbon emissions. Based on the single region input-output tables using the non-competitive imports assumption, this study estimated $CO_2$ emissions embodied in China's bilateral trade with 219 countries/regions over the period of 2000–2014, and analyzed the contribution of China's bilateral trade to global carbon emissions under the assumption of non-trade scenario. The results show that, $CO_2$ emissions embodied in China's exports and imports in 2014 were 2561.1 Mt and 1209.9 Mt respectively, and $CO_2$ emissions embodied in exports were higher than those in imports throughout the period. It is indicated that China had produced a large amount of $CO_2$ emissions for other countries through the international trade. And meanwhile, China avoided a large amount of $CO_2$ emissions with the rapid growth of imports. And furthermore, the net $CO_2$ emissions embodied in China's bilateral trade had been declining since 2011. At last, China's bilateral trade had extremely little impact on global carbon emissions. It is concluded that there is a possibility of reducing global carbon emissions based on the results of China's bilateral trade with countries along the routes of Silk Road Economic Belt and 21st-Century Maritime Silk Road.



## 1. Introduction

As the world's largest emitter, China alone produced 9040.7 Mt carbon dioxide ($CO_2$) emissions from energy activities in 2015 and it was responsible for 28.0% of global $CO_2$ emissions (International Energy Agency (IEA), 2017). Under the pressure of global emission reduction and international responsibilities, China submitted the Intended Nationally Determined Contribution (INDC) in June 2015: to achieve the peaking of carbon dioxide emissions around 2030 and make best efforts to peak early; and to lower $CO_2$ emissions per unit of GDP by 60% to 65% from the 2005 level by 2030 (National Development and Reform Commission (NDRC), 2015). The United Nations Framework Convention on Climate Change (UNFCCC) requires that countries are responsible for the $CO_2$ emissions emitted from all productive activities within their national geographic borders. Most $CO_2$ emission estimations are studied on the basis of a production-based accounting approach. The approach makes carbon constraint nations reduce their greenhouse gas inventories by importing goods from other countries with looser environmental standards. The increasing of $CO_2$ emissions embodied in international trade is the main reason why $CO_2$ emissions of developed countries increased with a relatively lower growth while $CO_2$ emissions of developing countries increased sharply (Weber et al., 2008; Nakano et al., 2009). In this situation, global $CO_2$ emissions are likely to continue to increase rather than decrease (Wyckoff and Roop, 1994; Ahmad and Wyckoff, 2003; López et al., 2018). In recent years, some scholars suggested that considering another consumption-based accounting approach may be conducive to promoting international climate change negotiations and equitable distribution of carbon emission reduction tasks (Pan et al., 2008; Peters, 2008; Peters and Hertwich, 2008a; Peters and Hertwich, 2008b). The IPCC fifth climate change assessment report also carried out a special discussion of consumption-based $CO_2$ emissions accounting method (Intergovernmental Panel on Climate Change (IPCC), 2014). In the context of globalization, $CO_2$ emissions embodied in international trade have become a key

* Corresponding author.
*E-mail address:* ningyd@dlut.edu.cn (Y. Ning).

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factor influencing the fairness of $CO_2$ emission reduction responsibility between the above two accounting approaches. The impact of international trade should not be ignored when China takes the $CO_2$ emission reduction responsibility, assigns reduction tasks and achieves carbon reduction targets.

China formally joined the World Trade Organization (WTO) in 2001, and then participated in international competition and cooperation in a broader magnitude. International trade has become the main driving force for China's rapid economic development. According to the UN Comtrade Database statistics, the volume of China's merchandise exports has reached USD 2134.5 billion in 2016, taking account in 13.5% of global exports (United Nations Statistics Division (UNSD), 2016). China produced large amounts of $CO_2$ emissions embodied in exports consumed in other countries at the cost of China's own energy consumption and environmental pollution. The value of China's merchandise imports has reached USD 1589.9 billion in 2016, and the trade structure of imports was significantly different from that of exports. Both volumes of crude oil and iron ores represented 10.9% of China's merchandise imports in that year (Department of Economic and Social Affairs Statistics Division (DESA), 2016). China has avoided many $CO_2$ emissions by increasing imports of energy and mineral resources with high carbon intensity while those exporters might release more $CO_2$ emissions due to the trade. By estimating $CO_2$ emissions embodied in China's exports and imports, it could make clear whether international trade made China undertake $CO_2$ emissions for other countries or avoid more $CO_2$ emissions, and further study the role of international trade in China's $CO_2$ emission reduction. In recent years, Brexit, USA withdrawing from the Trans-Pacific Partnership and the rising trade protectionism brought uncertainties to the development of international trade. To seek the development of China itself and the neighboring regions, China proposed the initiative of Silk Road Economic Belt and 21 st-Century Maritime Silk Road (B&R) in 2015. The B&R initiative follows the trend of economic globalization and it is to share China's development opportunities with countries along the routes and achieve common prosperity. With the further promotion and enhancement of the B&R initiative, the location distribution and industrial structure of China's international trade will change in the future, and the characteristic of $CO_2$ emissions embodied in China's international trade will be different. At this point, we calculate $CO_2$ emissions embodied in China's international trade and analyzes the contribution of China's international trade to global $CO_2$ emissions from the perspective of deglobalization, which both have certain research value and theoretical significance.

## 2. Literature review

The accumulated $CO_2$ emissions emitted in the production of the product are said to be "embodied" $CO_2$ emissions (Peters, 2008). $CO_2$ emissions embodied in trade are generally estimated by using emission relevant energy consumption in the production of export and import goods and services. The most common methodology for embodied $CO_2$ emission estimates is input-output analysis (IOA) (Leontief, 1970). According to the scale of input-output tables, there are two main approaches: the single-region input-output (SRIO) model and the multi-region input-output (MRIO) model. Critical distinctions between the two models can be made with regards to the treatment of the imported intermediate goods, assumption about technology and model complexity.

The SRIO model takes a single country and estimates $CO_2$ emissions embodied in its total trade with the rest of the world (ROW). However, the treatments of imports in the SRIO model are different. Two approaches can be found to deal with a country's imports. The competitive imports assumption refers to the same productive technology between the imported products and those produced domestically. The IO table using the competitive imports assumption does not distinguish imported products from the intermediate use or final use. The IO table using the non-competitive imports assumption treats the imported products as different from the domestic ones and tabulates them separately. The corresponding $CO_2$ emissions embodied in these imports are estimated using their origins based on the non-competitive imports assumption. A large number of embodied $CO_2$ emission studies use the SRIO model because of the simplicity of the model and its lower data requirement and easier calculation (Wiedmann et al., 2007; Sato, 2014). There are some typical studies of China's embodied $CO_2$ emissions using the competitive imports assumption, such as Chen and Zhang (2010), Li and Qi (2010), Lin and Sun (2010), Yan and Yang (2010), Xu et al. (2011). In recent years, more and more studies adopted the SRIO model with non-competitive imports (Su and Ang, 2010; Su et al., 2010; Wei et al., 2011; Dietzenbacher et al., 2012; Liu et al., 2013; Jiang et al., 2015; Liu et al., 2017). Su and Ang (2013) found that embodied $CO_2$ emissions obtained using the competitive imports assumption approach are higher by around 25–45% than those with the non-competitive imports assumption approach on the premise of the same basic data. It is generally considered unreasonable neglecting the impact of imports in production processes during the calculation of $CO_2$ emissions embodied in exports (EEX). However, due to the lack of emission data for imported products in SRIO model, several researches assumed the same emission intensity for both imports and China's domestic products to calculate emissions avoided by imports (EAI) (Weber et al., 2008; Chen and Zhang, 2010; Lin and Sun, 2010). This substitution would overrate China's $CO_2$ emissions embodied within import products (EEI) because China have higher emission intensity than most of its importers. Some researches adopted the emission intensity of one typical importer or the (weighted) average value of several importers to estimate China's EEI (Yan and Yang, 2010; Wei et al., 2011; Liu et al., 2013). And other studies calculated the EEI using input coefficients and emission intensities of China's importers where the imported goods and services are produced (Pan et al., 2008; Jiang et al., 2015; and Liu et al., 2017). These studies improved the estimation accuracy of China's EEI. In addition, all China's official input-output tables use the competitive imports assumption. Some researchers derived China's non-competitive (imports) input-output tables using the domestic production technology matrix (Pan et al., 2008; Su et al., 2010; Su and Ang, 2010; Wei et al., 2011; Liu et al., 2013; Su and Ang, 2013). But the same proportion of imported products in intermediate use and final use would introduce uncertainty in the embodied $CO_2$ emission estimation.

Limited to the lack of the trade data between China and global partners, SRIO models are rarely used to globally discuss China's $CO_2$ emissions embodied in the international trade. The MRIO model represents the interactions among industrial sectors within an economy and provides the spatial linkages of industries between regions based on a more complex data foundation compared to the SRIO model. By employing the MRIO model, a rapidly growing body of literature has been created in recent years that estimates emissions embodied in global trade and consumption-based $CO_2$ emissions (Sato, 2014; Wiedmann, 2009). Ahmad and Wyckoff (2003), and Nakano et al. (2009) measured embodied $CO_2$ emissions of 24 and 41 countries/regions using MRIO tables and other data of OECD database. Peters et al. (2011) and Atkinson et al. (2011) determined $CO_2$ emissions embodied in international trade among 113 and 15 countries/regions using the data provided by Global Trade Analysis Project (GTAP). Zhang et al. (2017) and López et al. (2018) adopted MRIO tables from the WIOD database to make an analysis on the pollution haven hypothesis. In the MRIO model, the exogenous demand is always the final use with the domestic

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