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Will economic restructuring in China reduce trade-embodied CO_2 emissions?

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ABSTRACT

We calculate carbon dioxide (CO_2) emissions embodied in China's net exports using a multi-regional input–output database. We find that the majority of China's export-embodied CO_2 is associated with production of machinery and equipment rather than energy-intensive products, such as steel and aluminum. In 2007, the largest net recipients of embodied CO_2 emissions from China include the EU (360 million metric tons, mmt), the US (337 mmt) and Japan (109 mmt). Overall, annual CO_2 emissions embodied in China's net exports totaled 1177 mmt, equal to 22% of China's total CO_2 emissions. We also develop a global general equilibrium model with a detailed treatment of energy and CO_2 emissions. We use the model to analyze the impact of a sectoral shift in the Chinese economy away from industry and towards services, both without and with a decrease in China's trade surplus, and a tax on energy-intensive exports, which reflect policy objectives in China's Twelfth Five-Year Plan (2011–2015). We find that without a decrease in the trade surplus, both policies will have a limited impact on China's net exports of embodied CO_2 emissions. The policies have an even smaller effect on global emissions, as reduced production in China is partially offset by increased production elsewhere.

1. Introduction

China's rapid growth over the last thirty years has brought great benefits but has come at a cost of large increases in energy use and environmental damage. With the rapid growth of its economy and international trade linkages, China has become the world's largest exporter, the second largest importer, and the second largest national economy in the world in value terms (The World Bank, 2012). In 2010, China accounted for 20% of global energy demand (BP, 2012) and surpassed the U.S. to become the world's largest consumer of energy and source of carbon dioxide (CO_2) emissions (International Energy Agency, 2011). A significant amount of China's CO_2 emissions are embodied in goods produced for export.

In recent decades, China has largely benefited from a global trend to relocate labor-intensive manufacturing from developed to developing countries. Given that developing countries generally have less advanced production technologies and fewer environmental restrictions, the shift of manufacturing is often considered tantamount to a transfer of fossil fuel consumption and environmental impact (Copeland and Taylor, 1994, 1995; Muradian et al., 2002; Tang et al., 2012).[1]

Large total and exported quantities of embodied CO_2 emissions in China translate into environmental damages and also make China a target of carbon tariff policies implemented overseas. Developed countries with strict climate policies have discussed imposing tariffs based on the carbon embodied in trade to avoid carbon leakage and to shore up the competitiveness of domestic producers (Bednar-Friedl et al., 2012). As carbon tariffs imposed in OECD (Organization for Economic Cooperation and Development) countries penalize carbon-intensive exporters, non-OECD countries, including China, could potentially suffer substantial welfare losses (Boehringer et al., 2012). One analysis has suggested that China in particular would suffer a GDP loss of 4% as a result of imposing such tariffs (Boehringer et al., 2011). China has grown aware of the vulnerabilities associated with the high energy

Abbreviations: CGE, computable general equilibrium; SRIO, single-regional input output (analysis); MRIO, multi-regional input output (analysis); FYP, Five-Year Plan (of China).

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[1] Quantitative evaluations of the environmental cost embodied in trade have been conducted by numerous studies at the global level (Davis and Caldeira, 2010; Peters and Hertwich, 2008; Skelton et al., 2011); and at the regional level, including for the US (Weber and Matthews, 2007), for Austria (Munoz and Steininger, 2010), for the Netherlands (Edens et al., 2011), for India (Goldar et al., 2011), for China (Liu and Ma, 2011) and for Estonia (Gavrilova and Vilu, 2012).

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and emissions intensity of its exports and has implemented policies to reduce export-embodied emissions.

In this paper, we analyze in detail China's trade-embodied CO_2 emissions and compare them to other major emitting regions. We then assess the impact policy could have on the magnitude of these emissions flows. Section 2 places our analysis in the context of relevant literature. Section 3 summarizes China's energy and climate policies that motivate this study. Section 4 describes our data and methods in detail. Section 5 presents the results of China's trade-embodied emissions in 2007 and an assessment of how proposed policies may change these emissions. Section 6 summarizes the results and offers some conclusions.

2. Literature review and motivation for this study

The magnitude of CO_2 emissions associated with China's trade has been widely studied. Previous research on China largely reflects three distinct lines of inquiry. First, researchers have used time series input–output databases for a single region to quantify trends in the emissions associated with China's trade. Weber et al. (2008) use this approach to show that China's emissions related to exports grow rapidly from 1987 to 2005, mainly due to rising consumption in developed countries. Yan and Yang (2010), Xu et al. (2011) and Minx et al. (2011) also use a single regional input–output (SRIO) approach to evaluate China's embodied emissions from 1992 to 1997, and adopt a structural decomposition analysis to investigate its drivers. A second focus of past work has been to analyze emissions transfers between China and one or more of its trade partners, including Japan (Dong et al, 2010; Liu et al., 2010), the U.S. (Du et al., 2011; Shui and Harriss, 2006), the U.K. (Li and Hewitt, 2008), and other Asian economies (Su and Ang, 2011). A third category uses sub-national input–output information—either alone or embedded in connection with international data—to study the magnitude of trade-related emissions across regions within China. For example, Guo et al. (2012) and Feng et al. (2013) have integrated China's provincial input–output data with international data to resolve domestic and international emissions transfers at the level of China's individual provinces. Su and Ang (2010, 2014) analyzed the effect of China's inter-regional trade and international trade on the domestic emissions through a hybrid emissions embodied in trade (HEET) approach.

From a methodological perspective, the embodied emissions literature can be separated into two categories. This acronym is defined above.SRIO analyses use an input-table for one region and approximate emissions embodied in trade flows by assuming that imports are produced using the same technologies as used for domestic production (see, for example, Dong et al., 2010; Du et al., 2011; Li and Hewitt, 2008; Liu et al., 2010; Minx et al., 2011; Shui and Harriss, 2006; Su and Ang, 2013; Su et al., 2013; Su et al. 2010; Weber et al., 2008; Xu et al., 2011; Yan and Yang, 2010). As illustrated by Su and Ang (2011, 2013) and Su et al. (2013), SRIO estimates can be biased as they neither distinguish technology differences between imported and domestic production nor capture feedback effects which occur when intermediate inputs with different carbon intensities are traded.

The second methodological category, multi-regional input–output (MRIO) analyses, addresses this shortcoming by using a global economic dataset in which countries are distinguished, bilateral trade flows are recognized, and imported and domestically produced intermediate inputs are tracked separately (Wiedmann, 2009; Wiedmann et al., 2007). MRIO approaches are adopted in global-scale analyses, such as Lenzen et al. (2004), Peters and Hertwich (2008), Davis and Caldeira (2010) and Peters et al. (2011b). Disadvantages of the MRIO approach include its extensive data requirements. In some sub-national analysis, the HEET approach, which combines the MRIO approach at the regional level and a SRIO approach at the national level, is applied to handle spatial aggregation bias at the regional level (Su and Ang, 2010, 2014). Beyond the input–output approaches, studies have also adopted computable general equilibrium (CGE) models to analyze the impact of policies on emissions embodied in trade. Examples include Babiker and Rutherford (2005), Boehringer et al. (2010), and Hübler (2011, 2012).

The contribution of the present study is twofold. First, we employ the approach used in Peters et al. (2011a) to generate a MRIO table based on the latest release of the GTAP database (Version 8, released in 2012 for the year 2007). The analysis allows us to compare on a consistent basis the direct and indirect emissions embodied in China's trade by sector with other regions and the global average. Second, with a better understanding of the origins of cross-regional differences in embodied emissions in hand, we develop and employ a multi-region, multi-sector static economy-wide model using this same data base. We use this model to assess the impact of two representative CO_2 control instruments in China aimed at reducing CO_2 emissions through changes in the sectoral structure ("economic rebalancing") of the Chinese economy or its exports. Our representative policies are based on objectives set out in China's Twelfth Five-Year Plan (FYP) (2011–2015). Specifically, we simulate policies that 1) increase the service sector share of China's economic output, with and without a decrease in China's trade surplus, and 2) increase export taxes on energy-intensive sectors in China (equivalent to a reduction in export tax rebates).

3. Policy background

China's policymakers have set forth targets for reducing energy, CO_2 emissions, and other pollutants over the near term (in Five Year Plans) and the medium-to-long term. China implemented a number of administrative and financial policies to conserve energy and reduce emissions in its Eleventh FYP (2006–2010). Energy, CO_2 and pollution targets are contained in China's Twelfth FYP, and China's Copenhagen commitment to reduce CO_2 emissions intensity by 40–45% has been incorporated into China's Medium Term Energy Plan (2005–2020) (Industrial Energy Efficiency Database, 2012; Natural Resource Defense Council, 2012). Decision makers claim that policy approaches are intended to incentivize both technical progress and what is commonly termed "structural change" or "economic rebalancing" in directions that favor energy efficiency and energy savings.[2] One source estimates that over 70% of China's energy savings reflected the technical approaches—including investment in energy efficiency measures and the closure of the most inefficient enterprises—in the Eleventh FYP (Xie, 2012). The government has called for a series of subsidies and government investment initiatives to boost the services industry, targeting a GDP value share for services of 47% in 2015 (State Council of China, 2011). The reduction in industrial production is expected to have a large impact on China's trade pattern and scale, and also have an effect on CO_2 emissions embodied in traded goods and services.

In part to address the issue of trade-embodied carbon, China has implemented measures to control the export of "energy-intensive, pollution-intensive and resources-consuming" goods. Reductions in tax rebates and increases in export tariffs applied to energy-intensive products have been implemented gradually since 2004. In 2004, for the first time, China canceled the export tax rebate on coke to limit exports of this commodity. In 2005 and 2006, China reduced the tax rebate on exports of energy-intensive sectors such as coal, iron, and chemical goods, and in 2007 China cut tax rebates on around one third of its total traded goods, including many types of energy-intensive products. Due to the impact of the global economic crisis, China reinstated the tax rebate on some energy-intensive sectors in 2009, but canceled them again in 2010 (Reuters, 2012). Aside from the tax rebate, China has also used export taxes to limit the exports from energy-intensive

[2] The term "economic rebalancing" is used in China to refer to two policy adjustments. The first is increasing the contribution of domestic consumption at the expense of overseas exports. In this connection, the Chinese government has announced a focus on increasing domestic demand as its primary task in the 12th FYP (China Daily 2012). Second, it is used to refer to shifting the industrial structure within China from predominantly heavy-industries to knowledge-intensive, high value-added industries such as services, which mostly have a lower energy footprint.