



Carbon emissions embodied in demand–supply chains in China



Hongguang Liu ^{a,*}, Weidong Liu ^b, Xiaomei Fan ^c, Wei Zou ^a

^a College of Public Administration, Nanjing Agricultural University, Nanjing 210095, China

^b Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

^c School of Remote Sensing, Nanjing University of Information Science and Technology, Nanjing 210044, China

ARTICLE INFO

Article history:

Received 27 July 2014

Received in revised form 4 June 2015

Accepted 8 June 2015

Available online 19 June 2015

JEL classifications:

C67

F18

Q56

Q57

R11

R15

Keywords:

Embodied emissions

Input–output

Demand–supply chain

China

ABSTRACT

Using the multi-regional input–output model (MRIO), the paper distinguishes the carbon emissions embodied in commodities for domestic final consumption (CBEs, consumption-based emissions) and those for export (EBEs, export-based emissions), and then calculates carbon emissions embodied in the demand–supply chains for consumption and export based on technical coefficients matrix of the MRIO for one country. Taking China as an example, we provide a dynamic analysis of CBEs, EBEs, and carbon emissions embodied in consumption and export demand–supply chains at the sub-national level based on the MRIO tables for 1997 and 2007. The results show that, in China, the transferred carbon emissions embodied in demand–supply chains driven by consumption and export both showed rapid growth during 1997–2007. And the net transferred carbon emissions embodied in the demand–supply chains showed an increasing trend as well. Less developed regions with abundant fossil fuels tend to net flow out carbon emissions.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) requires parties to submit annual National Emission Inventories to benchmark progress towards the goals of the UNFCCC (Peters, 2008). The UNFCCC system boundary include all greenhouse gas emissions and removals taking place within national (including administered) territories and offshore areas over which the country has jurisdiction, so it is named production-based emissions accounting (PBE). In the perspective of PBE, the emissions associated with exports are included but those associated with imports are excluded from the national account. Along with the globalization and expansion of international trade, industries including energy intensive industries are gradually transferring from developed countries (almost the Annex I countries that have a responsibility to reduce carbon emissions in UNFCCC) to developing and less developing countries (almost the non-annex I countries without stringent climate change policies in UNFCCC). For their part, the non-Annex 1 countries accept this industry transfer from developed countries given the economic benefit it brings them; however, the production technology of most developing

countries is generally lower than that of developed countries, meaning that the emission of one unit output is relatively higher, and comes in addition to the emissions caused by forest destruction as the consequence of industrialization in developing countries. Combined, these effects may make global emissions higher. This phenomenon is called “carbon leakage”, one main critique of PBE (Peters and Hertwich, 2008; Bednar-Friedl et al., 2012).

Aimed to solve problem of “carbon leakage”, many scholars have proposed the consumption-based emissions (CBE) accounting system and tried to assess the emissions embodied in global trade (Barrett et al., 2013; Davis and Caldeira, 2010; Munksgaard and Pedersen, 2001; Wilting and Vringer, 2007; Yang et al., 2014; Zsófia, 2013). Research on this topic could be roughly divided into two categories. The first is a separate study on carbon emissions embodied in the trade either internally within a specific-country or the trade between two countries (Lenzen, 1998; Sánchez-Chóliz and Duarte, 2004; Pan et al., 2008; Lin and Sun, 2010; Li and Hewitt, 2008; Yu and Wang, 2010; Xu et al., 2009; Dong et al., 2010; Du et al., 2011; Machado et al., 2001; Mäenpää and Siikavirta, 2007; McGregor et al., 2008; Rhee and Chung, 2006). The second is a comprehensive study on carbon emissions embodied in global trade between major countries or regions in the world (Ahmad and Wyckoff, 2003; Chen and Chen, 2011; Davis et al., 2011; Lenzen et al., 2004; Munksgaard et al., 2005; Peters et al., 2011). Authoritative research shows that the carbon emissions

* Corresponding author at: College of Public Administration, Nanjing Agricultural University, No. 1 WeiGang Street, XuanWu District, Nanjing, 210095 China. Tel./fax: +86 25 84395700.

E-mail address: liuhg@njau.edu.cn (H. Liu).

embodied in global trade have increased rapidly, with China currently being the world's largest carbon-export country (Peters et al., 2011).

In light of these findings, many other scholars began to study the issue of carbon emissions in China (Chen and Zhang, 2010; Dietzenbacher et al., 2012; Guan et al., 2009; Liu et al., 2015; Peters et al., 2007). Some scholars have estimated the embodied carbon emissions of China's foreign trade (Guo et al., 2012; Lin and Sun, 2010; Weitzel and Ma, 2014; Zhang, 2012, 2013). Their findings show that, in addition to the increase in China's own consumption level and accelerated investment in fixed assets, rapidly expanding export is the other major reason why China has seen an increase in its carbon emissions. Other studies have calculated the embodied carbon emissions in the trade between China and specific countries such as the UK, US, Japan, etc. (Dong et al., 2010; Du et al., 2011; Li and Hewitt, 2008; Xu et al., 2009; Yu and Wang, 2010). With the gradual increase in pressure on China to reduce its carbon emissions, the government has promised to reduce carbon emissions per unit of GDP by 40–45% between 2005 and 2020, and has incorporated these carbon reduction targets into the assessment indicators of the provincial administrative regions in economic and social development. However, China is a big country, with big gaps between regions in terms of their resource endowment, economic level, industrial structure and level of carbon emissions (Afton et al., 2011; Feng et al., 2009). Furthermore, it has been argued that the implementation of the regional emission reduction policy may exacerbate the inter-regional carbon leakage problem as there are fewer barriers to trade between the regions than to trade between countries (Afton et al., 2011; Feng et al., 2009; Meng et al., 2011). To engage with this problem, several studies have been conducted that have found a large-scale carbon leakage problem in different Chinese regions. Guo et al. (2012) and Shi et al. (2012) analyzed carbon emissions embodied in provincial final demand and inter-provincial carbon transfer within China by employing a multi-regional input–output (MRIO) table of 2002 for China. Meng et al. (2013) and Zhang et al. (2014) presented a dynamic analysis on the interregional transfer of CO₂ emissions of China and found that its CO₂ emissions embodied in interprovincial trade sharply increased in 2002–2007. Feng et al. (2013) calculated CO₂ emissions associated with consumption in each of the 30 Chinese sub-regions as well as emissions embodied in products traded between these sub-regions and the rest of the world on the basis of the MRIO table for 2007 in China. Su et al. (2010, 2013), Su and Ang (2011, 2014) also accounted for the consumption-based emissions of China, and they also depth analyzed the differentia of the results of models with different aggregations and assumptions.

Two general approaches to multi-region emission studies are the emissions embodied in the bilateral trade (EEBT) approach, as in Guo et al. (2012) and Zhang et al. (2014), and the MRIO approach, as in Meng et al. (2013) and Feng et al. (2013). The major differences between the two lie in the treatment of the feedback effect (Peters, 2008). Su and Ang (2011) indicated that the differences between EEBT and MRIO have been reported in some studies, but none has looked into the feedback mechanism of embodied emissions in detail. They showed that the approach using the competitive imports assumption gives estimates larger than those obtained using the non-competitive import assumption in China (Su and Ang, 2013), and they subsequently presented a hybrid EEBT model to comprehensively investigate the regional emission embodiments of China (Su and Ang, 2014).

Most previous studies apart from Feng et al. (2013) are primarily concerned with carbon emissions embodied in the commodities and the demand–supply chains for whole final use in China. Feng et al. (2013) studied emissions embodied in products traded within China that are triggered by subdivisions of final use (household consumption, capital formation, and international exports) for 2007, but their investigation lacked a dynamic analysis. In the current paper, we follow Feng et al. (2013) and conduct a dynamic analysis (1997–2007) on emissions embodied in inter-regional demand–supply chains caused by different components of final use within China, with the aim of contributing

useful commentary on Chinese regional policies on carbon emissions reduction. In this study, regional final use in China is split into final consumption and export, and then consumption-based emissions (CBEs) and export-based emissions (EBEs) are used to explicitly distinguish the eventual use of the emissions in different regions. In addition, the models used to estimate CBEs and EBEs are clearly written by breaking down the calculation procedure of the production-based emissions, and a comparison among results from different studies (including this study) is also given.

The following section will show how we used the MRIO model in order to establish the methodology for this study. The paper will then account for the data sources, and provide the results with analysis and comparison with others. Conclusions and policy recommendations will be promoted at last.

2. Methods

Multi-region input–output (MRIO) tables and their applications have aroused substantial interest in the forefront of environmental policy debates. Many previous studies such as Meng et al. (2013), Feng et al. (2013), and Su and Ang (2014) have applied MRIO to estimate CO₂ emissions embodied in regional trade in China. Similar with others, we treat MRIO model to adapt our study. Table 1 demonstrates our use of the MRIO model, where a country has n sub-national regions.

Where x_d^{rs} refers to domestic intermediate input from region r to produce output in region s ; y_d^s is the domestic consumption demand of region s for region r 's products. e_d^r stands for exports in region r , excluding entrepot trade; x_m^s signifies imports for intermediate inputs in region s . y_m^s is imported final consumption in region s ; e_m refers entrepot trade; x^r is the total output in region r . v^s refers to the added value in region s , and x^s is the total input in region s .

2.1. Direct carbon emissions of industries (PBEs)

The concept of PBE accounting, as used under the Kyoto Protocol, is a straightforward approach to account for carbon emissions. It is characterized by clear system boundaries and good data availability. In this study, we suppose the PBEs of the country to be C_{pro} , and the PBE of region r to be C_{pro}^r . The PBE of region r divided by the total output in region r could obtain the quantity of direct carbon emissions per unit of output, namely, the direct carbon emissions factor of region r , as the following formula demonstrates:

$$f^r = C_{pro}^r / x^r. \quad (1)$$

2.2. Carbon emissions embodied in the demand–supply chains: CBEs and EBEs

From horizontal angles in Table 1, we obtain

$$X = (I - A_d)^{-1} \cdot (Y_d + E_d) \quad (2)$$

where A_d expresses the domestic inter-industry requirements (the named domestic technical coefficient matrix), Y_d is the final use matrix for all regions, and E_d is the export matrix. For convenience, we denote matrix $(I - A_d)^{-1}$ (generally named Leontief inverse matrix or cumulative coefficient matrix) by B , and obtain the following:

$$X = B \cdot (Y_d + E_d). \quad (3)$$

By multiplying both sides of formula (3) by F , the national gross emissions can be expressed as follows:

$$C_{pro} = F \cdot X = F \cdot B \cdot (Y_d + E_d) \quad (4)$$

Download English Version:

<https://daneshyari.com/en/article/5064342>

Download Persian Version:

<https://daneshyari.com/article/5064342>

[Daneshyari.com](https://daneshyari.com)