Journal of Cleaner Production 135 (2016) 332–341

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

The study on the air pollutants embodied in goods for consumption and trade in China – Accounting and structural decomposition analysis

Guangyao Deng [a,*], Yufeng Ding [b], Suling Ren [a]

[a] School of Statistics, Lanzhou University of Finance and Economics, Lanzhou 730020, PR China
[b] College of Business and Finance, Shanghai Normal University, Shanghai 200234, PR China

ARTICLE INFO

Article history:
Received 15 December 2015
Received in revised form
19 June 2016
Accepted 20 June 2016
Available online 22 June 2016

Keywords:
Air pollutants
Multiregional input-output model
Structural decomposition analysis

ABSTRACT

Recently, comprehensive attention has been attracted to global warming. Meanwhile, China is a country with huge energy consumption and greenhouse gas emission. Therefore, it is urgent for China to reduce the air pollutants embodied in each unit of a good for a less greenhouse gas earth. In this paper, air pollutants embodied in goods consumption as well as import-export trade in China was accounted in 1995–2009. Besides, we checked the structural decomposition analysis of emissions' variation. The results showed: (1) in 1995–2009, air pollutants embodied in goods for consumption and import-export trade in China displayed a rising trend. Emission of carbon dioxide was the largest and methane, carbon monoxide, sulphur oxides, non-methane volatile organic compounds, nitrogen oxides, ammonia, nitrous oxide were in proper sequence based at the average level. (2) Air pollutants embodied in goods exported were larger than those in imported and difference among nations existed. (3) The percentages of carbon dioxide, methane, nitrogen oxides, sulphur oxides, carbon monoxide, non-methane volatile organic compounds embodied in Construction were larger than in other departments on the consumption side, while percentages of carbon dioxide, nitrogen oxides, sulphur oxides, carbon monoxide, non-methane volatile organic compounds embodied in Electrical and Optical Equipment was bigger on the trade side. (4) Emission reduction techniques reduced air pollutants embodied in goods consumption and import and export trade in China. Consequently, China ought to pay attention to emission reduction of carbon dioxide and raise awareness of air pollutants controlling, especially in Construction, Electrical and Optical Equipment and other departments. More importantly, China ought to strengthen cooperation with other nations in emission reduction and developing technologies so as to cut down air pollutants, not only for China but also for the earth.

1. Introduction

Lanza et al. (2006) pointed out, the average land surface temperature rose by 0.3 °C–0.6 °C and sea levels by an average of 12–25 cm. It is emission of greenhouse gas that caused global warming. As a result, greenhouse gas (GHG) control is a necessity required by economy sustainable development. China is the largest energy consumer and emitter of greenhouse gases according to the statistical data of World Input-Output Database after 2005. Therefore, it is also necessary to study the air pollutants embodied in goods for consumption and trade in China when considering the global environment. Currently, China's mode of economic development is high - carbon economy characterized by high energy consumption, high emission and high pollution. How to reduce the emission of air pollutants embodied in unit product became an urgent problem to solve for Chinese government. Embodied carbon is the direct and indirect carbon emissions in manufacture (Peters et al., 2011). Similarly, embodied air pollutants, which mean emissions during producing goods, may transfer together with goods trade. In the context of economic globalization, trading among nations are more and more frequent while air pollutants embodied in goods trading are larger and larger. Whether it is unfavorable for the country where huge amount of net goods export exits, such as China, to be responsible for emission reduction? It is worthy to study the calculation and variation of air

* Corresponding author.
E-mail address: dgy316203@163.com (G. Deng).

http://dx.doi.org/10.1016/j.jclepro.2016.06.114

pollutants embodied in goods consumed and traded.

The study on air pollutants embodied in goods consumption and trade mainly focused on embodied carbon. Some scholars studied embodied carbons in trade between several countries globally (Peters et al., 2011; Wiebe et al., 2012; Wu et al., 2016), some studied embodied carbons in one country or area, e.g. China (Su and Ang, 2013; Liu et al., 2015a; Liu et al., 2015b), Liaoning in China (Geng et al., 2013), European Union (Galli et al., 2013), Uruguay (Piaggio et al., 2015). Besides, scholars also studied influences of urbanization, industrial structure, outsourcing to carbon emission (Li et al., 2015; Chang, 2015; Gurtu et al., 2016). Of course, there were some researchers studying on other air pollutants, e.g. Berners-Lee et al. (2011) discussed Greenhouse gas foot-printing for small businesses. Liu and Wang (2015) studied embodied sulfur dioxide (SO_2) in China's exporting goods. Simas et al. (2015) measured the labor, energy, and greenhouse gas emissions footprints in the European Union's trade with the rest of the world. Based on papers referred above, input–output method is the main way to get air pollutants embodied in goods consumption and trade. What's different from studies above; in this paper, we applied Multiregional Input-output Model, so as to get more details in sources of import and export destinations of trade in which air pollutants embodied for China. And emissions of some air pollutants such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NOx), sulphur oxides (SOx), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) embodied in China's goods consumption and trade during 1995–2009 were studied.

Structural Decomposition Analysis (SDA), a kind of research method, is widely used in studies on carbon emission, energy consumption, and water resources management. (1) SDA has been applied to study drivers of carbon emission in countries (areas) below: China (Feng et al., 2012; Yuan and Zhao, 2016), top 10 emitters of the world (Pani and Mukhopadhyay, 2013), Beijing in China (Wang et al., 2013; Tian et al., 2013), European Union (Fonti and Pavan, 2014; Kopidou et al., 2016). (2) SDA method also was used to study drives of energy consumption in the following countries (areas):India (Das and Paul, 2013), China (Li et al., 2014; Zeng et al., 2014; Zhang and Lahr, 2014). (3) Still, SDA was used to research on drives of water resources management: Japan (Kondo, 2005), China (Zhang et al., 2012; Deng et al., 2016), Spanish (Duarte et al., 2014). However, in this paper, SDA was applied to check the variation of air pollutants embodied in goods consumption and trade in China from 1995 to 2009 and its structural decomposition analysis.

Though CO_2 is a big part of greenhouse gases (GHG), it is essential to study other GHG, e.g., Liu and Wang (2015) discussed on sulfur dioxide (SO_2). Besides, it is possible that others haven't studied on more air pollutants due to the lack of data. In our paper, eight kinds of air pollutants, CO_2, CH_4, N_2O, NOx, SOx, CO, NMVOC, NH_3 have been studied applying data from WIOD. In this way, we can discuss air pollutants embodied in goods consumed and traded in China generally. Although Peters et al. (2011) checked embodied carbon trade globally, they didn't combine SDA and MIRO model or study drives of embodied carbon trade. In our paper, SDA and MIRO model is applied together to answer drives of air pollutants embodied in goods consumed and traded in China. Indeed, regions in China have been studied by MIRO model (Deng et al., 2016). It is neglected that China can be studied as a country or an area in the world. What's more, embodied air pollutants in China only can be divided into import sources and export destinations when we take China as a region of the world. Comparing to previous studies, our work covered years in 1995–2009, 41 areas or regions, 35 industries and 8 air pollutants so as to discuss air pollutants embodied in goods consumed and traded in China more comprehensively. In this paper, we checked air pollutants embodied in goods consumed and traded in China applying MRIO model, but also analyzed drives of that by SDA method.

For emissions embodied in consumption and trade, it is unfair for China, a producer named World Factory, to undertake the duty of air pollutants. Those countries imported goods from China should undertake parts responsibilities. As a result, we checked emissions embodied in consumption and trade systematically and analyzed drivers.

The primary works in this paper are presented as follows: (1) Accounted China's air pollutants such as CO_2, CH_4, N_2O, NOx, SOx, CO, NMVOC, NH_3 embodied in goods consumption and import and export trading in 1995–2009 using Multiregional Input-output Model. But, previous studies that only consider one air pollution, such as Peters et al. (2011). (2) Divided China's air pollutants embodied in goods trading according to sources of import, export destinations and sectors, which has been neglected by previous researches, such as Su and Ang (2013). (3) Checked the structural decomposition analysis of emissions' variation, in order to investigate the impacts of trade structure between China and other nations on air pollutions.

2. Methods

Multi-region input–output model is introduced to calculate embodied emissions and SDA method to study drives of them in this department.

2.1. Calculate the amount of air pollutants embodied in goods consumption and trade

Referring to Peters et al. (2011), Zhang and Anadon (2014), we define air pollutants emissions' direct factor of sector i in country (area) r as θ_i^r as[1]:

$$\theta_i^r = \frac{P_i^r}{X_i^r} \tag{1}$$

where, P_i^r denotes air pollutants from sector i in country (area) r according to World Input-Output Database; X_i^r denotes the total output of sector i in country (area) r. combining air pollutants emissions' direct factor and Leontief inverse matrix, we can get air pollutants emissions' total factor, that is row vector λ:

$$\lambda = \theta(I - A^*)^{-1} \tag{2}$$

where, $\boldsymbol{\theta} = (\theta_1^1, \theta_2^1, \cdots, \theta_m^1, \theta_1^2, \theta_2^2, \cdots, \theta_m^2, \cdots, \theta_1^n, \theta_2^n, \cdots, \theta_m^n)$, m is the number of sectors and n is the number of countries (areas). I is an identity matrix, A^* is the direct consumption coefficient matrix:

$$A^* = \begin{pmatrix} A^{11} & A^{12} & \cdots & A^{1n} \\ A^{21} & A^{22} & \cdots & A^{2n} \\ \cdots & \cdots & \cdots & \cdots \\ A^{n1} & A^{n2} & \cdots & A^{nn} \end{pmatrix} \tag{3}$$

In Equation (3), A^{rr} is the direct consumption coefficient of using its own goods in intermediate use part in country (area) r, A^{rs} is the direct consumption coefficient of country (area) s using goods from country (area) r in intermediate use part. Then it will obtain trade volume of air pollutants embodied in goods trading through multiplying air pollutants emissions' total factor by goods trading

[1] Air pollutants emissions' direct factor can be defined in this way for any air pollutant.