



The effects of direct trade within China on regional and national CO₂ emissions



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ABSTRACT

Curbing national carbon emissions and clarifying regional carbon reduction responsibility are two challenges faced by China, both of which are influenced by interregional trade. To exclude the influence of trade balance, this paper proposes a methodology to parcel the pollution haven hypothesis into a multi-regional input–output model, applies it to a longer time gap, which is made up of two representative periods of Chinese economy (1997–2002 and 2002–2007), and clarifies the provincial and sectoral contributions to national emissions. We find that (1) embodied CO₂ emissions first remain relatively stable and then increase sharply for the two periods, and the changing trends are mainly determined by the decreasing carbon intensity and the expanding trade scale, respectively. (2) With the secondary industry as the main contributor, regional carbon spillover is mainly concentrated in the coastal provinces but it contributes to an increase of CO₂ emissions in the central and western regions. (3) The coastal and inland provinces contribute to the increase of national carbon emissions through interregional imports and exports, respectively; but the pollution haven hypothesis is not obvious and is only observed in 2002.

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1. Introduction

As the world's largest CO₂ emitter (IEA, 2009), China is a vast country with close interregional economic link and substantial variation in environmental regulations, which means that interprovincial trade may influence both regional and national CO₂ emissions (the pollution haven hypothesis, defined as a reduction in trade barriers will lead to a shifting of pollution-intensive industry from regions with stringent regulations to regions with weaker regulations (Copeland and Taylor, 2004)). This paper attempts to clarify the effects of interprovincial trade on China's regional and national CO₂ emissions in recent years, adopting a multi-regional input–output analysis mechanism.

Previous studies on CO₂ emissions embodied in China's international trade contain both static (e.g., Li and Hewitt, 2008) and dynamic (e.g., Pan et al., 2008; Zhang, 2009) analysis, while the existing studies on interregional trade are mainly limited to static analysis (e.g., Feng et al., 2013; Guo et al., 2012; Su and Ang, 2014), due to data availability (Feng et al., 2013). As far as we know, Meng et al.'s (2013) paper is the only dynamic analysis on China's interregional spillover of CO₂

emissions. However, Meng et al.'s study only analyzes the time span (2002–2007) when China's total CO₂ emissions increased quickly, and fails to present the period (1997–2002) when China's carbon intensity decreased sharply (Meng et al., 2011). The national CO₂ emissions and gross domestic production (GDP) of these two periods are shown in Fig. 1.

From 1997 to 2002, China experienced a quick economic growth, with annual average growth rate of 8.25%. However the total CO₂ emissions only increased from 3093 million tons of 1997–3377 million tons of 2002. In 1999, China even experienced a decrease in total CO₂ emissions. From 2002 to 2007, China's annual economic growth rate reached as high as more than 10%. At the same time, the total CO₂ emissions almost doubled during these 5 years. Not only the sharp increase in total CO₂ emission for the second period but also the quick decrease in carbon intensity for the first period attracts international concerns. For instance, some researchers even doubt the data accuracy of energy and emission statistics provided by the Chinese government (Liu and Yang, 2009; Peters et al., 2007; Sinton, 2001; Sinton and Fridley, 2000). This paper attempts to fill the gap that previous related studies only discuss the second period, and to provide a more comprehensive analysis on regional carbon spillover.

The pollution haven hypothesis is one of the most contentious areas of energy economics. For instance, Peters (2007), Zhang (2012), and Lopez

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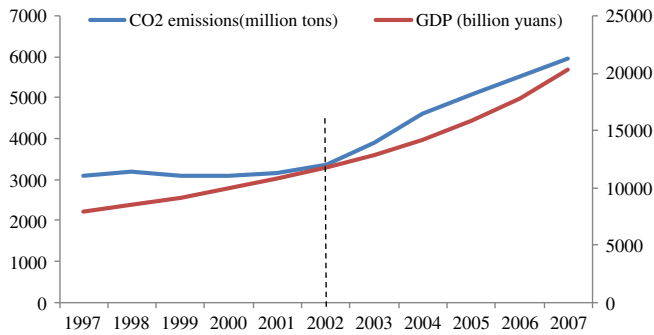


Fig. 1. National CO₂ emissions and GDP for 1997–2007. Note: National CO₂ emissions are obtained from the WIOD database (http://www.wiod.org/new_site/home.htm); national GDP data (the year 2000 is chosen as the base year) are obtained from China Statistical Yearbook of 2013 (<http://www.stats.gov.cn/tjsj/ndsj/2013/indexch.htm>).

et al. (2013) state that the total CO₂ emissions increase for trade, while Ackerman et al. (2007), Dietzenbacher and Mukhopadhyay (2007), and Tan et al.'s (2013) paper conclude that the pollution haven hypothesis does not hold. In addition, all these studies focus on the international trade, rather than interregional trade, although the latter has greater volume than the former. This paper attempts to discuss the pollution haven hypothesis from the perspective of trade within China and to clarify the effects of interregional trade on China's total CO₂ emissions. We hope to make some complements to previous studies (e.g. Feng et al., 2009; Zhang, 2009; Zhang et al., 2009), which analyze China's rapid increase in CO₂ emissions mainly from the angles of technology, economic structure, urbanization, and lifestyles.

Multi-regional input–output analysis (bi-regional input–output analysis can be observed as the simplest version of multi-regional input–output analysis with only two regions) can be divided into two types: one considers total bilateral trade between regions (EEBT approach) and the other considers trade to final consumption and endogenously determines trade to intermediate consumption (MRIO approach) (Peters, 2008). The EEBT approach has the transparency property and is considered superior when analyzing national trade and climate policy; the MRIO approach has the advantage of reflecting international feedback effects and is suitable for analyzing the global production system (Peters, 2008). Su and Ang (2010) further combine the EEBT and MRIO approaches and propose the hybrid emissions embodied in trade (HEET) approach. The characters of three approaches are summarized in Table 1.

There is a close relation among the three approaches. The EEBT and MRIO approaches are linked together through feedback effects (Su and Ang, 2011); and the HEET approach can be observed as a combination of the EEBT approach and the MRIO approach. Lopez et al. (2013) propose a methodology to parcel the pollution haven hypothesis into the bi-regional input–output analysis which adopts the MRIO approach to analyze the effects of regional specialization in value chain on total CO₂ emissions. However, this paper shows that the previous method fails to exclude the influence of trade balance on identifying the regional responsibility and tend to put more carbon reduction responsibility to the net exporter regions. This paper proposes a methodology to parcel the pollution haven hypothesis into the EEBT approach and we discuss the regional

contribution and sectoral efficiency from the perspective of carbon intensity.

This paper chooses the EEBT approach according to the following reasons. First, this paper focuses on CO₂ emissions embodied in interregional trade within China, rather than the national trade. This means the HEET approach is not suitable for our research. Secondly, this paper analyzes the impacts of direct trade, rather than considering the interregional feedback effects. This means the MRIO approach is too complex for this study. Thirdly, in order to ensure comparability among different years, the main data (multi-regional input–output tables and interprovincial trade tables) of this paper are obtained from Development Research Center of the State Council, P.R.C. (Li et al., 2010; Xu and Li, 2008), which only supports the EEBT approach.

More specifically, based on China's multi-regional input–output tables of 1997, 2002 and 2007, this present paper calculates CO₂ emissions embodied in interprovincial trade from both regional and sectoral perspectives, discusses the interregional carbon spillover, and clarifies the effects of trade on provincial and national CO₂ emissions. The main results of this paper are shown as below.

- 1) This paper proposes a methodology to parcel the pollution haven hypothesis into the multi-regional input–output analysis, which excludes the influence of trade balance on identifying the regional responsibility. First, with a simple example, we show that previous calculation approach may attribute more responsibility to the net exporter regions for the pollution haven hypothesis. Secondly, the proposed approach shows that provinces with lower carbon intensities for imported goods or higher carbon intensities for exported goods, and sectors primarily located in regions with greater carbon intensity should be responsible for the pollution haven hypothesis. Thirdly, the proposed approach is applied to Chinese economy, to discuss the changing trends and main contributors of regional and national CO₂ emissions.
- 2) This paper extends previous studies on regional spillover of embodied CO₂ emissions within China to a longer time gap, including two representative periods of Chinese economy. First, China's CO₂ emissions embodied in interprovincial trade remain relatively stable for the first 5 years (from 2293.72 million tons in 1997 to 2390.71 million tons in 2002) and increase sharply for the second 5 years (6225.90 million tons in 2007). Secondly, the changing trends of the scale of embodied CO₂ emissions for the two periods (1997–2002 and 2002–2007) are mainly determined by the decreasing carbon intensity and the expanding trade scale, respectively. Thirdly, the provinces and sectors with a large scale of embodied CO₂ emissions mainly concentrate in the coastal region and the secondary industry, respectively, and the most obvious carbon spillover is from the Pearl and Yangtze River Delta regions to the provinces around the Bohai Sea region.
- 3) This paper clarifies the effects of interregional trade on national CO₂ emissions from the perspectives of provincial and sectoral contributions. First, the pollution haven hypothesis was only held in 2002, and the interregional trade contributed to changes of national carbon emission by –2010.01, 38.91 and –118.49 million tons respectively for 1997, 2002 and 2007, respectively. Secondly, the coastal and inland provinces contribute to national CO₂ emissions through interregional imports and exports, respectively; and the

Table 1

Characters of three approaches of multi-regional input–output analysis.

	EEBT	MRIO	HEET
Features	Considering direct trade	Considering indirect trade	Considering direct and indirect trade
Advantages	Transparency	Entirely reflecting the interregional feedback effects	Partly reflecting the interregional feedback effects
Applications	Carbon emissions embodied in regional direct trade	Impacts of regional production system on regional carbon leakage	Impacts of regional production system on regional carbon leakage
Examples	Guo et al. (2012)	Lopez et al. (2013)	Su and Ang (2010, 2014)

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