Regional Inequality and CO_2 Emissions in China: a consumption-based MRIO approach

K. Feng [a], X. Li[b], L. Sun[c], K. Hubacek[a*]

[a] Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA.

[b] Sustainability Research Institute, School of Earth and Environment, University of Leeds, LS2 9JT, UK

[c] Department of Financial & Management Studies, School of Oriental and African Studies, University of London, London, WC1H0XG, UK

* Corresponding author, Email: Hubacek@umd.edu

Abstract:

There is ample evidence showing that the rich countries consume most of goods and services and at the same time gain most of the economic profits but that the poor suffer the environmental costs. In this study we argue that the inequality of economic gains and environmental consequences does not only exist at the global level but that we find the same patterns within a country's boarders using China as a case study. China, as the world's biggest emitter, attracts a lot of attention regarding its economic growth, technical progress and environmental degradation. Rather than a homogenous country, China is a vast country with substantial regional differences in physical geography, regional economic development, demographics, infrastructure, and lifestyles. Using environmentally extended multi-region input-output analysis, this paper calculate both consumption and production based CO_2 emissions for 30 regions in China and the emissions embodied in the inter-regional trade. Our results show that the rich coastal areas consume and gain most of the economic benefits whereas the poorer regions provide low cost production and bear most of the emissions. The central and south coastal regions gain profits from advanced infrastructural investment and exports, but impose a large amount of emissions on the central and western regions, which provide the raw materials and low cost products for the coastal area. A fairer distribution of benefits and costs would imply that the coastal regions assume the responsibility for emissions in other parts of China associated with consumption in coastal areas. A consumption based approach to carbon accounting is better suited to track emissions along the whole supply chain and allocate emissions based on final consumption.

Keywords: CO_2 emissions, MRIO, inter-regional trade, China

Introduction

As the world's biggest emitter, China is facing the challenge of balancing rapid growth of economy and environmental sustainability. Rather than a homogenous country that can be analyzed at the national level, China is a vast country with substantial regional differences in physical geography, regional economic development, demographics, infrastructure and household consumption patterns. Particularly, there are pronounced differences between the well-developed coastal regions and the less developed central and western regions, which lead to large regional discrepancies in CO_2 emissions. By using environmentally extended China MRIO analysis, in this study we present consumption-based CO_2 emissions and emissions embodied in the intra- and inter-regional supply chain in China. Although CO_2 emission is a global pollutant, it is commonly used as a proxy for other energy related emissions.

Methods

In this study, we include 26 provinces and 4 municipal cities except Tibet and Taiwan. The provinces and municipal cities are allocated to 8 big Chinese regions: North-East (Heilongjiang, Jilin, Liaoning), Beijing-Tianjin (Beijing, Tianjin), North (Hebei, Shandong), Central (Henan, Shanxi, Anhui, Hunan, Hubei, Jiangxi), Central-Coast (Shanghai, Zhejiang, Jiangsu), South-Coast (Guangdong, Fujian, Hainan), North-West (Inner Mongolia, Shannxi, Gansu, Ningxia, Qinghai, Xinjiang), South-West (Sichuan, Chongqing, Yunnan, Guizhou, Guangxi).

The 30 regions MRIO tables were used in this study. In a MRIO framework, different Chinese regions are connected through inter-regional trade. The technical coefficient matrix A* was calculated by $a_{ij}^{ks} = z_{ij}^{ks}/x_j^s$, z_{ij}^{ks} is the inter-sector monetary flow from sector *i* in region *k* to sector *j* in region *s*; x_j^s is the total output of sector *j* in region s. In a similar way we constructed a final demand matrix Y*, where y^{1n} is a vector of final goods and services in region *n* from region *1*. x* is the total output of sectors in all regions.

$$A^* = \begin{bmatrix} A^{11} & A^{12} & \cdots & A^{1n} \\ A^{21} & A^{22} & \cdots & A^{2n} \\ \vdots & \vdots & \ddots & \vdots \\ A^{n1} & A^{n2} & \cdots & A^{nn} \end{bmatrix};\ Y^* = \begin{bmatrix} y^{11} & y^{12} & \cdots & y^{1n} \\ y^{21} & y^{22} & \cdots & y^{2n} \\ \vdots & \vdots & \ddots & \vdots \\ y^{n1} & y^{n2} & \cdots & y^{nn} \end{bmatrix};\ x^* = \begin{bmatrix} x^1 \\ x^2 \\ \vdots \\ x^n \end{bmatrix};$$

Therefore, the MRIO framework can be written as:

$$x^* = A^* x^* + Y^* \qquad \textbf{[1]}$$

To solve x, we get

$$x^* = (I - A^*)^{-1} Y^* \quad \textbf{[2]}$$

where $(I\text{-}A^*)^{-1}$ is the Leontief inverse matrix which captures the both direct and direct inputs to satisfy one unit of final demand in monetary value; *I* is the identity matrix. To calculate the embodied emissions in the goods and services, we extended the MRIO table with environmental extensions by using CO_2 emissions as environmental indicator in equation 3.

$$CO_2 = F(I - A^*)^{-1} Y^* \quad \textbf{[3]}$$

where CO_2 is the total CO_2 emissions embodied in goods and services used for final demand. *F* is a vector of regional CO_2 emissions per unit of economic output.

Embodied CO_2 emissions in inter-regional

Fig. 1 shows the Central region in China with the largest amount of CO_2 emissions embodied in domestic export to meet domestic final demand in other regions, such as Central-coast (188 MMT or 39% of total embodied emissions in Central region's export) and North (84 MMT or 17%). The North has the second largest embodied emission in domestic export mainly to Central-Coast (25%), Beijing-Tianjin (20%) and Central (19%). North-West has become China's power-house which produces large amount energy for many other regions, such as North-East (20%), Central-Coast (20%), Beijing-Tianjin (17%) and Central (15%). In particular, Inner-Mongolia exports 66 trillion Watt Hours electricity to its neighbors in 2007, and Xinjiang is one of the largest oil producing regions in China, which supplies a huge amount of oil products to many other Chinese regions. South-West is a relatively poor region which produces goods consumed by South-Coast (88MMT or 42%) and Central-Coast (40MMT or 19%) regions mainly due to its proximity. From Figure 1 we also observe that Central-Coast, South-Coast and Beijing-Tianjin have relatively small amounts of emissions embodied in their domestic exports. It is because they are the richest regions in China with very advanced technology and infrastructure and usually produce goods which have low emissions but high value added. For example, Beijing consumes a large amount of goods which are produced outside of the region, thus externalize its emissions to other regions.

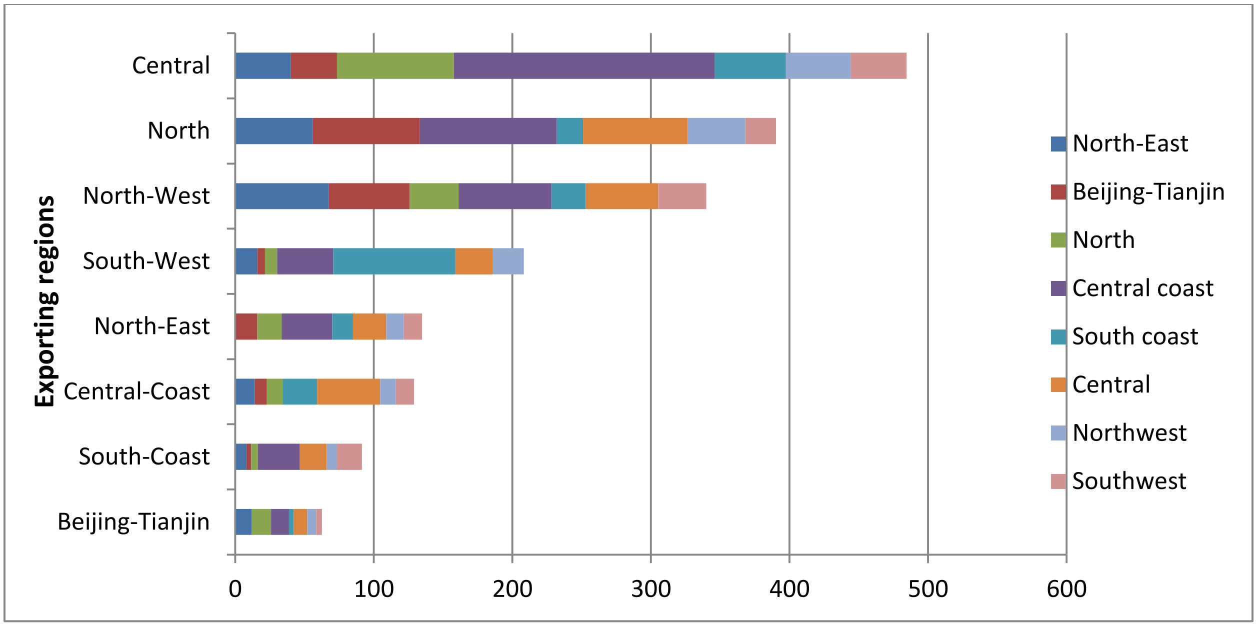

Figure 1: Embodied CO_2 emissions in inter-regional trade flows to satisfy domestic final consumption (Million Metric Tons)

Apart from domestic final demand, international exports are also a significant driver for China's CO_2 emissions. Central- and South- Coast regions gain a huge amount of profits from international exports due to their comparative advantage in terms of geographical location and advanced infrastructure. Exports in Central- and South-Coast regions contribute to more than 20% of their regional GDP. In fact, these two regions account for 74% of China's total exports (9). However, our results show that only 60% of emission associated with the export occurred within their regional borders, while 40% of their emissions embodied in international exports were caused in other regions. South-Coast's international exports led to a large amount of emissions in South-West (81 MMT), Central (60 MMT) and North-West (29 MMT). In addition, international exports in Central-Coast region caused 82 MMT, 36 MMT, 31 MMT and 20 MMT emissions in Central, North, North-West and North-East, respectively.

Our results demonstrate that there is huge inequality across Chinese regions between economic gains and environmental cost where the coastal regions obtain most profits from international trade but impose a huge amount of emissions on other regions in China.

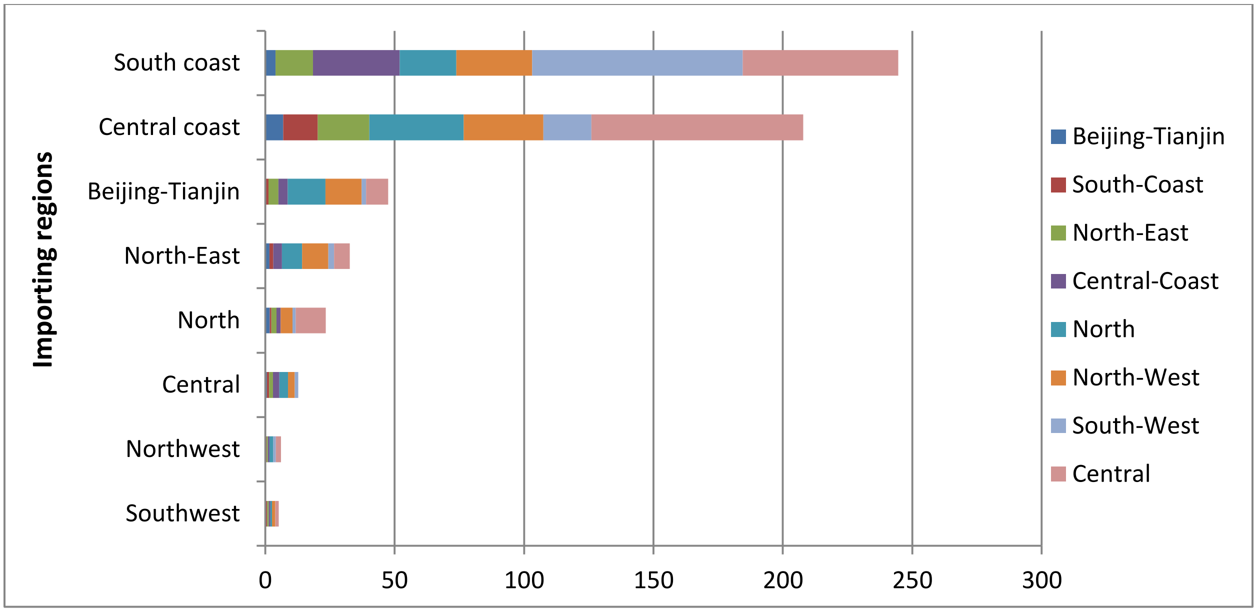

Figure 2: Embodied emissions in inter-regional trade to satisfy international export

Consumption-based CO_2 emissions inventory

There are also large regional disparities in terms of consumption patterns and associated per capita consumption emissions (see Figure 3). Beijing ranked top with approximate 12 metric tons CO_2 emissions per person, which is more than six times the CO_2 emissions per person in the lowest-ranked province Guangxi. In most provinces, the construction sector is the largest contributor to the total consumption emissions. This is due to the large scale of infrastructural investment across China to support the fast growth of the economy, and building infrastructure is a carbon intensive process which requires significant inputs from other carbon intensive sectors, such as iron and steel sector, electricity sector and minerals production sector. The contributions of construction sector to the regional CO_2 emissions range from 14% up to 51%. Figure 3 also shows that in highly urbanized areas, such as Beijing, Tianjin, Shanghai, where urban population accounts for more than 80% of the total, Petroleum, chemicals and minerals (14% - 20%) and Services (10% - 24%) are key contributors to the total consumption emissions. It is because the urban households consume more products and services in their daily life other than basic needs of foods and clothes compared to rural households.

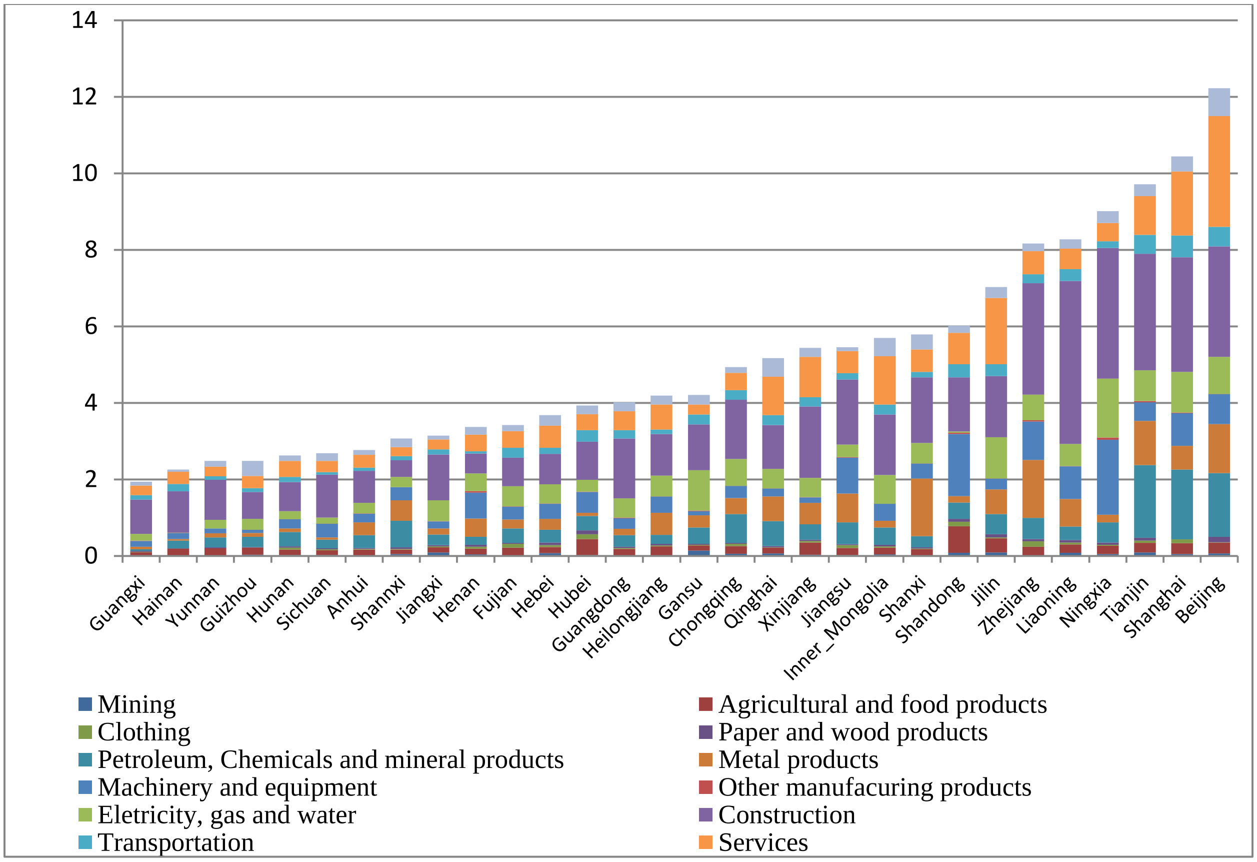

Figure 3: Per capita consumption-based CO_2 emissions by sectors (Metric Tons)