ESTIMATION OF HOUSEHOLD CARBON EMISSIONS IN CHINA BY USING A MRIO MODEL

Haidi Gao, Tsinghua University, Phone +86-10-62784805, E-mail: gaohaidi131@163.com
Xin Su, Tsinghua University, Phone +86-10-62784805, E-mail: x-su16@mails.tsinghua.edu.cn
Fei Teng*, Tsinghua University, Phone +86-10-62784805, E-mail: tengfei@tsinghua.edu.cn

Overview

The Paris Agreement sets landmark goals for combating climate change, with a view to keep the global average temperature rise “well below 2° C above pre-industrial levels”1. The unequal distribution of household carbon footprints is one of the main debate issues related to the deep decarbonisation policies. As the largest population country and carbon dioxide (CO2) emitter in the world, China’s household carbon emissions are also growing quickly. Under the framework of the Paris Agreement, countries and regions of the world have submitted their own Nationally Determined Contributions (NDC), seeking maximum protection of their own interests while addressing climate change. As the world's most populous country and the largest emitter of CO2, China promises that by 2030, CO2 emissions will peak and strive to reach its peak as early as possible; at the same time, further increase hydrofluorocarbons, methane, the control of non-CO2 greenhouse gases such as nitrous oxide, perfluorocarbon and sulfur hexafluoride.

As the global economy re-energizes, the flow of international trade in different countries and regions has led to an increasing gap between production-based emissions and consumption-based emissions at the national and regional levels. At present, the "Kyoto Protocol" and the United Nations Framework Convention on Climate Change (UNFCCC) use production-based emissions as the basis for accounting, accounting for national emissions with the principle of "producer responsibility" or "geographical boundary". In order to define emission liability, a discussion on “consumer responsibility” has emerged for the “producer responsibility” principle. Most developing countries that export goods and services advocate the use of consumption-based emissions as the basis for accounting.

Multi Regional Input Output Analysis (MRIOA) first appeared in an article by Isard in 19512. In this article, Isard theoretically introduced MRIOA. Over the past two decades, and especially since 2000, more and more MRIOA have been used to analyze emissions or environmental burdens in international trade. In 2003, Ahmad3 first used MRIOA to calculate production and consumption emissions between multiple countries. Then, in 2004, Lenzen4 and Peters5 and others gave a theoretical Multi Regional Input Output Model (MRIO) based on the manufacturing use table and the symmetric input-output table, respectively. The large scale of data requirements and the complex number requirements were not possible at the time. With the development of MRIOA and the support of the database represented by the GTAP database in terms of data size and complexity, it is possible to establish true MRIO. In 2007, Peters pioneered the global MRIO based on the GTAP database at the 16th International Conference on Input-Output. Subsequently, the research on MRIO became more and more perfect. At present, MRIO can basically restore the actual economic operation and emissions between different countries and regions, but the model requires a lot of data and accuracy. Compared with the Single Region Input Output Model (SRIO), the biggest advantage of MRIO is that it can accurately calculate the whole life cycle of greenhouse gas emissions in various countries and regions, and even track the global supply chain between different countries and regions. The current research on consumption-based emissions is based on MRIO accounting6-8, comparison and analysis of energy-related CO2 emissions9-11, such as the driving factors for carbon emissions12,13, carbon leakage, carbon transfer emissions14, the extended research also includes urban distribution and sectoral distribution in single-country consumption emissions, uncertainty analysis of transfer emission model methods, structural decomposition analysis of driving factors for transfer emissions15, and the impact of vertical division of international industries.

Methods

Most of the current studies estimate Chinese household carbon emissions by focusing the differences between production-based carbon emissions and consumption-based carbon emissions. This paper details all emissions from household consumption, revealed the economic flow and trade flow behind the emissions in China at macro level. The established global MRIO model in this paper is a static global model that includes 57 industry sectors of 140 countries and regions. It basically covers all countries and regions in the world. The most important data foundation of the model is derived from GTAP 9 database.

In fact, in addition to its own production, a country and region import products and services come from different countries and regions, and its export products and services flow to different countries and regions. So, the theoretical global MRIO model in row banlance is:

$$X^r = A^r X^r + Y^r \quad (1)$$

In formula 1, X^r is the total output for country r; Y^r is the terminal consumption matrix of any for country r, specifically include the government's terminal consumption column vector, the terminal consumption column vector of the investment, and the terminal consumption column vector of the household, which is $Y^r = Y_g^r + Y_i^r + Y_p^r$.

$$X^r = (I - A^r)^{-1} Y^r \quad (2)$$

Formula 2 is the deformation of the formula 1. By the deformation, the equilibrium equation with the Leontief inverse matrix $(I - A^r)^{-1}$ can be obtained, where I is the unit matrix. In the standard IOA framework proposed by Leontief, economic output is first determined and then environmental pressures and impacts are calculated. The relevant CO2 emission factor is the emission caused by the unit economic output, the ratio between the emissions data of any industry or region according to the industry sector and the total output of the industry sector.

$$E_{ic}^r = F_{ic}^r \cdot X^r = F_{ic}^r \cdot (I - A)^{-1} \cdot Y^r \quad (3)$$

In Formula 3, F_{ic}^r is the CO2 emission factor of the industry in country r, and E_{ic}^r is the CO2 indirect emissions of any country r.

$$E_c^r = E_{ic}^r + E_{dc}^r \quad (4)$$

In addition, combined with the CO2 direct emissions of terminal goods and services E_{dc}^r in the database, we can get the CO2 consumption emissions of the country r, and also can get the CO2 consumption emissions of the household, investment and government in three different themes.

Results

We find that the difference between direct carbon emissions and indirect carbon emissions is considerable, which is mainly caused by consideration of all producttion emissions from household consumption are taken into account. Furthermore, the changes in 57 sectors show that consumption upgrade in some sectors has taken place during recent years. We also find that consumption patterns and related emissions differ significantly by household size, the employment status, behaviour pattern and other demographic and behaviour characteristics.

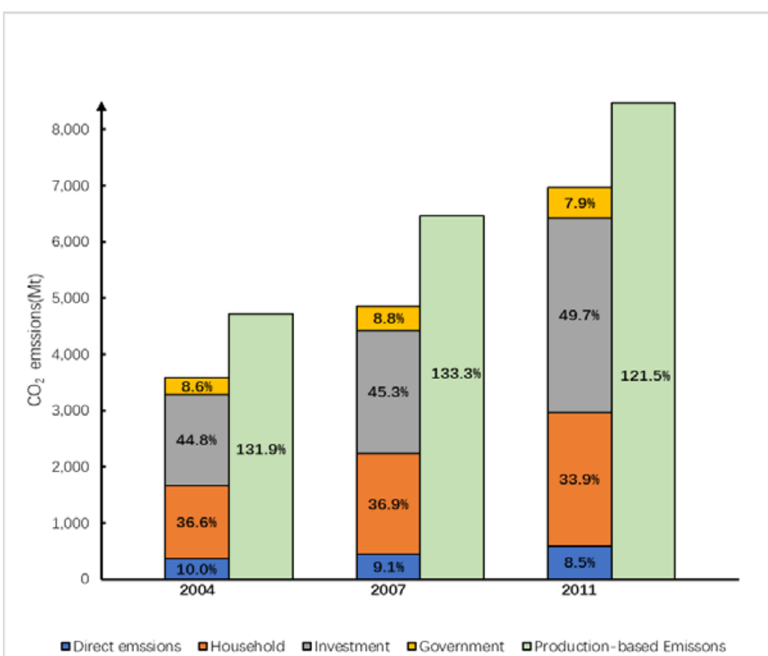


Fig.1 Consuption-based and production-based emission of China in2004,2007and2011

During the period from 2004 to 2011, China's production-based emissions were 20% to 30% higher than the consumption-based emissions in figure 1. At least between one-quarter and one-fifth of the emissions from land in China should be borne by foreign consumers. Especially in 2004 and 2007, China's production-based emissions were higher than consumption-based emissions by more than 30%. After the financial crisis, the Chinese government expanded domestic demand actively, which was reduced to 21.5% in 2011.

Direct emissions from China's consumption-based emissions account for only about 10%, and most of the emissions come from indirect emissions of the household, investment and government. Among them, investment accounts for the largest proportion, followed by consumption behavior of household and government. Although indirect emissions continued to increase from 2004 to 2007, the proportion of household, government and investment did not change too much, and China's economic structure remained basically unchanged. Affected by the financial crisis, the proportion of investment in 2011 has increased significantly. It can be seen from the other side that domestic demand in the financial crisis is mainly driven by investment behavior. On the contrary, the proportion of household consumption has dropped significantly, reflecting the fact that the living standards of residents have been affected to some extent during the financial crisis.

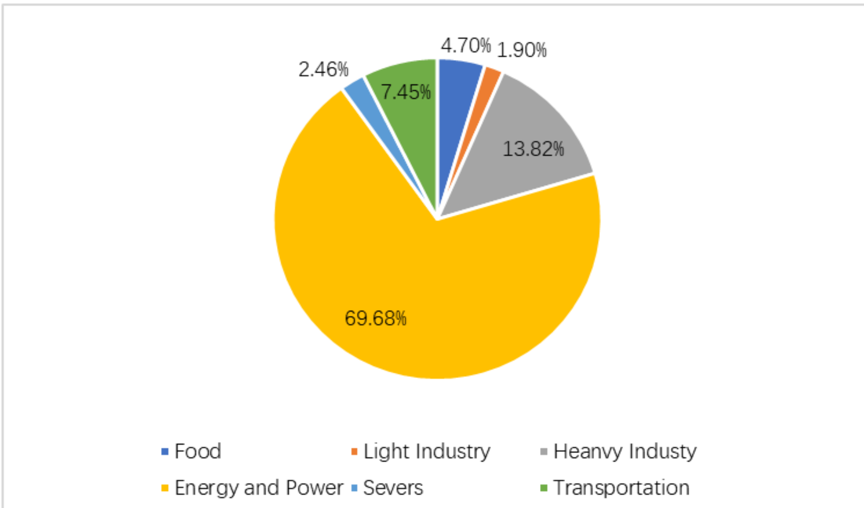


Fig 2.The proportion of household indirect emission from different sector of China in 2011.

The collection of indirect emissions of household consumption in various sectors in 2011 is shown in figure 2. Indirect emissions from household consumption mainly come from the energy production and supply sectors, accounting for about 70% of total indirect emissions. Followed by the production of heavy industrial products and the transportation. Service, light industry, food production and supply just account for a small share. The results show that although the amount of energy directly used by households is relatively small, the consumption activities of households are closely related to the production and supply of energy, and 70% of households indirect emissions can be traced back to the production and supply of energy. Therefore, improving the energy structure and promoting the development of clean energy is very conducive to China's emission reduction of greenhouse gases. Secondly, the service, light industry and other industries have high value-added and low emissions. Improving the economic structure can also promote low-carbon development actively in China.

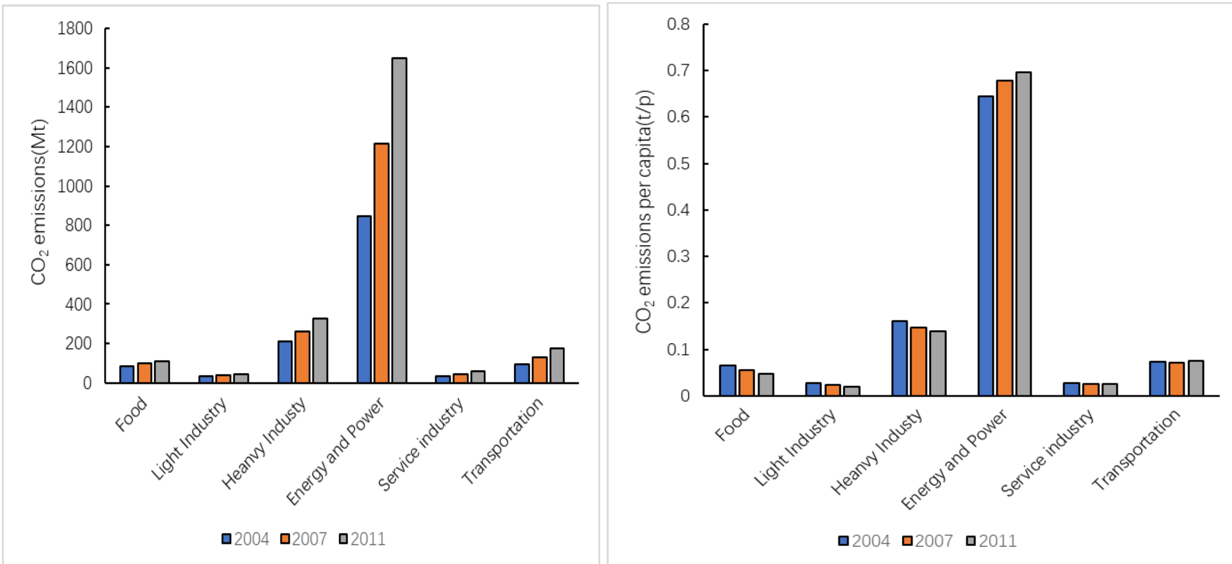
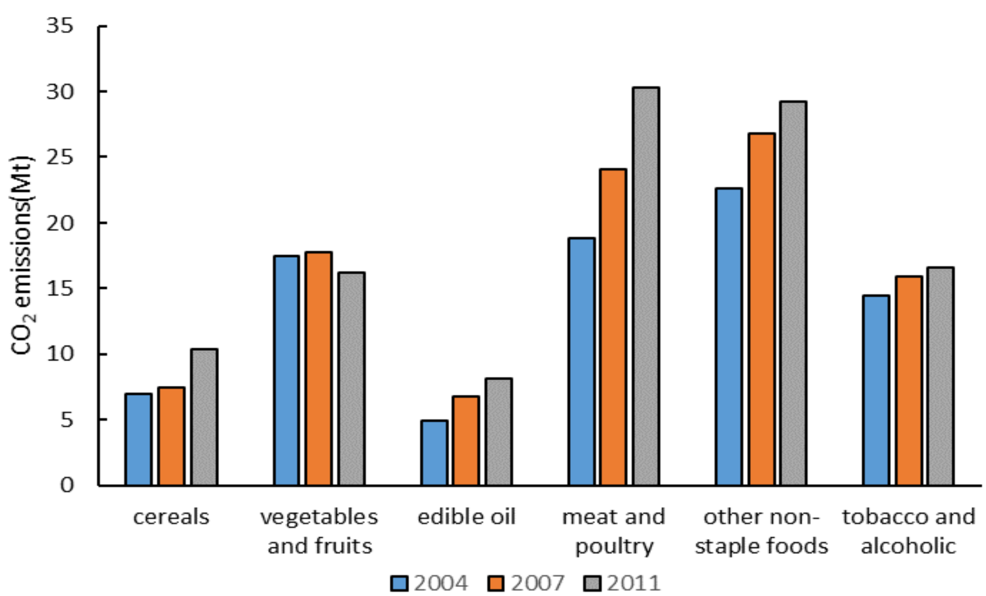


Fig.3 The household indirect CO_2 emission and percapita emission of China in 2004, 2007 and 2011

As shown in figure 3, from 2004 to 2011, the indirect emissions of households from various sectors have increased. However, the production and supply of energy are the fastest growing industry, and the growth of the transportation and the service are relatively rapid. Therefore, in the proportion of various industries, the proportion of energy production and supply has risen rapidly, while the proportion of services to the transportation has remained unchanged basically, while the proportion of food, light industry and heavy industry has declined. This shows that the years of rapid development of China's economy from 2004 to 2011 depended on the development of industries with high energy consumption and high emissions.



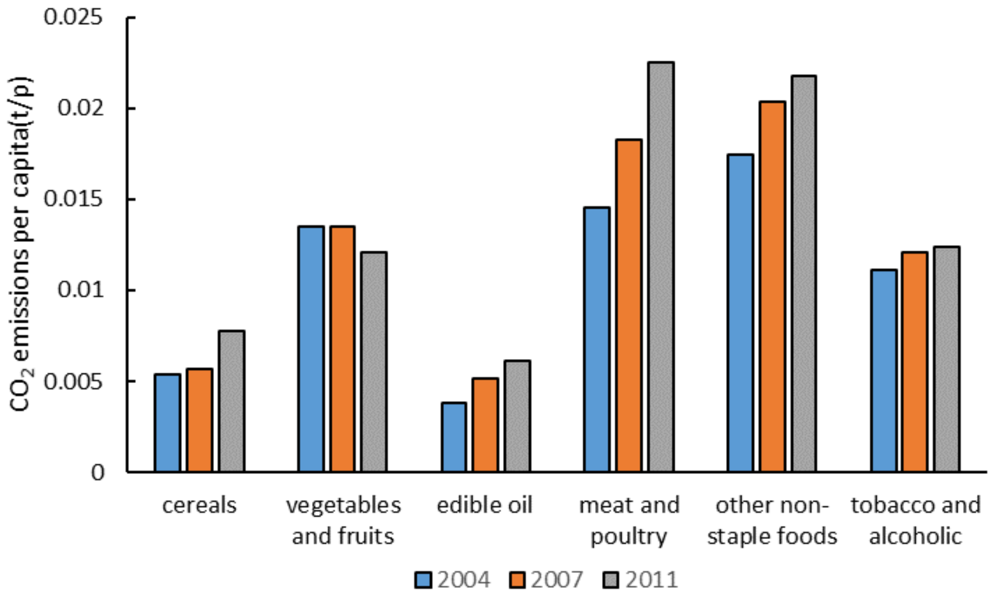


Fig.4 The indirect CO_2 emission structure of Chinese household in 2004, 2007 and 2011.

The indirect emissions of food consumption and per capita emissions of Chinese households are shown in figure 4. We also find that the indirect emissions caused by the consumption of cereals, edible oil, meat and poultry, other non-staple foods, and tobacco and alcoholic beverages all showed a rapid growth trend. On the one hand, China's population is growing fast; and on the other hand, it is because of the improvement of the living standards of the Chinese households. From the perspective of per capita emissions, there is also a similar upward trend, which fully reflects the process of upgrading the dietary consumption of Chinese people from 2004 to 2011, especially the growth trend of meat and poultry, milk, edible oil and other non-staple foods. The per capita emissions of vegetables and fruits have steadily declined, reflecting the development trend of the Chinese households' diet structure towards diversification, more edible oil and more meat.

Conclusions

We estimated the household carbon emissions in china by using a MRIO model. We find that consumption patterns and related emissions are significantly different among various households in terms of the social and economic development, household income improvement and daily life pattern. The results of this research can also be used for analysing government policies on energy and carbon emissions, especially carbon control policies.

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