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Household carbon inequality in urban China, its sources and determinants

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ABSTRACT

Designing mitigation policies for households requires knowledge of household carbon distributions. This study surveys the household carbon inequality in urban China and analyzes its sources and determinants using weighted household survey data. Different from existing literatures studying carbon inequality on the international or regional level, we focus on the household aspect and first survey its characteristics by some comparisons. By ascribing household carbon emissions calculated by the Consumer Lifestyle Approach to several consumption categories with the method of Gini coefficient decomposition, we find that residential consumption with high carbon intensity is the most important source of household carbon inequality in urban China. Food consumption and the consumption of educational, cultural and recreational services are the next largest sources because of the consumed quantities or carbon intensity. The application of Shapley decomposition shows the determinants of household carbon inequality in urban China and their contributions, which are household demographic characteristics (59.74%), household employment and income (24.31%), household burdens (8.00%), and household assets and financial plans (7.95%). The policy implications of these results are also discussed.

1. Introduction

Designing mitigation policies requires knowledge of the distribution of carbon emissions. Quite a few studies have investigated the international inequality of carbon emissions, including Heil and Wodon (1997, 2000); White (2000, 2007); Sun (2002); Alcántara and Duro (2004); Hedenus and Azar (2005); Padilla and Serrano (2006); Duro and Padilla (2006); Ezcurra (2007); Kahrl and Roland-Holst (2007); Duro and Padilla (2008); Duro et al. (2010); Cantore and Padilla (2010); Steinberger et al. (2010); Cantore (2011); Duro (2010, 2012, 2013) and Padilla and Duro (2013). Clarke-Sather et al. (2011) studied the carbon inequality on the sub-national scale in China during 1997–2007, and they found that the interprovincial carbon inequality in China is not regional in character and is different from the carbon inequality on the global scale. These studies provided the gross information about the distribution of carbon emissions and referred to the abatement duties between different countries or regions. The distribution of carbon emissions between households is also needed to be concerned as the households in the same region shall bear different responsibilities for emission reduction. However, to our knowledge, the specific study of carbon inequality at the household level in China and some other areas is still limited.

As Duro (2013) defines the carbon inequality at the global scale as the inequality of per capita carbon emissions between different countries and Clarke-Sather et al. (2011) defines the interprovincial carbon inequality as the inequality of per capita carbon emissions between different provinces, this paper defines household carbon inequality as the inequality of household per capita carbon emissions. Household carbon inequality reflects the differences in household carbon emissions according to the natural attribute. Moreover, according to the social attribute, household carbon inequality reflects households' different obligations in emission abatement and their distinct sensibilities to mitigation policies.

There are four reasons for us to focus on household carbon inequality in urban China. Firstly, a major part of the energy requirements and related carbon emissions of an economy is allocated to the household sector, in fact, more than 80% for the U.S. (Bin and Dowlatabadi, 2005) and 75% for India (Pachauri and Spreng, 2002). This allocation is more than 40% for China (Liu et al., 2011), but rises in the income and wealth of households, changes in consumers' lifestyles and the consumption of carbon-intensive goods and services in urbanization cause increases in household CO_2 emissions in China (Feng et al., 2011). As a result, the need for the household sector to reduce its energy use and CO_2 emissions has been emphasized in mitigation policies (Hamamoto, 2013). Secondly, household carbon inequality refers to the environmental

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justice, which is an important social problem involved all humanity, especially the socio-economically disadvantaged ones (Occelli et al., 2016). Thirdly, mitigation policies should be distinct to households according to the extent of household carbon inequality, as the rich should have more duties in abatement than the poor. As Clarke-Sather et al. (2011) put it, "internal dynamics of carbon inequality have the potential to shape future energy policies". Fourthly, because the poor and the rich have different abatement abilities, the extent of household carbon inequality will determine the effect of household mitigation policies. As Sauter et al. (2016) put it, "the more widespread pollution sources are, the larger are costs of implementing and monitoring environmental policies".

The literatures referred to household carbon inequality have studied the differences in CO_2 emission across different household groups. Using the cross-sectional data, Golley and Meng (2012) and Andrich et al. (2013) surveyed the per capita carbon emissions of households with different income levels. These literatures found that the rich emit more per capita but the poor are more emission-intensive, which suggests that the existence of significant inequality among households in CO_2 emissions. However, their limitation in quantitative analysis impairs their impact on household mitigation policies. Rosas et al. (2010) and Wang and Shi (2009) observed the dynamic variations in direct and indirect CO_2 emissions of different income groups in different years. Moreover, other literatures, such as Duarte et al. (2012); Büchs and Schnepf (2013); Brand et al. (2013); Chancel (2014); Han et al. (2015) and so on, distinguished households into groups by more factors other than income and surveyed their differences in CO_2 emissions. But it is still confused about the contribution of each factor. As Roca and Serrano (2007) and Kerkhof et al. (2009) have estimated the emissions associated with the consumption patterns of different groups of households classified according to their level of expenditure, this paper also concerns about the contribution of each expenditure category on household carbon inequality. As a result, this paper quantitatively measures the household carbon inequality in urban China and moreover analyzes the contributions of consumption categories and household characteristics to this inequality.

According to the Consumer Lifestyle Approach (CLA) advanced by Bin and Dowlatabadi (2005), household carbon emissions are embedded in consumption patterns which are determined by household socio-economic characteristics. Correspondingly, this paper firstly measures the inequality of carbon emissions in representative urban households in China using the Gini coefficient. Secondly, this paper uses the method of Gini coefficient decomposition to survey the sources of this inequality, i.e., the contributions of consumption contents to household carbon inequality. Thirdly, it uses the method of Shapley decomposition to survey the determinants of this inequality, i.e., the contributions of household socio-economic characteristics to household carbon inequality. The relations of the three parts are showed in Fig. 1.

This paper proceeds as follows: Section 2 introduces the survey data used in this study and the CLA method (Bin and Dowlatabadi, 2005), which is utilized to calculate household carbon emissions. Furthermore, this section details the methodologies we apply to measure and decompose the inequality of household carbon emissions. Section 3 reports and discusses the main results obtained from the application of these inequality measure and decomposition methodologies, which explains the inequality of household carbon emissions in urban China, its sources and determinants. Section 4 gives the main conclusions of this work and discusses the policy implications of it.

2. Data and Methods

2.1. Data Sources

The survey data used in this study come from the Survey of Consumer Finance in China (2011), which was performed by the China Center for Financial Research (CCFR), Tsinghua University. A total of 5761 samples are selected to represent urban households from the 24 cities all around Mainland China, which are Beijing, Jinan, Shenyang, Shanghai, Guangzhou, Chongqing, Xian, Wuhan, Baotou, Jilin, Xuzhou, Nanchang, Haikou, Kunming, Urumqi, Luoyang, Shuozhou, Yichun, Anqing, Quanzhou, Guilin, Panzhihua, Baiyin and Zhuzhou. As a consumer finance survey, it contains the quotas of household consumption categories, which will be applied to calculate household carbon emissions. The survey also contains households' demographic characteristics, financial characteristics and certain other socio-economic characteristics of them; some of these characteristics can be utilized as the probable determinants of household carbon emissions. Based on Duarte et al. (2012); Büchs and Schnepf (2013) and Brand et al. (2013) and including many more household features, the probable determinants of the household carbon emissions in urban China that we choose contain the demographic characteristics of each household (the size, marital status, gender of the family head, and education), employment and income (the employment, unemployment, retirement, net income, and income expectation), burdens (being educated, pre-education, elders living together, or supported elders), and assets and financial plans (the deposits, housing ownership, car ownership, or heritage plans). The city a household lives in (*j*.city) is the control variable. These factors and their directions are shown in Table 1, and their summary statistics are shown in Table 2.

The selective dataset can be taken to represent households in urban China broadly. First, the survey stratifies cities above the prefecture level in Mainland China into three categories according to their size, economic development level, savings level, consumption level and consumption conditions. Second, the 24 sample cities selected all include the three categories in the seven regions of Mainland China (according to the economic development level and geographical features and adopted by some authorities). The weights of these cities refer to the proportion of the population in the Chinese City (Town) Life and Price Yearbook (2009). Thirdly, after the sample cities have been selected and the number of representative households in each sample city has been determined, these households are randomly sampled according to the community distribution and population distribution in each sample city.

However, the selective dataset has distinct population distributions from the real population distributions for urban households in the seven regions of China, as shown in Table 3. This distinction exists because the weights of the cities in the survey, which are based on the proportion of the population in the Chinese City (Town) Life and Price Yearbook (2009), set many sample households in the central and western regions of China. When calculating households' carbon inequality all around urban China, we replicate the samples with different multiples in the seven regions to make the population portions of the

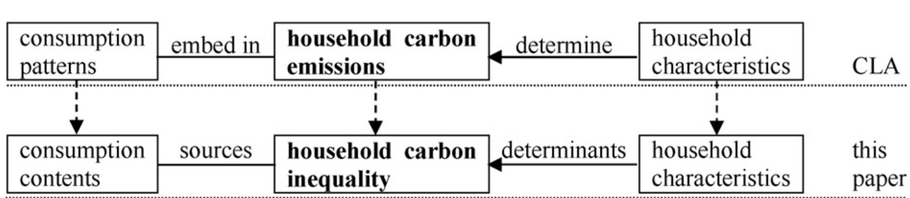

Fig. 1. Relations of this paper's three parts designed according to the CLA.