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Situation and determinants of household carbon emissions in Northwest China

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ABSTRACT

Household CO_2 emission is one of the main sources of carbon emissions. Reducing this type of CO_2 emissions plays an important role in decreasing global carbon emissions. Based on household CO_2 emission survey data in Northwest China, we analysed the current situation of household CO_2 emissions and produced a map of per capita household CO_2 emissions for each survey location. We also analysed the relationship between per capita household CO_2 emissions and explanatory factors using spatial econometric models. The results showed that 87.56% of the per capita household CO_2 emissions range from 0.3912 t to 2.5895 t. Carbon intensity and per capita income are the main explanatory factors of household CO_2 emission. High per capita CO_2 emissions are mainly related to carbon intensity, per capita income, January average temperature and urbanization level. The results also revealed the importance of other variables, such as total household population, age structure and July average temperature. This study contributes to the understanding of the main explanatory factors of household CO_2 emission in Northwest China and proposes some emission reduction measures.

1. Introduction

As the largest CO_2 emitter, China has established a target of decreasing CO_2 emission intensity to 60–65% of 2005 levels by 2030 (Tollefson, 2015). In addition, the country intends to reach its peak of CO_2 emissions circa 2030 and to make best efforts to peak early and increase the proportion of non-fossil fuels in primary energy consumption to approximately 20% by 2030 (Tollefson, 2014). Several studies indicate that household carbon emission should not be ignored; indeed, it has become one of the main sources of carbon emissions in China (Zhu, Peng, & Wu, 2012). For example, 30% of China's total carbon emissions are from household in 2004 (Wang & Shi, 2009). From a perspective of the contribution of final demand activities, Tian, Chang, Lin, and Tanikawa (2014) found that the proportion of household consumption of the total carbon footprint in China is 35%. It is important to analyse the household carbon emission to assist policy makers in efforts to improve the process of carbon emission reduction (Zhang, Liu, & Gao, 2014).

Papathanasopoulou (2010) analysed the impact of household expenditure on fossil fuels on CO_2 emissions and found that it was a critical element for further reducing CO_2 levels. According to a demographics analysis, Roberts (2008) found that reductions in household size and increases in the number of households lead to increases in energy demand. Pachauri (2004) used micro-level household survey data to analyse cross-sectional variations in total household energy requirements in India and found that the total household expenditure or income level has the most important impact on energy demand. Based on CO_2 emissions due to household consumption, Das and Paul (2014) found that population was one of the main causes of increases in household CO_2 emissions in India. Adeoti and Osho (2011) used survey data to analyse the impact of replacing kerosene lamps with PV lighting on CO_2 emissions, and they found that household-based PV lighting has an important impact on reducing CO_2 emissions in Nigeria. In addition, Munksgaard, Pedersen, and Wien (2000) found that private

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consumption is an important influencing factor of household CO_2 emissions in Denmark. Holian and Kahn (2015) used metro-level and household-level data to investigate the association between the CO_2 emissions from transportation and centre city quality of life. The results indicated that improving centre city quality of life may be benefit for local "green city". Seriño and Klasen (2015) explored the determinants of household carbon footprint in Philippine, and the results confirmed the household income as the main determinant.

Many factors affect carbon emission in China. Employing a consumer lifestyle approach to analyse impacts of household consumption, Feng, Zou, and Wei (2011) found that household income had an enormous impact on energy use and CO_2 emissions in China. Niu et al. (2011) designed questionnaires on household energy consumption and found that in Lanzhou, Northwest China, energy used for cooling, heating, cooking and lighting accounted for 87.87% of the total household energy used. Liu, Spaargaren, Heerink, Mol, and Wang (2013) reported that space heating was the largest emission source among household energy uses in North China. Ye et al. (2011) conducted surveys in Xiamen, Southeast China, calculating the condition of home energy usage and analysing the relationship between construction characteristics and urban household carbon emissions. Later, Ye, Qiu, Zhang, Lin, and Li (2013) found that green spaces and bodies of water were very important for reducing carbon emissions from household energy usage. Lin, Yu, Bai, Feng, and Wang (2013) analysed the main influencing factors of household greenhouse gas emissions in Xiamen City, the results identified that housing area and household size were the main influencing factors. Qu et al. (2013) reported that as family size and income increases, household CO_2 increases. Tian et al. (2014) found that as regional income grows, regional carbon footprint increases. Liu, Wu, Wang, and Wei (2011) used the input–output method to investigate the impact of household consumption on carbon emissions, and they found that household consumption is an important influencing factor of carbon emissions at the domestic level in China. Zha, Zhou, and Zhou (2010) implemented logarithmic mean Divisia index decomposition analysis to evaluate the influencing factors of CO_2 emission, with the results showing that energy intensity and income are two important influencing factors in China. Han, Xu, and Han (2015) analysed the determinants of household embedded carbon emissions in urban China, and they found that household income was the most important determinant. Li, Zhao, Liu, and Zhao (2015) analysed the characteristics of household carbon emission during the rapid urbanization in China, and the results indicated that household carbon emissions grew continuously and urbanization was one of the key influencing factors. Xu, Tan, Chen, Yang, and Su (2015) used survey data to estimate the urban household carbon emission in the Yangtze River Delta and analyse the contributing factors, and the results identified household income, the house area, household scale and age structure as the key factors.

These studies considered the research unit as an independent and homogeneous individual, without considering the spatial factors. In fact, there is spatial difference and spatial relations in natural environment and social economic conditions, for example in Northwest China. Semiparametric Geographically Weighted Regression (S-GWR) considers the spatial nonstationarity and spatial stationarity, indicating the potential to solve the spatial variation and relation. Spatial econometric methods have been used in the field of carbon emissions (Chuai et al., 2012; Elliott & Clement, 2015; Liu, Xiao, Zikhali, & Lv, 2014). Chuai et al. (2012) found that regional carbon emissions existed spatial dependency and spillover effects. Elliott and Clement (2015) used spatial econometric models to analyse the influence factors of carbon emissions, and the result confirmed the spillover effects on carbon emissions. Liu, Xiao, et al. (2014) suggested that spatial correlation, externality and heterogeneity should be considered when formulating policies. Spatial dependency and spillover effects are rarely considered in the study of household carbon emissions, and ignoring spatial factors may lead to biased estimated results. So this paper considers spatial factors using maps to demonstrate the spatial characteristics of per capita household CO_2 emissions in Northwest China. To analyse the influencing factors of household carbon emissions, spatial weight matrices as well as spatial econometric models were also generated.

The paper intends to explore these questions: (1) What is the situation of household CO_2 emissions in Northwest China? (2) What are the main factors impacting household CO_2 emissions? (3) What is the appropriate policy to reduce the household CO_2 emissions?

To address these issues, the paper is structured as follows. Section 2 describes data sources, the methods used to calculate household CO_2 emissions and spatial econometric models. Section 3 presents the current situation of household carbon emissions in Northwest China, identifies some determinants of household CO_2 emissions and represents the spatial distribution of the local coefficient between per capita CO_2 emissions and certain explanatory factors. Section 4 discusses the results and policy implications. Section 5 draws conclusions.

2. Data and methods

2.1. Study area and data

Northwest China mainly includes the provinces of Shaanxi, Gansu and Qinghai and the autonomous regions of Xinjiang and Ningxia (Fig. 1). Most of the area is located in arid or semi-arid regions, and the ecological state of the environment is fragile. In 2012, CO_2 emissions for energy are 722.13 million t, a carbon intensity which was calculated by dividing carbon emissions by gross domestic products (GDP) is 1.44 times higher than the national average level. The GDP per capita is 32,547 Chinese Yuan (CNY) in Northwest China, lower than the national average of 38,420 CNY. This region is in the accelerating developmental stage of Western Development, with a GDP average annual growth rate of 13.6% in the Eleventh Five-Year Plan Period (2006–2010), higher than the national average of 11.2%. As the level of economic development and consumption increases, demand of energy is also rising. Economic development in Northwest China largely depends on coal, and economic development occupies a larger growth space in household CO_2 emissions. Northwest China possesses rich coal resources, for example Shaanxi. As the base of national energy and chemical industry, Northwest China plays an important role in China's energy security.

As survey data can reveal phenomena that macro-data can't, a survey questionnaire was designed for household CO_2 emissions, including the family's basic information, detailed home address, direct energy consumption and indirect energy consumption. Direct energy mainly includes anthracite coal, bituminous coal, honeycomb briquette, gasoline, diesel oil, kerosene, liquefied petroleum gas, coal gas, natural gas and electricity. Indirect energy primarily includes the consumption of heat and tap water, food, clothing and toiletries (soapy, towel, toothbrush and so on), medical and health care, education, culture and entertainment, housing, transportation for shopping household goods and communication in household.

Prior to the survey, a detailed analysis was conducted to identify the most representative survey location (Fig. 1). There are many lakes and rivers in the southwest and northeast of Qinghai, for example Qinghai Lake, and many sandy lands and gobi deserts in