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Determinants of household carbon emissions: Pathway toward eco-community in Beijing

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ABSTRACT

Based on the household survey of "household energy consumption and living conditions in Beijing", in this paper, we estimate the determinants of household carbon emissions and its relation to a community's building, neighborhood and location attributes. We find that a community with energy-saving building attributes and with greater amenities in neighborhood significantly reduces the level of residential household carbon emissions. Meanwhile, a community that is far from public facilities tends to increase the probability of car purchase and results in higher transportation carbon emissions. Given the implications these findings have on eco-communities and urban sustainability, we further discuss the importance of the role of a community when conducting ecological studies and its role for designing strategies for urban ecological infrastructure (UEI) planning toward eco-friendly economy and society.

1. Introduction

The urbanization process refers to more than population growth and the physical expansion of cities; it involves changes in people's economic and social activities. Environmental changes in cities thus depend on both population size and energy consumption, and this is environmentally significant since such change is associated with a wide range of human social and economic activities as well as the transformation of materials and energy (Stern, Kawakami, Houde, & Zhou, 1997). Human energy consumption has radically revamped Earth's carbon cycle. At the global level, residential energy use has become second only to industrial energy use with 70 EJ (22% of global energy use) consumed annually in the mid-1990s (IEA, 2000); it is expected that energy consumption demand will continue to increase over the next 20 years (IEA, 2010). Integrating human consumption into ecosystem studies is critical to our understanding of ecosystem drives and patterns, as well as in developing policies for sustainable urban development.

Household energy consumption is determined by each household's characteristics and lifestyle, as well as by the characteristics of the living community that defines and constrains residents' social activities. A residential community provides more than just a physical space to inhabit; it directly affects the resources needed to support household activities through its spatial characteristics and its conjunction with public services and thus the extent of environmental pressure. From an ecological perspective, a residential community functions as an infrastructure that links nature, public service, and society; further, it socially grounds the nature of human environmental behavior. It is a mechanism through which the drivers of household carbon emissions can be captured. More importantly, it paves one possible path toward urban ecological infrastructure (UEI) by processing eco-community that integrates eco-logical associations among households and communities as well as the environment and related services (Li & Yang, 2015). Recently, an understanding of the ecological community has begun to develop, however, few studies have connected community attributes to household energy consumption and understand its role in the ecological infrastructure. In this study, we will analyze Chinese household carbon emissions and their relation to community attributes in Beijing.

China has witnessed an unprecedented urbanization, growing from 19.39% of total population living in urban areas in 1980 to 54.77% in 2014 (MacroChina Database). It is projected that by 2030, 1 billion Chinese will live in cities (Zhu, Shen, & Huang, 2011). This has been accompanied by increased housing demand and car ownership. According to the National Bureau of Statistics of China,

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the average living area per person living in urban areas increased from 24.5 square meters in 2002 to 32.9 square meters in 2014. Over this same period, the number of private cars increased by more than 23.5 times. Changes in household living environment and lifestyle are becoming more important components of energy consumption and carbon emissions in China. As of 2009, China has become the world's biggest producer of greenhouse gases, representing total emissions of 7527 million tons and 21% of the global emissions of carbon dioxide. China's per capita carbon emissions also exceeded the global average (World Bank, 2011). Among them, energy consumption in the residential sector amounted to 396.66 million tons standard coal, which represents 11% of total energy consumed in China in 2014 (National Bureau of Statistics of China, 2014). China has committed to reducing its carbon dioxide emissions per GDP by 40–45 percent before 2020, from base levels recorded in 1990.[1] The major burden of such carbon mitigation polices will fall on energy consumers, including both firms and households. Understanding household energy consumption patterns and how the patterns relate to their attached community is important to capturing determinants that shape household activities. This is essential to defining strategies for urban ecological planning aimed at eco-friendly economics and society.

Based on the survey of "household energy consumption and living conditions in Beijing" conducted in 2009, we estimate both residential carbon emissions and transportation carbon emissions. We empirically explore household social/economic characteristics and preferences of energy consumption and their effect on carbon emissions, integrating the role of the community in terms of its building, neighborhood and location attributes. We find that energy-saving building attributes and greater amenities in neighborhoods have a significant positive role on limiting household residential carbon emissions. Meanwhile, better access to public facilities tends to decrease the probability of car purchase and thus carbon emissions from transportation. Given the implications of these empirical results, this paper offers insight into both social and economic policy aimed at eco-communities.

Our study contributes to previous studies on eco-communities from several perspectives. Firstly, existing studies focus on explaining the concepts and indicators of eco-communities, as well as technologies or strategies needed to develop eco-communities (Han, Dai, Zhao, Yu, & Wu, 2008; Zhang, Shen, Feng, & Wu, 2013). Few studies have connected household performance with community characteristics or investigated the mechanism through which community characteristics impact on household performance. In our paper we indicate that eco-community not only provides residential service, but also impacts total household energy consumption, and the way of their energy consumption because these specific neighborhood and location attributes enable us to bind this information to a specific community. To our knowledge, this is the first paper that connects household carbon emissions from housing and neighborhood attributes to capture the characteristics of the eco-community. Being able to draw these connections has important policy implications for urban planning. Second, though the role of housing has been emphasized in environmental studies, most studies mainly conduct their analysis from the perspective of physical attributes of the housing in the existing emissions studies (Chen & Zhu, 2013; Reid & Houston, 2013). In this paper, we combine the physical and spatial features of housing in a more comprehensive way. Given the rapid increases in urbanization and the housing market in China, examining housing and neighborhoods in energy consumption is a critical perspective for capturing what drives carbon emission and future emission trends. The special case in China also provides a new way to understand the eco-community from the perspective of urban and market transformation. Third, this paper supplements the scarce studies on household energy consumption in China, which suffer from limited data. Based on the detailed information of household consumption and corresponding living conditions, this paper offers a way to comprehensively explore household consumption behavior and thus provides new evidences on existing environmental studies. Specifically, using micro information, we also connect the provision of public good around housing (including green land and public infrastructures) with household energy consumption behaviors, and calculate the positive externality of public goods.

In Section 2, related literatures are reviewed and the conceptual framework of the study is plotted. Section 3 introduces the household survey and Section 4 provides empirical results. Conclusions are in Section 5.

2. Related literatures and research design

Energy consumption is a human-environment transaction, which reflects the social and economic activity of households (Dalton, Jiang, Pachauri, & O'Neill, 2007). A large amount of interdisciplinary academic research is required to understand the role of economic and social factors in shaping household consumption and its effect on carbon emissions. Related literatures mainly focus on the role of household characteristics in household carbon emissions and less on the role of community (Braubach & Fairburn, 2010; Chen & Zhu, 2013; Dalton et al., 2007; Kohlhuber, Mielck, Weiland, & Bolte, 2006; Yang, Ge, & Zeng, 2010).

The study of environmental effects from a household perspective is complicated by heterogeneous household performance and interactions with social and political factors. Socio-economic and demographic characteristics of households (Dalton et al., 2007), household demand for appliances (Chen & Zhu, 2013; Druckman & Jackson, 2009), household attitudes and beliefs concerning energy use (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009), and household lifestyle (Bin & Dowlatabadi, 2005) have all been described as interactively influencing carbon emissions (Clapham, 2005; Holden & Norland, 2005; Seryak & Kissock, 2003; Stern, 2000; Van Raaij and Verhallen, 1983). In China, the linkage between household emissions and household lifestyle has also been investigated (such as, Du, Huang, & Kang, 2015; Li, Li, Guo, & Zeng, 2013; Wang, 2015; and; Yang, Wu, & Cheung, 2016).

Housing has long been central to the issue toward low-carbon consumption particularly from a technological perspective (Reid and Huston, 2013; Choy, Ho, & Mak, 2013; Zhu, Chew, Lv, & Wu, 2013). Existing researches find that residential carbon emissions vary within different houses due to heterogeneous building structures (Genjo, Tanabe, Matsumoto, Hasegawa, & Yoshino, 2005), size and types (Alfredsson, 2004), as well as building materials, which include brick, wood, and concrete (Börjesson & Gustavsson, 1998; Hammond & Jones, 2008).

The role of residential location on environment effects has been given attention due to its connection to commute behavior (Chang, Parandvash, & Shandas, 2010; Kaza, 2010; Ma, Heppenstall, Harland, & Mitchell, 2014; Qin & Han, 2013), and because of its relationship to environmental justice (Braubach & Fairburn, 2010; Kohlhuber et al., 2006). Its role is also highlighted as it relates to urban spatial development (Ewing & Rong, 2008), which implies that planning parameters including building density and land use mix are important factors that impact household carbon emissions (Qin & Han, 2013). In addition, endogenous decisions of household choice and transportation have been investigated (Pinjari, Bhat, & Hensher, 2009; Waddell, 2001) and the importance of residential

[1] On the eve of the 15th Conference of Parties (COP15) of United States Framework Convention on Climate Change (UNFCCC).