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The impact of household consumption on energy use and CO_2 emissions in China

Zhen-Hua Feng [a,b], Le-Le Zou [d], Yi-Ming Wei [b,c,*]

[a] School of Management, University of Science and Technology of China, Hefei 230026, China
[b] Center for Energy and Environmental Policy Research, Beijing Institute of Technology, Beijing 100081, China
[c] School of Management and Economics, Beijing Institute of Technology (BIT), 5 South Zhongguanccun Street, Haidian District, Beijing 100081, China
[d] Institute of Policy and Management, Chinese Academy of Sciences, Beijing 100190, China

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ABSTRACT

In this paper, the consumer lifestyle approach is applied to analyze the impact of consumption by urban and rural households on energy use and CO_2 emissions for different regions and income levels in China. Grey Model is used to compare the relationship between energy consumption, consumption expenditure and CO_2 emissions for different lifestyles. The results show that direct energy consumption is diverse for urban households and simple for rural households in China. Direct energy consumption and CO_2 emissions are increasing faster for urban than for rural households. Indirect energy consumption and CO_2 emissions for urban households are much greater than the direct consumption values. The total indirect energy consumption and CO_2 emissions differ by regions and the structures are different, but the latter differences are not obvious. The impact of household income is enormous. Indirect energy consumption and CO_2 emissions are higher for high-income than for low-income households. The structural difference for indirect energy consumption and CO_2 emissions for households with different income levels is significant. The higher the income, the more diverse is the energy consumption and CO_2 emission structure. The structures for indirect energy use and CO_2 emissions are diverse for urban households, but simple for rural households.

1. Introduction

Greenhouse gas emissions caused by household energy consumption have become a focus on a worldwide basis. The long-term energy consumption policies and measures in China are mainly focused on certain industrial production sectors. However, household energy use represents an important proportion of all energy consumption and CO_2 emissions. Approximately 45–55% of total energy use is influenced by consumer activities [1]. Household energy consumption is closely related to CO_2 emissions. Munksgaard et al. [2] used a decomposition method to analyze the relationship between Danish household consumption and CO_2 emissions from 1966 to 1992. Reinders et al. [3] analyzed household energy consumption in 11 European Union countries and found that household energy consumption varied with expenditure. Household indirect energy demands and spending were linearly related. Pachauri [4] used survey data for 1993–1994 to analyze the impact of household energy consumption in India. The results showed that socio-economic, demographic, geographic, family and residential factors affected energy consumption, with household expenditure and income levels having the greatest impacts. Alfredsson [5] concluded that green consumption could reduce energy use and CO_2 emissions, albeit rather weakly. Bin and Dowlatabadi [6] used the consumer lifestyle approach (CLA) to study the relationship between consumer activities and energy use and related CO_2 emissions. Their results showed that 80% of energy consumption and CO_2 emissions could be attributed to consumer behavior and related economic activities. The indirect effects of consumer behavior caused by energy consumption and CO_2 emissions were twice those of direct actions. Lenzen et al. [7] used input–output analysis to evaluate sustainable household consumption from a global perspective. Their results showed that energy needs are quite different across countries and do not support the Kuznets curve. Rao and Reddy [8] used microlevel data to study changes in household energy use in India. Reddy and Srinivas [9] analyzed Indian household energy consumption patterns and the factors that influence them. Rosas-Floresa and Gálvezb [10] researched the trends in Mexican residential energy use, analysis shown that important factors contributing to the increase include changes in the types of housing built, heating, cooling, water-heating equipment and other appliances. Ouyang et al. [11] studied the rebound effect in the

* Corresponding author. School of Management and Economics, Beijing Institute of Technology (BIT), 5 South Zhongguanccun Street, Haidian District, Beijing 100081, China. Tel./fax: +86 10 68911706.
E-mail addresses: ymwei@deas.harvard.edu, ymwei@263.net (Y.-M. Wei).

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Table 1
Categorization of household living behavior.

Category	Urban households	Rural households
Direct influence	Home energy use including lighting, cooking, heating, etc.	Home energy use including lighting, cooking, heating, etc.
Indirect influence	Food; clothing; residence; household facilities, and services; medicine and medical services; transport and communication services; education, cultural and recreation services; miscellaneous commodities and services	Food; clothing; –[a]; household facilities, and services; medicine and medical services; transport and communication services; education, cultural and recreation services; miscellaneous commodities and services

[a] Not including residence energy consumption for rural households. Categories according to Bin and Dowlatabadi [6] and Wei et al. [14].

household energy efficiency of China and its related negative influence on the energy demand. Other researchers have focused on the relationship between residential energy use and efficiency effects [12,13].

China is a typical dualistic society. There are many significant differences between urban and rural areas [14]. Although China has developed very rapidly in recent years, there are still large gaps between urban and rural areas. To investigate the impact of household energy consumption and CO_2 emissions, we studied urban and rural areas separately. Owing to differences in social and economic structures, the energy consumption patterns in urban and rural are very different.

Many factors impact household consumption, energy use and CO_2 emissions, such as region and income [4]. Wei et al. [14] used CLA to quantify the direct and indirect impacts of lifestyle choices by urban and rural households in China on energy use and related CO_2 emissions during 1999–2002. Based on the study by Wei et al. [14], we use CLA [6] to analyze energy consumption and CO_2 emissions for urban and rural households and compare the patterns for different regions and household income levels. Grey relational analysis is used to analyze the relationship between the energy consumption, household consumption expenditures and CO_2 emissions for different lifestyle choices. The research questions include: (1) What are the trends for household energy consumption and CO_2 emissions? (2) What are the relations between household energy consumption and CO_2 emissions for rural and urban households? (3) What influence do energy consumption and personal consumption expenditure have on CO_2 emissions? (4) What is the impact of regional and income disparities on energy consumption and CO_2 emissions? (5) What lifestyle choices account for the largest proportion of energy consumption and CO_2 emissions?

The remainder of the paper is organized as follows. Sections 2.1 and 2.2 review the CLA and grey relational analysis methods used. Section 2.3 describes the source data. The empirical results are presented in Section 3 and discussed. Conclusions and policy suggestions are proposed in Section 4.

2. Methodology

2.1. CLA method

The term 'consumer' refers to those who purchase and use products and services for individual or household consumption. A lifestyle is a way of living and is reflected in consumption behavior [6].

Based on the work of Bin and Dowlatabadi [6], we compare and analyze consumption patterns for urban and rural households in China and the resulting differences in energy consumption and CO_2 emissions. Households use energy directly, such as for lighting and heating, and consumers need to buy and use a range of products to meet their needs, such as clothing, food, housing and travel. The production and processing of these commodities entail extensive energy consumption [14]. The basic principle of CLA is to decompose all the components of a household's lifestyle. The total energy consumption of households is broken down into a variety of lifestyle areas in Table 1. According to Bin and Dowlatabadi, CLA comprises the following factors [6]:

(1) External environment variables, such as cultural background, social consumption attitudes and technology development, those shape a consumer's decision process.
(2) Individual determinants, such as attitudes, personal preferences and consumption motives, which are personal psychological variables influencing a consumer's decision-making.
(3) Household characteristics, such as size, income, location and housing area, those influence a consumer's decisions.
(4) Consumer choices, such as purchases and the use of services and equipment.
(5) Consequences, such as energy use and related environmental changes, resulting from consumer behavior.

The external environment has the greatest impact on consumer behavior. External environmental factors, which are very wide in scope, are closely related to long-term accumulation of social factors that include culture, history, consciousness and concepts. Personal decision factors for urban and rural households in China, which are not significantly different among groups in this study, are mainly decided by living environment and family traditions. Here we analyze the impact of factors (3)–(5).

Using the CLA method defined above, we calculated the energy consumption and CO_2 emissions for urban and rural households in different categories.

For direct energy consumption and CO_2 emissions, data on household energy use, including lighting, cooking and heating, were taken from China Energy Statistical Yearbooks [15–19]. CO_2 emissions arising from direct energy consumption were calculated as:

$$CO_2\_direct = F\_m \times CO_2\_coefficient, \quad (1)$$

where F_m is a matrix of energy consumption. Here we consider five fuels: coal, petroleum, natural gas, electricity and heat. Thus, F_m is a 1×5 vector-matrix. $CO_2\_coefficient$ is a 1×5 matrix of CO_2 coefficients for fuels.

Indirect energy consumption is related to the purchase and use of products to meet the consumer's needs, such as clothing, food and residences. The production processes for these commodities entail extensive energy consumption (Table 1) [6].

According to Bin and Dowlatabadi [6] and Wei et al. [14] and taking into account data in China Statistical Yearbooks [15–19] and China Energy Statistical Yearbooks [20–23], we linked the eight categories to production sectors, as shown in Table 2, to calculate indirect energy consumption and CO_2 emissions.[1]

[1] When discussing the impact of rural household consumption on energy use and CO_2 emissions, the paper does not consider the impact of the residence. The rationale for this decision lays in the fact that the end-use energy shown in Construction in China Energy Statistical Yearbook did not contain energy use of rural construction.