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Study on affecting factors of residential energy consumption in urban and rural Jiangsu

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ABSTRACT

The purpose of this paper is to study the difference of residential energy consumption between urban and rural Jiangsu areas. The main results are as follows. The residential energy consumption structures in both urban and rural regions have shifted from being predominantly coal based to a multitier structure. Along with the development of urbanization, the gap in residential energy consumption per capita between urban and rural became narrowed over the study period. The space energy efficiency effect plays an important role in decreasing urban residential energy consumption at the aggregate level. However, the population effect and floor area effect are the most stable factor increasing urban residential energy consumption. With regard to rural residential energy consumption, the space energy efficiency effect and the floor area effect are the largest contributor to energy demand over the study period. The population effect plays an important role in decreasing rural residential energy consumption over 1996–2011. However, the contribution from the energy mix effect was negligible during the study period.

Contents

1. Introduction

Residential energy consumption is the second largest energy consuming sector in China although it lags behind the industry sector by far [34]. However, the percentage of residential energy consumption in national energy consumption in China is much below the world average level [16]. With the rapid development of industrialization and urbanization, residential energy demand is likely to continue its rapid growth, which may lead to a serious pressure on energy security and environmental protection.

Since the start of economic reform in 1979, Jiangsu economy has undergone a high-speed development. Nowadays, Jiangsu

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Province has become one of the most developed regions in China, which has brought substantial and profound change of household energy consumption. Nowadays, more and more households are becoming interested in using quality energy sources, that is to say the substitution of commercial energy for a non-commercial one. Thus, studying the influence factors governing the change of residential energy consumption in urban and rural Jiangsu may help policy makers to draw up energy-saving planning.

The rest of the paper is organized as follows. The literature review is presented in Section 2. Section 3 describes the methods utilized in this paper and the related data. The main results are given in Section 4. Section 5 offers concluding remarks.

2. Literature review

Nowadays, China has become one of the largest energy consumers in the world [33]. During the past decades, increasing energy demand in China in combination with the acceleration of environmental degradation has raised the concern of policy makers and energy analysts regarding the adverse effects of energy use and related CO_2 emission. However, the decomposition technique is a useful tool to explore the contribution of the factors which influence energy consumption (or related CO_2 emission) in China.

So far, the SDA (Structural Decomposition Analysis) method and IDA (Index Decomposition Analysis) method have been widely applied to analyze the driving forces governing energy consumption (or related CO_2 emission). The input–output theory is the foundation of SDA method. The SDA model was firstly proposed by Syrquin [15]. A review on SDA theoretical foundation and major features was provided by Rose and Casler [18]. Su and Ang [21] examined the new methodological developments in SDA and compared four such SDA methods analytically and empirically through decomposing changes in China's CO_2 emissions. Based on the deviation from proportional growth model and SDA model, Wang et al. [23] developed a new SDA model that directly interprets the changes of sectoral shares of output. The SDA method was utilized to study the factors governing energy consumption or energy-related CO_2 emission. For example, the SDA method was utilized to study the change of energy consumption structure in Japan over the study period 1985–2000 [13]. Roca and Serrano [17] also used the SDA approach to explore the contributions of different impact factors to the waste gas emission in Spain over the period 1995–2000, as well as the relationship between the waste gas emissions and household consumption. Based on the SDA method, the hybrid energy input–output model was used to decompose driving factors to identify how these factors impact changes in energy intensity [7]. The priority of SDA method is to give detailed reasons of the change of energy consumption. However, the input–output table is not available annually.

If the energy consumption or related CO_2 emission can be expressed as a Kaya identity, the contributor of different factors can be calculated according to the IDA method. The IDA technique also includes two different methods: Laspeyres IDA and the Divisia IDA. The details on two kinds of IDA methodologies were given by Ang and Zhang [3] and Sun [22], respectively. The priority of IDA is the use of time-series data year by year. Each IDA can be applied in a time-series or period-wise manner. A time-series analysis involves yearly decomposition using time-series data, and its results show how the impacts of predefined explanatory factors have evolved over time. A period-wise analysis compares indices between the first and the last year of a time period for a given country (or region, industry, etc.) [31].

The Laspeyres IDA includes Paasche index, basic Laspeyres index, Shapley index, Fisher ideal index, and Marshall–Edgeworth index etc. They are all based on the basic Laspeyres and Paasche indices. For instance, the Fisher ideal index is actually a geometric average of the Laspeyres and the Paasche indices, while the Marshall Edgeworth index is an arithmetic average of the two. Because the Laspeyres decomposition approach always led to a residual, the Laspeyres decomposition approach only yields an approximate decomposition. According to the principle "jointly created and equally distributed", the Laspeyres decomposition is refined to complete decomposition analysis by Sun [22].

The Divisia IDA includes the arithmetic mean Divisia index (AMDI) and the logarithmic mean Divisia index (LMDI) [31]. Ang (2004) compared various methods and concluded that the LMDI method was the preferred method, due to its theoretical foundation, adaptability, ease of use and result interpretation, along with some other desirable properties in the context of decomposition analysis. Because there are the logarithmic terms in the LMDI formulae, complications arise when the data set contains zero values. Eight strategies to handle zero values in LMDI method were given by Ang and Liu [2]. Based on C–D production function, Wang et al. [23,25] generalized the LMDI method, which could consider many factors. Zhang and Song [32] divided China's final energy consumption into two parts: production energy consumption and resident energy consumption. Under this framework, the LMDI method was utilized to decompose the China's final energy consumption into seven influencing factors.

So far, the LMDI method has been widely utilized by many scholars to explore China energy issues. The LMDI method was utilized by Ma and Stern [14] to decompose changes in energy intensity in the period 1980–2003. Wang et al. (2010) also used the LMDI method to study the potential factors influencing the growth of electricity consumption in China's industrial sector during 1998–2007. Chung et al. [6] utilized the LMDI method to explore the respective contributions of changes of residential energy use in Hong Kong. The decoupling index combined with the LMDI method was used to analyze the contribution of the factors which influence energy-related CO_2 emissions in Jiangsu Province over the period 1995–2009 [24].

Because of the growing concern over residential energy consumption, four research strands have emerged. The first strand of research focuses on improvement of residential energy efficiency. Both the floor area and growing income played an important role in the growing energy consumption for residential house heating [10]. Zhong et al. [35] pointed that implementing incentive policy was also important in improving residential energy efficiency. The second strand of research focuses on change of residential energy consumption structure. Sathaye and Tyler [20] explored the residential energy consumption structure from traditional biomass to commercial fuel types in urban China, India, the Philippines, Thailand, and Hong Kong. Zhang [29] also pointed that the direct combustion of coal in China's residential sector had been decreasing while the use of electricity and natural gas had been growing since 1990s.

The third strand of research focuses on direct and indirect residential energy consumption. The consumer lifestyle approach developed by Bin and Dowlatabadi [4] was utilized to study the relationship between and energy use and energy-related CO_2 emission. Based on the theory of the consumer lifestyle approach, the direct and indirect impact of lifestyle of urban and rural residents on China's energy use and the related CO_2 emissions during the period 1999–2002 was studied by Wei et al. [27]. The consumer lifestyle approach was also applied by Feng et al. [9] to study the impact of energy consumption by urban and rural households and CO_2 emission for different regions and income levels in China. The fourth strand of research focuses on affecting factors of residential energy consumption. The factors that contribute to the change in rural residential commercial energy consumption in China were studied by Zhang and Guo [30]. The LMDI