Journal of Cleaner Production 114 (2016) 443–451

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Impacts of urbanization on renewable energy consumption in China

Jun Yang [a], Wei Zhang [a,*], Zongyi Zhang [a,b]

[a] School of Economics and Business Administration, Chongqing University, 400030, Chongqing, PR China
[b] Southwest University of Finance and Economics, 610074, Sichuan, PR China

ARTICLE INFO

Article history:
Received 2 August 2014
Received in revised form
19 July 2015
Accepted 31 July 2015
Available online 11 August 2015

Keywords:
Urbanization
Renewable energy
China

ABSTRACT

In this paper, we used the logarithmic mean Divisia index method to investigate the impact of urbanization on renewable energy consumption growth (RECG). The growth in renewable energy consumption is attributed to the urbanization effect, energy mix effect, energy intensity effect, economic effect, and population effect; RECG can be roughly divided into the slow growth stage, the fluctuant growth stage, and the accelerated growth stage. The results showed that the energy mix effect, economic effect, and population effect positively affected RECG. However, a significantly negative relationship was found between energy intensity and RECG. Furthermore, the contribution of urbanization differed in RECG stages, and urbanization contributed more to the total energy consumption growth than to RECG. This study would thus provide policymakers with insights about the link between urbanization and renewable energy consumption.

1. Introduction

China has undergone a dramatic transformation in the last three decades from a predominately rural society to a rapidly urbanized society. Steady migration to cities lead to an urbanization rate of over 50% of the population by 2013 or over 690 million people (O'Neill et al., 2012). Based on current industrialization trends, another 300 million rural residents are expected to migrate into urban areas by 2020. Increased urbanization may have a larger impact on energy consumption, with the consumption of urban residents being about four times that of rural residents (Hubacek et al., 2009; Geng et al., 2014; Zhang et al., 2015). Each 1% increase in When the urbanization will result in an additional energy consumption of approximately bout 345.8 million tons of oil equivalent (MTOE), including coal, oil, natural gas, and renewable energy (Aunan and Wang, 2014; Tan et al., 2015; Ren et al., 2015). In order to minimize the impact of urbanization on the environment, a shift from fossil fuel consumption to renewable energy will be necessary. In this study, we investigated the impact of urbanization on renewable energy consumption, and we provided policymakers with insights about the link between urbanization and renewable energy consumption.

Previous studies on the relationship between urbanization and energy consumption focused on the impact of urbanization on the energy consumption of sector production, the impact of urbanization on the structure of energy consumption, and the impact of energy consumption on the environment in the process of urbanization.

Urbanization and energy consumption are closely related. Parikh and Vibhooti (1995), Imai (1997) and Al-mulali et al. (2013) found that the relationship between the scale of urbanization and energy consumption are positive. In contrast, Zhou et al. (2012) reported a strongly negative correlation between energy consumption and urbanization in China. In addition, Mishra et al. (2009), Shahbaz and Lean (2012), Al-mulali et al. (2012), Ghosh and Kanjilal (2014) reported short-run and long-run Granger causality between urbanization and energy consumption. However, Halicioglu (2007) found the Granger causality relationship between urbanization and energy consumption is conclusive over the long term but inconclusive over the short term. Further, Salim and Shafiei (2014) argued that there is unidirectional causality from non-renewable energy use to population density in the short run. However, no causal linkage was found between urbanization and non-renewable energy use. Similarly, no causal trend was observed between renewable energy use and any of the demographic factors.

As the process of urbanization develops further, the structure of energy consumption will change at a rapid rate, and oil might finally replace coal (Sathaye and Meyers, 1985; Jones, 1991). Thus, the per capita energy consumption is generally higher in areas of

* Corresponding author. Tel.: +86 186 8085 1792.
E-mail address: cqdxzhangwei@163.com (W. Zhang).

http://dx.doi.org/10.1016/j.jclepro.2015.07.158
0959-6526/

high urbanization than that in areas of low urbanization, and the energy consumption structure is more advanced in the former areas (Lenzen et al., 2006; Sun et al., 2014). Wang (2014) explored the effects of urbanization on residential energy consumption (REC) and production energy consumption (PEC) by a time-series analysis, and the results showed that urbanization slows down the per capita REC growth because of the economies of scale.

With the development of urbanization, the energy consumption pattern of each sector varies. Studies regarding this usually focus on residential energy consumption and commercial energy consumption during the process of urbanization (Ediger and Huvaz, 2006). Poumanyvong et al. (2012) investigated the influence of urbanization on transport and road energy use in low-, middle-, and high-income countries during 1975–2005. They found that the change in urbanization levels had a greater impact on transport and road energy use in the high-income group compared with that in the other groups and the urbanization elasticity of transport and road energy use in the middle-income group is smaller than that in the low-income group. Zhou et al. (2012) analyzed three energy-consuming sectors associated with urbanization: residential households, the transportation industry, and the building materials industry. Transportation and the production of building materials were identified to be the most significant linkages between urbanization and energy consumption.

Rapid urbanization in developing countries has been a major contributor to global warming (Parikh and Vibhooti, 1995; Tuo, 2013; Wan and Wang, 2013; Wang and Yang, 2014). Poumanyvong and Kaneko (2010) argued that the impact of urbanization on emissions is positive for all the income groups, but it is more pronounced in the middle-income group compared to the other groups. Martínez-Zarzoso and Maruotti (2011) pointed out that the relationship between urbanization and carbon dioxide (CO_2) emission presented an inverted-U shape, and that the emission-urbanisation elasticity was positive for low urbanization levels. Zhang and Lin (2012) found that urbanization increases energy consumption and CO_2 emission in China. In general, the impact of urbanization on CO_2 emission in central China was greater than that in eastern China, and the impact of urbanization on energy consumption was greater than that on CO_2 emission in eastern China.

Previous studies mainly focused on the relationship between urbanization and total energy consumption, but the relationship between urbanization and renewable energy consumption has not been studied in China. Currently, China leads the world in terms of annual energy consumption, coal utilisation, and CO_2 emissions. Although the geographical area of China is more or less the same as that of the US, the population of China is 4.6 times more than that of the US – namely, the bearing capacity of land resources in the face of urbanization is four times greater in China compared to the US. If such feasible ways to establish ecological cities is not found for China as renewable energy, new materials, and new technologies, the per capita natural resource will be unable to endure the burden of urbanization (Lin and Ouyang, 2014). Thus, every effort should be made to urbanize China ecologically.

To study the impacts of urbanization on renewable energy consumption in China, we used the index decomposition analysis (IDA) method. In the index decomposition, the Laspeyres decomposition and Divisia decomposition are the most commonly used methods. Logarithmic Mean Divisia Index Method (LMDI) is one of the Divisia Decomposition Method. According to Ang (2004), the multiplicative LMDI is a preferred index decomposition method from both theoretical and practical perspectives. The LMDI has three advantages. Firstly, the LMDI allows for complete decomposition and eliminates the residual error. Secondly, the data may be zero or negative. Finally, the method of decomposition can readily be constructed (Wang et al., 2014). Consequently, this paper will focus on LMDI to analyze the impact of urbanization on renewable energy consumption. In Section 2, the logarithmic mean Divisia index is briefly described. The empirical results are presented in Section 3. In Section 4, discussions are provided. Section 5 presents the conclusions and policy implications.

2. Methods

Factor decomposition method was originally used to analyze the driving factors that could cause changes to the economy, environment and employment. Currently, there are two main decomposition methods: structural decomposition analysis (SDA) and index decomposition analysis (IDA). The SDA is a static method based on input–output table (Hoekstra and van der Bergh, 2003), while the IDA can be used to analyze the effects of various factors based on the total index decomposition (Ang, 1996; Sun and Ang, 2000; Choi and Ang, 2003; Ang, 2004; Ang and Liu, 2007). Compared to the SDA, the IDA has low data requirements and obvious advantages in analyzing the effects of various factors on the variable change (Ang and Lee, 1994; Gonzálezn et al., 2014). Thus, we employed IDA for present study.

In 1871, the index decomposition method was first proposed and used to explore the impact of output and price on firm sale. With the emergence of energy crisis and climate change in the 1970s, the index decomposition method developed constantly and been widely applied in energy supply and demand, greenhouse gas emissions, the material flow and transformation of energy and energy efficiency.

The IDA holds the rationale that the change of objective variable can be decomposed into the combination of various factors change, thus the contribution of various factors can be distinguished and the most influential factors be identified. In the IDA, the data can be divided into two categories, time series decomposition and interval decomposition. Time series decomposition analyzed the change between the t and t + 1 year, while interval decomposition only studied the change between the two benchmark years and ignored the change of middle years. Compared with interval decomposition, time series decomposition can provide detailed information support for energy consumption trajectory and decision factors; furthermore, time series decomposition can explain the change mechanism of objective variable. Thus, we exployed time series decomposition for the present study.

In the IDA, the Laspeyres decomposition and Divisia decomposition are the most commonly used methods. Laspeyres decomposition, similar to the differential method, studies the influence of a factor on variable based on other factors unchanged; but it can't decompose the cross effect of various factors on variable. Divisia decomposition can also be derived by differential, but the object of differential is time rather than various factors. Logarithmic Mean Divisia Index (LMDI) is one of the Divisia Decomposition Methods. Compared with other index decompositions, Ang (2004) found that LMDI can be used to effectively solve the zero or negative value problem. Therefore, we used LMDI to decompose the renewable energy.

The variables used in this study are defined as follows. RE^t is the renewable energy consumption in year t; TE^t is the total energy consumption in year t; GDP^t is the gross domestic product (GDP) in year t; UP^t is the urban population in year t; and TP^t is the total population in year t.

The renewable energy consumption in year t (RE^t) can be expressed as Eq. (1):

$$RE^t = RT^t \times EG^t \times GU^t \times UT^t \times TP^t \quad (1)$$