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Does industrial agglomeration promote the increase of energy efficiency in China?

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ABSTRACT

Whether industrial agglomeration can promote an increase in energy efficiency is of great importance to not only China's energy conservation and emissions reduction plans, but also China's future sustainable development. This paper uses statistical data from 285 cities, from 2004 to 2013, to analyze the effect of industrial agglomeration on energy efficiency. The spatial autocorrelation tests show that there is significant spatial autocorrelation and spatial heterogeneity in urban energy efficiency. Although dynamic spatial econometric results show that industrial agglomeration can promote an increase in energy efficiency from a country level, there are significant differences at a regional level. In the east, the effect of industrial agglomeration on energy efficiency has a threshold effect, but in central and western areas, industrial agglomeration can promote the increase of energy efficiency, with the positive effect in western areas greater than that in central areas. Finally, based on the research, this paper puts forward concrete suggestions to enhance energy efficiency.

1. Introduction

Although China's economy, since its reform and opening up, has achieved rapid growth by relying on factor-driving, the costs have been serious environmental pollution and a huge energy loss. At the same time, although it has achieved rapid economic growth, China still has a large number of rural poor whose needs have yet to be met; the social welfare system remains at a low level. It follows that it is critical for China to ensure sustainable economic growth into the future. At present, China is facing both increasingly strong economic downward pressure and energy conservation and emissions reduction pressures; we have to not only maintain the sustainable development of the economy but also achieve the goal of energy conservation and emissions reduction. Although adjusting final use behaviors has a certain role in conserving energy and reducing emissions, improving energy efficiency plays a more important role because China consumes a large amount of energy and its energy utilization efficiency is relatively low compared to more developed countries. The key way to solve these problems is to enhance energy efficiency.

Compared to more developed countries, China's energy utilization efficiency is relatively low. For example, in 2011, China's GDP accounted for 10.48% of the world's GDP but China's energy consumption accounted for 18.33% of the world's total energy consumption. Energy consumption per unit of GDP in China was 1.75 times that of the world average, was 2.25 times that of the United States, was 3.63 times that of Germany and was 4.18 times that of Japan, indicating that there was a wide gap between China and the leading developed countries in energy efficiency. Meanwhile, in 2013, the energy efficiencies (GDP per unit of Energy consumption) in east, central and western areas were 1.73, 1.38 and 1.10 ten thousand Yuan per ton of standard coal respectively. There were also significant differences in energy efficiency between different regions. How to improve energy efficiency in China will therefore have an important significance on China's energy conservation and emissions reduction, as well as sustainable development.

With China's gradual integration into the global industrial system and with urbanization being constantly pushed, the process of industrial spatial agglomeration has gradually taken root, albeit, with advantages and disadvantages. On the one hand, industrial agglomeration can promote the improvement of labor productivity by increasing returns to scale, knowledge and technology spillover and competition, leading to the promotion of regional economic growth. Industrial agglomeration can also promote technical progress and achieve a circular economy which can reduce energy consumption and pollutant emissions to a certain extent. On the

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other hand, industrial agglomeration can bring some energy and environmental problems. First, industrial agglomeration can bring about a capacity expansion and a sharp increase in energy consumption, and this may be accompanied by a sharp increase in pollutant emissions. Second, local governments may reduce their environmental and pollutant emission standards in order to attract industry, with the agglomeration region then becoming a pollution haven. Third, industrial agglomeration may lead to frequent "free rider" behavior with enterprises not making an effort to improve the environment. Industrial agglomeration can thus have important effects on regional energy efficiency, but the effects are uncertain. If industrial agglomeration improves regional energy efficiency, it indicates that industrial agglomeration is conducive to regional energy conservation and emissions reduction as well as sustainable growth; otherwise, it is not conducive to either regional energy conservation and emissions reduction or sustainable growth. It thus follows that elucidating the effect of industrial agglomeration on energy efficiency, and the way it exerts that effect, will be of great significance in China's future energy conservation and emissions reduction, as well as on sustainable economic growth.

Based on both new economic geography and urban economic theory, this paper takes a thorough look at the effect of industrial agglomeration on energy efficiency in the hope that it will provide both a theoretical and empirical reference for the development of China's future energy conservation, emission reduction and industrial agglomeration. The rest of this paper is organized as follows. A literature review is given in section 2. Section 3 introduces an econometric model based on theoretical framework analysis, and explains the variables and data sources. Section 4 gives the spatial autocorrelation test and regression results; Section 5 draws conclusions and provides some implications.

2. Literature review

Many scholars have carried out research into the factors that influence energy efficiency, most of which focus on the effects of industrial structure adjustment and change on energy efficiency. Due to the large difference in productivity between varying industries, when the energy factor shifts from a low productivity sector to a high productivity sector, it can improve an economy's total energy efficiency. Usually, changes in how industry is structured, especially those changes in the services and light-heavy industries, affect energy efficiency the most. Research conclusions are quite varied though. Some scholars believe that industrial structure adjustment can promote an increase in energy efficiency including UK (Graham and Kim, 2008) and China (Yu et al., 2016), but others argue that industrial structure adjustment does not necessarily promote an increase of energy efficiency and may even have the opposite effect (Chen et al., 2011). Further analysis finds that China's industrial structure adjustment and change are not only reflected in the structure of secondary and tertiary industries, but also reflected more specifically in the relevant industrial geographical spatial agglomeration (Cainelli et al., 2015). Analyzing the effects of industrial agglomeration on energy efficiency will therefore be more important than discussing the effects of industrial structure adjustment on energy efficiency. On the one hand, the rate of return on energy, together with capital and labor as inputs, can be affected by monetary, technological and competitive externalities which are brought on by industrial agglomeration (Fazio and Maltese, 2015); conversely, industrial agglomeration will inevitably affect industrial structure adjustment and change, closely linking it with the change in energy efficiency.

In the new economic geography, the mechanism by which industrial agglomeration improves energy efficiency mainly focuses on three aspects. First, mature factor markets in agglomeration areas are conducive to reducing production costs by improving the quality of energy; at the same time, infrastructure improvement and sharing in agglomeration areas can also significantly improve the scale efficiency and allocation efficiency of energy factors (Krugman, 1991). Second, the knowledge and technology spillover effect caused by industrial agglomeration is conducive to technological innovation and the progress of enterprises, both of which can reduce energy consumption and increase economic output. This is essential for the improvement of energy efficiency (Ke and Yu, 2014). Third, the imperfect competition effect caused by agglomeration will give enterprises incentive to devise ways to save energy when faced with rising energy prices, promote the transformation, upgrade or update of their equipment, and then improve energy efficiency. These three mechanisms can lead to a positive effect of agglomeration on energy efficiency, and this is beneficial to the improvement of energy efficiency overall.

There can be a downside, though, in that excessive agglomeration of industrial space may also lead to increased competition in the market, price increases of factor resources (such as land, labor, energy and rent), and can lead to negative effects of agglomeration on energy efficiency (Brülhart and Mathys, 2008). Industrial agglomeration may not only make it difficult to produce a knowledge and technology spillover, but also make it more likely to lead to repeated construction, energy waste and overcapacity in fierce homogenization competition; this is not conducive to improving energy efficiency. Therefore, whether industrial agglomeration improves energy efficiency or not depends on the positive effects and negative effects; if the positive effects are greater than the negative effects, agglomeration is conducive to improving energy efficiency; otherwise energy efficiency can be suppressed. Many scholars have made empirical analyses about the effect of industrial agglomeration on energy efficiency from different perspectives, but they differ widely in their conclusions. Some scholars believe that industrial agglomeration is conducive to improving energy efficiency (Otsuka et al., 2010), but others find the effect of industrial agglomeration on energy efficiency not significant, or even negative (Cerina and Mureddu, 2014).

Although research on the effect of industrial agglomeration on energy efficiency has been widely studied, there is still a need for further research. First, the existing literature uses DEA or SFA to measure energy efficiency and only looks at energy, capital and labor to focus on GDP, Most literature does not incorporate environmental factors into measurements of energy efficiency and therefore cannot fully reflect the two sides of "good output" and "bad output" of energy consumption. It follows, there may be bias and error on the evaluation of economic performance and social welfare (Zhou et al., 2008). To date, there are two main ways to deal with "bad output": radial models and non-radial models. The radial models are represented by models of constant returns to scale (CRS); these measure input oriented energy efficiency assuming a constant output. However, by making the strict assumption that all inputs reduce in the same proportion, these models deviate from the real economy to a certain extent. The non-radial models are represented by models of slack-based measure (SBM). Because the efficiency calculation of these SBM models includes non-radial slack variables, these SBM models can avoid the assumption that all the inputs reduce by the same proportion. However, as the optimization of SBM models is based on the loss of the original proportion information of the frontier projection value, so it may lead to some errors in measuring energy efficiency. In order to effectively resolve the problems of both CRS models and SBM models, Tone and Tsutsui (2010) constructed an EBM model that integrates radial and non-radial characteristics and proved the superiority of this model to both CRS and SBM models. As a result,