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Can urbanization process and carbon emission abatement be harmonious? New evidence from China

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ABSTRACT

As the largest carbon emitter and developing country in the world, China's rapid urbanization in recent decades plays a significant role in carbon emissions. However, there is still no consensus on whether urbanization process and carbon emission abatement in China can achieve a harmonious state. Based on the panel data of China's 30 provincial-level regions during 2001–2014, this paper uses the threshold regression model and the mediating effect model to investigate the effect and its mechanism of urbanization process on carbon emissions measured by three indicators: carbon emission scale, per capita carbon emissions, and carbon intensity. The results show that urbanization can contribute to declines in carbon emission scale, per capita carbon emissions, and carbon intensity. That is to say, urbanization can present an abatement effect on carbon emissions. However, such an abatement effect is diminishing with a deepening urbanization. Moreover, the relationship between urbanization and carbon emissions is mediated by four mediating variables, i.e., technological progress, industrial structure, energy consumption structure, and foreign direct investment. Therefore, a harmonious relationship between urbanization and carbon emission abatement can be achieved if policy-makers attempt to arouse the positive mediation roles of such factors when formulating relevant policies.

1. Introduction

Developing countries are facing the increasing challenge of achieving urbanization and mitigating carbon emissions. Such a dilemma can be attributed to their extensive development mode, as an accelerated urbanization process contributes to rapid increases in fossil fuel use and corresponding carbon emissions (Madlener and Sunak, 2011). However, the influence direction and mechanism of urbanization on carbon emissions still remain unclear at the theory level, because urbanization can boost both emissions and green technological innovation. A nonlinear relationship between urbanization and carbon emissions may exist. As the largest carbon emitter and developing country in the world, China's rapid urbanization in recent decades plays a significant role in carbon emissions. Therefore, it is important and representative to investigate the nonlinear effect of urbanization on carbon emissions in China. In addition, it is also necessary to further explore the determinants that affect the relationship between urbanization and carbon emissions. Undoubtedly, these can help policy-makers to coordinate the conflict between urbanization and carbon emissions.

Existing studies have carried out some investigation on the relationship between urbanization and carbon emissions (e.g., Parikh and Shukla, 1995; York, 2007; Chikaraishi et al., 2015; Kasman and Duman, 2015; Sun et al., 2016). However, there is still no consensus on whether urbanization process and carbon emission abatement can achieve a harmonious state. Some studies assert a positive relationship between urbanization and carbon emissions (e.g., Cole and Neumayer, 2004; Parshall et al., 2010; Sadorsky, 2013a; Wang et al., 2014; Hao et al., 2016), while others argue that a rapid urbanization can lead to a decrease in carbon emissions (e.g., Liddle, 2004; Mishra et al., 2009a). In particular, Martinez-Zarzoso and Maruotti (2011) proposed an inverted-U shaped relationship between urbanization and carbon emissions. In their study, yet, a regression model with urbanization's square term is established to test the presupposed nonlinear relationship between urbanization and carbon emissions. This study aims to provide further evidence on a nonlinear relationship between urbanization and carbon emissions based on the threshold effect method with China's provincial-level data. In particular, the mediating effect model is adopted to further identify the determinants of the threshold effect.

China is particularly suitable for such an analysis, since in the most

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recent decade, the country has experienced a high-emission development pathway, becoming the world's largest carbon emitter with 28% of global emissions (Wang et al., 2015). Since 2013, 53.7% of the Chinese population has been living in cities, making urbanization process more than ever challenging for the sustainable development of the country. Like many countries, urbanization process strengthens the dilemma between environmental protection and economy growth. This predicament is mainly caused by industrial development because of its important role in energy consumption. For instance, the terminal industrial energy consumption (IEC) in 2014 accounted for about 50% of the total terminal energy consumption in China, and has resulted in much more carbon emissions than the residential sector (Auffhammer et al., 2016).

Therefore, this study investigates the causality between urbanization and carbon emissions and contributes to existing literature in four aspects. First, we adopt three different indicators (carbon emission scale, per capita carbon emissions, and carbon intensity) to investigate the effect of urbanization on carbon emissions in a more comprehensive way. Second, this study helps quantify the nonlinear effects of urbanization on carbon emissions at China's provincial level over the period 2001–2014 with the support of the threshold regression method. Third, we examine the effects of urbanization on carbon emissions at different stages of urbanization, by dividing 30 provincial-level regions into several groups based on the threshold values of urbanization rate and per capita GDP. Finally, we explore the influence of multiple mediating variables on carbon emissions in urbanization process through the multiple mediating effect model, to identify crucial mediators for coordinating the conflict between urbanization and carbon emissions. Through such a series of comprehensively investigations on the causality between urbanization and carbon emissions in China, we expect to provide some important policy implications for facilitating the positive role of urbanization in energy saving and emission reduction.

The rest of the study is structured as follows: Section 2 presents literature review. Section 3 describes the used method and data. In Section 4, we report and discuss the estimation results. Section 5 draws main conclusions and provides some policy implications.

2. Literature review

Currently, the relationships between urbanization and carbon emissions, including linear and nonlinear ones, have been widely confirmed in a number of current studies (e.g., Jiang and Lin, 2012; Zhang et al., 2014; Chikaraishi et al., 2015). A stream of literature claim that urbanization has increased energy demand and produced more carbon emissions (e.g., Parikh and Shukla, 1995; Cole and Neumayer, 2004; York, 2007; Zhu et al., 2012; Sadorsky, 2013a; Kasman and Duman, 2015). For example, the extensive expansion of urbanization brings about more urban population and gives rise to intensive urban economic activity caused by residence, transport, and recreation, leading to more carbon emissions (e.g., Parikh and Shukla, 1995; Hossain, 2011; Martinez-Zarzoso and Maruotti, 2011; Al-Mulali et al., 2012). However, some studies argue that urbanization has lowered energy consumption and carbon emissions by using improved public infrastructure (e.g., Liddle, 2004; Mishra et al., 2009a). Per capita carbon emissions, for instance, has been greatly reduced by the development of large-scale public transport (Lebel et al., 2007). In addition, Xu and Lin (2015) tested the effects of industrialization and urbanization on carbon emissions in China during 1990–2011, showing different U-shaped relationships in different regions via non-parametric additive regression models. Others investigate the relationship between urbanization and carbon emissions on the basis of Environmental Kuznets Curve (EKC), asserting that the development of urbanization is able to improve environment when economic development reaches a certain level (e.g., Martinez-Zarzoso and Maruotti, 2011; Hao and Peng, 2017).

Obviously, there are completely different conclusions with regard to the effect of urbanization on carbon emissions. This is likely due to the following reasons. First, the effect of urbanization on carbon emissions depends on a country's economic development level (Poumanyvong and Kaneko, 2010; Madlener and Sunak, 2011; Sharma, 2011; Li and Lin, 2015). The above sample intervals are diverse so that research objects are in different economic development stages, thus resulting in different results. Second, different model specification and indicators have great influence on regression results, leading to the uncertainty of the results (differences in coefficients and significance levels). Additionally, the needs of economic and social development cannot be comprehensively reflected if the total carbon emissions are selected as single measurement indicators, as both carbon intensity and per capita carbon emissions are closely related to economic development. Therefore, this paper employs carbon emission scale, per capita carbon emissions, and carbon intensity as dependent variables. This is more appropriate for a comprehensive analysis.

Overall, the rapid development of urbanization is a double-edged sword, which has both positive and negative effects on carbon emissions. On the one hand, the energy consumption and carbon emissions in urban areas are likely to decline when the positive role of urbanization comes into play, pushing the areas toward the “green” direction. Similarly, Sun et al. (2018) and Yang et al. (2016) suggested that urban transportation improvement brought about by urbanization can increase air pollutant emissions in the short run but reduce it in the long run. On the other hand, urban energy consumption and carbon emissions will continue to increase when the negative role of urbanization works. It is expected that the impact of urbanization on carbon emissions depends on the game results between positive and negative role. Therefore, we assume that there is a threshold effect of urbanization on carbon emissions, and go one step further to test the specific threshold value.

More recently, some scholars have begun to discuss the key factors that influence the relationship between urbanization and carbon emissions. Chikaraishi et al. (2015), for example, showed that a country's per capita GDP and the proportion of service industries are important factors affecting the relationship between urbanization and carbon emissions. Besides, there are many factors that can influence carbon emissions, such as technological progress, energy consumption structure, economic development, and industrial structure (Madlener and Sunak, 2011; Jiang and Lin, 2012; Song and Wang, 2018). However, most existing studies take the influence factors as simple environmental variables for regression testing (i.e., identify whether a certain variable has an impact on urbanization, carbon emissions or their relationship), failing to explore how these variables play roles in the relationship between urbanization and carbon emissions. This paper identifies the influence channels of urbanization on carbon emissions based on the multiple mediating effect model, in order to fill such a gap.

3. Methodology and data

3.1. Panel threshold regression model

It has been proved that there is a non-linear relationship between urbanization and carbon emissions (Cao et al., 2015). As mentioned above, different urbanization levels may have different impacts on carbon emissions. Hence, we use the threshold regression model to identify potential inflection point(s) at different urbanization stages under the condition of considering the influences of the control variables (i.e., the factors that may have important effects on the dependent variable except the key independent variable). Generally, the mediating variables are included in the control variables.

(1) Per capita GDP (*PG*). The relationship between environmental quality and economic development is commonly described by the environmental Kuznets curve (EKC). There are a number of empirical studies that use the EKC theory to investigate the relationship between environmental degradation and economic growth.