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How does urbanization affect GHG emissions? A cross-country panel threshold data analysis

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HIGHLIGHTS

- Taking balanced panel data of 60 countries for 1971–2012 as a sample.
- The relationship between urbanization and GHG emissions is evaluated by the threshold model.
- The role of urbanization path including small towns, big cities and urban agglomerations is evaluated.
- The policy recommendations about GHG abatement during the process of urbanizationare provided.

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ABSTRACT

Taking the balanced panel data of 60 countries from 1971 to 2012 years as a sample, the relationship between urbanization and greenhouse gas (GHG) emissions was checked based on the threshold model. It was found that the relationship between the urbanization ratio and GHG emissions was always positive, suggesting that urbanization will inevitably lead to an increase in GHG emissions, irrespective of how high the rate of urbanization is. However, when the urbanization ratio passed 23.59% or the GHG emissions exceed 42,287 kt of CO_2 equivalent, urbanization will have more impact on GHG. Also, the urbanization paths influence the relationship between urbanization and GHG emissions. When the population in urban agglomerations of more than 1 million of total population is higher than 20.01% or the population in the largest city of urban population is above 48.27%, positive correlation between urbanization and environmental pollution will be more significant.

1. Introduction

In recent years, along with the continuous improvement of the level of global industrialization, urbanization has become an important issue. With the active promotion of governments, the level of urbanization of all countries in the world has increased rapidly. Against this special urbanization background, the speed and concentration of population and industry in cities have brought about resources' problems and environmental problems that cannot be ignored.

The question to be addressed is whether the increasing GHG emissions are caused by urbanization. With the development of the world economy, the demand for fossil energy is increasing. This is the main reason for the increasing concentration of CO_2 in the world and the generation of the earth's greenhouse. Therefore, the study of GHG emissions has a certain value for in-depth understanding of fossil energy consumption and energy economics. This is worth further study. However, there is no agreement. Some researchers consider that the relationship between emissions and urbanization is linear, but some researchers have found an inverted U-shaped relationship. Why have the existing studies failed to reach agreement? In fact, GHG emissions are divided into two types: (a) industrial and (b) urban commercial and residential. On the one hand, urbanization brings population agglomeration. The increasing demands of the urban population due to the population agglomeration and changing lifestyles are accelerating the development of that construction industry and increasing the use of motor vehicles, thereby polluting the urban air. We will call pollution the "life effect" of urbanization due to the deterioration of air quality resulting from population agglomeration in cities.

On the other hand, urbanization also brings industrial agglomeration. Because of the industrial agglomeration, cities can deal with pollution by discharging pollutants more centrally and improving the efficiency of their pollution treatment facilities, thereby effectively

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alleviating the air pollution. Moreover, compared with small cities, large cities have many tall buildings, more land and energy, more centralized and more convenient treatment of domestic waste, and reduced costs of pollution control. In addition, transportation is one of the main sources of environmental pollution. With urban development, most of the population lives in cities. Thus, the environmental pollution caused by traffic and transportation is reduced. Therefore, urbanization has realized the centralized treatment of industrial air pollution, alleviated the air pollution caused by production, and has not aggravated environmental pollution [1]. We will reduce the cost of pollution caused by industrial agglomeration in cities, thus improving air quality as the "production effect" of urbanization.

The improvement of urbanization rates has either worsened the air quality or reduced the cost of pollution control, thus, helping to improve air quality, depending on the balance between the two effects: "life effect" and "production effect".

The existing research either directly tests the linear relationship between urbanization and pollution emission or adds the quadratic of urbanization rate in the regression model to test the nonlinear relationship between urbanization and environmental pollution. Although these studies can provide abundant empirical evidence for in-depth understanding of the relationship between urbanization and environmental pollution, this is not enough. Firstly, heterogeneity is a common problem of panel data. That is to say, each individual in a study is different, and structural relationships may vary across individuals [2]. For countries in different stages of development, with different production technologies and different environmental quality, the relationship between urbanization and environmental pollution will change with the differences of these characteristics. Therefore, to study the relationship between urbanization and environmental pollution, we must take the heterogeneity of different countries into full consideration, rather than trying to get a standardized and unique conclusion. Secondly, although adding the quadratic of urbanization rate in the regression model is a universal method to study nonlinear relations, this method cannot find the turning point in nonlinear relations accurately. In contrast, the threshold model is a good choice.

For the above reasons, taking GHG emissions as an example and based on the threshold model, the relationship between urbanization and environmental pollution is tested in this study. Furthermore, the different relationships under different urbanization levels, different levels of pollution, and different stages of development, different energy use efficiency, different population sizes, and different urbanization paths are discussed.

This paper contributes the existing research from the following two aspects. On the one hand, in the previous studies, the quadratic of urbanization rate was added to the regression equation to test the nonlinear relationship between urbanization rate and environmental pollution. In this paper, the nonlinear relationship is tested by the threshold effect model. The difference between the two methods is that, only if the relationship between urbanization and environmental pollution reverses from positive to negative or from negative to positive, the nonlinear relationship can be checked. If the relationship between urbanization and environmental pollution is always positive or negative, the previous researches failed to test the differential relationship between them, but the threshold effect model can. On the other hand, the relationship between urbanization and environmental pollution are not only related to the level of urbanization and pollution, but also depends on the economic development, population sizes, and urbanization paths. Here, the above different relationships are further discussed.

This paper is structured as follows. After reviewing the relevant literature in Section 2, we present our regression model and describe the data in Section 3. The empirical results are discussed in Section 4, and further analyses for countries with different urbanization paths are presented in Section 5. Section 6 concludes.

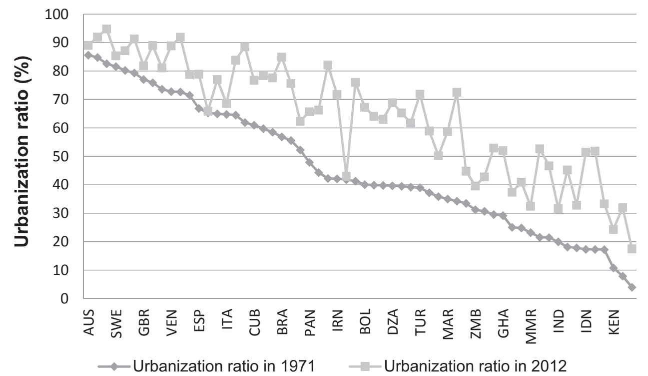

Fig. 1. The urbanization ratio of 60 countries in 1971 and 2012. Notes: The country name and code are listed in Appendix 1. Sources: World Development Index Database (WDI).

2. Trends of global urbanization and GHG emissions

Fig. 1 depicts the trend of urbanization in 60 countries from 1997 to 2012. As can be seen from Fig. 1, the urbanization rate of most countries such as Austria (85.6% in 1971, 89.0% in 2012), Australia (65.3% in 1971, 65.9% in 2012), Sweden (81.6% in 1971, 85.4% in 2012), Italy (64.8% in 1971, 68.6% in 2012), Egypt (41.8% in 1971, 43.0% in 2012), has shown an obvious growth trend, and the urbanization rate of some countries, such as Korea, Rep. (42.3% in 1971, 82.1% in 2012), Malaysia (34.3% in 1971, 72.5% in 2012), Dominican, Rep. (41.3% in 1971, 76.0% in 2012), China (17.3% in 1971, 51.9% in 2012), Turkey (38.9% in 1971, 71.8% in 2012), has doubled. These figures are enough to prove that the rapid development of the global urbanization process in recent years has been very surprising.

At the same time, great changes have also taken place in global greenhouse gas (GHG) emissions. In 1971, the top five countries for GHG emissions were the United States (US), China, Brazil, Japan, and the Democratic Republic of Congo (DR Congo), while in 2012, the top five countries for GHG emissions were China, the US, India, Brazil, and Japan. Fig. 2**.** depicts the changes of GHG emissions in several major countries, including China, the United States, Japan, India, the United Kingdom (UK) and Brazil during 1971–2012. As can be seen from Fig. 2, GHG emissions in the US and China are much higher than are those in other countries. In 1971, GHG emissions in the US were the largest in the world, and the second largest country for GHG emissions was China. In 2004, the GHG emissions in China exceeded the GHG emissions in the US. China has become the world's largest producer of GHG emissions. During 1971–2012, GHG emissions in developing countries increased rapidly; for example, China's GHG emissions increased by 550%, India's GHG emissions increased by 298%, and Brazil's GHG emissions increased by 208%. Compared with developing

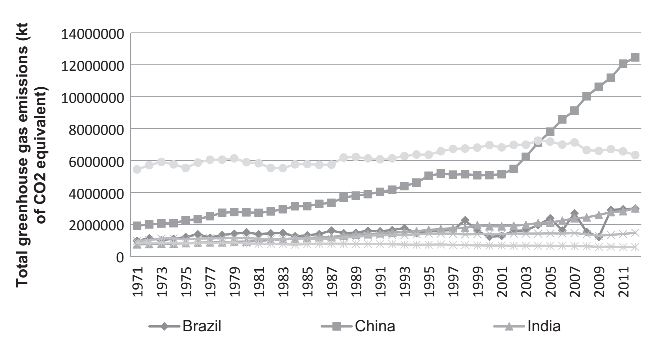

Fig. 2. The total greenhouse gas emissions in six countries during 1971–2012. Sources: World Development Index Database (WDI).