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A disaggregated analysis of the environmental Kuznets curve for industrial CO_2 emissions in China

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HIGHLIGHTS

- The existence of EKC hypothesis for industrial carbon emissions is tested for China.
- A semi-parametric panel regression is used along with the STIRPAT model.
- The validity of the EKC hypothesis varies across industry sectors.
- The EKC relation to income exists in the electricity and heat production sector.
- The EKC relation to urbanization exists in the manufacturing sector.

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ABSTRACT

The present study concentrates on a Chinese context and attempts to explicitly examine the impacts of economic growth and urbanization on various industrial carbon emissions through investigation of the existence of an environmental Kuznets curve. Within the Stochastic Impacts by Regression on Population, Affluence and Technology framework, this is the first attempt to simultaneously explore the income/urbanization and disaggregated industrial carbon dioxide emissions nexus, using panel data together with semi-parametric panel fixed effects regression. Our dataset is referred to a provincial panel of China spanning the period 2000–2013. With this information, we find evidence in support of an inverted U-shaped curve relationship between economic growth and carbon dioxide emissions in the electricity and heat production sector, but a similar inference only for urbanization and those emissions in the manufacturing sector. The heterogeneity in the EKC relationship across industry sectors implies that there is urgent need to design more specific policies related to carbon emissions reduction for various industry sectors. Also, these findings contribute to advancing the emerging literature on the development-pollution nexus.

1. Introduction

Industry sector is the major emitter of carbon dioxide emissions, contributing around 61.4% of the total emissions in 2013 by the estimates of the International Energy Agency (IEA) statistics [1]. As to developing countries, the share of industrial carbon emissions is much higher than global average level, like around 80.1% for China. Owing to the industrialization, the amount of industrial carbon emissions in China have increased from 3405.2 million tons in 2000 to 8977.1 million tons in 2013 [1]. As the global top carbon dioxide emissions emitter, China has made a commitment in the 2015 United Nations Climate Change conference in Paris to peak CO_2 emissions and reduce CO_2 emissions per unit of GDP by 60 to 65 percent by around 2030 compared to the 2005 level. To achieve this target, industry sector, the main contributor of CO_2 emissions, is obviously considered as the main area for China to develop carbon mitigation policies.

Referring to industry sector, it could not be ignored that different industry sectors have different potentials of CO_2 emissions depending on their individual industrial processes [2]. In China, industry can be divided into three individual sectors, including manufacturing, mining, and electricity and heat production. As shown in Fig. 1, during the recent decade, energy-related CO_2 emissions from these three sectors in China keep growing and vary by their different energy mix and diversified industry characteristics.

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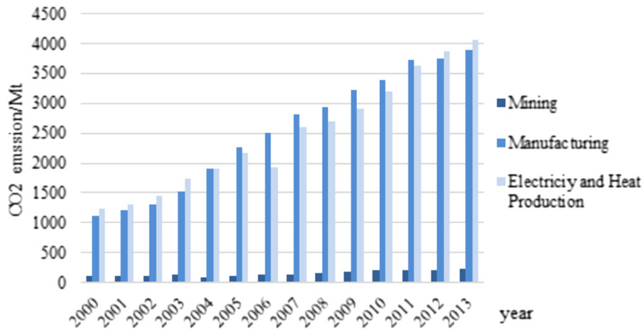

Fig. 1. CO_2 emissions from disaggregated industry sectors in China, 2000–2013.

In 2013, the manufacturing added value accounted for 81.47% of the total industrial output, which resulted in 3889.83 million tons of carbon emissions. While the electricity and heat production sector contributed to large amount of carbon emissions with 4064.51 million tons. It should be noted that, since 2012, the electricity and heat production sector has surpassed the manufacturing sector, becoming the top carbon emissions emitter in industrial sector. Hence, to design policies more precisely, there is further need to investigate the heterogeneity in the behavior of carbon emissions among these sectors and respectively explore its relation to development.

Previous studies have argued that industrial CO_2 emissions are closely related to economic growth, which is accompanied by the process of industrialization. Based on experience from industrialized countries, CO_2 emissions will change as the level of industrialization rises. In the next twenty years, the level of industrialization is expected to keep rising in China, which indicates a possibility of continuing increase in carbon emissions. Moreover, intricately intertwined with rapid economic growth, urbanization also has great effects on energy consumption and CO_2 emissions due to the changes in industrial structure and land use. However, the relationship between the emissions and urbanization is usually neglected in the extant literature. To better curb carbon emissions in China, it's critical to simultaneously identify the relationship between CO_2 emissions and economic growth, as well as urbanization.

Environmental Kuznets curve (EKC) has been widely adopted as a tool to represent the relationship between environment and development. Although the conclusions of empirical studies have varied from each other due to the diversities in time span, models, indicators, and countries or regions, most studies confirmed the existence of EKC at the country and city level [3]. In the recent studies, some scholars shift their attention to the investigation on the pollution and development relationship from the sector perspective, especially in transport and industrial sectors [4–8]. From this perspective, one can analyze the pollution and development relationship at relatively smaller and more specific scale and help design and implement low-carbon policies more effectively. Considering this, the heterogeneity in the relationship across various sectors has aroused emerging interest but by far still is insufficient, which entails further look at the EKC for industrial carbon emissions at a more disaggregated level.

This paper contributes to examining the EKC relationship between industrial CO_2 emissions and economic growth, as well as urbanization within the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) framework over the period 2000–2013. In the context of Chinese disaggregated industrial sectors, the present study attempts to examine the existence of the heterogeneity in the industrial carbon emissions EKC relationship among three sectors and then puts forward some more pertinent suggestions related to carbon emissions reduction policies. To the best of our knowledge, there has never taken efforts in investigating the existence of heterogeneity in the EKC relationship between these variables for industrial sector at a disaggregated level, especially taking account of urbanization. And our present study takes a fresh look at this topic and makes a novel attempt to make up the gap.

The remainder of the paper is organized as follows. Section 2 briefly reviews the EKC studies in the existing literature, from which this study's contribution is proposed. Section 3 develops the STIRPAT model especially for testing the urbanization-industrial carbon emissions EKC nexus, describes the data and estimation methods, including parametric and semi-parametric panel fixed effects regressions. Section 4 presents main findings on income/urbanization- industrial carbon emissions EKC nexus for three domain industrial sectors, and also compares and discusses empirical results. The conclusion and policy suggestions are described in Section 5.

2. Literature review and this study's contribution

The environmental Kuznets curve is a theoretical tool widely used for examining the relationship between environmental and economic variables, which claims that environmental quality deteriorates with economic development at low income levels and turns to improve at high-income levels [9]. Whether continued increase in national income brings more harm to the environment is of important significance from a policy viewpoint. Hence, in the recent two decades, the relationship between environmental pollution and development has been intensively investigated since Grossman and Krueger [9] put forward the EKC hypothesis. The research of CO_2 emissions and development nexus could be identified into two strands. The first strand is to explore the dynamic relationship between environmental pollution and economic growth, and concentrates on testing the validity of EKC hypothesis between these two variables [4,10–12]. And the second strand is to construct a multi-dimensional framework which attempts to bring sub-segments of the economy into modeling the EKC hypothesis. Variables like trade openness, urbanization and technological improvement are adopted in such a framework. York, Rosa, and Dietz adopted the STIRPAT model augmented with measures of ecological elasticity in the study of pollution and development relationship. They found the incorporation of population, affluence and modernization indicators give a more precise specification of the sensitivity of environmental impacts to the forces driving them [13]. And the impact of characteristic variables on EKC shapes can be shown directly by the coefficients of separate multiplicative terms [14–20]. The second strand is an emerging hot spot of EKC research.

Among the variables in the multi-dimensional framework, urbanization has been regarded as an explanatory factor for CO_2 emissions that arouses more interest [18,21–23]. On one hand, urbanization may raise the level of CO_2 emissions due to congestion and industrial concentration. On the other hand, a higher level of urbanization leads to scale advantage in abatement technology of urban areas, which will slow down emissions to some extent [24]. In early studies, urbanization acts only as an explanatory variable, and the relationship between carbon emissions and urbanization is found linear. Some of these studies raised that urbanization has positive effects on CO_2 emissions. For example, Poumanyvong and Kaneko [24] used a panel of 99 countries to detect the effects of urbanization on carbon emissions from 1975 to 2005. However, there remains evidence contradictory to that. Sharma [25] examined the influence factor based on data from 69 countries and figured out that the effect is negative in these countries. The same