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Study of the relationship between greenhouse gas emissions and the economic growth of Russia based on the Environmental Kuznets Curve

Xuechun Yang [a], Feng Lou [a], Mingxing Sun [a], Renqing Wang [a,*], Yutao Wang [b,c,*]

[a] Institute of Ecology and Biodiversity, School of Biological Sciences, Jinan 250100, Shandong University, China
[b] Department of Environmental Science & Engineering, Fudan University, 220 Handan Road, Shanghai 200433, China
[c] Fudan Tyndall Centre, Fudan University, 220 Handan Road, Shanghai 200433, China

HIGHLIGHTS

- GHG emissions related to economy is estimated in Russia from 1998 to 2013.
- The energy consumption constituted the largest proportion, followed by fugitive emissions.
- A Environmental Kuznets Curve was validated under a business-as-usual scenario.
- Proper scope of GHG emissions needs to be considered in EKC studies.

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ABSTRACT

Russia is typical of the extensive economic development pattern. Its economic growth greatly relies on natural resources, especially fossil fuels, which can lead to large quantities of greenhouse gas (GHG) emissions. In this study, which is based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, we systematically estimated the economy-related GHG emissions in Russia over the period of 1998–2013 in terms of energy consumption emissions, industrial process emissions, animal husbandry emissions, and fugitive emissions. The proportion and variations in the different emission categories were analyzed in the Russian context. The inverted U-shaped relationship between the GDP per capita and economy-related GHG emissions per capita was tested, and the results supported the Environmental Kuznets Curve (EKC) hypothesis under a business-as-usual scenario. Our estimation indicated that Russia will reach its turning point in 10 years if its economic growth rate remains stable. Since optimizing the energy structure and improving the energy efficiency and changing industrial structure will have a positive effect on GHG emission reduction in Russia, the Russian government needs to guide its economic development to reach its EKC turning point through the implementation of effective policies, instead of waiting for the turning point. This study analyzed the impact of the economic development on GHG emissions in Russia and will serve as a reference for countries and regions that are at this stage of the economic transformation process.

1. Introduction

Global warming has become one of the world's biggest challenges, and greenhouse gas (GHG) emissions have influenced both the natural environment and human life. According to the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC), GHG emissions and other human-driven factors have been the leading causes of global warming since the middle of the 20th century. The continuous emission of GHGs results in the warming of all the elements in the climatic system and causes enduring changes in that system. The average ground temperature on Earth increased by 0.85 °C from 1880 to 2012, and it is predicted to continue increasing over the next 100 years [1].

Carbon emissions have been extensively studied on national and regional scales, with most of the research focusing on the relationship between carbon emissions and their possible influencing factors, including economic growth, population, energy

* Corresponding authors at: Department of Environmental Science & Engineering, Fudan University, 220 Handan Road, Shanghai 200433, China (Y. Wang); Institute of Ecology and Biodiversity, School of Biological Sciences, Jinan 250100, Shandong University, China (R. Wang).

E-mail addresses: wrq@sdu.edu.cn (R. Wang), yutaowang@fudan.edu.cn (Y. Wang).

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consumption, energy intensity, and industrial structures. Some researchers studied national groups such as the Gulf Cooperation Council (GCC) countries, Organization for Economic Cooperation and Development (OECD) countries, and Middle Eastern & North Africa (MENA) countries. Others investigated a specific country such as China, Pakistan, Malaysia, etc. [2–10].

The impact of economic growth on GHG emissions is empirically important in terms of carbon emission reduction. The Environmental Kuznets Curve (EKC) is widely used to investigate the relationship between economic development and environmental pollution [11]. The majority of EKC-related studies (in which the GHG emission data used were not calculated in detail) focused on the energy-economy-carbon-nexus analysis [5,12–21]. Less attention has been given to the scope of the data, and this lack may have led to inaccurate results.

The relationship between the economic development and greenhouse gas emissions in Russia has seldom been studied. Russia's unique historical, cultural, social, and geopolitical context have greatly influenced its development. Russia is an emerging economies, Russia is vast in territory and rich in natural resources, which made Russia a typical country of resource based economy. However, Russia inherited its traditional resource-based industrial structure from the Soviet period, and there is a conflict between Russia's economic development and its GHG emission reduction [22]. The development patterns in Russia may have a certain reference value for other resource dependent economies, therefore, the study of the relationship between economy-related GHG emissions and the GDP in Russia has important implications in both theory and practice.

In this study, we applied the 2006 IPCC Guidelines for National Greenhouse Gas Inventories to calculate the economy-related GHG emissions from different sources. The emission sources considered in this study included energy consumption, industrial processes, animal husbandry, and fugitive emissions. The specific emissions from the iron and steel industry, primary aluminum production, ammonia gas manufacturing, and cement manufacturing were estimated. We tested the EKC between the economy-related GHG emissions per capita and GDP per capita in Russia during the period of 1998–2013. The rest of this paper is as follows: Section 2 gives a literature review and identifies the research gaps. Section 3 presents the methodologies and data collection for this research. The results are described in Section 4. Section 5 is a discussion of this study. The conclusion is presented in Section 6.

2. Literature review

The relationship between a nation's economic development and its GHG emissions is regarded as empirically important. There are various methods for investigating the relationship between economic growth and carbon emissions. Some researchers applied the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model for analysis [23–25]. Other researchers employed the STIRPAT-EKC model to study the relationship between economic growth and carbon emissions. Martínez-Zarzoso combined the STIRPAT model and the Environmental Kuznets Curve hypothesis to test the impact of urbanization on carbon emissions and obtained an EKC for the relationship between urbanization and carbon emissions [26]. Lin also employed the STIRPAT model to analyze the EKC between economic development and carbon emissions in 5 African countries. However, the inverted U-shaped was not valid for the African economies and carbon emissions [14]. Some other approaches were also utilized. Song et al. estimated the CO_2 emissions in the Yangtze River Delta region from 1995 to 2010 using the logarithmic Divisia decomposition index method and analyzed the main factors influencing the emission quantities [27]. The EKC model is well developed and widely applied in the examination of the economy-emission relationship [12–17,19,28,29]. However, the scope of the data utilized in most studies typically considered the total emissions, including natural emissions, which is beyond the scope of economy system. In our research, we tested the EKC hypothesis with more specific data and compared our results with other EKC investigations.

The Kuznets Curve hypothesis was proposed by Kuznets to investigate the relationship between economic growth and income distribution and was described as an inverted U-shaped relationship [30]. After years of research, it was found that the relationship between environmental pollution and per capita income also corresponded to the inverted U-shape curve, which was then called the Environmental Kuznets Curve [11]. Paukert analyzed the environment and economic relationship in more than 50 countries at different developmental levels and found that the countries studied were at different stages of the inverted U-shape curve [31]. Recent studies have shown that the inverted U-shaped relationship between economic growth and carbon emissions was evident [5,12,32,33], but it was not always validated. Kang et al. found an inverted N-shaped relationship between the economic development and carbon emissions in China from 1997 to 2012 [34]. Soytas et al. focused on the relationships among energy consumption, income, and CO_2 emissions in the USA during the years 1960–2004 and reached the conclusion that there was no inverted U-shape relationship between income and CO_2 emissions [35]. Begum et al. tested how 3 factors, economic development, energy consumption, and population, affected the emission quantities of CO_2 in Malaysia from 1970 to 2009. However, the inverted U-shaped relationship was not found between the GDP per capita and CO_2 emissions per capita [9].

In many EKC studies, the CO_2 emission data used included not only human-induced emissions, but natural emissions such as the emissions from forest fires. The improper scope of the data may have led to inaccurate results. For instance, Ajmi et al. conducted an environment-energy-growth study in which the aggregate carbon emissions were used and found remarkable time-variable causalities connecting the economic growth to the carbon emissions in Italy and Japan; however, no Environmental Kuznets Curve was obtained [17]. Kais et al. used data on CO_2 emissions from the World Development Indicators (published by the World Bank) in their research and tested the impact of economic development on the environment for 58 countries from 1990 to 2012. While the EKC hypothesis was supported, the scope of the World Bank data was inappropriate [19]. Wang et al. derived data from the British Petroleum Statistical Review to analyze the relationship between urbanization and CO_2 emissions, but did not use disaggregated data [36]. In some studies, the disaggregated data were considered, but the data were mostly energy-related. For instance, Dogan et al. analyzed how renewable and non-renewable energy, income, and trade openness affected the CO_2 emissions of the European Union from 1980 to 2012, and the EKC hypothesis was validated. However, the emissions were energy-based, and the economy-related carbon emissions were not considered separately when the researchers studied the relationship between income and carbon emissions [29]. In Zoundi's investigation, 25 African countries were chosen and the impact of renewable energy, GDP, and population on energy-related carbon emissions were studied from 1980 to 2012. The inverted U-shaped relationship between income and the energy-based emissions was also tested, but the complete Environmental Kuznets Curve was not obtained [21]. When assessing the relationship between economic development and carbon emissions, the scope of the calculations needs to be redefined to obtain more precise results. Thus, the first research gap has been identified: