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Interregional differences of coal carbon dioxide emissions in China

Jiandong Chen [a], Shulei Cheng [a], Malin Song [b,*], Jia Wang [a]

[a] School of Public Finance and Taxation, Southwestern University of Finance and Economics, Chengdu 611300, China
[b] School of Statistics and Applied Mathematics, Anhui University of Finance and Economics, Bengbu 233030, China

HIGHLIGHTS

- We focus on interregional differences in China's coal carbon dioxide emissions.
- We construct an emission decoupling elasticity index.
- Expenditure on environmental protection is the intermediate variable for the index.
- We use the Gini coefficient to decompose emissions by source and incremental source.
- Interregional emission and economic growth differences deviate due to govt. policy.

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ABSTRACT

Coal is one of the main fuel sources in China. This paper sheds light on the evolution of China's interregional differences in CO_2 emissions from coal by constructing a Gini coefficient and decoupling elasticity index for emissions from 1997 to 2012 and explains why emission differences deviate from economic growth differences. The study decomposed the Gini coefficient of CO_2 emissions from coal by source, incremental source, and region. It also divided the decoupling elasticity of carbon emissions into two components: effects of environmental expenditure and effects of emission reduction policy. The findings of the study are as follows: First, interregional differences in China's overall CO_2 emissions from coal are characterized by periodic fluctuation. Second, the differences in emissions from raw coal, the concentration effect of emissions, and the emission differences within regions are the three main factors in the overall difference changes in coal's carbon emissions in China. Last but not least, the decoupling between provincial CO_2 emissions from coal and economic growth is on the whole weak. Based on the above findings, the author offers four suggestions for emission reduction.

1. Introduction

As the largest developing country in the world, China faces a particularly tough low-carbon development path (Dou, 2013). According to statistics, China's CO_2 emissions from burning fossil fuels have been the highest worldwide since 2007, and have reached more than 6 billion tons currently (International Energy Agency IEA, 2009). If the present growth rate and energy consumption structure do not change, China's emissions increment will be more than 13 billion tons in 2020, and carbon emissions intensity will reach twice the global average (Xu et al., 2014). Therefore, low-carbon development and emissions reduction are important for not only China's sustainable economic growth but also worldwide emissions reduction programs.

China relies heavily on coal for its energy requirements over the years, and the situation has not significantly changed (Guan et al., 2008; Bloch et al., 2012). In 2009, 83% of China's CO_2 emissions came from coal burning (IEA, 2009). Therefore, how to effectively implement coal's CO_2 emissions reduction while ensuring stable economic growth at the same time–a win-win situation–is still a huge challenge for the Chinese government.

Establishing a low-carbon economy involves decoupling economic development from CO_2 emissions. CO_2 emissions gradually decline after reaching a peak with sustained economic growth over a long period (Wang, 2011). Even so, government policy can significantly affect the arrival time of peak CO_2 emissions. Coal has an important role in China's energy consumption structure (Bloch et al., 2012), and coal consumption inevitably leads to large amounts of CO_2 emissions. Therefore, it is particularly important that economic growth be forcefully decoupled from coal's CO_2 emissions.

* Corresponding author.
E-mail address: songmartin@163.com (M. Song).

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Previous studies mainly discussed emissions from three sources: coal, oil, and natural gas. Relatively few studies focused on CO_2 emissions from a specific fossil energy source. Given that China is mainly a coal-consuming country, coal's CO_2 emissions merit serious consideration. Therefore, this study breaks down coal fuel into raw coal, cleaned coal, other washed coal, and briquettes.

This article focuses on China's interregional differences in CO_2 emissions from coal (CEC). CO_2 emissions reduction mainly consists in optimizing interregional emission differences and harmonizing them with economic growth. Meanwhile, since China is the world's largest emitter, investigating interregional differences in its CO_2 emissions will shed light on the evolution and causes of global CO_2 emission differences (Clarke-Sather et al., 2011).

Although many scholars have conducted in-depth studies on carbon emission differences between countries (Heil and Wodon, 1997; Cantore, 2011; Sauter et al., 2016), interregional emission differences within a specific country have rarely been examined. Although Clarke-Sather et al. (2011) have analyzed China's provincial carbon emission differences, they do not discuss what factors influence the evolution of emission differences and why these differences are closely related to economic growth.

Different scholars have used different decomposition methods to explain the regional differences in China's CO_2 emissions. Clarke-Sather et al. (2011) measured the differences between Chinese provinces using the Gini coefficient. At the same time, they studied the contributions of the eastern, central, and western parts of China to the country's overall emission differences using the Theil index. The Logarithmic Mean Divisia Index (LMDI) method is another widely used decomposition method (Lu et al., 2007; Chen and Lin, 2015; Deng et al., 2015). Like LMDI, Structural Decomposition Analysis (SDA) is also used to explain regional differences in CO_2 emissions (Zhang and Qi, 2011; Bloch et al., 2012).

The Theil index only has the function of group decomposition. It cannot decompose carbon emission differences by other dimensions, such as sources, increments, and incremental source. Although the Gini coefficient can be used to decompose emission differences multi-dimensionally, the existing literature focuses only on group decomposition (Heil and Wodon, 1997; Duro, 2013). LMDI and SDA can realize perfect decomposition, but these two decomposition methods have some defects. For example, although each region has different energy consumption structures at different times, these methods simply put together the CO_2 produced by different energy sources, which would fail to capture the contribution of each source to CO_2 emissions.

In general, the interregional industrial layout adjustment, migration of highly polluting energy-intensive enterprises, and intraregional emission reduction goals reflect government policy preferences. Many studies have proved that governments have a critical impact on environmental protection (Becker and Henderson, 2000; Kearsley and Riddel, 2010; Yin et al., 2016). This article also focused on the Chinese government's role, especially the influence of fiscal support for environmental protection on the evolution of regional differences in CEC.

According to Montinola et al. (1995), Qian (2000), and Wilson (2016), the Chinese government exerts a strong impact on the market. Yuan and Zuo (2011) find that the central government of China has an increasing role in all aspects of emissions reduction. However, China is in a transition period. It is a difficult job to consider regional emissions reduction, while maintaining stable economic growth at the same time (Meng et al., 2011; Dou, 2013; Song and Zhou, 2014). Considering that the Chinese government's policy preferences determine regional fiscal expenditures on environmental protection and the level of economic development, which in turn determine the scale of regional carbon emissions (Kang et al., 2012; Keho, 2016), an analysis of local government policy preferences can help us clearly reveal the interregional emission differences trend in China. Therefore, this paper provides the rationale of decoupling the relationship between CEC and economic growth. Further, the decoupling elasticity index is a bridge connecting the Chinese government policy preferences, fiscal expenditures on environmental protection, CEC, and economic development.

Both CO_2 emissions and economic growth are the products of human activity (Jamieson, 2010). Although economic growth relies on energy consumption and energy consumption will inevitably cause emissions, the scale of emissions can be “decoupled” from economic growth. The decoupling index was born after the “four multiples revolution” and “ten multiples revolution” (Schmidt-Bleek and Klüting , 1993; Weizsäcker et al., 1997) and has gradually evolved into two methods: the OECD decoupling index (OECD, 2002; European Community, 2005; United Nations Environment Programme, 2011) and the Tapio decoupling elasticity index (Tapio, 2005; Vehmas et al., 2007; Ren et al., 2014). The former is relatively simple and is easy to measure; the latter can avoid the influence of statistical dimensions and the base period. Although the decoupling index has an incomparable advantage in discussing the relationship between CO_2 emissions and economic growth (Tapio, 2005), the development of the index is not sufficient at present.

The contributions of this paper are mainly threefold. First, this paper used the Gini coefficient as a tool to study the evolution of the regional differences in China's CEC. Through a multi-dimensional Gini coefficient decomposition by source, incremental source, and region, this article revealed the determinant factors in the trend of China's regional CEC differences, especially the dynamic contributions of different types of coal consumption. Second, this paper extended the decoupling elasticity by transforming it to a continued product form and introducing an intermediate variable. We then expound the relationship between China's interregional CEC differences and economic growth as well as energy consumption. Third, this paper analyzed government policy preferences, especially the fiscal expenditure on environmental protection, which attempts to sort out the relationship between regional industrial relocation, environmental fiscal expenditure differences, CEC differences, and economic growth differences.

The rest part of this paper is arranged as follows. Section 2 introduces the methods and data sources. Section 3 expounds the evolution trends in China's interregional CEC differences, decomposing it by source, incremental source, and region. Meanwhile, this study examines the decoupling elasticity between CEC, fiscal expenditures on environmental protection, and economic growth. Section 4 discusses the findings from the perspective of the coal consumption structure, government policy preferences, and regional migration of industry in China. Section 5 provides the conclusions and policy recommendations.

2. Methods and data

2.1. Measuring CEC

Due to inadequate data, measurement of CO_2 emissions relies mainly on estimation. Thus, this paper employs the first method provided by the *IPCC Guidelines for National Greenhouse Gas Inventories* (2006). Because of the vital position of coal in China's energy consumption and carbon emissions, we further divide coal into different categories based on China Energy Statistical Yearbook. We obtain total CEC by combining the Total Final Consumption, Thermal Power, Heating Supply, and Statistical Difference in the Energy Balance Table by Region. The formula is given