Dynamics of China's regional carbon emissions under gradient economic development mode

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ABSTRACT

Regional economic development in China is extremely uneven, which leads to the variation of the status quo and development trend of carbon emissions in different regions, and thus has a huge impact on the construction of the future carbon trading market, in particular the allocation of emission reduction targets. In this article, we adopt a spatial econometric approach to analyze the spatial characteristics of China's regional carbon emissions under its gradient economic development mode. Results indicate that carbon emissions show strong spatial dependence and convergence across regions. Specifically, carbon emissions of different regions in China are characterized by club convergence, as the country's gradient developing mode has enhanced the spatial agglomeration effects. Furthermore, we analyze the evolving trends of regional emission shares, and build a basic framework for the allocation of regional emission reduction targets in China's future carbon emissions trading market.

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1. Introduction

As the world's largest energy consumer and carbon dioxide emitter, there is no doubt that China will face enormous pressure on emissions reduction. In 2009, the Chinese government made a commitment to reduce its greenhouse gas (GHG) emissions per unit GDP by 40% to 45% by 2020, compared to the 2005 level. Further, in 2011, the Chinese government proposed the target of reducing its carbon intensity by 17% till 2015, compared to the level of 2010. China's carbon dioxide emissions reached 8332.5 Mt in 2010, accounting for 25.1% of the world's total. Taking China's current development stage of rapid industrialization and urbanization into consideration, the demand for energy consumption is rigid, and the coal-dominated energy consumption structure is difficult to change in a short-term, we can conclude that China's emission peak has not yet to come, and thus the emission reduction task is still tough for China. As an important approach for carbon emissions reduction, the cap and trade system would be introduced to China in the near future.

Carbon emissions have strong spatial properties. Regional factors such as industrial structure, energy structure, technological level, the level of urbanization and population growth, together with inter-regional factors including trading structure, economic and technology spillovers, determine the evolution of carbon emissions trend. Operating experience of the European emissions trading system (EU ETS), especially the emission reduction target allocation of National Allocation Plans (NAP), provides a good reference for the construction of China's future carbon emissions trading market as well as the allocation of emission targets. Among different regions in China, the level of economic development and the distribution of resource endowments are unbalanced, and the level of emissions is thus diverse. Therefore, in order to build China's future carbon emissions trading market, we must take the spatial properties of China's regional carbon emissions into account. To achieve the emission reduction target fairly and effectively, we need to allocate emission reduction targets under the premises of emissions reduction and socio-economic development.

Based on the convergence theory of regional economic growth and the spatial econometric model, we have a better understanding of the spatial characteristics and the evolution trend of China's regional carbon emissions. The remainder of the paper is organized as follows: Section 2 reviews the present literature on the influencing factors, the relationship between carbon emissions and economic growth, and the spatial distribution of China's regional

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Fig. 1. Differences of China's regional social economies.

CO$_2$ emissions; Section 3 analyzes the spatial distribution of China's regional carbon emissions under its gradient economic development mode; from the perspectives of the spatial correlation and convergence, Section 4 focuses on the influencing factors of the spatial characteristics of China's regional carbon emissions; Section 5 describes dynamics of the shares of China's regional carbon emissions; followed by conclusions and policy suggestions in Section 6.

2. Literature review

Currently, studies on China's CO$_2$ emissions mainly focus on the national aggregate level. Two main methods have been adopted. The environmental Kuznets curve that simulates the hypothesized relationship between environmental degradation and income per capita is used to analyze the growth path of aggregate CO$_2$ emissions and estimate the turning point of income. The other approach that has been commonly used is the factor-decomposition model like Kaya identity. It is used to illustrate China's CO$_2$ emissions under different scenarios and to identify driving forces behind (i.e., economic growth, energy efficiency and industrial structure) and the impact mechanism thereof.

Up to now, there have been many studies centered on the CO$_2$ emissions in China, while most of them are limited at the national level. Some studies focused on the CO$_2$ emissions; others analyzed the relationship between carbon emissions and economic growth. (Detlef et al., 2003; Chen, 2005; Zhang et al., 2009; Lin and Jiang, 2009). For exemple, Zhang et al. (2009) found a unidirectional Granger causality running from energy consumption to carbon emissions in the long run, but no causality from carbon emissions to economic growth. Others studied factors that influence energy-related carbon emissions (Zhang and Cheng, 2009; Fan et al., 2007; Liu et al., 2007; Wang et al., 2005; Wu et al., 2005; Guan et al., 2008). They demonstrated various situations for carbon emissions and revealed underlying driving forces, such as economic development—one of the most important factors, energy consumption structure, energy intensities and population growth.

Regional carbon emissions and emissions reduction are totally different in China due to the diverse economic development and

energy structure. However, literature regarding characteristics, impact factors and the spatial distribution of China's regional CO$_2$ emissions, as well as the relationship between economic growth and carbon emissions are relatively limited. Zhang et al. (2011) studied regional characteristics and factors of energy-related carbon emissions. Results showed that economic development is the dominant driver of energy demand and carbon emissions; while the decline in energy intensity has a negative effect on carbon emissions, which is more effective for provinces with higher elasticity of energy intensity (Meng et al., 2011). Yu et al. (2012) found the most important indicators affecting regional emission characteristics: CO$_2$ emission intensity and emissions per capita. However, CO$_2$ emission per unit of energy consumption is not obvious in clustering and the fuel mix has little effect on emission reductions. Feng et al. (2009) selected five regions of China, and found that technological improvements haven't been able to fully compensate for the increase in emissions due to the growth of population and national wealth. The above results are also in line with results from Li et al. (2012), in which, technology improvement contributes to a small reduction in CO$_2$ emissions in most regions in China.

Most studies above on regional carbon emissions have analyzed different factors affecting the mechanism of carbon emissions from the regional perspectives, rather than from the spatial point of views. As shown in Fig. 1, China's regional social economies represent the mode of gradient development: the developed eastern coastal region, the middle region, and the underdeveloped middle and western regions. Different factors affect the balance of inter-regional social and economic development differently, which is called "gradient economic developing mode"[1]. Under the gradient development mode, diverse initial resource endowments lead to

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[1] The so-called "gradient economic development mode¨is the formation of long-term state of regional gradient social-economic development under certain conditions, which is the result of significant differences on the level of socio-economic development among regions during the same period due to differences in initial endowments in different countries or different regions in the same country. There exit interactions of "polarization effect¨and "spillover effect¨in the gradient economic development mode. The former refers to the aggregation of production factors from adjacent less developed areas to the developed central areas, and the