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Carbon dioxide emissions quotas allocation in the Pearl River Delta region: Evidence from the maximum deviation method

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ABSTRACT

To achieve the Chinese government's CO_2 emissions reduction target and build a carbon trading market in the Pearl River Delta (PRD) region, an initial allocation of CO_2 emissions quotas among cities in this region is fundamental. Different from the previous CO_2 emissions quotas allocation methods, this paper uses the maximum deviation method (MDM) to allocate CO_2 emissions quotas in the PRD region by taking the imbalanced development of different cities into consideration. Three principles including equality (represented by a population indicator), efficiency (represented by a GDP indicator) and feasibility (represented by a historical CO_2 emissions indicator) are considered in the method. The results reveal that the allocations derived by the MDM are more balanced than those derived using either single indicator approach or the information entropy method, and more closer to the development targets of Guangdong province. The more balanced allocations will be conducive to stimulating the development of under-developed cities and narrowing the gap between developed and under-developed cities, thus help to achieve the sustainable development in the PRD region. This paper helps to enrich the emissions quotas allocation methods and provides a new equitable method for policy makers to allocate emissions quotas under imbalanced development circumstances.

1. Introduction

Global warming has become a major challenge in the world. According to a report of Intergovernmental Panel on Climate Change (IPCC) in 2013, the global average temperature has increased 0.85 °C from 1980 to 2012 (IPCC, 2013). The rise in global temperature will cause a series of environmental problems, such as glacier melting (Larsen et al., 2017) and climate-driven species redistribution (Pecl et al., 2017). The main reason for these climate problems is the intensification of industrialization, which has led to a continuing increase in carbon dioxide and other greenhouse gas emissions (An et al., 2016). To achieve the sustainable, healthy and harmonious development of the economy and society, each country has the responsibility to reduce its greenhouse gas emissions.

China now has surpassed the United States to become the largest CO_2 emissions country and is facing increasing pressure to reduce these emissions (Zhao et al., 2017). Fig. 1 shows the world's CO_2 emissions in 2013 (World Bank, 2017). The deeper the color is, the greater the amount of emissions will be. At the Copenhagen climate conference in 2009, the Chinese government promised to cut the country's CO_2 emissions per unit of GDP by 40%–45% by 2020 compared with the emissions in 2005. Recently, it committed to cut its CO_2 emissions per unit of GDP by 18% of the 2015 level by 2020 in the *13th Five-Year Plan* (2016–2020) (The State Council, 2016).

The Chinese government has made many efforts to meet these targets. One of the most important of which has been the establishment of a carbon emissions trading market (Han et al., 2016). National Development and Reform Commission of China (NDRCC) has piloted carbon emissions trading in seven provinces and cities in 2013 and expected to start the emission trading market in 2017. One of those seven pilots was Guangdong province, the most economically developed province in China. The PRD region, an area composed of nine major cities (Guangzhou, Shenzhen, Foshan, Dongguan, Zhongshan, Zhuhai, Jiangmen, Zhaoqing and Huizhou) in Guangdong province, represented more than 85% of that province's GDP and 9% of China's GDP in 2015, and is among the top three regions in China in terms of economic development (National Bureau of Statistics of the People's Republic of China, 2016). Fig. 2 shows the geographical position of Guangdong province and the

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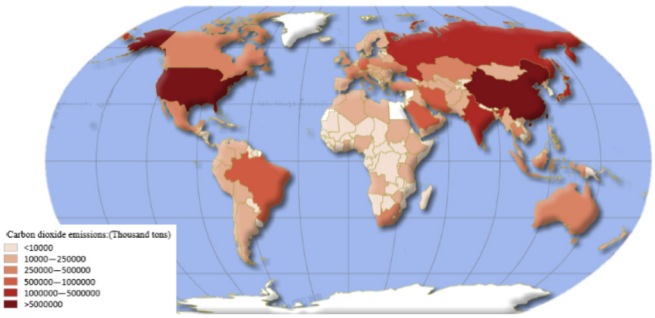

Fig. 1. The distribution of CO_2 emissions in the world in 2013 (World Bank, 2017).

Fig. 2. The geographical position of the PRD.

PRD region. However, the PRD region is also one of the most polluted regions in China. As reported, the top four high-haze regions in China are the Beijing-Tianjin-Hebei, the Yangtze River Delta, the PRD and the Sichuan-Chongqing region, as shown in Fig. 3 (NetEase, 2014). To build a carbon trading market in the PRD region, an initial allocation of CO_2 emissions quotas among cities is fundamental. Therefore, an open question arising concerns how best to allocate CO_2 emissions quotas among the nine cities in the region to achieve the Chinese government's CO_2 emissions reduction target for 2020.

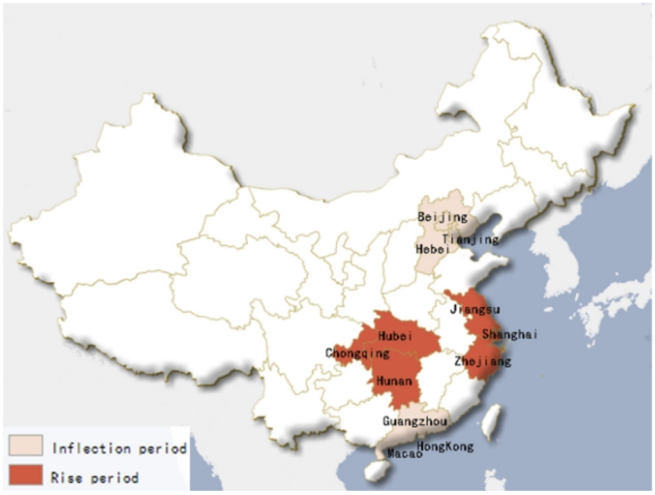

Fig. 3. The top four high-haze regions.

Academically, the CO_2 emissions quotas allocation problem has been widely studied. However, the majority of the previous studies focused on the allocation of CO_2 emissions quotas from national level, provincial level or industrial level using single or composite indicator approaches (Zhou and Wang, 2016). The economic development of the nine cities in the PRD region is fairly imbalanced, as the historical levels of CO_2 emissions and populations are. Therefore, the allocation of CO_2 emissions quotas in the PRD region needs to follow the principle of "common but differentiated responsibility". It is the common responsibility of cities to protect and restore the environment, but the levels and forms of cities' individual responsibilities may be differentiated according to their own circumstances (Miao et al., 2016). Thus, how to design a scientific and feasible method to allocate CO_2 emissions quotas tailored to different cities' circumstances in the PRD region has become an urgent task for the Guangdong government. This study constructs a comprehensive index incorporating equality (represented by a population indicator), efficiency (represented by a GDP indicator) and feasibility (represented by a historical CO_2 emissions indicator) principles, and uses the maximum deviation method (MDM) to get the weight of each principle in order to take account of the imbalanced development of the cities in this region. The MDM is an objective evaluation method and it can reflect the weight of different evaluation programs, while the calculation process is simple. Moreover, to show the advantage and feasibility of the MDM in the allocation of CO_2 emissions quotas in the PRD region, this study compares the allocation results using the MDM with those obtained using other allocation methods (single indicator approach, information entropy method). This study finds that the allocation results by using MDM are more balanced and closer to the development targets of Guangdong province, which will be conducive to stimulating the development of under-developed cities and narrowing the gap between developed and under-developed cities in the PRD region.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 introduces data definitions and methodologies. Section 4 provides the results and discussions. Section 5 provides conclusions and policy implications.

2. Literature review

Zhou and Wang (2016) summarized that four major methods including the indicator, optimization, game theoretic and hybrid approaches had been proposed for the allocation of CO_2 emissions. Each approach has its strengths and weaknesses, and none is superior in all respects. Zhou and Wang (2016) pointed out that the indicator approach was the most commonly used method, simple and easy to be understood. Therefore, this study only reviews the indicator approach using both single and composite indicators.

2.1. The literature on the CO_2 emissions allocation using the single indicator approach

Many scholars have used the single indicator approach to investigate the allocation of carbon dioxide emissions quotas due to its simplicity and ease of use (Miketa and Schrattenholzer, 2006). The emissions allocations are discussed from different perspectives of fairness. However, the concept of fairness has not yet reached a unified definition due to the different understanding of fairness. Several scholars argued that efficiency should be treated as one type of fairness, while others took the opinions that sovereignty criterion and egalitarianism criterion representing different perspectives of fairness in the international carbon allocation (Zhou et al., 2014). This study reviews the relevant principles and the corresponding allocation criteria from three aspects: equality,