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Optimization analysis of carbon emission rights allocation based on energy justice—The case of China

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ABSTRACT

Carbon emission rights allocation affects the effective operation of carbon trading system, and then the achievement of energy saving and emissions reduction objectives. Reasonable allocation scheme should meet the principle of justice. Carbon emission rights allocation based on energy justice is a novel and worth discussing subject. This paper explores the optimization of carbon emission rights allocation based on energy justice. The justice-based model is built with the aid of Gini coefficient. The way to optimize allocation scheme with constraints of population, ecological productive land, fossil energy resources and GDP is discussed. Results show that fossil energy resources and ecological productive land play more important role in the allocation. The prime example is Inner Mongolia, its quota percentage change reaches up to 150.01%. As the GDP and population growth rate are fixed in a given interval, the quota allocation in eastern China shows some interesting results. When the GDP growth rate is 6.25%, the quotas of eastern China will not change with varying population growth rate. The allocation will enter a relative stable stage as the population growth rate is greater than or equal to 6.4‰. These results can provide China with experience to deal with the new problem appeared in carbon trading system like two-children policy and the new normal of economic growth.

1. Introduction

Carbon trading, an effective tool that the international community takes to tackle climate change (Cui et al., 2014; Sun et al., 2017), is the crucial initiative which gives the full play to the decisive role of market in energy saving and emission reduction (ESER). Carbon trading seeks marginal costs of greenhouse gas reduction with the power of market, thereby minimizes the treatment costs of permitted emissions. The smooth implementation of carbon trading depends on perfect carbon trading market (Tan and Wang, 2017; Cong and Lo, 2017). As the important carrier of carbon emission right, carbon trading market boasts huge space for development. The objectives of controlling greenhouse gas emission could be promoted and fulfilled via the market mechanism. The mature carbon trading market could play the decisive role in resource allocation and reduce the costs of ESER.

Reasonable allocation scheme is positive to develop carbon trading. The allocation plan of carbon emission rights among countries could be generally summarized as: (a) Per capita emission allocation scheme (Aldy, 2006). The choice of time span is crucial in this scheme. Some scholars believe that the reasonable time span is from 1900 to 2005, and it is unfair to developing countries without considering per capita cumulative emission (Wei et al., 2012). Besides, population is a dominating factor in this scheme, so it may give incentives to change population policy (Bode, 2003). (b) Allocation scheme considering historical responsibility (Höhne and Blok, 2005; Wang et al., 2013; Liu and Lin, 2017). The long-term accumulated emissions of developed countries had overdraft the earth's environment, which is the main cause of climate change (Pan et al., 2014; Raupach et al., 2014), and developed countries should perform historical responsibility. (c) Other allocation schemes, such as GDP carbon emission intensity allocation scheme (Baer, 2013; Schandl et al., 2016). A country's quota is inversely proportional to its GDP carbon emission intensity. From the perspective of historical responsibility and

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different developing stages, it is unfair for developing countries to reduce their quotas because of temporary high energy intensity. Therefore, a single GDP carbon emission intensity principle can't be only relied on.

Allocation principle also plays an important role in carbon trading system. Kverndokk (1995) used conventional justice principles to evaluate emission permits, the results showed that the population is a very crucial factor in the distribution. Starkey (2012) explored equality-based personal carbon trading and found the measurement of justice can provide a quantitative basis for justice principle interpretation. Energy justice provides a framework to perceive disparities of energy system in recent years. Heffron and Mccauley (2014) discussed the role of energy justice in enabling the growth of wind energy industry, the authors found that energy justice contributes to increased national economic growth. Bouzarovski and Simcock (2017) believed that geographic disparities play an important role in energy justice, and geographic underpinnings of energy affordability contributes to the rise of energy injustices. Sovacool et al. (2017) pointed out that energy analysis and planning needed to be guided by energy justice principles. Energy justice has emerged as a new crosscutting social science research agenda which seeks to apply justice principles to energy system (Jenkins et al., 2016), which is also applicable to carbon trading system.

In terms of measure index selection, Gini coefficient (Heil and Wodon, 1997; Druckman and Jackson, 2008; Dai et al., 2018), as the most commonly used measure index of inequality (equality), is widely used in the calculation of carbon emission rights allocation (Cantore and Padilla, 2010; Zhang and Wang, 2017). Sun et al. (2010) established a framework for discharge allocation license with Environmental Gini Coefficient. Qiu et al. (2011) selected four indicators including land area, population, ecological capacity and fossil energy reserves, to evaluate the equity of carbon emission allocation based on Gini Coefficient. Teng et al. (2011) used Lorenz curve and Gini index to adjust per capita historical cumulative emission and measure inequality in climate change area. Zhou et al. (2017) presented five secondary-level indicators that influence provincial carbon trading quota allocation, and every index is related to population. Reviewing these literature, population (Kverndokk, 1995; Zhou et al., 2017), national economic growth (Heffron and Mccauley, 2014)), geographic disparities (capacity) (Qiu et al., 2011; Bouzarovski and Simcock, 2017) and fossil energy reserves (Qiu et al., 2011) are the main research objects. Gini coefficient is taken as the measure index. Energy justice can perceive disparities of trading system, carbon emission rights allocation based on energy justice is worthy of further research and exploration.

Scholars carry out a lot of researches and develop various allocation schemes (Zhang et al., 2014, 2016; Wang et al., 2015; Li et al., 2017a,b; Younsi et al., 2017; Xiong et al., 2017), which are useful and worth referring. However, if energy justice is neglected in the allocation process, the allocation result is unreasonable and will naturally bring a series of problems. It is difficult to reach consensus among countries in the world owing to this unreasonable scheme. From the national level, the local governments are inclined to respond negatively to allocation scheme. Supposing that the allocation scheme loses certain significance, carbon dioxide emissions cannot be reduced effectively. Moreover, the allocation scheme needs to reflect current economic and policy situation. This paper innovatively constructs an optimized model of carbon emission rights allocation under constraints of multiple variables, including population, economic development and natural environment from energy justice perspective based on Gini Coefficient. Take the case of eastern China, the optimization with variables of population growth rate (two-children policy) and economic growth rate is discussed. The critical value of population growth rate and economic growth rate related to allocation are found, and realistic policy suggestions are provided, which have not yet been reported in current literature.

The rest of this paper is organized as follows. Section 2 provides a brief description of the model developed for this study. Section 3 is about a scenario study of the actual system about China. Discussions of the research are presented in Section 4. Conclusions and further perspectives are discussed in Section 5.

2. Model and method

2.1. Index selection

The energy justice-based carbon emission rights allocation scheme with the aid of Gini coefficient is a novel model that contains multiple variables. Finding the sensitive variables that affecting carbon emission rights quota (Pan et al., 2014; Hu et al., 2017) is the premise and key to optimize the allocation. The selection of variables (indices) should meet the following principles: (a) The principle of justice. Energy justice is an important issue in carbon emission allocation (Sovacool et al., 2016), and the selected indexes should be based upon this principle owing to historical responsibility and other aspects. (b) Scientific principle. The indexes should be related to the complex ESER system, and effectively reflect the situation of carbon emissions. (c) Feasibility principle. The selected indexes should be easy to access and easy to operate.

From the point of view of population size, everyone has the equal right to have a certain carbon emission rights quota. Populous areas should be given due consideration in the allocation scheme. Therefore, the population (such as two-children policy in China, which has a stimulating effect on population size) is selected as the evaluation index. Secondly, the economic development degree should also be taken into consideration. The economic degrees of different regions correspond to different carbon emissions rights quotas (both historical responsibility and energy justice principle should be considered). In addition, the quota of carbon emission rights is also related to the actual contribution of the region to the national carbon sequestration (carbon sequestration mainly refers to the absorption and reserve of carbon dioxide by the ecosystem. The ecological productive land is selected as an index to measure the actual contribution of this area to the national carbon sequestration).

The current fossil energy resources of different areas are of great differences, which should also be taken into account in carbon emission quota allocation. Take Inner Mongolia and Shanxi for example, as the major coal producing provinces in China, they have produced a large amount of coal. In truth, the coal is mostly transported to other provinces in China, and it is not consumed by themselves. They get benefits, while other provinces have greater benefits. But, regrettably, the ecological damage is caused very seriously by coal mining. Based on this, it is necessary to give these areas proper consideration in the process of allocation (Zhang and Hao, 2015) (compensation for historical contribution). Some even argued that if one area had more fossil energy, it should be allocated more carbon emission quota (Qiu et al., 2011). Talking objectively, this is a reasonable difference caused by the natural resources. Based on this, the fossil energy resources should be pay attention to rather than ignore it.

To sum up, the following four indicators are selected: regional population size, ecological productive land, GDP and current fossil energy resources. This paper starts from energy justice and aims to explore the optimal allocation of carbon emission rights.

2.2. Carbon emission allocation based on energy justice

To improve the allocation efficiency and rationality of allocation