Analysis of the Potential Impact for Different Initial Allowance Mechanisms on Economy

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Abstract. Effective carbon allowance mechanism is the key to achieve the goal of carbon peaking and carbon neutrality. To solve the prominent problem of energy and environmental constraints, different allocation mechanisms have different potential impacts on the economy. This study first analyzes the relevant research on the carbon allowance mechanism in the power industry. On this basis, a new regional carbon emission allowance method (ZSG-DEA) for the electricity industry is constructed, and the influence of different carbon allowance mechanisms on provincial carbon emission, electricity transfer and economy loss are analyzed, to provide a scheme for China's electricity carbon emission allowance.

1 Introduction

Climate change is one of the most serious challenges for people in this century[1]. In this study, the previous model of economic growth with high energy consumption and high emissions cannot be sustained, and energy conservation and emission reduction have become a common responsibility that the world must bear[2]. As a major energy consumer and carbon emitter, the Chinese government actively participates in addressing climate change and environmental governance[3].

In order to promote the realization of the emission reduction target, the Chinese government has carried out carbon trading pilot work in seven regions including Tianjin, Chongqing and Shenzhen since 2011, and after several years of exploration and accumulation, the national unified carbon market was officially launched at the end of 2017[4]. At present, only power banks with relatively complete data statistics have been included in the national carbon trading system. Therefore, the establishment and improvement of the carbon trading system still needs a lot of research work. Among them, the initial allocation of carbon emission rights is an important part of the establishment of carbon trading market, which has a significant impact on the economy

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and emission reduction efficiency[5]. Therefore, allocating carbon emission right rationally is of great significance to sustainable development of our country.

The importance of allowance in the emission trading market was initially proposed by Hahn[6]. Based on the principle of equality in per capita emissions, Park et al. flexibly transformed the Boltzmann distribution in physics and applied it to the initial allocation of carbon emission rights among countries, combined the index of per capita historical carbon emission and population size, and conducted empirical research on eight countries from these two levels[7]. Hepburn et al. examined the effects of an emissions trading scheme (ETS) on equilibrium emissions, output, prices, market concentration, and profits based on a generalized Cournot model[8]. However, in the initial pilot stage, the allocation methods of carbon trading allowance in each pilot city are not uniform, which makes the value level of carbon emission rights in the trading market vary from high to low, which brings obstacles to the further construction of a national unified carbon market and future cross-regional trading, and is not conducive to price discovery[9]

Based on the above analysis, there are quite a few theoretical studies on the initial allocation of carbon dioxide emission allowances in the power industry, but the comparative analysis of potential economic impacts under different carbon emission allocation mechanisms is rarely involved in literature. Therefore, this paper intends to explore the impact of different carbon allowance mechanisms on the economy based on the zero-sum game DEA model.

2 Methods and data

2.1 The model of ZSG-DEA

In this paper, electricity is taken as the only input variable of the ZSG-DEA model, and population and GDP are selected as the output variables. Thereafter, carbon allowance is allocated according to the allocated electricity, and the carbon allowance of external electricity are further allocated according to the impact of external electricity. Based on this, this paper studies the carbon allowance of the power sector in 30 regions of China in 2019. The details of ZSG-DEA model are as follows:

$$
\begin{aligned}
& Min\,\delta_0 \\
& \sum_{i=1}^{n} \lambda_i x_{ik} \left[1 + \frac{x_{i0}(1-\delta_0)}{\sum_{i\neq 0} x_{ik}} \right] \leq \delta_0 x_{0k}, k = 1, \cdots, l \\
& \sum_{i=1}^{n} \lambda_i y_{ij} \leq y_{0j}, j = 1, \cdots, h \\
& \lambda_i \geq 0, i = 1, \cdots, n
\end{aligned}
$$

Where: x is power; y is GDP and population; n is the number of DMU; l represents the number of input factors; h represents the number of output factors.

In this model, if the relative efficiency δ_0 of DMU_0 is overinvested, the excess part will be allocated to other DMU according to the ratio $\left[\frac{x_{i0}(1-\delta_0)}{\sum_{i\neq 0} x_{ik}}\right]$, and the amount obtained by DMU_i from DMU_0 is $\left[x_{ik}\times\frac{x_{i0}(1-\delta_0)}{\sum_{i\neq 0} x_{ik}}\right]$. Since all DMU are simultaneously reducing the proportion of input, after this redistribution, the amount of redistribution of input k to DMU_i is:

$$x'_{ik} = x_{ik} - x_{ik}(1-\delta_i) + \sum_{0\neq i}\left[x_{ik}\times\frac{x_{i0}(1-\delta_0)}{\sum_{i\neq 0} x_{ik}}\right], i = 1,\cdots,n$$

After several iterations, reasonable allocation of input variables is carried out, and DEA is finally effective and the optimal allocation scheme is obtained.

2.2 Data

In this paper, the data of 30 regions in China in 2019 are selected, including power energy, non-power energy, capital, labor force, GDP, and population. The above data are obtained from China Statistical yearbooks and regional statistical yearbooks. Due to the limitation of the data of the statistical yearbook, this paper only detailed the situation of all the external power transfers in Xinjiang, and the other provinces took more than 15 billion kWh of external power transfers.

3 Results and discussion

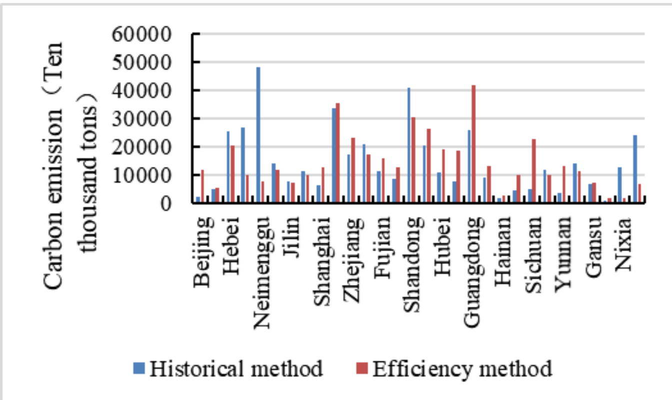

Figure 1 Comparison of carbon emissions in different regions by historical method and efficiency method

3.1 Carbon emission under different principles for carbon allowance

In the allocation of carbon dioxide, there is a clear difference between the efficiency method and the historical method. As shown in Figure 3-1, compared with the grandfather method, Inner Mongolia, Shanxi, Ningxia, Xinjiang, Shandong and Hebei are the main forces of CO2 allowance transfer. Beijing, Shanghai, Zhejiang, Hubei, Hunan, Guangdong, Sichuan and Yunnan have excessive carbon emission credits, with Sichuan having the highest carbon emission credits, and Guangxi and Hainan also receiving large carbon credits. Sichuan and Yunnan are dominated by hydropower, which accounts for more than 80% of the total power generation. As a result of the development of large amounts of clean electricity, these regions receive more carbon dioxide allowances, which can be used to trade on the carbon market for additional economic support to develop more clean electricity. Shandong, Inner Mongolia, Shanxi and Xinjiang are dominated by thermal power, and the proportion of thermal power is above 77%. The proportion of thermal power in Guangdong is also higher, at 66.4%; However, its high utilization rate in terms of electricity has led to an increase in CO2allowance.

3.2 Transferred electricity under different principles for carbon allowance

Under the premise of meeting the original power transaction, when the power industry is in a favorable position, as shown in Figure 3-2, under the grandfather law, Zhejiang and Xinjiang have the largest power transfer, accounting for 0.18% and 0.20% of the total power, respectively. The western region is the main force of power transfer, accounting for 0.39% of the total electricity, accounting for 58.34% of the total electricity. The central region is the main receiving area of electricity, and the received electricity accounts for 0.39% of the total electricity. In addition, under the efficiency method, Zhejiang and Inner Mongolia have the most power transfers, accounting for 0.29% and 0.49% of the total power, respectively. The western region is the main force of power transfer, accounting for 8.08% of the total electricity, accounting for 70.36% of the total electricity. In addition, under the optimization of resource allocation, the electricity consumption of economic development in central, western and eastern regions increased, among which Henan and Anhui consumed the most electricity.

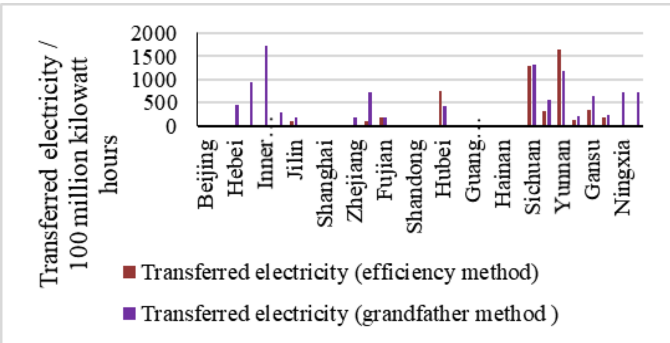

Figure 2 Comparison of power transfer between different regions by grandfather method and efficiency method

3.3 Economic loss under different principles for carbon allowance

Under different carbon allowance mechanisms, the analysis of economic losses is mainly explained from the following three parts.

The economic output of Shanghai is most affected by external power transfer, mainly by Hubei, Sichuan and Zhejiang. The economy of Zhejiang, Beijing, Chongqing, Guangdong and other regions is also greatly affected by the external power transfer, Zhejiang is mainly affected by Fujian, Ningxia, Anhui and Sichuan, Beijing is mainly affected by Hebei, Chongqing is mainly affected by Sichuan, Guangdong is mainly affected by Yunnan. Sichuan's external power transfer has the greatest impact on the economy of other regions, followed by Gansu. Although Inner Mongolia and Shanxi have more external power transfer, they are mainly lost to eastern China, which receives a lot of other external power transfer. As a result, the economic impact of these two regions on other regions does not rank first. The power transferred out of Gansu is less than that of Inner Mongolia, but the power lost to western and central regions that are in urgent need of development and receive less power transferred out from other regions. The power transferred out of Gansu plays a very important role in the economic development of these regions, and the lack of such power will cause great economic losses. In the analysis of the impact on population, Hebei is the most affected, mainly affected by Inner Mongolia's external power transfer. The population of Ningxia, Gansu and Liaoning are also relatively affected, Ningxia is mainly affected by the power transfer from Gansu, Gansu is mainly affected by Qinghai, and Liaoning is mainly affected by Inner Mongolia. Inner Mongolia's external power transfer has the greatest impact on the population of other regions, followed by Gansu, Xinjiang, Sichuan and Qinghai.

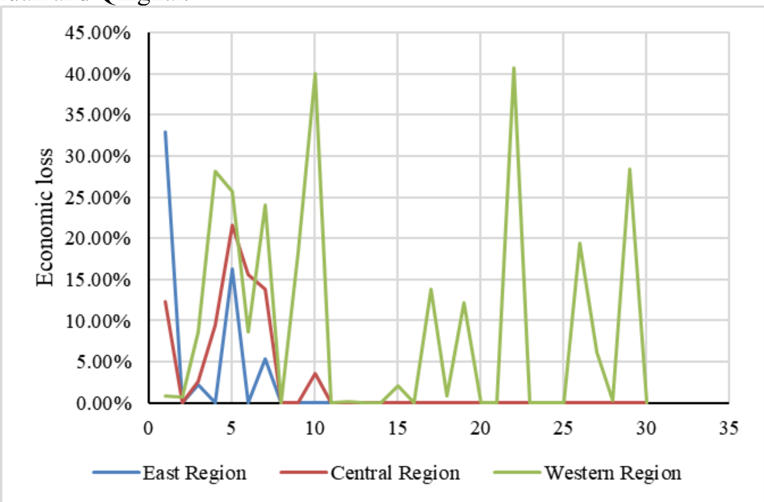

Figure 3 Comparison of economic losses in the western middle and east

4 Conclusion

ZSG -DEA allocation based on efficiency principle will produce some disadvantages. In regions with few carbon allowances, the cost of electricity generation will rise because of the purchase of carbon allowances, which will be borne by local producers and consumers, resulting in deadweight losses. After the unfair distribution, the cost of electricity production in the west increases, and the cost of energy advantage is transformed into economic advantage, which further aggravates the inequality and leads to the disadvantage of the western region in the carbon market. In addition, the western region transmits a large amount of electricity for the development of the eastern region to develop the economy of the province, and the carbon emissions of the production of external electricity is borne by the producers, which further aggravates the burden of electricity generation in the western region.

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