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The Influence of Allowance Allocation Methods on CO_2 Emission Reduction: Experiences From the Seven China Pilots

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One of the key elements influencing the performance of a carbon trading system, are the methods of allocating the initial CO_2 emissions. This paper tries to use a quantitative description method to analyze the influence of the different allocation methods on the level of CO_2 emissions based on the seven pilot trading markets from 2009 to 2013 in China. The results show that different methods bring about various degrees of impacts, through direct and indirect constraint mechanism, influence the CO_2 emission cut finally. Although due to the complexity of the direct and indirect constraint mechanism, attempting to compare the effects of different allocation methods is difficult by using the data of carbon emission cut from seven pilot markets in China, the paper shows that the allowance allocation methods, through the constraints imposed on enterprises, significantly reduce regional carbon emissions.

Keywords: allowance allocation, carbon trading system, CO_2 emission, China pilot markets

Introduction

China, as the largest developing country, has been committed to environmental governance and pollution reduction, and has approved seven pilot markets to establish a carbon trading system to cut carbon emissions. Seven pilot markets were officially launched and operated in 2013 and 2014 and continue to operate. Based on the study on the pilot markets, this paper investigates the influence of different allowance allocations on the CO_2 emission cut. The purpose of this study is to explore the differences among allowance allocation methods in order to contribute to possibly implementing better model or methods mixes for the distribution of initial allowances for the coming national emission trading system (ETS). For the upcoming establishment of a unified national carbon market, this research can serve to provide as a reference. The structure of this paper is as follows: the first part is the literature review; the second part introduces the different carbon quota allocation

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methods in China; the third part is data test; the fourth part is the conclusion; the fifth part is the policy recommendations.

Literature Overview

Regarding the theory of the distribution of carbon emission rights or allowance in the emission trading system, Chinese scholars focus on analysis of the initial allowance allocation model and the prediction of future development. Among them, Liu (2012) made a detailed description about the initial allocation of greenhouse gas emissions quota from the perspective of paid distribution and free distribution. W. B. Lin and B. Liu (2015) compared China's carbon market construction program and market performance (mainly including carbon price and trading volume), and made a forecast of future development. Based on this, Xuan and Zhang (2013) and Sun and Ma (2013) described the theoretical international allocation of carbon emission allowance, focusing on the proposed policy recommendations, including free distribution or allocation is primary, and auction and fixed price sales supplementary for the pilot markets in China. From the viewpoint of primary emissions reduction market fairness and the cost of emissions reduction, Ding and Feng (2013) analyzed free and market based distribution methods, and came to the conclusion that the best path is to start with free allocation and have a gradual transition to auctions and other market based allocation methods. Meanwhile, Qi and Wang (2013) compared several carbon allowance allocation methods, and considered that the initial model should be based on the mixed model, they also believe that the baseline method can be more effective incentives to reduce emissions. As can be seen from the above literatures, the scholars focus on the introduction and analysis of the carbon allowance allocation method, while the research on the contribution of the allowance method to the carbon emission reduction is less. Therefore, this paper is based on this perspective and focuses on the analysis of carbon emission reduction efficiency under the different allocation methods and the same allocation method with different conditions.

Different Carbon Allowance Allocation Methods in China

In the face of increasingly severe climate and environmental problems, the Chinese government selected seven markets as the pilots to establish a trading system in 2011. The first pilots started operating in 2013. As in the case of the EU ETS there is a question of which level of power shapes which aspects of the ETS. Using the theory of "multi-level governance" (MLG) in a similar manner as of (Skjaerseth & Wettestad, 2010) this paper thinks that most probably the NDRC decided the number of pilots and selected the regions to become pilots, but that the regional (R)DRCs had considerable influence on the actual implementation. In the Chinese case it has more of a "two-level governance" model as opposed to the EU where the European Commission really was the "epistemic entrepreneur" (ibid.). There is surprisingly little discussion of the question if there was a master plan behind the selection and implementation of the regional ETSs. One author (Zhang, 2015) writes:

> These pilot regions were deliberately selected to be at varying stages of development and are given considerable leeway to design their own schemes. These schemes have features in common, but vary considerably in their approach to issues such as the coverage of sectors, allocation of allowances, price uncertainty and market stabilization, potential market power of dominated players, use of offsets, and enforcement and compliance.

Zhang does not give any reference for this assumption and one could argue that the pilots are not very spread when it comes to level of development, five of them are big cities. That makes sense if one wants to test different systems in the big cities who clearly are the biggest and fastest growing emitters, but not if a regions

representing the different levels of development. As Wang, Yang, and Zhang (2015) express it “China has a tremendous regional imbalance in both economic and social development”. A detailed discussion of the question of governance is beyond the scope of this article, but we find Zhang’s point of view reasonable as there are clear indications that the regions have power to “obstruct” in various ways the “central” line. An example is the electric car policy (cf. Wan, Sperling, & Wang, 2015). In any case one should keep in mind that most probably the fact that the pilot markets have carried out different allocation methods was not part of a very detailed top-down test strategy by the NDRC. The fact that the implementation, most probably including the allocation methods were mainly decided on by each pilot that does not mean that there is no possibility to compare and draw some lessons from the development in the emissions in the various pilots—and compared to non-pilot regions.

Carbon trading is used in all pilots, but given the free allocations, it is not the main mechanism of the Chinese pilots. Direct constraints are carbon emissions standards imposed on enterprises, while the indirect constraints consist of the voluntary self-restraint of the enterprise itself but first and for most of the constraints imposed on from other companies via auction strategies and by being actors in the game of setting baselines. For society as a whole, the number of constrained enterprises directly affects the reduction of carbon emissions, and this number directly depends on the inclusion standard that is the level of emissions that means that a company will be part of the pilot regulations. The distribution of carbon emission allowance in China is mainly based on three different methods—and combinations thereof.

(a) the grandfathering method;

(b) the baseline method;

(c) the competitive game method.

In Pilot markets the allocation methods have been formulated according to their own development needs, forming one or a mix of methods in each market. The specific analysis is as follows:

The grandfather method refers to allocating the allowance according to the history emissions of the enterprise, it totally depends on self-restraint, thus the constraining force depends. Enterprises in the process of self-restraint do not need to take into account the carbon emissions of other companies, the primary hard constraint for these enterprises is their own emissions history.

The baseline method is based on certain criteria where the emissions for a specific company are based on the industry-wide carbon emissions standards. Information asymmetry means that the enterprise which will be selected as the future standard is unknown, so wise companies will continue with a process of self-restraint to avoid any possibility of exceeding the standard. In addition, enterprises should also take into account the self-restraint of other companies in their industry, because they affect each other’s rankings, and jointly affect the choice of the baseline. The indirect constraint is therefore a kind of double constraint.

When companies reduce carbon emissions, they will reduce efficiencies, under the conditions of self-restraint, taking into account their own interests, enterprises will gather industry information that may become a standard enterprise or gather all business information, and estimate their own carbon emissions position in the industry. For those enterprises which are under the potential standards, the external constraints will be very tiny. The external constraint of the baseline method is a local constraint which is based on differences in carbon emissions within the industry. In addition, the carbon emissions of all enterprises in the industry can always be divided into different sizes of groups which are large, medium, and small respectively, and carbon emissions of small enterprises are always far lower than large enterprises, so the external constraints

for small businesses have little effects. Therefore, there is a marginal diminishing effect in the external constraints for large, medium, and small enterprises. Through the analysis we can see that the baseline method is an increase external constraint based on the self-restraint. The external constraints have different effects on different enterprises in the same industry, which has the characteristics of “local constraint”.

The competitive game method is complicated. Specifically, after the government has recorded history emissions for the enterprises, they are grouped according to their industry categories and their size with fixed carbon allowances allocated to each group. The group is then established as a unit, and each enterprise will simultaneously login to a government system to apply for allowance as they see fit. The government system based on certain predetermined standards, automatically distributes the allowances. Enterprises that accept the allocations can leave with these allowances and those that do not accept will play a game to allocate the remaining total group allowance, the distribution of which is mainly determined through pricing mechanism. The highest bidder will get the carbon allowance that the enterprise wants, thus, no matter how many allowance exist in the overall market, enterprises pay more since the bidding mechanism raise the cost. If an enterprise can not accurately estimate the amount of carbon quota that they need or does not accept the quota allocated by the system, there will be the risk of adding additional costs. Because of the existence of risk, companies based on self-restraint will consider the restraint of other enterprises in the same group to ensure that the carbon quota reported by the enterprise being consistent with the quota allocated by the government.

Both the competitive game method and the baseline method are subject to self-restraint and external constraints of other enterprises, but the external constraint of the baseline method is localized. The competitive game method does not exist. The reason is that it will be classified as a group of enterprises with the same size, there is no significant difference among the emissions in the same group, thus, remediating the shortcomings of baseline method that mixed with all enterprises, and the shortcomings of external constraints of enterprises have been adjusted.

To sum up, the different carbon allowance allocation methods mainly impose influence to enterprise, through hard and soft constraints. It can be seen that, in terms of the soft constraints to enterprises, the least strong is history method, followed by baseline method, and the strongest is the competitive game models. However, in terms of hard constraints, three methods do not follow a linear trend.

Carbon emission allowance implementation of specific methods and corresponding industry-related information in each pilot is as follows:

Table 1

Carbon Emission Allowance Implementation of Specific Methods

Hubei	Grandfather method	Steel industry, Glass and other building materials, Car manufacturer, General equipment manufacturing, Petrochemical, papermaking, Chemical industry, Chemical fiber, Non-ferrous metals and other metal products, medicine, Food Industry, Ceramic manufacturing	
	Baseline method	Electricity industry, Cement industry, Heat and cogeneration industry	
Shanghai	Grandfather method	Steel industry, Petrochemical, Chemical industry, Nonferrous metals, Building materials, Textile, papermaking, rubber, Chemical fiber, Market, Hotel, Business office building, Railway station	
	Baseline method	Electricity industry, Aviation industry, Airport, port	
Tianjin	Grandfather method	Steel industry, Petrochemical, Chemical industry, Oil and gas exploration	
	Baseline method	Electricity industry, Heat and cogeneration industry	
Beijing	Existing facilities	Total historical emissions	Manufacturing, Other industry, Service industry
		Historical emission intensity	Heating, Thermal power

Table 1 to be continued

Beijing	New facilities	Baseline method	Metal or non-metallic mineral products, Thermal power, Heat production and supply, Cement manufacturing industry, Universities and engineering research and development, Large hospitals
Shenzhen	Baseline method	Electricity industry, Gas, Water Manufacturing, Heat	
	Competitive game method	Metal rolling and machinery equipment manufacturing, Plastic industry, Food industry, Communications industry, Printing industry	
Guangdong	Grandfather method	Comprehensive utilization of resources in electricity industry generation units (The use of coal gangue, oil shale, coal-water slurry and other fuels), Mine exploitation of cement industry, Powder grinding production, Steel short process enterprises and petrochemical enterprises	
	Baseline method	Electricity industry coal—fired and gas—fired generating units, Clinker production and powder in cement industry, Steel long process enterprise	

At the same time, we also give the location of the pilot provinces in China. Due to the Shenzhen city in Guangdong Province, We do not mark it.

Figure 1. The location of the pilot provinces in China.

Date Test

Carbon Emissions Comparison

Figure 1 compares the carbon emissions of the seven existing carbon trading pilot markets in China, and the two neighboring non-pilot provinces (Shaanxi and Hebei). Shaanxi is close to Hubei and Chongqing, and Hebei is near Beijing and Tianjin. It can be seen that companies are subject to constraints because the pilot markets are engaged in carbon trading, so carbon emissions in these region are reduced to some extent. However, due to the specific binding forces, there are differences in the extent of regional carbon emissions reductions. Compared with the pilot markets, enterprises in non-pilot cities are not subject to any constraints and the CO_2 emission in these regions continue to increase carbon emissions. Therefore, carbon trading system

is effective in constraining enterprises and reducing carbon emissions. However, there are obvious differences in inter-regional carbon emissions due to different constraint forces.

Carbon Market Comparison

Among the seven pilot markets, another difference lies in the criteria following which enterprises are selected. The analysis shows that the choice of inclusion criteria plays a decisive role in the number of firms in the society. Figure 2 selects five pilot markets to compare the different impacts of inclusion criteria on emissions reductions. It can be seen that compared with the other four markets, carbon emissions reductions in Chongqing after the implementation of carbon rights trading have increased significantly, by an amount that is far higher than in other cities. The reason is that the inclusion of corporate standards in Chongqing mainly considers the carbon emissions of enterprises from 2008 to 2012, which is longer than that of other pilot markets. Of course, the reduction of carbon emissions is not determined by a single factor, there must be other factors, such as the number of enterprises and emissions standards.

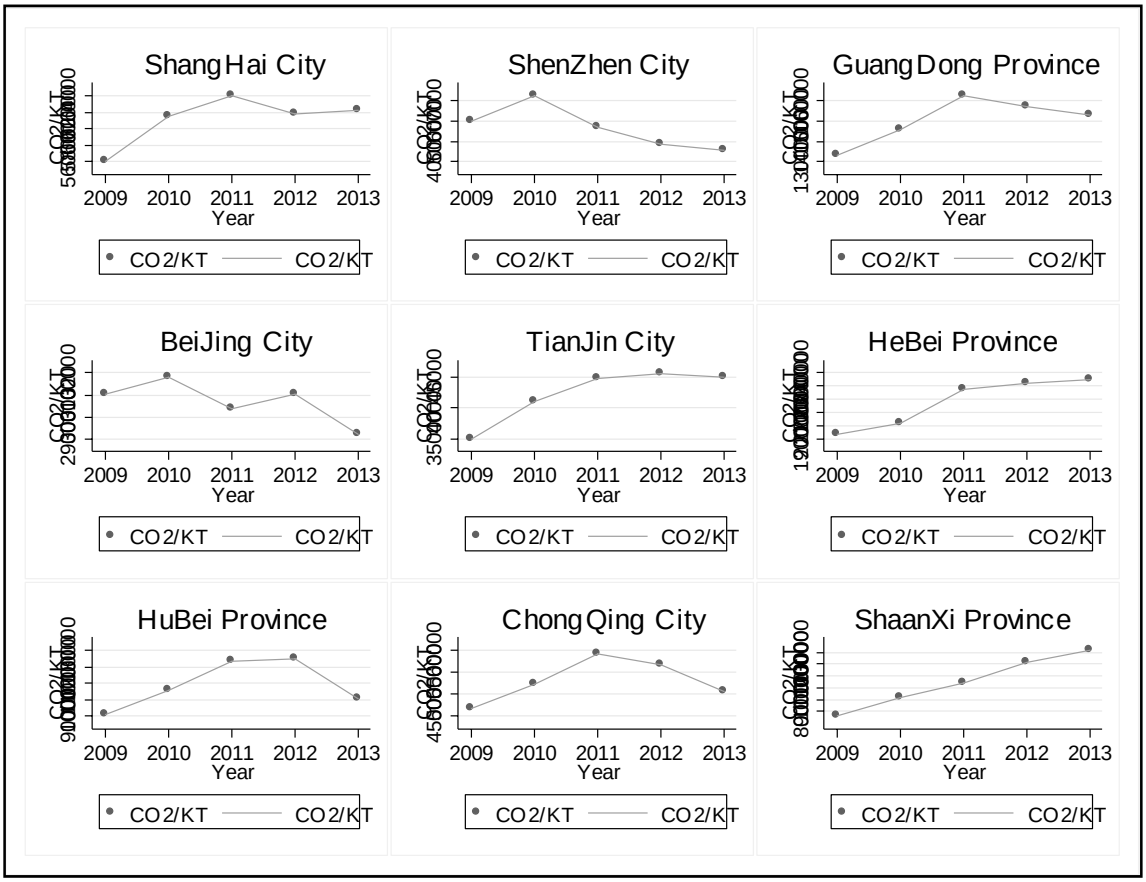

Figure 2. Comparison of carbon emissions between pilot markets and non-pilot provinces. Source: China Statistical Yearbook.

An Internal Comparison of the Carbon Assignment

The preceding analysis discusses the implementation of the three carbon distribution methods in the pilot markets. Due to data constraints, this paper explores the influence of the historical approach and baseline methods; Tianjin and Hubei are selected as the comparison regions. The history approach takes the petrochemical industry as the object of study, while the baseline method examines the electric power and heat

industries. The industry carbon emissions calculated here are only approximations, but it is good enough to show the trend.

Internal Comparison of the History Approach

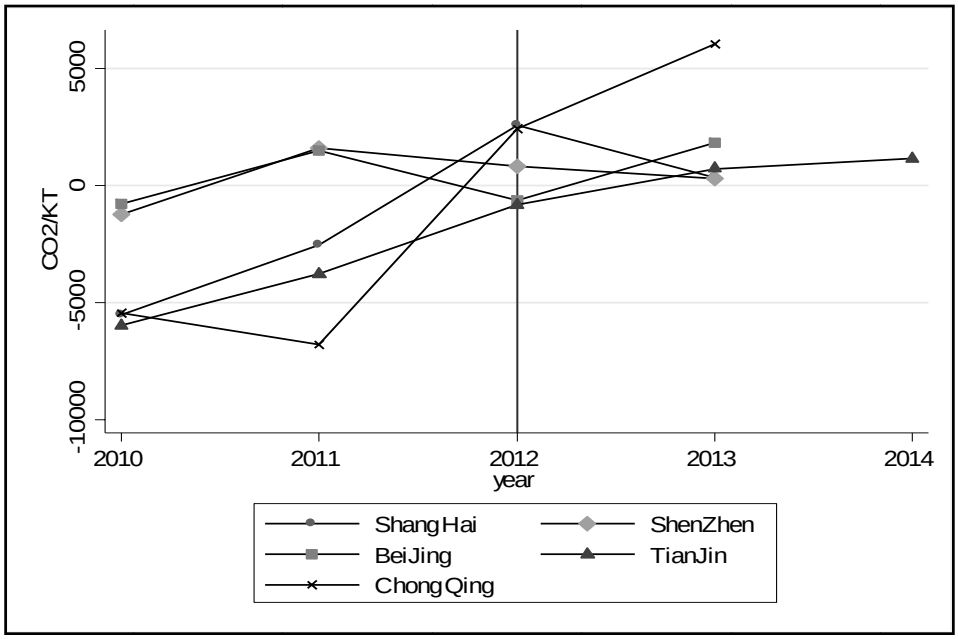

Figure 3. Comparison of inclusion criteria. Source: China Statistical Yearbook.

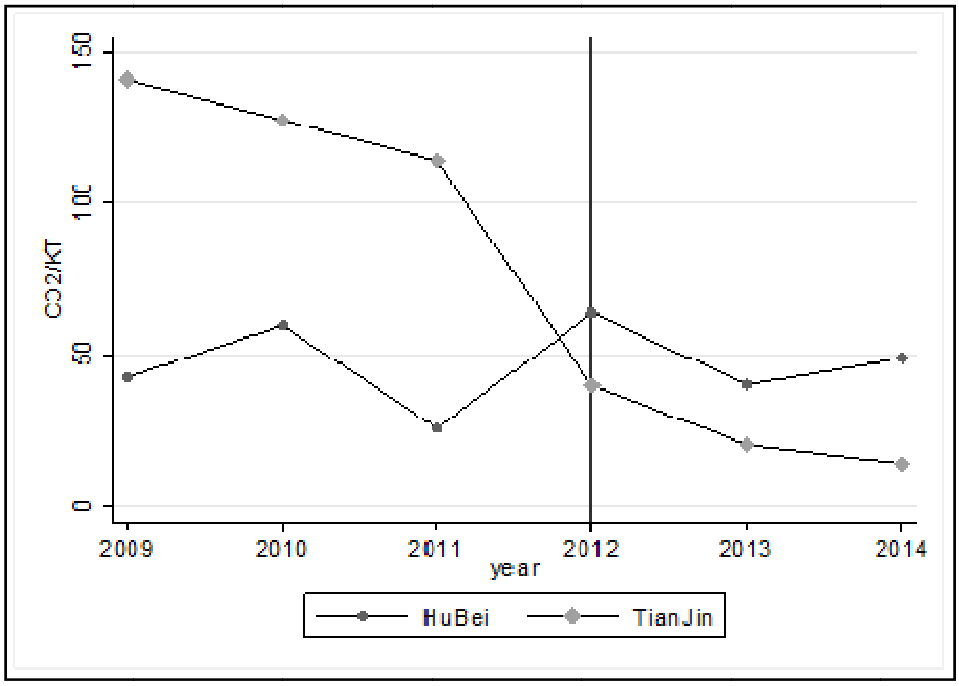

Figure 4. Internal comparison of the history method. Source: China Statistical Yearbook.

Since both Tianjin and Hubei use the history approach for carbon allocation methods, they are selected as the comparative target to analyze carbon emissions trends for the petrochemical industry from 2009 to 2014, as shown in Figure 4. It can be seen that industry carbon emissions for the petrochemical industry in Tianjin

showed a significant downward trend, while Hubei shows an uncertain trend with increasing and decreasing fluctuations. The chart shows that in the petrochemical industry, the effect of implementation of history approach is better in Tianjin than in Hubei in terms of enterprise restraint. The reason is that Tianjin takes the advanced carbon reduction efficiency and technological level into consideration when allocating allowances according to history approach, while Hubei has not.

Internal Comparison of the Baseline Method

In order to compare the effects of the baseline method the thermal power industry in Tianjin and Hubei from 2009 to 2014 was selected for the research, and the change of carbon emissions growth rate was used to reflect the status of the reduction of carbon emissions, as shown in Figure 5. As can be seen, from 2010 to 2014, there are 3 among the four years, in which the carbon emission cut has realized in Hubei Province, indicated by the dots below 0; while there are only 2 in Tianjin. The comparison can show that the baseline method in Hubei Province is more strict or binding. Specifically, Hubei's growth rate in 2011 compared with 2010 is -0.36, which means that the growth rate of carbon emissions in 2011 has slowed. The increase in growth rates for 2012 and 2011 is -34.47, which means that the slowdown in carbon emissions growth in 2012 is greater. The growth rate in 2013 compared with 2012's is 27, which means that the growth rate of carbon emissions in 2013 not only did not slow down but also rebounded sharply. The growth rate in 2014 compared with 2013's is -17.99, which means the growth rate of carbon emissions has slowed. It also can be analyzed Tianjin trend situation. To be exact, for the thermal power enterprises, the first 50% of the amount of carbon emissions for business units is used as the benchmark value in Hubei Province, but in Tianjin only the average carbon dioxide emissions per unit of output from 2009 to 2012 is used to determine the baseline level.

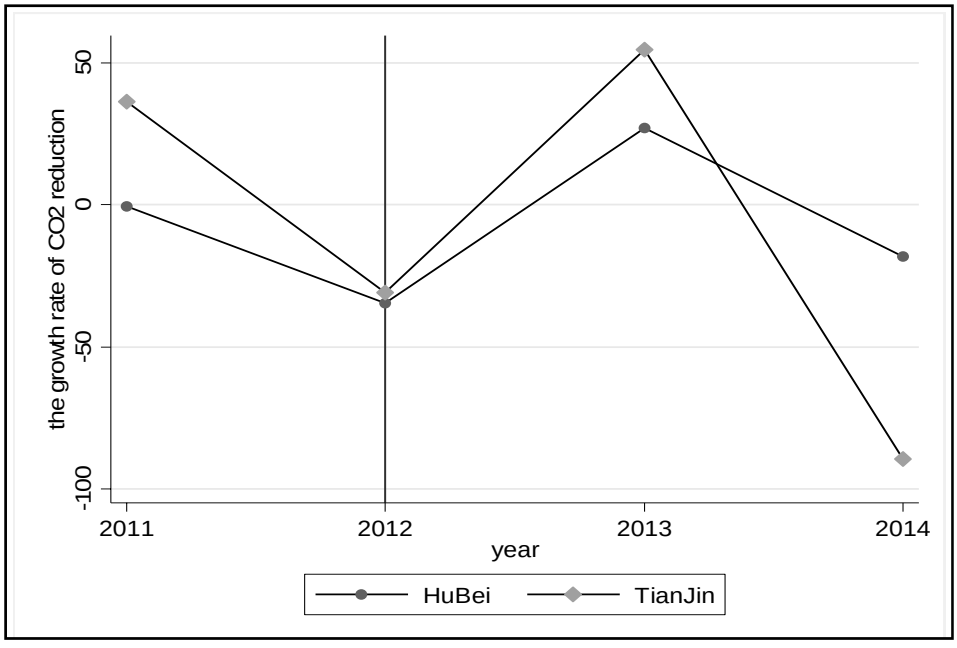

Figure 5. Internal comparison of the baseline method. Source: China Statistical Yearbook.

Conclusion

In order to explain the framework of emission trading system influencing emission cut, this paper explores the influence of allowance allocation methods to the goal. Combined with the data from pilot markets in China,

the analysis shows that the initial allowance allocation methods have a significant effect in reducing emissions. In order to illustrate the effect of other factors on the constraint to enterprises' behaviour and other effects, further evidence must be examined, but this research provides a new perspective for the accurate analysis of the differences and effects of different carbon emission allowance allocation methods.

Suggestion

Based on the upper analysis, this paper puts forward the corresponding suggestions in order to provide reference for the establishment of pilot cities or national carbon market.

First, establishment of a carbon emissions trading market is necessary. According to the empirical analysis, the carbon emission reduction results of the pilot provinces and cities which have established the carbon emissions trading markets are significant. Environmental problems become increasingly serious and economic development needs benign guide. Carbon emissions trading market is currently the most effective measure to limit carbon emissions, and the effects of this means in China's pilot provinces and cities have also been confirmed, so the expansion of the scope of the pilot or the establishment of a national carbon trading market for China's environmental quality improvement has a positive effect.

Second, state should design more scientific emission standards. The enterprise access criteria determine the number of carbon reduction companies in a region, as well as the effect of carbon reduction. The design of emission standards should take into account the relevant factors. In terms of mechanism design, scientific principles should be followed and state should take into account the time span, the scale of enterprises, the type of industry, and the economic impact. The carbon emission restriction should be carried out gradually. In this paper, we can see that the different choices of time span will have an effect on the number of enterprises which will directly affect the effect of regional carbon emission reduction. Therefore, it is very important to determine reasonable time span of selection criteria.

Finally, government should fully consider the results of pre-emission reduction and emissions. When government constrains carbon emissions of enterprises, it must face its early emission reduction results and carbon emissions. And if government considers the results of early emission reduction in the design of the mechanism, it will increase the enthusiasm of enterprises to reduce carbon emissions. At the same time, a comprehensive and reasonable consideration about the enterprise's initial carbon emissions has a positive meaning for the fairness of the mechanism design.

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