Research on carbon trading mechanism of enterprise emission reduction behavior

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Abstract. As one of the effective measures to reduce greenhouse gas emissions, the carbon trading mechanism has received increasing attention from countries around the world and has made significant development. This paper reviews the emergence and the development of carbon emissions permit trading and compares the research of scholars at home and abroad in recent years on the emission reduction behavior of carbon trading mechanisms, and conducts a literature analysis review mainly focusing on relevant policies, research methods, the impact on enterprises' emission reduction behavior and incentive mechanism under the game perspective. The results show that the carbon trading mechanism dramatically facilitates promoting enterprises' emission reduction behavior. Finally, development suggestions are made to construct China's carbon emissions trading market.

Keywords: carbon trading mechanism; emission reduction effect; enterprise

1 Introduction

Global warming has become a serious challenge facing the world today. According to statistical analysis, China has become the world's largest emitter of greenhouse gases, and in 2019, China's carbon dioxide emissions reached 14,093 million tons, accounting for 27% of the global emissions, making it urgent to strengthen low-carbon emission reduction. Its global CO2 emissions for 2015-2021 are shown in the Figure 1. Since 2005, China's only meaningful experience in carbon trading has been accumulated through its participation in the Clean Development Mechanism (CDM) of the Kyoto Protocol. From 2008-2012, in order to achieve sustainable development, developed countries set strict carbon emission standards, requiring major industrial countries worldwide to emit a minimum average of 5.2% CO_2. [1] The validity of the Kyoto Protocol opened the door to carbon emission permit trading.

China is currently accelerating the construction of a national carbon market to carry out carbon emissions trading (CET) through the most cost-effective market-based means. This will force relevant enterprises to consciously undertake carbon emission reduction and play an important role in achieving new carbon emission reduction targets. China is relatively behind in establishing a carbon emissions trading market,

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however, as of April 2023, eight cities, including Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong, Shenzhen, and Fujian, have launched carbon emissions trading pilots. Since 2012, China's CET pilots have involved several high-carbon industries and thousands of enterprises. This paper evaluates and summarizes the CET pilot policy and experience from multiple perspectives, which is conducive to further improving the CET system and preparing for the scientific development of the national carbon market. [2] In this paper, we used CiteSpace software to summarize 201 papers on China Knowledge Network in the past five years with the keyword of "carbon trading and emission reduction", and the related research on carbon trading is shown in Figure 2.

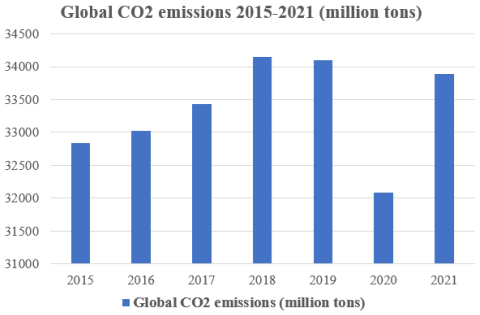

Fig. 1. Global CO2 emissions (million tons), 2015-2021

Fig. 2. Share of studies related to carbon trading mechanism, 2018-2023

2 Relevant Studies on Carbon Emission Trading Mechanism

China's carbon emissions trading mechanism began in 2011 with the issuance of the Notice on the Pilot Project of Carbon Emissions Trading, which was officially launched in June 2013. The national carbon emissions trading system was launched at the end of 2017. The main legal bases of the current national carbon emissions trading system include the Interim Measures for the Management of Carbon Emissions Trading, a departmental regulation issued by the National Development and Reform Commission at the end of 2014, and the Regulations on the Management of Carbon Emissions Trading,

issued in 2016. [3] China's experience can make a significant contribution to these developing countries and regions in the academic debate, as it is the only developing country that has established its own emissions trading system.

2.1 Concept of Carbon Emission Trading Mechanism

The carbon emissions trading mechanism (ETS) is one of the two main cost-effective mechanisms for controlling carbon emissions. In the case of ETS, carbon emission rights are a tradable commodity, and participants with high carbon abatement costs will pay for emission rights to obtain more emissions, while participants with low abatement costs will be rewarded for their more emission reductions. [4] ETS is mainly in three forms: one is the mandatory emission reduction model of quotas, which is applied to the power industry; the second is the cooperative model of emission reduction of participating entities, in which the market emission reduction mechanism directly drives the industry to reduce emissions; and the third is the voluntary emission reduction model, in which each region or different types of buildings determine different targets and emission reduction requirements according to their actual and characteristic requirements, i.e., CCER.[5] Its carbon trading approach is shown in Figure 3. In the long run, it is imperative to provide financing and financial support for energy saving and emission reduction activities on a regional scale through the establishment of national or regional carbon markets.

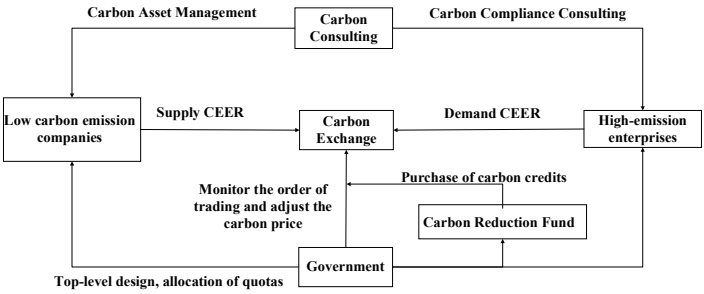

Fig. 3. Flow chart of carbon trading method

2.2 Theoretical Study of Carbon Emission Trading Mechanism

Domestic and foreign scholars have conducted game studies on how to determine the incentives between the government and enterprises under the guidance of carbon emissions trading. Cai Binqing [6] et al. constructed an evolutionary game model between the government and the building supply side, where static carbon tax and dynamic carbon emissions trading compliant policies have a great impact on promoting the development of green buildings. li and Gao [7] used a three-way evolutionary game model to analyze the effects of key variables such as subsidies, carbon taxes, and technology transfer fees on firms' independent R&D strategies and technology introduction strategies. Xu and Le[8] constructed an evolutionary game model under three scenarios: government-firm, firm-public and government-firm-public, and studied the key factors

affecting firms' innovation decisions under different scenarios. Sun, Zhenglin [9] et al. constructed a government-firm evolutionary game model to analyze how the government should formulate policy combinations to promote firm innovation. Huang Xin [10] et al. set up two scenarios of local government cooperation and non-cooperation, and compared the equilibrium of Stackelberg's emission reduction problem among firms under the two scenarios using a differential game approach, and concluded that regional government cooperation could improve firms' R&D investment in emission reduction.

In addition to the game perspective, many scholars have conducted other model-related studies. Wang [11] and Hu [12]used a multi-subject-based model and a computable general equilibrium (CGE) model, respectively, to analyze the Chinese pilot ETS market's economic impact. A simulation approach was used to assess the macroeconomic impact of the Chinese carbon market.CEG is a top-down model that captures the activities at the industry-wide level. A multi-subject-based model is the most typical bottom-up analysis technique to capture the activities and interactions between various specific subjects effectively. Tang [13]et al. developed a multi-intelligence-based model to study the impact of different CET designs to find the most suitable CET design for China. The proposed bottom-up model includes all major economic agents in the general equilibrium framework, including different subsidy allocation rules, carbon price levels, penalty rates, and subsidy rates, to analyze each factor's impact on the energy efficiency and emission reduction of enterprises.

3 Impact of Carbon Trading Mechanism On Enterprises' Emission Reduction Behavior

Enterprises are not only an important player in the carbon trading market, but also a key unit of economic activity in all countries. According to the market economy theory, it is most cost-effective for enterprises to use carbon trading to reduce carbon emissions. Through their study, Liu [14] et al. found that the government plays a leading as well as a planning role in the carbon trading process, while enterprises have almost no say in the process. In the real situation, enterprises occupy the position of the main trading body in the whole carbon trading process, but from the analysis of the development situation, enterprises are mostly absent. It is necessary to enhance the position of enterprises as the main trading body and reduce government intervention, so as to optimize the internal trading behavior of carbon emission rights and reduce the transaction cost more effectively.

The study of evolutionary games and related models found that technological innovation helps enterprises to reduce costs and increase efficiency, and more fully play its role in emission reduction. Shen Hongtao [15] et al. used a double difference model to find that carbon trading significantly enhances the short-term value of a firm, but does not have a significant impact on its long-term value. Based on the Starkberg model, Zhou Chunling [16] et al. found that the size of the initial coefficient of the initial carbon emission of a firm has an impact on the firm's output and market, regardless of the maturity of carbon reduction technology. Based on the estimation method of triple difference, Yao Xing [17] et al. found that carbon trading policy can promote the

introduction of corporate research talents and increase the expenditure on scientific and technological research and development, thus further promoting the development of corporate green innovation. The proposed bottom-up model includes all major economic agents in the general equilibrium framework to analyze the impact of each factor on energy saving and emission reduction of enterprises.

4 A Study of Carbon Trading Mechanism for Corporate Emission Reduction Technology Incentives

In considering the whole process of emission reduction activities, a policy instrument based on the market environment is more incentive and more helpful to enterprises than a purely command-based policy instrument. Jaffe [18]argues that firms will consciously engage in more technological innovation to improve resource efficiency in the face of pressure from environmental regulation. This positive "innovation compensation effect" will partially or even completely offset the negative "compliance cost effect", which can improve the productivity and competitiveness of firms, i.e., the famous "Porter The "strong Porter hypothesis". The "strong Porter hypothesis" suggests that environmental regulation can promote both technological innovation and productivity and business performance. The "weak Porter hypothesis" suggests that environmental regulations promote technological innovation, but there is still uncertainty about the direction and magnitude of the ultimate overall benefit to firm productivity. Li Yi[19] argued that carbon trading is a low-cost way to motivate emission reduction subjects, and the price of carbon credits is one of the driving forces of the carbon emission reduction process. Yanli Wang [20] et al found that the efficiency of corporate investment by alleviating the financing constraints of enterprises, improving underinvestment, and inhibiting overinvestment. Carbon trading policy as a kind of environmental regulation exposes firms to additional emission reduction costs, which may also make firms' investment behavior more cautious and have a positive impact on their investment efficiency.

These studies make it possible to identify the importance of technology incentives, taking into account the gap between the expected and actual benefits to firms. If the market is in a free competition situation, then policy guidance can better control the behavior of firms and allow them to innovate better. Other scholars focus on policy support in the research process and use policy to guide technological change. They believe that to carry out better technological innovation, more enterprises should be encouraged to actively optimize their own technology so that they can lead the further development of the whole technology, which can better protect the environment and achieve the long-term development of human beings.

5 Summary and Prospect

The carbon trading mechanism is a flexible and effective policy tool to solve the carbon emission problem, which helps to ensure the reduction of emission reduction costs and the improvement of emission reduction efficiency of the whole society. A review of the

existing literature shows that the relationship between the government and enterprises is established through an evolutionary game model, and it can be found that the carbon trading mechanism can significantly promote energy saving and emission reduction by enterprises under government incentives. The higher the participation of enterprises in the carbon trading market, the higher the relative equilibrium of the market supply and demand. At the same time, technical means such as environmental regulations can play a good incentive role for enterprises to reduce emissions. This paper studies the impact of the carbon trading mechanism on enterprises' emission reduction behavior, which, on the one hand, can help enterprises to have carbon quota constraints to achieve reasonable production and mitigation plans, to obtain the maximum benefit to promote the long-term development of enterprises.

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