

Review of Research on China's Carbon Trading Policy and Corporate Green Technological Innovation

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Abstract: Faced with the climate warming crisis caused by excessive greenhouse gas emissions, China has proposed the "dual carbon" goal and implemented carbon emission trading policies. Scholars have conducted extensive empirical research on the policy effects of carbon emission trading policies on carbon reduction, economic performance, and other aspects, but there is little literature that focuses on the impact of policies on enterprises from a micro perspective. Against the backdrop of achieving high-quality development in China, the importance of enterprise green technology innovation as an important supporting force is increasing day by day. Therefore, this study summarizes relevant concepts, theoretical foundations, the impact of carbon emission trading policies on green technology innovation, and the specific mechanisms of their effects. It provides a review and provides relevant suggestions for future research.

Keywords: Carbon Emissions Trading; Green Technology Innovation; Enterprise.

1. Introduction

Over the past four decades since the reform and opening-up, China has achieved the miracle of rapid economic development, becoming the world's second-largest economy and the largest industrial country. However, the excessive pursuit of high economic growth in the past has also caused severe environmental pollution and ecological damage. According to relevant reports, China's carbon emissions reached 9.899 billion tons in 2020, accounting for about one-third of the global total, indicating that China's greenhouse gas reduction activities are extremely important for mitigating global warming. China actively shoulders the responsibilities of a major country and devotes itself to global ecological civilization construction. In September 2020, President Xi Jinping announced at the 75th United Nations General Assembly that China will strive to achieve carbon peaking by 2030 and carbon neutrality by 2060. The "dual carbon" goals have also become a key component of the 14th Five-Year Plan, providing direction for China's environmental governance. However, it is difficult for China to change its fuel use structure dominated by non-renewable energy sources such as coal, oil, and natural gas in the short term. Therefore, implementing effective emission reduction policies is crucial, and the carbon emissions trading policy has emerged under the "dual carbon" vision.

As the carbon trading market continues to advance nationwide, scholars have increasingly focused on carbon emissions trading policies, mostly from a macro perspective, concerning the energy conservation, emission reduction, and economic effects of these policies. However, China's economy has entered a "new normal," facing the transformation requirement of high-quality development. Carbon emissions trading policies are no longer just crucial tools for regulating carbon reduction and economic development but must also address a series of issues, such as the sustainability of low-carbon economic development. Relevant documents indicate that green technological innovation is an important support for achieving the "dual carbon" goals and high-quality development. In October 2021,

China's State Council issued the "Action Plan for Peaking Carbon Dioxide Emissions Before 2030," incorporating green technological innovation into the "Top Ten Actions for Carbon Peaking," further highlighting the important role of green technological innovation in strengthening environmental protection and achieving green development. Therefore, to achieve steady development of the low-carbon economy and promote green and high-quality economic growth, it is necessary to clarify the relationship between carbon emissions trading policies and green innovation and find a balance point for coordinated development.

Currently, China implements its carbon trading policy through a unique model of pilot projects followed by nationwide promotion, which aligns with China's national conditions. Therefore, this paper organizes and summarizes domestic research findings, aiming to promote theoretical and practical innovations in green technological innovation in China.

2. Theoretical Support

2.1. Relevant Concepts

2.1.1. Carbon Emission Trading Policy

Carbon emission rights refer to the legitimate right for enterprises to emit greenhouse gases, primarily carbon dioxide. The carbon emission trading policy is a market-incentive environmental regulatory policy designed by the government based on market mechanisms. Unlike traditional command-and-control environmental regulations, it relies on market signals to guide enterprises in conducting carbon reduction activities. Specifically, relevant government departments set the total carbon emission cap for a region within a year and allocate initial free quotas to enterprises in various pilot regions based on past carbon emission data, thereby commoditizing carbon dioxide emission rights. When enterprises exceed their carbon emission quotas, they need to purchase additional quotas to cover the shortage; conversely, when their actual emissions are less than their carbon quotas, they can sell their carbon quotas on the carbon market to obtain excess returns. This approach internalizes the negative

externalities resulting from carbon emissions, ultimately achieving the purpose of controlling and optimizing the total carbon emissions.

2.1.2. Green Technological Innovation

Bernauer and Wield (1994) first proposed the concept of green technological innovation, defining it as the collective term for technologies, processes, and products that can meet environmental protection needs, reduce energy consumption intensity, and maximize the utilization of natural resources. Varadarajan (2017) summarized and found limitations in previous definitions, arguing that green innovation involves implementing sustainable development strategies in technological innovation, such as optimizing resource utilization efficiency and increasing productivity. As the importance of environmental protection has risen, many domestic scholars have conducted research on green technological innovation. Lv Yan et al. (1998) believed that green innovation can achieve resource conservation and pollution reduction throughout the entire product production process and categorized it into three levels: terminal treatment technological innovation, green process innovation, and green product innovation. In 2019, the National Development and Reform Commission and the Ministry of Science and Technology of China jointly issued the "Guiding Opinions on Building a Market-Oriented Green Technological Innovation System." The document pointed out that green technology, as an emerging technology, involves fields such as energy conservation and environmental protection, ecological agriculture, environmental treatment and restoration, covering the entire process of product design, manufacturing, and recycling.

2.2. Theoretical Basis

2.2.1. Property Rights Theory

Coase considers that clear property rights can reduce the risks associated with economic operations and enhance transaction efficiency. Furthermore, through constraint mechanisms, clear property rights can ensure that individuals' behaviors remain at an equilibrium level, thereby achieving maximum benefits. He believes that internalizing external costs can be achieved by clarifying issues related to property rights ownership.

Based on the theory of property rights, environmental resources can be regarded as a type of property right. By assigning reasonable prices and usage costs to these resources, entities can freely trade them in the market, ultimately achieving optimal allocation of environmental resources. Carbon emission rights are one of the environmental property rights and can be traded as a commodity on the carbon trading market. The carbon trading market is a market where the government determines environmental property rights, forming equilibrium prices that effectively guide the allocation of resources between high-carbon and low-carbon industries. This, in turn, incentivizes enterprises to reduce carbon emissions per unit of output through green innovation, addressing the "double externality" issue of green technological innovation to a certain extent.

2.2.2. Theory of Technological Innovation

The term "technological innovation" was introduced by the renowned American economist Joseph Schumpeter in his book *The Theory of Economic Development* published in 1912. Schumpeter viewed "innovation" as a new production function that involves the recombination of new production factors and conditions and their introduction into the

production system. Furthermore, based on the content of innovation, Schumpeter classified it into five types and believed that the core driving force for economic development and growth is technological innovation that can improve processes or procedures.

Green technological innovation originates from Schumpeter's theory of innovation. With the development of global industrialization, issues such as environmental pollution and resource scarcity have become frequent, posing a serious threat to the sustainable development of all mankind. Countries have gradually realized the importance of protecting the environment and are increasingly focused on achieving a win-win situation for both economic development and ecological harmony. Technological innovation is the core of economic growth and development, while "green" embodies the concept of environmental protection and conservation. Therefore, green innovation is the best choice for enterprises facing severe environmental challenges, and it is also the inevitable path for China to achieve low-carbon and environmentally friendly development.

2.2.3. Porter's Theory

Professor Porter of Harvard University (1991) takes a dynamic perspective and believes that appropriate, reasonable, and flexible environmental regulations can force enterprises to engage in technological innovation activities. The benefits derived from these activities can offset the costs incurred by enterprises in environmental governance, thereby enhancing their competitiveness. This is known as the "Porter Hypothesis." Specifically, it can be understood from two aspects: "innovation compensation benefits" and "first-mover advantage benefits." On the one hand, the implementation of environmental regulations by the government, to a certain extent, promotes technological innovation and optimal resource allocation among enterprises, thereby improving production efficiency. The economic benefits obtained can compensate for the costs arising from environmental regulations. On the other hand, the prevalence of the concept of ecological environmental protection and the supervisory role of environmental regulations can make enterprises aware of the importance of green environmental protection. They will actively engage in green innovation and take environmental responsibility, thereby establishing a green brand image and taking the lead in seizing a dominant market position.

3. Research Status on the Relationship between Carbon Emission Trading Policy and Green Technological Innovation

3.1. The Impact of Carbon Emission Trading Policy on Green Technological Innovation

Domestic implementation of carbon emission trading policies is relatively recent, but numerous scholars have conducted related research, and most have affirmed the driving role of carbon trading policies in promoting green technological innovation. Liu Ye et al. (2017), based on data from A-share listed companies in Shanghai and Shenzhen, China, used a triple difference-in-differences model to analyze the impact of the carbon emission trading pilot policy on corporate R&D innovation. The results showed that the carbon emission trading system significantly and positively affected corporate green technological innovation. Cai

Wugan et al. (2018), taking listed companies in Shanghai that were included in carbon trading as the research object, used the Propensity Score Matching (PSM) method and established a counterfactual analysis framework for research. The empirical analysis found that the carbon emission trading policy increased the innovation investment of emission-controlled enterprises, which could promote ecological innovation in enterprises in a long-term and stable manner. Zhong Changbiao et al. (2020) used the Difference-in-Differences (DID) method to study the same issue and found that the low-carbon pilot policy played a positive role in promoting green technological innovation among regional enterprises. From the perspective of the nature of green patents, it was found that enterprises were more inclined to develop green utility model patents. The research by Hu Jiangfeng et al. (2020) also showed that implementing the carbon emission trading pilot policy could simultaneously promote both the quantity and quality of corporate innovation, but with a greater emphasis on low-level innovation. Chen Hong et al. (2023), based on panel data from Chinese A-share listed companies from 2010 to 2020, conducted an empirical analysis using the multi-period DID method. The results showed that the carbon trading pilot mechanism could positively affect the growth of corporate R&D investment.

Some studies have put forward opposing views, arguing that carbon emission trading policies hinder green innovation. Yang et al. (2016) conducted a study using a questionnaire survey to investigate the impact of China's implementation of the carbon emission trading pilot policy on corporate perceptions. The results showed that the pilot policy did not impose significant environmental regulatory pressure on enterprises, making it difficult to significantly and positively influence their green technological innovation behavior. Chen et al. (2021) conducted an empirical study based on data from Chinese A-share listed companies from 1990 to 2018. The results indicated that due to the impact of reduced cash flow and expected earnings, enterprises would choose to decrease production, suggesting that China's implementation of the carbon trading pilot policy had a negative impact on corporate green technological innovation.

3.2. The Impact Mechanism of Carbon Emission Trading Policies on Green Technological Innovation of Enterprises

From the perspective of the carbon market itself, Yi Ming et al. (2018) found in their research that an increase in carbon prices significantly positively affects enterprises' green technological innovation behavior. Wei Lili et al. (2021) conducted a study by establishing a price signaling mechanism and discovered that carbon emission trading policies positively influence enterprises' green technological innovation activities. Furthermore, as carbon prices rise, this positive impact becomes more significant. Lv et al. (2021) also examined the effectiveness of carbon trading policies from the perspective of enterprise innovation. Their empirical results indicate that both high carbon trading prices and high price volatility promote enterprise innovation. Song Deyong et al. (2021) used the PSM-DID model to explore the relationship between carbon emission trading policies and green technological innovation of pilot enterprises based on data from eight provincial and municipal pilot projects. The results show that compared to the historical method, the benchmark method has a stronger promotional effect on green technological innovation activities, and the historical method

tends to inhibit the innovation motivation of enterprises with higher levels of past innovation.

From the perspective of internal factors within enterprises, Li Dayuan et al. (2021), based on upper echelons theory and the resource-based view, found that the age of the CEO plays a negative moderating role in the relationship between carbon trading policies and corporate innovation investment, while the age of the company positively promotes this relationship. Wang Xinhong et al. (2023) discovered that the carbon trading pilot policy can positively influence corporate green technological innovation through the environmental attention of the executive team, with a more significant promotional effect on state-owned enterprises.

Furthermore, Wang Fengrong et al. (2022) conducted research based on panel data from A-share listed companies from 2010 to 2018. The results showed that carbon trading can promote high-quality green technological innovation in enterprises by internally enhancing the level of corporate environmental responsibility and externally alleviating financing constraints. Li Chuang et al. (2023) took listed companies in key carbon-emitting industries as the research object and used a triple difference-in-differences model to explore the incentive mechanism of China's carbon emission trading policy on corporate green technological innovation. The results indicated that macro-level market demand, meso-level industry competition, and micro-level internal corporate control factors can all effectively play a moderating role, influencing the relationship between the two.

4. Review and Prospect of Research

Through sorting out and summarizing domestic and international research, it can be seen that scholars have conducted extensive research on the relationship between carbon emission trading policies and green technological innovation, and have obtained meaningful results, providing valuable theoretical and empirical experience for this study. However, there are still some deficiencies that need further improvement, which are as follows:

(1) regarding whether emissions trading policies can promote green technological innovation behavior in enterprises, scholars have employed various empirical research methods but have not reached a consensus. Further research is needed to investigate the validity of the "Porter Hypothesis" in the Chinese context. In terms of research methods, domestic scholars tend to use secondary data for empirical research, which falls under quantitative research. In the future, more consideration should be given to qualitative methods such as questionnaire surveys, interviews, and case studies to obtain primary data. This is because organizational employees often have a clear perception of the factors that influence the relationship between carbon trading constraints and corporate green technological innovation, thereby broadening scholars' research on the factors and mechanisms affecting this relationship.

(2) although some literature has explored the impact of carbon emission trading policies on green technological innovation and analyzed specific mechanisms, most of the research focuses on the carbon market itself and external environmental factors, remaining superficial and failing to delve into the systematic impact mechanisms within enterprises. Future research needs to pay more attention to the influence of internal factors within enterprises on this relationship. Furthermore, in the context of environmental protection and technological change, green technological

innovation increasingly relies on the interaction and synergy between external environmental regulation and internal corporate governance. Future research should incorporate corporate internal governance and carbon trading pilot policies into the same framework to systematically study their impact mechanisms on green technological innovation.

(3) considering the uneven and inadequate development across regions in China, there are differences in economic development levels and enterprise development status, which makes the conclusions not universally applicable. More scientific exploration is needed in the future to fully consider the impact of enterprise and regional heterogeneity on green technological innovation, addressing the deficiencies and further improving the carbon emission trading policy.

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