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中国排出量取引制度と企業のイノベーション

China's Carbon Emissions Trading System and Corporate Innovation

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博士後期課程

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Abstract

The purpose of this study is to review existing research on carbon emissions trading system and corporate innovation. This study, after referring to the research on European Union carbon emission trading system, Tokyo-Saitama Prefecture emission trading system, and corporate innovation so far, reviewing the relevant literature on China's pilot carbon emission trading system and corporate innovation, found four shortcomings of the existing research. Regarding all previous studies, (1) Either in Europe, Japan, or China, R&D expenditure can be hardly used as indicator of technology innovation to explain whether investment in R&D can help to improve the environment. Regarding research on China's Pilot emission trading system, the author finds that (2) for research based on the data of listed companies, listed companies only account for a small part of the companies participating in China's pilot carbon emissions trading system, and the scale is large, and there is a certain deviation in sample selection, (3) for research based on the questionnaire, the reliability of the data is questionable. Most of the respondents are state-owned companies. Whether to fill in the real data in the face of government pressure is worth exploring, (4) lack of relevant research on the effect of national carbon emissions trading system on corporate innovation. In response to the deficiencies, two topics for future research have also been proposed: (1) Obtaining environmental R&D expenditures and environmental patent data of various companies from the China Association of Environmental Protection Industry. This database includes R&D expenditures and patent data for environmental improvement of 7,085 companies from 2016 to 2018, and includes not only listed companies and state-owned companies but also companies with other operating and management systems. (2) Using the Regression Discontinuity Design (RDD) to study the effect of China's carbon emissions trading system on corporate innovation. It is closer to quasi-natural experiments and the estimated results are more accurate. In addition, the research will focus on the national emission trading market. The results of this study may have reference significance for China's carbon emission trading system and corporate innovation in the future.

Keywords: CHN-ETS, EU-ETS, Tokyo-Saitama prefecture ETS, Corporate innovation, Literature review

要旨

この研究の目的は、排出量取引制度と企業革新に関する既存の研究をレビューすることである。この研究は、これまでの欧州連合域内排出量取引制度、東京都・埼玉県排出量取引制度と企業革新に関する研究に言及し、中国のパイロット排出量取引制度と企業革新に関する関連文献を検討した後、既存の研究の4つの問題点を発見した。全ての論文について、(1)ヨーロッパ、東京都・埼玉県、中国に関する研究のいずれにおいても、研究開発費をイノベーション変数として使用する限り、それが、環境改善のために投資された研究開発費であるかどうかを説明できない、という問題がある。中国パイロット排出量取引制度に関する論文について、(2)上場企業のデータに基づく研究については、上場企業は中国のパイロット排出量取引制度に参加している企業のごく一部しか占めておらず、規模が大きく、サンプル選択に一定の偏差がある。(3)アンケートに基づく研究については、データの信頼性に疑問がある。回答者のほとんどは国有企業であり、政府の圧力に直面しているために、実際のデータを入力するかどうかは検討する価値がある。(4)全国規模で排出量取引制度が企業のイノベーションに与える影響に関する研究は不足している。

以上の問題を克服するため、本研究は将来の研究に向けて次の 2 点を提案する。(1)中国環境保護産業協会から企業の環境研究開発費用と環境特許データを取得する。このデーターベースには 2016 年から 2018 年まで 7085 社の環境改善のための研究開発費と特許データを含めて、上場企業と国有企業だけでなく、ほかの運営体制と管理体制を持つ企業も含む。より説得力を持つ。(2)回帰不連続デザインを使用して、企業のイノベーションに対する中国の排出量取引制度の影響を研究する。このモデルは準自然実験に近く、推定結果はより正確である。それに、国レベルの排出量取引市場を中心として研究する。この研究の結果は、将来の中国の排出量取引制度と企業革新に関する研究に参考となる可能性がある。

キーワード：中国排出量取引制度、欧州連合排出量取引制度、東京都・埼玉県排出量取引制度、企業革新、レビュー研究

1. Introduction

At present, climate change due to greenhouse gas (GHG) emissions is the most serious problem in the world. According to the 2014 IPCC report, GHG emissions in recent years have been the highest in history. In response to climate change, many countries and regions have launched the Emissions Trading System (ETS). In 2011, China's National Development and Reform Commission approved a pilot project for carbon emissions trading in seven provinces and cities, including Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong and Shenzhen. On December 19, 2017, the national carbon trading system was officially launched. China hopes to promote low-carbon innovation through market-based means of achieving low-carbon development. One of the main policy goals of the emissions trading system is to promote investment in clean low-carbon technologies and to promote technological innovation.[1] In the short term, achieving emission reduction targets or reducing emission reduction costs depends heavily on technological innovation (Fischer & Newell, 2008; Kemp & Pontoglio, 2011). In the long run, incentives for low-carbon technologies may be the most important criteria for measuring the success of climate policy (Pizer & Popp, 2008). Thus, research to assess the effect of emissions trading system on technological innovation has always been a focus of researcher and policymaker interest.

This study reviews relevant research on the effect of the European Union Emissions Trading System (EU-ETS), Tokyo-Saitama prefecture Emissions Trading System on corporate innovation, and discusses the effect of the China Pilot Emissions Trading System (CHN Pilot ETS) on corporate science and technology innovation. We also refer to related papers on, and propose shortcomings of existing research. In addition, future research topics are proposed.

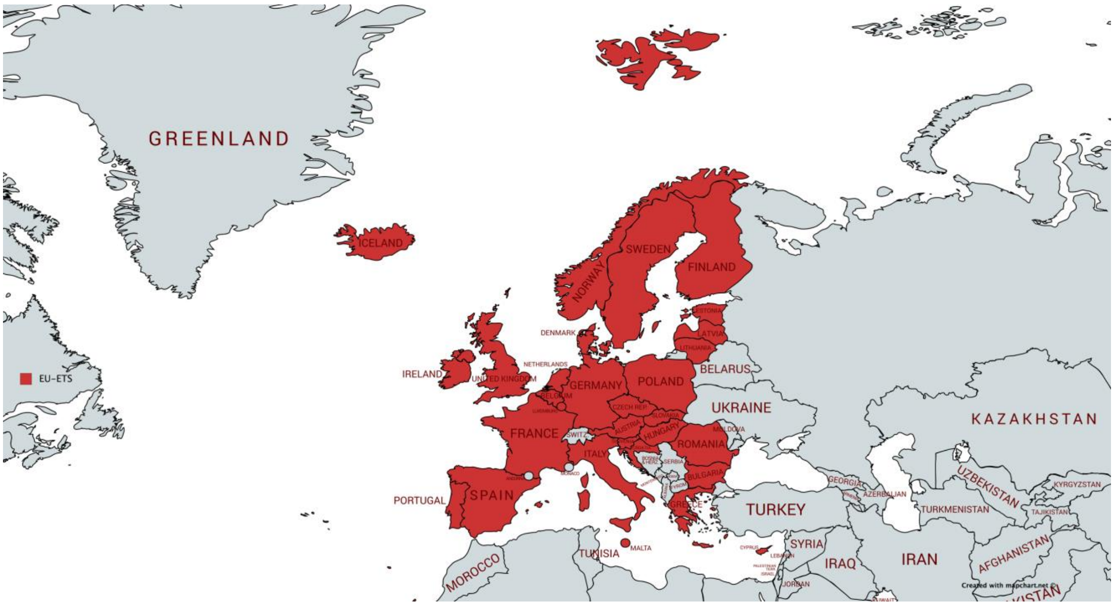
2. Research Trends

2.1 EU Emissions Trading System and Corporate Innovation

The EU-ETS is the world’s first multi-country emission trading system and the world’s largest emissions trading market. The system is currently in operation in 31 countries and covers around 45% of EU GHG emissions. At the same time, the EU has many of the world’s top 500 companies, and their high-energy facilities emit more GHG emissions, it is notable how to reduce costs through enterprise technology innovations. Therefore, there is much research on the effect of EU-ETS on corporate innovation. Related studies can be divided into two main categories.

[1] According to description provided by the European Commission (https://ec.europa.eu/clima/policies/ets_en , accessed February 25, 2020).

Figure 1 The Region under the EU Emissions Trading System



The first type of research is based on qualitative research methods such as survey interviews and case studies, and analyzes the effect of the EU-ETS on corporate decision-making innovation behavior.

Pontogilo et al (2008) discuss the potential and consequences of innovation during the first phase of the EU-ETS. Through a case study of the Italian paper industry[2], they analyze whether EU-ETS could influence corporate innovation, and conduct a survey to collect information on investment strategies and innovation decisions. As a result, a majority (52%) of the respondents claim that they do not implement or plan to innovate to reduce carbon emissions, and only 13% of surveyed operators say they have achieved innovation. At the same time, the survey also covers machine suppliers. The results show that no company can reduce their carbon footprint and improve their carbon efficiency as a selling point for their products. Through a survey of the Italian paper industry, a wait-and-see response strategy is reached. Companies characterize for a dominance of conservative and cautious strategies for technological innovation.

Anderson et al (2011) conduct a survey of companies that has participated in the EU-ETS in Ireland. It investigates the changes in carbon-friendly technology during the pilot phase[3] and whether to change the technology portfolio based on the company's carbon price. In order to gain an accurate understanding of the Irish trade sector, they survey all Irish companies that have installed EU-ETS equipment. At the beginning of the pilot phase, there are 72 companies (106 devices) in the Irish trade sector, 4 are closed, and a total of 68 potential respondents. The survey is mailed to each company, and 27 companies complete and respond. The rate of response of this survey is 40%. Among these companies, 48% use new equipment, 74% make process or operation changes, and 41% convert fuel to some degree during the pilot phase. Overall, the research finds that EU-ETS is effective in promoting technological innovation.

Rogge et al (2011) also analyze how EU-ETS affects innovation. This study examines the effect of EU-ETS on R&D, demonstration, recruitment and organizational changes. The qualitative study is based on a number of case studies conducted between 2008 and 2009 by 19 power producers,

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2 Paper industry is one of the energy-intensive industries in Italian.

3 The first phase, also known as the pilot phase, runs from 2005 to 2007, was the trial operation phase to accumulate experience through actual operation and to prepare for the second phase in EU.

technology providers and project developers in the German power industry. The study finds that the EU-ETS has limited effect on innovation due to its initial rigor and lack of predictability.

The second type of research is based on a quantitative approach to econometric models and analyzes the effect of EU-ETS on technological innovation.

Schmidt et al (2012) empirically evaluate the effect of climate policy on technological change by focusing on assessing the changes that climate policy has made to the rate and the direction of corporate innovation activities. The study is conducted using survey data on the power sector in seven EU countries and using multiple regression models. They find that the effect of the EU-ETS is limited and even controversial. The first and second phases of the system have a significant positive effect on the total rate of adoption[4] by power generators, but not on the firms' total RD&D[5] decisions. The third phase of the system has a significant negative effect on the total rate of adoption in corporate activities, but does not significantly affect the firms' total RD&D decisions of corporate innovation activities. At the same time, the long-term emission reduction target policy is an important determinant of corporate innovation activities, and this policy has a large positive effect on the firms' total RD&D decisions of corporate innovation.

Martin et al (2013) use a unique dataset based on interviews with managers of 770 manufacturing companies in six European countries to build firm-level innovation indicators related to climate change. They use multiple regression models to analyze the effect of the EU-ETS on corporate innovation. In the interview, innovation is defined as process innovation and product innovation, and the company's innovation index is divided into 1-5 levels. Most companies in the sample which participating in the EU-ETS are found to be implementing climate-related innovations that focus on process innovation[6] rather than product innovation[7].

Borghesi et al (2015) study various factors that influence the adoption of environmental innovation (EI). They examine the effect of the EU-ETS on emissions reduction and energy efficiency innovations by applying the Italian Community Innovation Survey Data (CIS) from 2006 to 2008. The results show that sectors participating in the EU-ETS are more likely to be innovated than those not. However, the rigor of industry policies has a negative bearing on its innovation. The authors believe this is due to the early adoption of innovative measures by some companies and various characteristics of the industry.

Inoue (2015) studies the effect of the EU-ETS on R&D intensity[8]. The author uses firm-level panel data constructed from the EU Industrial R&D Investment Scoreboard and corporate CSR reports. The author finds that corporations that have a policy or a strategy to comply with the EU-ETS are more likely to encourage R&D investment.

Calel & Dechezlepretre (2016) obtain EU-ETS Company and non-EU-ETS Company data from the EPO, and they analyze the effect of EU-ETS on low-carbon innovation based on PSM-DID. The study believes that EU-ETS caused an 8.1% increase in low carbon patents.

In conclusion, the methods of studying EU emissions trading system on corporate innovation are diverse, including both qualitative and quantitative studies, and the overall view is that ETS can

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4 Adoption refers to investments in new installations (state-of-the-art technologies) by users and represents the diffusion stage.

5 RD&D (research, development and demonstration) refers to activities from basic laboratory research activities, via the development of marketable products to the demonstration of pilot projects, and comprises invention and innovation.

6 Investing to find cleaner production processes that help to reduce emissions on site.

7 Developing new products that are cleaner and thereby reduce emissions of the customer.

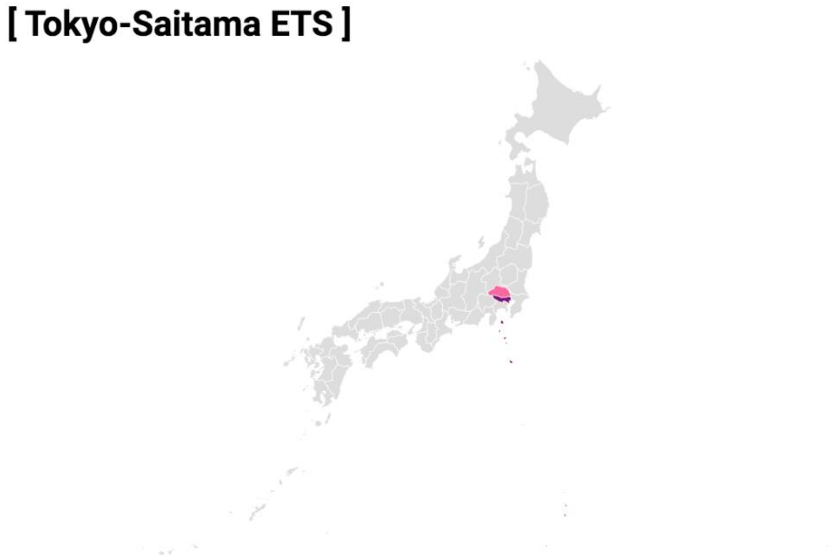
8 R&D intensity refers to R&D expenditure divided by net sales.

facilitate corporate innovation.

2.2 Tokyo and Saitama Emissions Trading System and Corporate Innovation

Tokyo Emissions Trading System, the cap-and-trade program of the Tokyo Metropolitan Government, is Japan's first mandatory ETS launched in April 2010. Under the ETS, large offices and factories are required to reduce emissions by 15% or 17% in its second period[9] and 25% or 27% in the third period[10].

Figure 2 The Region under the Tokyo-Saitama Prefecture Emissions Trading System



Saitama Target Setting Emissions Trading System (TSET) was established in April 2011 as part of the Saitama Prefecture Global Warming Strategy Promotion Ordinance. Under the ETS, large buildings and factories in Saitama are required to reduce emissions by 15% or 13% in its second compliance period[11].

Hamamoto (2019) examines the effect of the TSET program launched by Saitama Prefecture in Japan in 2011 on the adoption of low-carbon technology. This study uses the facility-level data of the manufacturing sector from 2008 to 2017 in the form of a questionnaire, and they use the Average Treatment Effect on the Treated (ATET) model to verify the effect of the TSET plan on high-efficiency equipment investment. The results show that the plan only promoted the adoption of high-efficiency machinery and equipment for the first three years of the second compliance period, and do not promote the company's investment in high-efficiency equipment during the first compliance period[12].

2.3 China Emissions Trading System and Corporate Innovation

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9 The second period of the Tokyo Emissions Trading System is from 2015 to 2019.

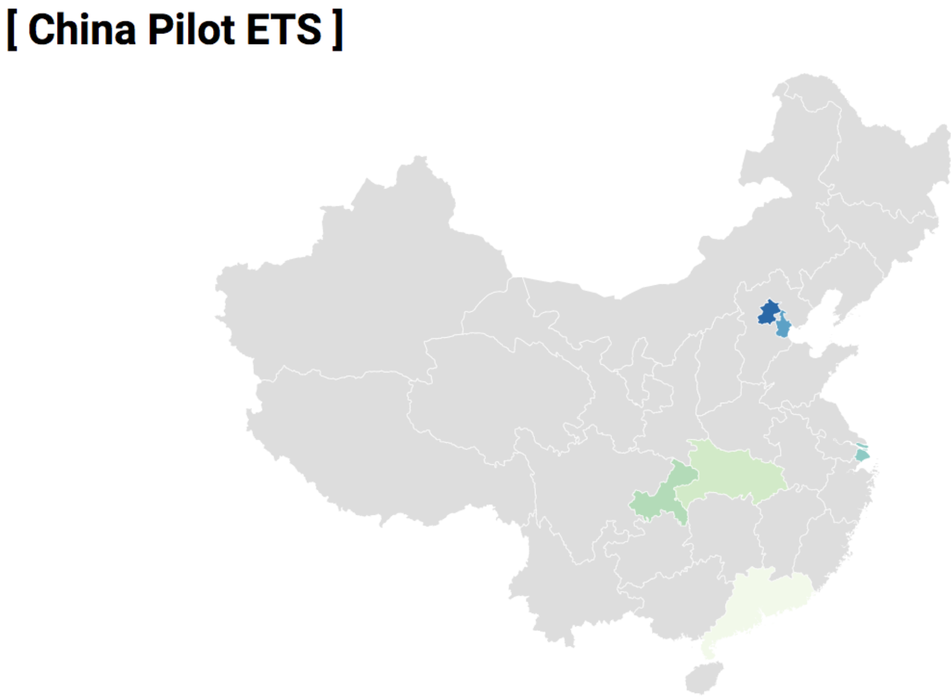
10 The third period of the Tokyo Emissions Trading System is from 2020 to 2024.

11 The second compliance period of the Saitama Target Setting Emissions Trading System is from 2015 to 2019.

12 The first compliance period of the Saitama Target Setting Emissions Trading System is from 2010 to 2014.

The China Emissions Trading System (CHN-ETS) was officially launched on December 19, 2017. Currently, there is few research on the effect of CHN-ETS on low-carbon innovations in participating companies. The CHN Pilot ETS was announced in 2011, with seven provinces and cities including Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong and Shenzhen as pilot areas. Due to the short start-up time and the difficulty in obtaining relevant data, little research has been done on the effect of CHN Pilot ETS on low-carbon innovations in participating companies. A few existing studies mainly use quantitative analysis, and data sources can be divided into two categories.

Figure 3. The Region under the China Pilot Emissions Trading System
(Shenzhen is included in Guangdong province)



The first type of research relies on listed company data. Liu & Zhang (2017) are concerned about the effect of CHN Pilot ETS on corporate R&D innovation. The triple difference method (DDD) is used to test the effect of CHN Pilot ETS on corporate R&D intensity using data from 1006 Chinese A-listed companies from the Wind database and financial data from the CSMAR database from 2008 to 2015. In this study, the CHN Pilot ETS increases the intensity of R&D investment of companies participating in the system, directly and indirectly affects the R&D investment of companies by increasing the company's cash flow and net asset yield.

Cai et al (2018) use a propensity score matching method based on cross-section data of 54 industrially listed companies in Shanghai and its neighboring provinces in 2015 and 2016 to assess the effect of CHN Pilot ETS on corporate eco-innovation. In selecting companies, most of the companies participating in the CHN Pilot ETS are industrial companies, so the treatment group and control group companies selected are listed industrial companies. Since all treatment group companies are required to join the CHN Pilot ETS, Shanghai, which starts CHN Pilot ETS early, is selected. After analyzing annual reporting data from 14 Shanghai-listed industrial companies, 3 companies with abnormal data that do not meet the research requirements are proposed. Thus, the final treatment group contains 11 companies. They also select 52 listed companies in four provinces adjacent to Shanghai (Jiangsu, Zhejiang, Anhui and Shandong) to reduce bias on the choice of control group companies participating in the CHN Pilot ETS. Since 9 companies with unusual data do not comply with research requirements, the control group ultimately left 43 companies. The results show that CHN Pilot ETS has facilitated corporate R&D investment.

The second type of research relies on questionnaire surveys. Zhang et al (2019) analyze the perceptions and understandings of various policies through a survey of the CHN Pilot ETS, and the effect of different policies on low-carbon innovation of participating companies based on a sequential probit regression model. The study finds that the policy pressures on the CHN Pilot ETS and on national and local mid-term to long-term carbon footprint reduction targets are relatively small. They also find that air pollution prevention policies and government-ordered energy conservation policies has a significant effect on corporate innovation decisions. The result shows that the CHN Pilot ETS is not effectively promoting low-carbon innovation for participating companies, but mid-term to long-term carbon emissions reduction targets have a positive effect.

Based on the above, there are few studies on the effect of CHN-ETS on corporate innovation. The overall view is that the CHN Pilot ETS can drive corporate innovation.

2.4 The Link between R&D, Patent and Innovation

When using R&D and patents as innovation factors, some scholars are discussing whether R&D and patents are representative. Both R&D and patents can be representative factors of innovation (Rogers, 1998).

R&D is widely regarded as one of the key factors for innovation (Kleinknecht & Mognen, 2002). Becheikh (2006) also believes that in addition to company size, R&D is the most important determinant of innovation for researchers. The advantage of using R&D as an innovation factor is that it can directly indicate the specific amount of R&D investment, but it is more inclined to innovation input rather than innovation output. Coe and Helpman (1995) use an innovation capital stock variable of R&D statistics to assess the effect of foreign innovation on the domestic economy. In addition, R&D activities create a climate to the benefit of questioning, which is conducive to the flexibility and creativity of enterprises, their ability to integrate new perspectives and their adaptability to market changes (Freel, 2000).

At the same time, in most of the economics literature, the number of patents is also generally considered to be one of the most suitable indicators of innovation (Hagedoorn & Cloodt, 2003). Katila (2013) also believes that patents and their subsequent patents provide an effective method for measuring innovation performance. The advantage of using patents as an innovation factor is that it represents innovation output, and patent research has longer time span (Crosby, 2000).

In summary, the author suggests that R&D and the number of patents can be used as innovation variables. It will help research on ETS and corporate innovation.

3. Results and Future Works

Based on previous studies adopted R&D expenditures as indicator of technology innovation in Europe, Japan, and China, it is hard to conclude that whether improvement in environment can be achieved by investing in R&D. From this perspective, low-carbon patents may be more representative to be a dependent variable. For an enterprise's innovation plan, ETS may be only part of it, the company may also be affected by carbon taxes and low-carbon emission reduction plans or renewable energy plans.

Also, existing research on the effect of CHN-ETS on corporate innovation still has certain flaws. First, for research based on listed company data, listed companies account for only a small portion of the CHN Pilot ETS, and the size of the company is large. There is a deviation in sample selection. Second, regarding research based on questionnaire surveys, the reliability of investment data on low-carbon technology research and technology investment data from other companies is doubtful. The companies surveyed are industrial companies, most of which are state-owned companies, and it is worth considering whether state-owned companies will fill in the actual data when considering government pressure. Third, all existing research is on the effect of the CHN Pilot ETS on corporate innovation, and there are few studies on the National Emissions Trading System (CHN-ETS) on corporate innovation.

Based on the deficiencies of the above existing research, I would like to consider the following two points as future research subjects. First, we obtain environmental R&D expenditures and environmental patent data from the China Association of Environmental Protection Industry. This association received a commission from the Ministry of Ecology and Environment of the People's Republic of China to investigate the environmental R&D expenditures, the number of environmental patents, and financial data of 7,085 companies from 2016 to 2018. At the same time, we are also trying to find databases that contain longer period and more companies.

In addition, we try to study the effect of the National Emissions Trading System (CHN-ETS) on corporate innovation by using Regression Discontinuity Design (RDD). The RDD can be used to test the effectiveness of policies. It is closer to quasi-natural experiments and the estimated results are more accurate. By using empirical analysis, we can investigate whether the national carbon trading system is effective.

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