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ディスカッションペーパー

排出量取引制度と炭素リーケージ

ー レビュー研究 ー

Carbon Emissions Trading System and Carbon Leakage

- A Review Study -

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Abstract

This article reviews related literature on the impact of the world's major carbon emissions trading systems (ETS) on carbon leakage and summarizes the definition and channels of carbon leakage. The results of this literature tell us (1) When studying carbon leakage, we should not only pay attention to the carbon emissions from regulated to unregulated regions but also pay attention to the volume of imports and exports and foreign direct investment (FDI). (2) There is little research on the impact of Japan's regional carbon emissions trading system on carbon leakage. In addition, the author also proposes two future research topics. Firstly, a difference-in-difference-in-differences (DDD) model can be established to study the net carbon transfers from regions regulated by Japan's regional carbon emissions trading systems to those not regulated by it. Furthermore, a difference-in-difference-in-differences model can also be used to investigate the impact of Japan's regional carbon emissions trading systems on the foreign direct investment (FDI) inflow of other prefectures and foreign subsidiaries. The author believes that these studies may provide a reference for the formulation of future environmental policies.

Keywords: Tokyo-Saitama prefecture ETS, EU ETS, China ETS, Carbon leakage, Literature review

要旨

この研究は、世界の主な排出量取引制度と炭素リーケージに関する既存の研究をレビューし、炭素リーケージの定義とチャネルを要約した。本研究の結果から、(1)炭素リーケージを研究する際には、規制地域から非規制地域への炭素排出量だけでなく、輸出入量や海外直接投資にも注意を払う必要がある。(2)日本の地域レベルの排出量取引制度が炭素リーケージに与える影響に関する研究はほとんどない。という二つの点が示唆された。さらに、本研究はまた 2 つの将来の研究トピックを提案する。まず、三重差分法モデルを確立し、日本の地域レベルの排出量取引制度によって規制されている地域から規制されていない地域への正味の炭素移動を調査できる。それに、三重差分法モデルを利用し、日本の地域レベルの炭素排出量取引制度に規制される地域が他の県と海外の子会社への海外直接投資に与える影響を研究することもできる。本研究は、将来の炭素排出削減に関する環境政策の策定のための参考になるかもしれない。

キーワード:東京都・埼玉県排出量取引制度、欧州連合排出量取引制度、中国排出量取引制度、炭素リーケージ、レビュー研究

1. Introduction

Carbon emissions has gradually become of common concern around the world in recent years. Several regions and countries have formulated strict climate policies in order to mitigate excessive carbon emissions. However, most of these climate policies are unilateral climate policies, and it is likely that emissions will transfer from restricted regions to non-restricted regions in various ways. This situation may lead to carbon leakage. In this case, the policies formulated and implemented will become ineffective because of the transfer of carbon emissions.

So far, the direction of carbon leakage has been confirmed in some mitigation policies in many regions and countries, as going from restricted regions to non-restricted regions. This study will verify this viewpoint through existing research, whether carbon leakage will cause carbon emissions to flow from regions with strict climate policies to regions with looser climate policies.

Market-based carbon mitigation policies[1] have been implemented in European Union, the United States, China, Japan, and other regions and countries. In Japan, a regional carbon emission trading system was launched in Tokyo metropolitan and Saitama prefecture in 2010 and 2011, respectively. Although a large number of scholars have studied and verified whether there is carbon leakage in the EU ETS and China ETS, few scholars have studied whether the Tokyo metropolitan ETS and Saitama prefecture ETS has caused carbon leakage.

Therefore, this study reviews the relevant research on the European Union Emissions Trading System (EU ETS), China Emissions Trading System (China ETS) on carbon leakage, and clarifies the definition and channels of carbon leakage. By contrasting existing research, it raises a topic whether Japan's regional Emissions Trading System (Japan regional ETS) will cause carbon leakage. In addition, the future researches are proposed.

2. Literature Review

2.1 EU ETS and Carbon leakage

The impact of the EU ETS on carbon leakage has been becoming increasingly important and numerous researchers have studied such a topic. One main finding is that the EU ETS can result in carbon leakage.

According to Demailly and Quirion (2006) and Ponssard and Walker (2008), EU ETS may cause a large number of emissions leaks in the EU cement industry by both increased imports and the relocation of production. Demailly and Quirion (2006) investigate the impact of two allocation methods on the EU 27 cement industry by adopting the CEMSIM-GEO[2] model. They find that if grandfathering method[3] is adopted, 50% of past emissions will be sufficient to maintain EBITDA[4].

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1 Market-based carbon mitigation policies refers to taxes and fees, subsidies, and the use of pollution control trading systems.

2 CEMSIM represents a partial equilibrium model of the world cement industry developed by the IPTS. GEO represents a spatial international trade model.

3 With grandfathering, covered entities receive emission allowances according to their historical emissions in a base year or base period.

4 EBITDA stands for Earnings Before Interest, Taxes, Depreciation and Amortization.

However, it may result in CO2 leakage significantly. Also, the authors claim that in terms of an output-based allocation of over 75% of historic unitary emissions, there is almost no leakage. Ponssard and Walker (2008) use the Cement Trade and Competition (CTC) model to explain the potential impact of EU ETS on production decisions in the European country market. The results show that the increase in non-EU imports may offset more than 70% of the EU's cement industry emissions reduction. Bernard et al (2009) conclude that although the issue of carbon leakage in the EU does not represent a real point of view, it has affected many specific sectors which require further investigation. Monjon and Quirion (2011) argue that the European cement production may fall by 25% and aluminum production may decrease by 14% due to EU ETS. They claim that the increase in emissions caused by aluminum production outside the EU is equivalent to the reduction (26%) in emissions within the EU, while the leakage reduction rate of cement represents 20%. Bohringer et al (2012) compare 12 Computable General Equilibrium (CGE) models with the finding that the leakage rate is between 5% and 19% with a mean value of 12%. They also conclude that carbon leakage can be significantly reduced by adopting appropriate balance measures such as border carbon adjustment (BCA), tax exemptions, and output-based allocations. Marcu et al (2013) predict that there is a risk of significant production leakage in some energy-intensive industries. Paroussos et al (2013) calculate the carbon leakage rate when the EU adopts a unilateral climate policy. They insist that the leakage can be significantly reduced if China joins efforts to reduce emissions mitigation. Specifically, if the USA joins the effort in the EU, the leakage rate will only drop to 25%. If China joins the effort, the leakage rate will drop to 3% from 2015 to 2050. This is attributed to both the market size of China's emission and the energy intensity features of its production. Boutabba et al (2016) analyze whether and to what extent are cement and steel industries under the EU ETS affected by carbon leakage. Net imports[5], carbon price, and demand indicators are used in their econometric models. In addition, exchange rates and energy prices are adopted to avoid the omitted variable bias in econometric estimates. The empirical results show that some negligible carbon leakage has occurred over time and the one in the steel industry is affected greater than in the cement industry. They point out that short-term leakage is insignificant but long-term leakage will be serious. Afterward, Boutabba et al (2017) investigate the risk of carbon leakage from primary aluminum under the EU ETS by the same method. They argue that the European primary aluminum sector is affected receives negligible carbon leakage but this effect becomes stronger in the final period of the analysis. Koch et al (2019) analyze the political causal effect on outward foreign direct investment (FDI) decisions of German multinational firms. They argue that all EU ETS firms on average have increased their subsidiaries outside the EU by 28% ± 24% relative to the local holding firms. Such a conclusion proves that EU ETS can lead to carbon leakage.

However, some researchers disagree with such opinion with the opposite conclusion that EU ETS does lead to carbon leakage.

Reinaud (2008) explores the effect of EU ETS on the competitiveness of the primary aluminum industry by an early econometric analysis from 2005 to 2007. The results show that the correlation between CO2 prices and net imports is negative and not statistically significant, which indicates that European primary aluminum did not suffer from carbon leakage during the period. This conclusion was proved again by Sartor (2013) a few years later. The author also finds no evidence to support that the level of the carbon price between 2005. In addition, the second quarter of 2011 has led to carbon

5 Net import value is equal to the value of imports minus the value of exports.

leakage in the European primary aluminum industry. Moreover, the coefficient estimate representing the effect of CO2 prices on net imports of primary aluminum is neither statistically significant nor positive. Naegele et al (2019) assess whether the emission cost caused by the EU ETS has led to carbon leakage in European manufacturing. The author uses the Global Trade Analysis Project (GTAP) trade and input-output data and administrative data from the EU ETS to calculate trade flows in embodied carbon and value. The author considers both the effect on net trade flows and bilateral trade flows. No evidence reveals that the EU ETS has caused carbon leakage. Dechezlepretre et al (2019) investigate the effect of the EU ETS on the geographical distribution of carbon emissions of multinational companies. The empirical analysis is based on the unique dataset for the period 2007-2014 from the Carbon Disclosure Project, which tracks the carbon emissions of multinational corporations by geographic region. This data includes the regional carbon emissions of 1122 companies of which 261 of them have participated in the EU ETS. However, the author finds no evidence that the EU ETS has led to a displacement of carbon emissions from Europe towards the rest of the world. Branger et al (2020) explore the potential operational leakage over the first and two-phase of the EU ETS in the cement and steel sector. Using ARIMA regression and Paris-Winsten estimation, they find no significant effect of the carbon price on net imports in these sectors. Verde et al (2020) review the econometric literature that tests for related carbon leakage by the EU ETS. The result shows that there is no evidence of significant carbon leakage.

2.2 China ETS and Carbon leakage

Some scholars have started to study China's ETS in recent years and most of them believe that China's ETS will lead to carbon leakage.

Wang et al (2015) use detailed quantitative assessments to identify the industrial sectors facing carbon leakage risks in China. The results show that 17 four-digit industries[6] were highlighted based on the dual criterion of carbon and trade, which are considered to exert an actual risk of carbon leakage. Subsequently, Wang et al (2018) study the potential carbon leakage risks inside and outside the ETS. The results show that within the ETS, six and eight four-digit subsectors are considered at risk of carbon leakage under a regulated and liberalized electricity market, respectively. Zeng et al (2018) believe that existing research literature mainly focuses on the industrial sector, and there is little attention to carbon leakage in the electricity sector. This article fills up the research gap by analyzing the carbon leakage problem of the electricity sector under the China ETS. Specifically, a Law & Economics approach is applied to review legal documents on electricity/carbon regulation and examine the economic incentive structures of stakeholders in the inter-regional and intra-regional electricity markets. Through these analyses, two forms of electricity carbon leakage are determined. Also, the author points out that China’s electricity carbon leakage is still a serious problem and has not attracted enough attention. Gao et al (2020) investigate whether the China ETS reduces carbon emissions and how it affects the carbon leakage problem. Firstly, they calculate the production-based emissions, consumption-based emissions, and carbon leakage of 28 sectors in 30 provinces from 2005 to 2015 according to the provincial environmental input-output table. Then, they use the difference-in-difference (DID) and difference-in-difference-in-differences (DDD) models to analyze the effectiveness of ETS. The conclusion is that China ETS encourages the outsourcing of carbon

[6] The Standard Industrial Classification (SIC) is a system for classifying industries by a four-digit code. Established in the United States in 1937, it is used by government agencies to classify industry areas.

emissions from pilot areas to non-pilot areas, leading to carbon leakage. At the same time, this effect may cause a specific imbalance in emissions among Chinese provinces.

However, other researchers disagree with such a conclusion. Zhou et al (2020) establish a DDD model to identify the direction of carbon leakage in China pilot ETS. Data is collected from six major sectors from 1997 to 2016. The results show that the China pilot ETS will lead to carbon leakage from the non-pilot region to the pilot area. However, as the level of market participation increases, the direction of inter-regional and total carbon leakage will gradually shift from reverse to forward. However, the author mentions that the different results may be connected with the degree of market participation. As market participation increases, the direction of inter-regional and total carbon leakage will gradually shift from reverse to forward. Meanwhile, Qian et al (2018) claim that it is important to determine the coverage of the sector while designing China's national ETS and to consider the carbon leakage of uncovered sectors. The author evaluates policy options by setting up six scenarios in China's CGE model. All circumstances indicate that partial coverage will not lead to significant inter-sectors carbon leakage in the current construction of the China national ETS.

3. The Definition and Channels of Carbon Leakage

In order to better study carbon leakage and solve the problem of carbon leakage, the author believes that we should understand what carbon leakage is and what channels are available for carbon leakage.

3.1 Definition

Carbon leakage can be broadly defined as the displacement of economic activities or changes in investment methods. It is usually through unilateral carbon control policies that directly or indirectly cause greenhouse gases (GHG) emissions to flow from controlled regions to non-controlled regions. In order to define carbon leakage more rigorously, this article summarizes some official definitions and directive document definitions for reference.

"According to the definition of the European Commission, "*carbon leakage refers to the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with laxer emission constraints. This could lead to an increase in their total emissions*[7]".

The Recital 24 of Directive 2009/29/EC reported by the EU ETS Directive defines it as follow:

"*In the event that other developed countries and other major emitters of greenhouse gases do not participate in this international agreement, this could lead to an increase in greenhouse gas emissions in third countries where industry would not be subject to comparable carbon constraints (carbon leakage), and at the same time could put certain energy-intensive sectors and subsectors in the Community which are subject to international competition at an economic disadvantage. This could undermine the environmental integrity and benefit of actions by the Community*[8]." (European Commission, 2009, pp. 63-87)

The Intergovernmental Panel on Climate Change (IPCC) (2014) defines it as follows:

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7 Carbon Leakage, *European Commission* [website], https://ec.europa.eu/clima/policies/ets/allowances/leakage_en, (accessed 1 February 2021).

8 European Commission, 'Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community (Text with EEA relevance)', *EUR-Lex*, 2009, 63-87, http://data.europa.eu/eli/dir/2009/29/oj, (accessed 6 May 2009).

"*Phenomena whereby the reduction in emissions (relative to a baseline) in a jurisdiction/sector associated with the implementation of mitigation policy is offset to some degree by an increase outside the jurisdiction/sector through induced changes in consumption, production, prices, land use and/or trade across the jurisdictions/sectors. Leakage can occur at a number of levels, be it a project, state, province, nation or world region.* " (IPCC, 2014, p. Annex II)

3.2 Channels

Carbon leakage are regarded to occur through three channels under the ETS: competitiveness channels, investment channels, and energy price channels.

The competitive channel is the short-term impact of carbon leakage. The main reason is that the unilateral strict climate policy will weaken the competitiveness of the energy-intensive industries in the regulated region, which leads to a decrease in exports and an increase in imports, resulting in carbon leakage.

Investment channel is the long-term impact of carbon leakage. Whether it is due to the decline in industrial competitiveness caused by strict climate policies, or concerns about the prospects of strict climate policies, firms shift their investments to countries with less stringent climate policies. This behavior can also cause carbon leakage.

The energy price channel is the long-term effect of carbon leakage. As emission reduction regions reduce the use of fossil fuels, it may depress the world's overall energy prices, leading to consumption and emission growth in other non-regulated regions, and ultimately leading to carbon leakage.

According to the articles of Marcu et al (2013), Tan et al (2018), and Verde (2020), they also roughly divide carbon leakage into these three types. However, the author will focus on a competitive channel and investment channel in future studies.

4. Results and Future Work

In this article, I reviewed the analysis of the impact of the world's major ETS on carbon leakage (e.g. EU ETS, China ETS) and understand the definition and channels of carbon leakage. Based on existing research, the author realized that,(1) in addition to the carbon emissions of regulated and unregulated regions, we should pay attention to the impacts on the imports and exports, as well as FDI when studying carbon leakage. (2) To the best of our knowledge, there is no research on the impact of Japan's regional ETS (Tokyo Metropolitan ETS and Saitama Prefecture ETS) on carbon leakage so far. The author believes that Japan, as the world's fifth-largest carbon emitter[9], is also worthy of attention on its ETS.

Therefore, the author will focus my future research on the impact of Japan's regional ETS on carbon leakage and propose two research methods. First, a DDD model can be established to study the net carbon transfers from the prefecture which take part in the ETS to the prefecture which did not. Second, a DDD model can also be established to investigate the impact of Japan's regional ETS on other prefectures and foreign subsidiaries' FDI.

The author believes that through these methods, we can better understand the impact of the ETS on carbon leakage. It will help in the formulation of future climate policies.

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[9] Each Country's Share of CO2 Emissions, *Union of Concerned Scientists*[website], https://www.ucsusa.org/resources/each-countrys-share-co2-emissions, (accessed 12 August 2020).

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