Carbon Leakage or Bridging the Energy Efficiency Gap?
: A case of Japanese emission Trading Scheme

Taisuke SADAYUKI, Toshi.H. ARIMURA

1. Introduction

The purpose of this research is to examine the carbon leakage due to the introduction of regional ETSs in Tokyo (since 2010) and Saitama (since 2011). If the carbon leakage is a severe issue, we may find an increase of GHG emissions outside of Tokyo or Saitama. Another reason to examine the regional ETSs in Japan is to investigate the impact of ETS on the energy efficiency gap. Once they face the regulation on CO_2 emissions due to ETS, energy efficiency may become a higher priority at the targeted facilities. In this case, the introduction of ETS may promote energy efficiency by bridging the energy efficiency gap. If these firms facing ETS have facilities outside Tokyo or Saitama, they may also promote energy efficiency in those facilities now that the firms have better information.

2. Methods

We make use of facility level annual panel data of Greenhouse Gas (GHG) emission between 2009 and 2014 collected under the "Act on Promotion of Global Warming Countermeasures" where institutes in all sectors must submit annual reports on CO_2 emission produced in every "large-scale facility (hereinafter, LF)" who consumes 1,500 kilolitres or more of oil equivalents energy per year.

We apply difference-in-difference approach and estimate the following emission equation to examine the impact of ETS:

$$\ln(E_{ft}) = \sum_{r\in\{T,S,O\}} \tau_r \, Region_{fr} \times ETS_{it} + \psi_t + \lambda_f + \mathbf{GEJE}_{ft}\boldsymbol{\beta} + \mathbf{X}_{ft}\boldsymbol{\gamma} + \varepsilon_{ft}$$

where i and f denote institute and large-scale facility (LF) respectively. The variable t and r denote year and region in Tokyo (T), Saitama (S) or other prefectures (O). The dependent variable $\boldsymbol{E_{ft}}$ captures energy-originated CO_2 emission from facilities f at year t. Year-fixed effect and facility-fixed effect are captured by $\boldsymbol{\psi_t}$ and $\boldsymbol{\lambda_f}$ respectively. Further, $\boldsymbol{Region_{fr}}$ takes one if LF f is located in region r and zero otherwise. The dummy $\boldsymbol{ETS_{it}}$ takes one if institute i has a LF facing Tokyo and/or Saitama ETS at year t. Thus, the

parameter $\boldsymbol{\tau_r}$ captures the impact of ETS on energy-originated CO_2 emission from facility f located in region r. If the effect of carbon leakage from facilities in Tokyo/Saitama to facilities in non-regulated regions is greater than the effect of bridging the energy efficiency gap, we expect to have a negative sign for $\boldsymbol{\tau_r}$ for other prefectures (0). We control the impacts of the Great-East-Japan-Earthquake by $\mathbf{GEJE}_{ft}$ and other factors such as electricity price, emission factor, heating-degree days, or cooling-degree days are included in $\mathbf{X}_{ft}$.

3. Estimation result

Dependent variable : $\ln(E_{fit})$

Targeted industry :	Overall industry	Manufacturing sector	Service sector
(τ_r) Region × ETS			
(τ_T) Tokyo	-0.103**	-0.101**	-0.046**
	(0.008)	(0.023)	(0.010)
(τ_S) Saitama	0.003	-0.006	0.001
	(0.009)	(0.010)	(0.017)
(τ_O) Other pref.	-0.046**	-0.017*	-0.037**
	(0.005)	(0.007)	(0.009)
Facility-fixed effects	✓	✓	✓
Year-fixed effects	✓	✓	✓
Control variables	Disaster variables, Heating & Cooling degree days, Electricity price, Emission factor		
Observations	32319	19775	12628
# LFs in treatment	3430	1444	1997
(#LFs in Tokyo)	703	128	589
(#LFs in Saitama)	539	374	164
(#LFs in other pref.)	2188	942	1244
# LFs in control	2785	2257	542
R2(within)	0.2490	0.2409	0.2790

(**,*,+) show (1,5,10%) significant levels based on two-sided test. Facility-cluster-robust standard errors in parentheses.
Samples are restricted to LFs of institutes who have at least one LF in Kanto area, and who are present in data since 2009.
Samples with E_{fit} above 99th percentile and below 1st percentile, and E_{fit} showing a significant change are excluded.

The table shows the estimation results regarding the estimates of $\boldsymbol{\tau_r}$. The estimates of $\boldsymbol{\tau_O}$ show negative and significant signs. This implies that the effect of bridging the energy efficiency gap is greater than the negative impact of carbon leakage. Interestingly, the impact is greater for service sector (3.7%) than the manufacturing sector (1.7%).

4. Conclusion

By conducting a facility level econometric analysis, we found that, once facilities in Tokyo or Saitama faces ETS, not only these facilities but also those outside Tokyo and Saitama of the same institutes reduced CO_2 emission even though they are not under ETS. This implies that the impact of ETS in bridging the energy efficiency gap overweighs the impact of carbon leakage.