An Empirical Study of Tokyo Emission Trading Scheme:
An Expost Analysis of Emissions from Office and University Buildings

March 2017

Toshi H. Arimura[1] & Tatsuya Abe[2]
Waseda University

1. Introduction

Emission trading schemes have become a popular economic instrument to deal with climate change. EUETS has been the first comprehensive ETS to control carbon dioxide (CO_2) emissions. In the US, Regional Greenhouse Gas Initiative started in 2010 and the California system followed. In Asia, Korean introduced the first cap and trade scheme. Finally, China, the largest emitter of Greenhouse Gas, implemented seven regional ETS as a pilot scheme and finally announced the introduction of national level ETS in 2015.

In Japan, the national government has not adopted emission trading scheme yet. Tokyo metropolitan government successfully introduced an ETS, namely, the Tokyo Emissions Trading Scheme (Tokyo–ETS), in 2010 (Arimura, 2015). This ETS is the first cap-and-trade ETS in Japan.

The target of this scheme is large facilities and buildings. This is the first ETS to regulate GHG emission from office buildings. Tokyo ETS consists for two phases. Phase I started in 2010 and ended in 2014. Phase II started in 2015 with more stringent emission target. Facing the start of Phase II of Tokyo ETS, the Tokyo metropolitan government reviewed emissions from the regulated buildings and confirmed emission reduction.

One should note, however, that Japan experienced the Great East Earthquake in 2011, which was followed by the nuclear accident in Fukushima. This nuclear accident caused the problem of electricity supply in Japan. The shortage of electricity was severe especially in Tokyo since the nuclear power plants in Fukushima belong to Tokyo Electric Power Companies, which has supplied electricity to Tokyo area, almost in monopolistic way.

Facing this crisis, Japanese government promoted energy saving behaviors and

[1] Faculty of Political Science and Economics & Research Institute for Environmental Economics and Management, Waseda University. We appreciate the financial support from RIEEM and Ministry of the Environment. Email: toshi.arimura@gmail.com.
[2] Graduate School of Economics, Waseda University

investment all over Japan. Further, the power companies faced difficulties in restarting their nuclear power plants after regulation inspections due to more stringent safety regulation and position from the public. This shutdown of the nuclear power plants made consumer of electricity to expect to higher electricity prices since the power companies have to rely on more expensive fuel such as natural gas or renewable energy. Consequently, the all the consumers expected higher electivity prices.

This situation led to a hypothesis that emission reduction in Tokyo areas may have been caused by the electricity crisis, rather than by Tokyo ETS. Thus, it is worth examining the exact impact of Tokyo ETS. This paper empirically investigates the effects of Tokyo ETS using facility level panel data.

This paper contributes to the empirical literature of ETS. In the typical analysis of ETS, the researchers have focused the ex-ante analysis using a theoretical analysis or a computable general equilibrium (Böhringer & Lange, 2005). Recently, the researchers such as Petricky & Wagner (2014) or Wagner *et al.* (2014) started to conduct ex-post analysis of ETS because the ex-post data have become available. This paper is in line with the recent development on the empirical literature.

2. Tokyo ETS

In Tokyo areas, facilities consuming 1,500 kiloliters of oil equivalents per year are subject to Tokyo ETS. In 2013, 1,392 facilities had to comply with the Tokyo ETS. By August of 2013, a reduction of 63,000 CO_2-tons was reported.

To mitigate the burden, the Tokyo ETS provides three types of domestic offset credits: (1) small- and medium-sized installation credits within the Tokyo area; (2) outside Tokyo Prefecture credits; and (3) renewable energy certificates. International credits, however, cannot be used to offset GHG emissions in this scheme.

The amount of small- and medium-sized installation credits issued that year was approximately 3,000 t-CO2, The amount of renewable energy credits was approximately 120,000 tons of CO2.

3. Data

We conducted a mail survey in 2015. We chose commercial building sector and universities for several reasons. First, under Tokyo ETS, commercial buildings are the major target of regulations. There are few power plants and manufacturing facilities in Tokyo. Second, both commercial buildings and universities face relatively less influence of economic fluctuations.

We sent questionnaires to 824 owners of office buildings and 340 universities all over in Japan. We received 414 replies from the office buildings and 271 from universities. The response rates were 50.2% and 79.7 % for office buildings and university buildings, respectively.

Office building owners were asked to report their CO_2 emission level from 2009 to 2013. They were also requested to reports, the number of employees, the size of floor space and their experience of rolling blackouts and other requests for energy savings from the power companies.

We also sent similar questioners to universities. That is, university were requested to provide CO_2 emissions from 2009 to 2013. We also prepared questions specific to universities. For example, we asked the number of students to capture the size of universities. Further, we asked the ratio of science/engineering students as well as the number of students.

Table 1 and 2 illustrate the summary statistics of commercial buildings and universities, respectively. Annual CO_2 emission from office buildings was 7092 tons on average (Table 1). Annual CO_2 emission from university buildings was 10196 tons on average.

Table 1 Summary Statistics: Office Buildings

	Number of Observations	Mean	Standard Deviation	Median	Min	Max
Energy Consumption	1268.00	4027.46	3702.57	2809.00	253.00	37298.00
CO2 Emissions	1268.00	7092.24	6302.02	4947.00	453.00	55077.00
Electricity Consumption	1268.00	123791.51	123066.36	86470.50	4538.00	1261920.00
Floor Space	1268.00	57877.54	49906.32	44379.00	75.13	304400.00
Employee	1268.00	2002.54	2355.36	1170.50	3.00	10994.00
Rolling Blackout	1268.00	1.89	0.36	2.00	1.00	3.00
CDD (Cooling Degree Days)	1263.00	478.96	122.57	498.00	10.00	652.00
HDD (Heating Degree Days)	1263.00	958.07	244.04	899.00	707.00	2654.00
Vacancy Rate	1195.00	9.78	2.23	9.00	7.00	19.00
Tokyo ETS	1268.00	0.32	0.47	0.00	0.00	1.00
Saitama ETS	1268.00	0.03	0.17	0.00	0.00	1.00

Table 2. Summary Statistics: University Buildings

	Number of Observations	Mean	Standard Deviation	Median	Min	Max
Energy Consumption	1210.00	5368.70	6678.13	2914.00	1156.00	62481.00
CO2 Emissions	1210.00	10196.19	12706.24	5497.50	1841.00	120002.00
Electricity Consumption	1210.00	160466.71	214809.22	93340.50	5100.00	2472687.00
Floor Space	1210.00	123776.85	102086.89	95084.50	87.77	957903.00
Number of Student	1210.00	5680.23	4601.42	4692.50	0.00	22773.00
Ratio of Engeneering Students	1111.00	56.46	40.70	58.00	0.00	100.00
Rolling Blackout	1195.00	1.88	0.37	2.00	1.00	3.00
CDD (Cooling Degree Days)	1200.00	461.85	151.31	498.00	10.00	652.00
HDD (Heating Degree Days)	1200.00	1052.56	395.22	906.00	707.00	2654.00
Tokyo ETS	1210.00	0.18	0.38	0.00	0.00	1.00
Saitama ETS	1210.00	0.02	0.15	0.00	0.00	1.00

Table 3 exhibits the transition of annual average CO_2 emission from office buildings. The first column shows the emission in Tokyo. The second one shows emission in Saitama where ETS was also in place. The third column corresponds to emission from the rest of Japan. One can observe that CO_2 emission in Tokyo decreased after the ETS introduced in 2010 while emissions elsewhere increased in 2013 relative to 2009.

Table 3: Transition of CO2 Emissions by Region (Office Buildings)

	Tokyo	Saitama	Nationwide (excluding Tokyo and Saitama)
2009	8609.4	6494.0	7448.2
2010	8000.8	6189.5	6990.5
2011	6669.3	5360.7	6707.3
2012	7361.1	5875.2	7761.9
2013	7956.4	7351.7	8380.6

Table 4 exhibits the transition of annual average CO_2 emission from univerisity buildings. The first column shows the emission in Tokyo. The second one shows emission in Saitama where ETS was also in place. The third column corresponds to emission from the rest of Japan. One can observe that CO_2 emission increased in 2013 relative to 2009 in all areas.

Table 4: Transition of CO2 Emissions by Region (University Buildings)

	Tokyo	Saitama	Nationwide (excluding Tokyo and Saitama)
2009	8,449	6,154	10,601
2010	8,196	6,188	10,328
2011	7,004	5,275	9,585
2012	8,588	6,171	11,188
2013	9,511	7,048	12,546

4. Econometric Results

To quantify the impact of ETS, we estimated the following equations for the office buildings and universities.

$$E_{ijt} = X_{1,it}\beta_1 + X_{2,it}\beta_2 + X_{3,it}\beta_3 + \mu_i + \varepsilon_{it}$$

In this equation, E_{it} denotes emission from building *i* in year t. Individual Effects are captured by μ_i. A vector of policy variables are expressed by X_1. Characteristics of facilities are captured by X_2 . Other exogenous factors such as weather or vacancy rate of buildings are expressed by X_3.

Table 5 exhibits the estimation results for office buildings. Model 1 is a pooled OLS estimation. Models 2 to 6 are fixed effect models. In model (1), the coefficient of Tokyo ETS dummy is negative and statistically significant. In model (2), after controlling individual effects, the coefficient of Tokyo ETS dummy is still negative and statistically significant. These result show the effectiveness of Tokyo ETS. In model (3), we included the interaction term between Tokyo ETS dummy and the number of employees to examine whether the size of emission reduction depend on the size. The coefficient of interaction term is negative and statistically significant. Thus, the larger the building is, the larger the emission reduction is. In models (5) & (6), we added the interaction terms between Tokyo ETS dummy and year dummies to examine the difference of effectiveness across years. The results hint that the effectiveness of ETS became greater as time went by during this period.

Table 5: Estimation Results of Office Buildings

	Dependent variable : log(CO2 emission)					
	Pooled	FE	FE	FE	FE	FE
	(1)	(2)	(3)	(4)	(5)	(6)
(Intercept)	6.48***					
	(0.33)					
2010	0.13	−0.18***	−0.18***	−0.18***	−0.15**	−0.15**
	(0.13)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
2011	−0.02	−0.26***	−0.26***	−0.26***	−0.21***	−0.21***
	(0.10)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
2012	0.08	−0.12***	−0.12***	−0.12***	−0.06	−0.06
	(0.10)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
2013	0.17	−0.09**	−0.09**	−0.09**	0.01	0.01
	(0.11)	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)
Tokyo ETS (TETS)	−0.20***	−0.12***		0.10	−0.03	0.18
	(0.05)	(0.03)		(0.11)	(0.03)	(0.11)
I(TokyoETS * log_employee)			−0.02***	−0.03**		−0.03**
			(0.00)	(0.01)		(0.01)
I(TETS * 2011)					−0.09***	−0.09***
					(0.03)	(0.03)
I(TETS * 2012)					−0.10***	−0.10***
					(0.03)	(0.03)
I(TETS * 2013)					−0.14***	−0.14***
					(0.03)	(0.03)
Saitama ETS	−0.10	−0.04	−0.04	−0.04	−0.06	−0.06
	(0.11)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Log(floorspace)	0.20***	0.26***	0.26***	0.26***	0.26***	0.26***
	(0.02)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Log(Employee)	0.04***	0.33***	0.34***	0.34***	0.34***	0.35***
	(0.01)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
CDD	0.00	0.00***	0.00***	0.00***	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HDD	0.00	0.00***	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Vacancy Rate	0.00	−0.03***	−0.03***	−0.03***	−0.02**	−0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Rolling Blackout	0.06	−0.04	−0.04	−0.04	−0.06**	−0.06**
	(0.08)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
R^2	0.14	0.31	0.32	0.32	0.33	0.33
Adj. R^2	0.14	0.23	0.23	0.23	0.24	0.24
Num. obs.	1195	1195	1195	1195	1195	1195

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 6 exhibits the estimation results for university buildings. Model 1 is a pooled OLS estimation. Models 2 to 6 are fixed effect models. In model (1), the coefficient of Tokyo ETS dummy is negative and statistically significant. In model (2), after controlling individual effects, the coefficient of Tokyo ETS dummy is still negative and statistically significant. These result show the effectiveness of Tokyo ETS. In model (3), we included the interaction term between Tokyo ETS dummy and the size of buildings, i.e. the size of floor space, to examine whether the size of emission reduction depend on the size. The coefficient of interaction term is negative and statistically significant. Thus, the larger the building is, the larger the emission reduction is. In models (5) & (6), we added the interaction terms between Tokyo ETS dummy and year dummies to examine the difference of effectiveness across years. The results hint that the effectiveness of ETS differed year by year.

Table 6: Estimation Results of University Buildings

	Dependent variable : log(CO2 emission)					
	Pooled	FE	FE	FE	FE	FE
	(1)	(2)	(3)	(4)	(5)	(6)
(Intercept)	2.74***					
	(0.35)					
2010	−0.28**	−0.03	−0.03	−0.03	−0.03	−0.03
	(0.12)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
2011	−0.32***	−0.11***	−0.11***	−0.11***	−0.10***	−0.10***
	(0.10)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
2012	−0.12	0.06***	0.06***	0.06***	0.07***	0.07***
	(0.09)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
2013	−0.06	0.15***	0.15***	0.15***	0.16***	0.16***
	(0.10)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Tokyo ETS (TETS)	−0.15***	−0.08***		−0.11	−0.02	−0.02
	(0.06)	(0.02)		(0.31)	(0.03)	(0.31)
I(tETS * log_floorspace)			−0.01***	0.00		0.00
			(0.00)	(0.03)		(0.03)
I(TETS*2011)					−0.09***	−0.09***
					(0.02)	(0.02)
I(TETS*2012)					−0.07***	−0.07***
					(0.02)	(0.02)
I(TETS*2013)					−0.09***	−0.09***
					(0.02)	(0.02)
Saitama ETS	−0.27*	−0.09**	−0.09**	−0.09**	−0.11***	−0.11***
	(0.14)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Log(floorspace)	0.41***	0.34***	0.34***	0.34***	0.35***	0.35***
	(0.02)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Log(Studnet)	0.04	0.07	0.07	0.07	0.08	0.08
	(0.02)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
CDD	0.00***	0.00*	0.00*	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HDD	0.00***	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ratio of Engeneering Students	0.01***	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Rolling Blackout	−0.03	−0.03	−0.03	−0.03	−0.02	−0.02
	(0.08)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
R^2	0.39	0.52	0.51	0.52	0.53	0.53
Adj. R^2	0.39	0.40	0.40	0.40	0.41	0.41
Num. obs.	1093	1093	1093	1093	1093	1093

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5. Conclusion

In this paper, we empirically investigated the effects of Tokyo ETS using individual facility level data of office buildings and universities. We found that Tokyo ETS overall has been successful in reducing CO_2 emissions relative to other regions. But, we did not control the impacts of permit prices. This is an area of future work.

References

Toshi.H.Arimura (2015) "Japanese Environmental Policy," in the Routledge Handbook of Environmental Economics in Asia. Edited by Shunsuke Managi, pp.516-531

Chris Böhringer and Andreas Lange (2005) “Economic Implications of Alternative Allocation Schemes for Emission Allowances,” Scandinavian Journal of Economics, Vol.107, No.3, pp.563-581.

Sebastian Petricky and Ulrich J. Wagner (2014) “The Impact of Carbon Trading on Industry: Evidence from German Manufacturing Firms” Kiel Working Paper. No.1912

Ulrich Wagner, Mirabelle Muûls, Ralf Martin and Jonathan Colmer (2014) “The Causal Effects of the European Union Emissions Trading Scheme: Evidence from French Manufacturing Plants” presented at IZA Workshop: Labor Market Effects of Environmental Policies, Bonn, Germany