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Effectiveness of Multiple-Policy Instruments:

Evidence from the Greenhouse Gas Reduction Policy in Japan

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Abstract

"Management-based regulation" has no tangible incentives and such regulations may not be effective. Therefore, a mixed policy that uses both "management-based regulation" and with some clear incentives may be effective and necessary. In this paper, we investigate the effectiveness of combination of "management-based regulation", some economic incentives and/or information provision on climate change actions. We focus on the "*Emissions Reduction Program*" (*ERP*) in Japan, which is one of "management-based regulation", aiming to promote large facilities reducing greenhouse gas (GHG) emissions. Using the prefecture-industry level aggregated data, we find that information provision, reward for good practices and designation of responsible department for climate change has positive impacts on GHG emissions reduction under *ERP*.

Keywords: Management-based regulation, Provincial-level policy, Greenhouse gas reduction

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1. Introduction

There has been significant growth in the use of weak regulations, and their use is likely to increase even more in coming years because weak regulations are potential policy instruments for reducing greenhouse gas (GHG) emission. A typical form of weak regulation is mandatory information disclosure programs such as the *Toxic Reduction Inventory* and the G*reenhouse Gas Reporting Program* in the United States. Another type of weak regulation is "management-based regulation", which requires regulated firms to plan, review production technology, set goals for environmental performance and identify a set of actions for achieving the set goals (Bardach and Robert 1982; Bennear 2007). Such regulations are characterized by the lack of clear incentives for achieving the set goals and no punishment for not achieving the set goals. For management-based regulations to be successfully implemented, some form of government support and/or incentives may be necessary.

If there are no transaction costs for identifying and enforcing an effective response, any type of regulation policy such as technology-based, performance-based and management-based regulation can be effective (Coase 1960; Coglianese and Laser 2003). However, in reality, there are some transaction costs (Komesar 1994), and therefore, the government must use incentives to encourage certain behaviors and deter others (Coaglianese and Laser 2003). In this situation, "management-based regulation" may be desirable because it can be used to obtain the most relevant information about which method is effective and efficient for achieving pollution emissions reduction (Ayres and Braithwaite 1992; Coglianese and Laser 2003).

Typically, management-based regulation has two features: mandatory planning and mandatory reporting. The first requires firms/facilities to make a plan to reduce pollution emissions. The second requires firms/facilities to report their progress, including a reduction in pollution emissions. Sometimes the report must be publicly disclosed, but implementation of the plan is not mandatory. This is the case for the Pollution Prevention program (P2 program) in the United States and the *Energy Conservation Act* in Japan. P2 programs are state-level pollution prevention policies based on “management-based regulation”, and different states have different requirements (Harrington 2013).

However, such types of “management-based regulation” may not work because the implementation of plans depends on whether the firms/facilities consider the benefit from the implementation to be greater than its cost (Coglianese and Laser 2003; Becker 1974). Therefore, as argued by Harrington (2013), a mixed policy that uses both “management-based regulation” and some incentives or support such as information provision may be effective and necessary. Hence, this paper contributes to the literature by describing how weak incentives and the support of information provision contribute to the effectiveness of management-based regulations.

This study examines a management-based regulation that was implemented in Japan from1995, the "*Emissions Reduction Program*" (*ERP*). The primary objective of this policy is to reduce the GHG emissions of large facilities by imposing mandatory planning and mandatory reporting. One distinctive feature of the policy is that prefectures provide incentives like rewards for "good" practices, while there is no tangible punishment for not achieving the GHG reduction goals defined in the *ERP* planning document. In addition, the *ERP* requires facilities to identify the department (or division or group) responsible for implementing the *ERP* plan. Prefecture governments also provide information on how to reduce GHG emissions (by replacing standard bulbs with LED lights, setting the temperature, etc.).

Thus far, several empirical studies have analyzed the effectiveness of weak regulations. For instance, Clarkson et al. (2011) investigated the impact of mandatory disclosure on pollution emissions reduction. Kube et al. (2019), Vidovic and Khanna (2007), Khanna and Damon (1999) and Hoang et al (2018) examined the effects of a "voluntary" information disclosure program on environmental performance. In contrast, there is little empirical evidence on the effectiveness of "management-based regulation". Arimura and Iwata (2015) investigated the effectiveness of the *Energy Conservation Act* using firm-level data from the hotel sector. Rourke and Lee (2007) examined the impacts of one P2 program, the *Toxics Use Reduction Act* in Massachusetts, using firm-level data, while Bennear (2007) and Harrington (2013) investigated the effectiveness of the P2 program on the use of toxic substances across states with and without the P2 program using facility-level data. As for *ERP*, Yajima and Arimura (2017) examined its impacts on CO_2 emissions reductions. However, there are several gaps in the literature regarding the effectiveness of "management-based regulation". Yajima and Arimura (2017), Arimura and Iwata (2015) and Bennear (2007) explored only the overall effects of the policy. In contrast, Harrington (2013) investigated the different effects of various aspects of the policy, such as "Technical Assistance", "Goal setting", the "Reporting requirement" and the "Planning requirement". However, it is still unclear which types of support and incentives can support the successful implementation of "management-based regulation".

It is challenging to examine the effectiveness of the *ERP* because the implementation of the *ERP* at the prefecture level may be unobservable. For example, prefectures with little pollution may implement strict environmental regulations, while prefectures with considerable pollution may impose weak regulations to avoid the overall macroeconomic effects of such regulations. In such cases, a mere comparison of the environmental outcomes between these two prefectures may lead to biased estimates. To overcome this challenge, we use fixed effect models to control for time invariant unobservable effects, verify our results by conducting numerous robustness checks and confirm that time varying unobservable effects are not correlated with the *ERP* variable. The prefectures in Japan differ in how they implement the *ERP* in terms of “information provision”, “reward for good practices” and “information disclosure”. We exploit this variation to examine the effectiveness of the *ERP* under different scenarios of *ERP* implementation. To the best of our knowledge, no prior study has examined the effectiveness of management-based economic instruments involving information provision and uncertain incentives with no tangible punishment for not achieving the set goals. Our study contributes to the literature by focusing on this topic.

This paper proceeds as follows. Section 2 describes the *ERP* in detail. Section 3 provides our empirical strategies and outlines the data. Section 4 discusses the results of the basic estimation. Section 5 explains the additional analysis that is conducted. Section 6 concludes by discussing the direction of future studies.

2. Background

Due to the risks associated with climate change, the attention to weak regulation in environmental policy increased during the 1990s in Japan. As a result, since the 1990s, prefectures have implemented various policies to reduce GHG emissions. In particular, the *ERP* has largely been adopted. The *ERP* aims to reduce the GHG emissions of large facilities by using mandatory planning and mandatory reporting of the implementation of the plan. The main targets of the policy are facilities consuming energy at a rate equivalent to 1,500 kiloliters or crude oil[1].

The brief history of the *ERP* is summarized in Panel A of Table 1. As shown in this table, in 1995, Ibaraki introduced the policy and was the first prefecture to do so. The use of this policy spread after Tokyo’s implementation in 2001 (Baba 2010). By the end of 2014, 30 of 47 prefectures had adopted the policy. One reason for this diffusion is that this type of policy is relatively easier to establish than more stringent policies, such as the Emission Trading Scheme (ETS), because it does not involve strong requirements even if the regulated facilities do not make “good” progress. Next, we explain the main requirements, penalties and some prefectural differences in the content of the policy.

2.1 Requirements and Penalties

The regulated facilities are subject to two main requirements. First, they have to regularly make and submit an energy conservation plan, which should describe the specific methods to be used to reduce CO_2 emissions. The period for the submission of these plans varies among the prefectures. Typically, prefectures require regulated facilities to submit a plan every three years. Second, prefectures require regulated facilities to submit an annual report on the progress of their efforts. Prefectures expect large facilities to “voluntarily” comply with these two requirements to reduce GHG emissions. This means that prefectures do not establish severe penalties for not achieving a reduction in GHG emission, but there are some penalties for not complying with these two requirements.

If the regulated facilities do not submit their plan or the progress report, prefectures may impose two types of penalties. First, prefectures can order the noncompliant facilities to comply with the requirements. Some prefectures publicly announce the names of facilities that refuse to comply with the order. However, most prefectures do not impose penalties [1] for the "bad" progress of GHG emissions reduction. Hiroshima is the only prefecture that imposes a fine for such type of noncompliance. Therefore, it is unclear whether this type of policy works. Some prefectures have additional requirements and effectively promote GHG reduction by providing incentives and support. In the next subsection, we describe prefectural differences in the policy.

2.2 Additional Requirements, Support and Incentives

The specific elements of the *ERP* differ among the prefectures. Table 2 shows the major support, incentives and requirements of the prefectures and indicates which prefecture introduced each type of contents. This paper focuses on the following six issues: *Goal setting (Absolute or Intensity), Information disclosure, Inspection of planning, Information provision, Designation of responsible department/division, Reward for "good" practices*.

First, *Goal setting*, is an additional requirement that requires the regulated facilities to set a quantitative target for GHG emissions reduction. Twenty-six of the 30 prefectures have adopted such a requirement[2], and there are three types of targets: "*Absolute*", "*Absolute*

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[1] Saitama prefecture and the Tokyo Metropolitan Government have successfully introduced emission trading schemes (ETSs) as extensions of the *ERP*. However, Saitama prefecture does not impose penalties for facilities that do not improve their GHG emission reductions and use a very special type of ETS. The Tokyo Metropolitan Government does impose penalties for facilities that do not exert sufficient effort; however, it failed to implement the ETS (See: Aoki, 2010).

[2] In its *ERP* guidelines, Kyoto prefecture does not mention anything about setting goals. However, in the Iwate,

and Intensity", "*Absolute or Intensity*". The first type of target implies that facilities have to set an absolute target, and 13 of 26 prefectures adopt such a requirement. The second one requires facilities to set a target regarding an improvement in intensity in addition to the absolute target; this is the most stringent type of target. Three of 26 prefectures have adopted this requirement. The third type of target allows facilities to adopt either an absolute target or an improvement in intensity; 10 of 26 prefectures adopt such a requirement. Sugino and Arimura (2011) studied the relationship between the setting of targets and environmental activities. They showed that if an industrial association sets an absolute target for emissions reduction, then the firms belonging to that association tend to invest in energy efficiency. Therefore, setting a target may promote emissions reductions.

Second, *Information disclosure* is a provision that requires the regulated facilities to publish their plan and progress report on the internet. Twenty-six of 30 prefectures have implemented this provision. In many cases, prefectures provide these reports on their websites. Some prefectures publish the reports on their websites and require the facilities to publish them. A few prefectures do not publish the reports and require the facilities to publish them. Once the reports and plans are uploaded on the internet, anyone can see the progress of the corresponding facility. Therefore, this provision may pressure facilities to reduce GHG emissions.

Tochigi and Shiga prefectures, it is optional for regulated facilities to set goals. In the present paper, we do not distinguish these cases because the latter case implies that the regulated facilities are not required to set a goal.

Third, *Inspection of planning* is a provision that prefectures use to suggest how regulated facilities can reduce GHG emissions when their plans are considered to be insufficient; 9 of 30 prefectures adopt this provision. Saitama, Kyoto, Osaka, Hyogo and Tottori prefectures inspect both the plan and report. The Tokyo Metropolitan government inspects the plan and an intermediate report. Kanagawa prefecture inspects the plan. Nagano prefecture inspects the plan and the progress report. Iwate prefecture inspects the format of the plan and the report. If a facility fails the inspection, it has to revise and resubmit the plan. Even if facilities fail this inspection, they are not faced no penalties in addition to resubmission. This provision may pressure the facilities to improve their plans.

Fourth, prefectures use the *Information provision* clause provide information on how facilities can achieve GHG emissions reduction. Fourteen of 30 prefectures provide such information. In many cases, a guideline that contains various measures to achieve GHG emissions reduction as well as a form for the plan is available on the prefectures' websites. This way, facilities can easily find the guideline when they download the form for the plan. Moreover, these guidelines are available for any facility that finds it on the website. Therefore, the impact of information provision is interpreted as "easy to find the guideline for GHG emissions reduction".

Some studies mention that one barrier for success is a lack of information on how to achieve GHG emissions reduction (Nishio et al. 2011; Allcott and Greenstone 2012;

Harrington 2013; Martin et al 2012). Moreover, some authors mention that using an information-based approach can eliminate this type of barrier (Dendup and Arimura 2019; Pizer et al. 2011). Therefore, information provision may promote GHG emissions reduction.

Fifth, prefectures use the *Designation of responsible department/division* provision to require regulated facilities to identify which department/division is responsible for taking action to address climate change. Fourteen of 30 prefectures require such a provision. Some studies have argued that there is a relationship between organizational structure and environmentally friendly actions. Martin et al. (2012) provided evidence on such a relationship. These scholars found a positive relationship between the existence of an environmental department and the adoption of environmentally friendly activities. Therefore, this provision may have a positive impact on GHG emissions reduction.

Finally, prefectures use the *Reward for "good" practices* provision to reward facilities that incorporate "good" practices, including sufficient GHG emissions reduction, the development of environmentally friendly products and other innovative practices. Six of 30 prefectures adopt this provision. Generally, prizes are nonmonetary; however, some prefectures provide a monetary prize, such as financial support for the purchase of energy-efficient equipment, in addition to a nonmonetary prize. When facilities receive a prize, prefectures can provide this information on their websites. Eccles et al. (2012) showed that prizes promote GHG emissions reduction. Therefore, the provision of rewards may be an incentive for enhancing GHG emissions reduction.

To summarize, basically, the *ERP* can be interpreted as a mix of mandatory planning and mandatory reporting policies, i.e., "management-based regulation". Moreover, taking the heterogeneity of the prefectures into consideration, the *ERP* is a very unique multiple-policy instrument.

3. Empirical Strategy

This section discusses our empirical analysis. Our purpose is to investigate the effect of the policy on GHG emissions reduction and to identify which provisions are effective. To simplify the analysis, we focus on the impact of the policy on CO_2 emissions, which can be used to represent GHG emissions.

Generally, CO_2 emissions can be decomposed into four factors: economic activities, energy intensity, carbon intensity and structural factors (Ministry of the Environment, 2016). The first factor is made up of the total outputs that are affected by the facilities' economic activities and the macroeconomic situation. The second factor is measured by the amount of energy per output and is determined by temperature and technologies. The third factor is measured by CO_2 emissions per energy and depends on fuel choices and technologies. The last factor is measured by structural changes, including changes in industrial structures and people's awareness.

Following the literature, we apply the difference-in-difference approach using prefecture-industry level aggregate data on the manufacturing sector from 1990 to 2014. We specify the model as:

$$\ln(y_{ijt}) = \alpha_0 + \boldsymbol{\beta X_{ijt}} + \delta_1 ERP_{it} + \lambda_t + \mu_i + \varphi_j + \theta_{ij} + \varepsilon_{ijt}$$

where *i* denotes the prefecture, *j* denotes the industry and *t* denotes the time period.

y_{ijt} is a dependent variable. We use two variations of the dependent variable because the regulated facilities may achieve CO_2 emissions reduction by either a reduction in total emissions or by an improvement in intensity. The first variation is measured by the log of total CO2 emissions, and the second is measured by the log of CO_2 emissions per workers.

$\boldsymbol{X_{ijt}}$ is a vector of control variables representing the four factors mentioned above. First, to control for the effects of economic activities, we include the natural log of the prefecture-industry level aggregated added value and the natural log of the prefecture-industry level aggregated number of facilities. Second, we include the natural log of cooling-degree days and heating-degree days, which capture the effects of temperature[3]. We use cooling-degree days and heating-degree days for the capital of each prefecture as a representative value. Information on the fuel structure of each industry is difficult to obtain. Moreover, information on other technological factors is difficult to obtain; however, these

[3] Cooling degree-days is defined as the annual sum of the difference between the average temperature and 24 degrees for each day in which the average temperature is hotter than 22 degrees. Heating degree-days is defined as the annual sum of the difference between the average temperature and 14 degrees in each day in which the average temperature is colder than 14 degrees.

factors may be similar in each industry across time. For this reason, we run another regression analysis that includes industry-specific time trends as interactions between year dummies and industrial dummies to weaken the effect of omitted variable bias.

ERP_{it} is a dummy variable indicating the implementation of the *ERP*. This variable is set to one when prefecture *i* introduces the policy in period *t*. Finally, λ_t is a time-specific effect that indicates any structural changes, changes in people's awareness and time-specific shocks such as the Great East Japan Earthquake that occurred in 2011. μ_i is a prefecture-specific time constant used to measure unobserved factors. φ_j is an industry-specific time constant used to measure unobserved factors. θ_{ij} is a prefecture-industry specific time constant used to measure unobserved factors. ε_{ijt} represents an idiosyncratic error.

4. Data Sources and a Description of the Data

In this study, we use 10 industries belonging to the manufacturing sector in 47 prefectures for the period from 1990 to 2014. The summary statistics are shown in Panel B of Table 1. Information on the variables was obtained from several data sources. For CO_2 emissions, we use the Energy Consumption Statistics by Prefecture published by the Ministry of Economics, Trading and Industry (METI). We obtain information on added value and the number of offices and number of workers in each prefecture's industry from the Census of Manufacturing report published by the METI. To calculate cooling-degree days and heating-degree days, we obtained data on the average temperature of each day from the Japan Meteorological Agency. For information on the policy, we collected data from each prefecture's website and policy guidelines.

４． *Empirical Results*

The main results are shown in Table 3. We find that the *ERP* enhanced efforts made for CO_2 emissions reduction. The policy variable is statistically significant at the 10% level for total CO_2 emissions and at the 5% level for CO_2 emissions per worker. All coefficients of the policy are negative. These results are robust even if we include industry-specific time trends.

These coefficients imply that if a prefecture has implemented the policy, then, on average, its CO_2 emissions are 5% or 6% lower than that of a prefecture that did not implement the policy. If we use CO_2 emissions per worker as a dependent variable, then the impact of the policy on the dependent variable is slightly greater, ranging between 6% and 7%. One possible interpretation is that, in general, for the regulated facilities, an improvement in intensity is relatively easier to obtain than achieving an absolute reduction in CO_2 emissions because an improvement in intensity does not require CO_2 emissions reduction or the reduction of productions.

5. *Robustness Checks/Additional Analysis*

In this section, we conduct some robustness checks on our basic results described in Section 4.

In addition, we explore the effects of additional requirements, support and incentives on CO_2 emissions reduction.

5.1. A Dynamic Panel Specification

The fuel mix may be adjusted by facilities in the long term, as we can see in the case of electricity demand (Otsuka 2015). Therefore, we apply the dynamic-panel approach as a robustness check of our basic results. In addition to incorporating the main variables of interest and control variables, we include two lagged dependent variables. The dynamic-panel specification of our model is as follows:

$$\ln(Emission_{ijt}) = \alpha_0 + \boldsymbol{\beta X_{ijt}} + \sum_{k=1}^{2} \gamma_k \ln(Emission_{ij,t-k}) + \delta_1 ERP_{it} + \lambda_t + \mu_i + \varphi_j + \theta_{ij} + \varepsilon_{ijt}$$

In this model, the presence of lagged variables causes the fixed estimator to be biased. To address this issue, we apply a two-step first-difference generalized method of moments (FD-GMM) using the Arellano-Bond estimator.

The main results are summarized in Panel A of Table 4. All models include the full set of year dummies. Model (Ⅱ) and model (Ⅳ) include industry-specific time trends. First, we check some requirements for applying the FD-GMM. Then, we conduct the Hansen-J test for overidentifying restrictions. Panel A of Table 4 shows that the null hypothesis that all instruments, with the exception of model (I), are valid is not rejected. Second, we test serial correlation in the error term. To use the FD-GMM estimator, there must be serial correlation in t-1 and but not for t-2. Panel A of table 4 also shows that the null hypothesis that there is no serial correlation for the first order is rejected, but for all models, the null hypothesis that there is no correlation for the second order is not rejected. Therefore, our models are valid.

Panel A shows that the *ERP* is still statistically significant at least at the 10% level for CO_2 emissions per capita. The policy variable is statistically significant at 10% for the model using total CO_2 emissions with an industry-specific trend. These results indicate that the effects of the *ERP* on CO_2 emissions per capita are more robust than those on total CO_2 emissions.

5.2. The Possibility of Endogenous Implementation.

The literature has widely discussed the endogeneity problem of models for the implementation of environmental regulations. Some qualitative studies argued that the implementation of the *ERP* may be nonrandom. Baba et al. (2010) mentioned that the amount of CO_2 emissions in the prefectures may be correlated with the implementation of the policy. Moreover, Aoki (2010) found that the government of the Kanagawa prefecture failed to implement the *ERP* because the firms objected to the policy.

Therefore, we conduct a *placebo test* to determine whether endogeneity exists. Placebo tests are often conducted using the difference-in-difference approach, which is used to test the parallel trend assumption. The following procedure is used. First, we include t+1 or more leads in the policy variable[4]. Next, we check the statistical significance of the lead terms. If these variables are not statistically significant, there is no significant difference in the treatment and control groups in terms of the trend of the dependent variable before and after the implementation.

Our results are summarized in Panel B of Table 4. We find that no lead variables are statistically significant at any significance level except the t+1 lead term in model (Ⅳ). We conduct an F test to determine the joint significance of the lead terms. In every model, we cannot reject the null hypothesis. In other words, there is weak evidence that

[4] The number of leads vary among papers. However, many studies used 3 or 4 leads; therefore, we include 4 leads in our models.

endogeneity exists in the model for the implementation of the policy.

5.3. The Effects Change Over Time

In Section 4, we confirm that the policy has a positive impact on CO_2 emissions. However, this result is interpreted as showing that there has been an average effect after the implementation of the policy. Thus, we cannot determine at which time the policy becomes effective. To address this issue, we conduct another regression analysis in which the policy variable is replaced with the interaction between the simple time trend and the policy variable. Moreover, because the effects may not be linear, we include the interaction between the quadratic time trend and the policy variable.

The results are shown in Panel B of Table 5. We find that the interaction between the simple time trend and the policy variable is statistically significant at least the 10% level of significance. The coefficients range between 1% and 2% for both total CO_2 emissions and CO_2 emissions per worker. Moreover, the interaction between the quadratic time trend and the policy variable is not statistically significant; however, both interactions are jointly significant at least the 10% level of significance. These results imply that the effects of the *ERP* diminish over time; however, the coefficient of quadratic term is small, indicating that this decrease occurs very slowly over time.

5.4. Analysis of the Effects of Additional Requirements, Support and Incentives.

Finally, we investigate the impact of additional requirements, support and incentives mentioned in Section 2. We define a separate policy variable for each provision; the variable takes the value of one if the prefecture implements the provision. We define two variables for the provision of *Goal setting*, *Goal1* and *Goal2*, which refer to "*Absolute*" and "*Intensity*", respectively. Finally, we conduct regression analysis for these variables separately.

Panel A of Table 5 summarizes the results for the effects of each additional requirement, support and incentive incorporated by the prefectures. We find that providing information affects CO_2 emissions reduction and is significant at the 10% level for total CO_2 emissions and at the 5% level for CO_2 emissions per workers. In contrast, *Designation of responsibility* is statistically significant at the 10% level only for CO_2 emissions per capita. These results imply that Information provision and the Designation of responsibility may be effective; however, the former effects are not robust. Information disclosure in the facilities' reports does not enhance CO_2 emissions reduction and may not pressure facilities to reduce CO_2 emissions. In contrast, we find that using a reward is statistically significant at the 5% level for both CO_2 emissions and CO_2 per workers; however, the variable is statistically significant at the 10% level when industry-specific trends are included. We also find that there is no evidence that setting a target has an impact on CO_2 emissions reduction. These results contradict Sugino and Arimura's (2011) finding. Finally, we find that Inspection of planning is statistically significant at the 5% level regardless of whether or not we control for industry-specific trends. On the other hand, this variable is statistically significant at the 10% level for CO_2 emissions per workers without industry-specific trends.

6. *Conclusion*

In this paper, we investigate the effectiveness of *Emissions Reduction Program* which aims to induce large facilities in Japan to voluntarily reduce CO_2 emissions. The policy requires large facilities to make and implement a plan to reduce emissions; however, facilities that do not exert much effort are not penalized. This policy is unique in that its composition differs among prefectures. The purpose of this study is to analyze the impact of the policy and reveal which incentives and requirements are essential for promoting voluntary efforts.

We find that *Emissions Reduction Program* positively impacts CO_2 emissions reduction. On average, in prefectures that introduced the policy, CO_2 emissions are 5% lower than those in the other prefectures. Moreover, we find that in prefectures that implemented the policy, the manufacturing sectors has reduced CO_2 emissions 1% per year.

Some studies argued that endogeneity exists in models for the implementation of the policy. They mentioned that local governments have trouble introducing strict regulations such as ETS, which means that implementation may be affected by some unobserved factors. Therefore, we evaluate endogeneity by conducting "the *placebo test*", which is a test that checks for the validity of the parallel trend assumption using the difference-in-difference approach. We confirm that there is weak evidence of omitted variable bias with regard to the policy variable in our models.

We collect information about prefectural differences in terms of the content of the policy and analyze which elements effectively promote voluntary efforts to reduce CO_2. The results show that providing information on measures that can be incorporated to achieve CO_2 emissions reduction, establishing who is in charge of environmental activities, giving advice regarding how CO_2 emissions can be reduce and rewarding "good" efforts, all have a positive impact on CO_2 emissions reduction in total and/or in intensity. However, setting a target of CO_2 emissions reductions and publishing the report about each facility's proceeding are not effective.

Our results have some policy implications. The results of this study imply that a mix of mandatory planning and mandatory reporting can effectively induce large facilities to reduce their CO_2 emissions. Moreover, policies that include other support that will address problems related to incomplete information and/or incentives for "good" practices are more effective.

In the future, studies can address the following issues. First, although the "*placebo test*" did not detect the presence of an endogeneity problem, the policy variables in our estimation have large coefficients, which may indicate that there are unobserved factors that cause bias in our models. Therefore, facility-level data may be needed to address this bias.

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Table 1

Panel A: Implementation Year of the *ERP* in each Prefecture

Year	Prefecture
1995	Ibaraki
2001	Tokyo
2002	Iwate, Shiga, Saitama
2003	Hyogo, Mie
2004	Ishikawa, Hiroshima, Aichi
2005	Tochigi, Miyazaki, Tokushima
2006	Kyoto, Osaka
2007	Nagano, Shizuoka, Wakayama
2008	Nagasaki, Kagawa, Hokkaido, Yamanashi, Gifu
2009	Okayama, Gunma, Kanagawa, Kumamoto
2010	Tottori
2011	Kagoshima
2012	Akita

Panel B: Summary Statistics

Variables	*N*	*Mean*	*S.D.*	*Min*	*Max*
ln (*Emissions*)	12277	3.82	2.03	-2.787	9.019
ln (Emissions/*workers*)	11993	-5.072	1.485	-9.915	-0.34
ln (*Added_value*)	11990	11.224	1.456	4.259	16.183
ln (Number_of_offices)	11993	5.7	1.181	1.946	9.273
ln (*Hot*)	12277	6.845	0.938	-1.609	7.926
ln (*Cool*)	12266	5.748	0.739	0.742	7.078
ERP	12277	0.228	0.42	0	1
Information Disclosure	12277	0.181	0.385	0	1
Information Provision	12277	0.106	0.308	0	1
Designation of Responsibility	12277	0.116	0.321	0	1
Inspection of Planning	12277	0.075	0.263	0	1
Goal1 (Absolute target requirement)	12277	0.074	0.261	0	1
Goal2 (Intensity target requirement)	12277	0.097	0.296	0	1

Table 2 Prefectural Differences in the *ERP*

Prefecture	Goal Setting	Information Disclosure	Inspection	Information Provision	Designation	Reward
Hokkaido	A	*Yes*	*No*	*No*	*No*	*No*
Iwate	**N**	*No*	*Yes*	*No*	*No*	*No*
Akita	A	*Yes*	*Yes*	*No*	*No*	*No*
Ibaraki	A or I	*No*	*No*	*No*	*No*	*No*
Tochigi	**N**	*No*	*No*	*No*	*Yes*	*No*
Gunma	A	*Yes*	*No*	*Yes*	*Yes*	*No*
Saitama	A or I	*Yes*	*No*	*Yes*	*Yes*	*Yes*
Tokyo	A or I	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Kanagawa	A or I	*Yes*	*Yes*	*Yes*	*Yes*	*No*
Ishikawa	A	*Yes*	*No*	*Yes*	*Yes*	*No*
Yamanashi	A and I	*Yes*	*No*	*No*	*No*	*No*
Nagano	A and I	*Yes*	*Yes*	*Yes*	*Yes*	*No*
Gifu	A or I	*Yes*	*No*	*Yes*	*No*	*No*
Shizuoka	A	*Yes*	*No*	*No*	*No*	*No*
Aichi	A or I	*Yes*	*No*	*Yes*	*Yes*	*No*
Mie	A	*Yes*	*No*	*No*	*No*	*No*
Shiga	**N**	*Yes*	*No*	*Yes*	*Yes*	*No*
Kyoto	A	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Osaka	**N**	*Yes*	*Yes*	*Yes*	*No*	*No*
Hyogo	A	*Yes*	*Yes*	*Yes*	*Yes*	*No*
Wakayama	A	*No*	*No*	*No*	*No*	*No*
Tottori	A and I	*Yes*	*Yes*	*No*	*No*	*No*
Okayama	A or I	*Yes*	*No*	*No*	*Yes*	*Yes*
Hiroshima	A	*Yes*	*No*	*No*	*Yes*	*No*
Tokushima	A or I	*Yes*	*No*	*Yes*	*Yes*	*No*
Kagawa	A or I	*Yes*	*No*	*No*	*No*	*No*
Nagasaki	A	*Yes*	*No*	*Yes*	*No*	*No*
Kumamoto	A	*Yes*	*No*	*No*	*No*	*No*
Miyazaki	A	*Yes*	*Yes*	*No*	*No*	*Yes*
Kagoshima	A or I	*Yes*	*No*	*No*	*No*	*Yes*

A denotes "*absolute target*", I denotes "intensity" and N denotes "Not necessary".

Table 3 Estimation Results for the impact of *ERP* on CO_2 emissions

Dependent:	ln (*Emissions*)		ln (*Emissions per capita*)	
Variable/Models	[1]	[2]	[3]	[4]
ERP	-0.055*	-0.047*	-0.068**	-0.060**
	(0.029)	(0.025)	(0.030)	(0.026)
*Industrial dummy*year dummy*	N	Y	N	Y
Observations	11,979	11,979	11,979	11,979

The control variables are not shown are the log of value added, log of number of offices, log of cooling-degree days, log of heating-degree days and full set of year dummies. Robust standard errors clustered by prefecture-industry level appear in parentheses. * p<0.10; ** p<0.05; and ***, p<0.01.

Table 4

Dependent	ln (*Emissions*)		ln (*Emissions/workers*)	
Panel A: Estimation results of the dynamic-panel specification				
	[1]	[2]	[3]	[4]
ERP	-0.024	-0.019*	-0.027*	-0.028**
	(0.015)	(0.011)	(0.014)	(0.011)
AR (1)	0.00***	0.00***	0.00***	0.00***
AR (2)	0.817	0.221	0.935	0.184
Sargan test	0.102	0.099*	0.738	0.227
Hansen test	0.026**	0.119	0.837	0.379
Observations	11,484	11,484	11,305	11,305
Panel B: Estimation results of the placebo test				
	[1]	[2]	[3]	[4]
ERP_t	-0.09***	-0.08***	-0.10***	-0.10***
	(0.02)	(0.02)	(0.02)	(0.02)
ERP_{t+1}	-0.01	-0.01	-0.02	-0.02*
	(0.01)	(0.01)	(0.01)	(0.01)
ERP_{t+2}	0.00	0.00	0.00	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
ERP_{t+3}	0.01	0.01	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
ERP_{t+4}	0.00	0.01	0.01	0.01
	(0.02)	(0.02)	(0.02)	(0.02)
*Industrial dummy*year dummy*	N	Y	N	Y
Observations	11,979	11,979	11,979	11,979
F test	0.623	0.498	0.684	0.443

Robust standard errors appear in parentheses in Panel A, and robust standard errors clustered by prefecture industry appear in parentheses in Panel B. The control variables not shown are the log of value added, log of the number of offices, log of the cooling-degree days, log of the heating-degree days and the full set of year dummies. Two lagged dependent variables are included in Panel A. AR (1) and AR (2) respectively denote the p-value from testing for first- and second-order serial correlations. The Sargan test and Hansen test denote the p-values from testing for overidentification restrictions. * p<0.10; ** p<0.05; and ***, p<0.01.

Table 5

Dependent	ln (*Emissions*)		ln (*Emissions/Workers*)	
Panel A: Estimation Results for each requirement, support and incentive				
	[1]	[2]	[3]	[4]
Information Provision	-0.085*	-0.076*	-0.103**	-0.090**
	(0.045)	(0.039)	(0.046)	(0.040)
	[5]	[6]	[7]	[8]
Designation of Responsibility	-0.054	-0.048	-0.080*	-0.073*
	(0.046)	(0.040)	(0.047)	(0.041)
	[9]	[10]	[11]	[12]
Information Disclosure	-0.030	-0.019	-0.023	-0.010
	(0.059)	(0.047)	(0.061)	(0.050)
	[13]	[14]	[15]	[16]
Reward for Good Practices	-0.188**	-0.160*	-0.177**	-0.141*
	(0.091)	(0.082)	(0.090)	(0.078)
	[17]	[18]	[19]	[20]
Goal 1	0.063	0.056	0.054	0.045
	(0.045)	(0.040)	(0.046)	(0.042)
	[21]	[22]	[23]	[24]
Goal 2	0.046	0.041	0.063	0.057
	(0.047)	(0.041)	(0.048)	(0.042)
	[25]	[26]	[27]	[28]
Inspection of Planning	-0.123**	-0.107**	-0.094*	-0.073
	(0.051)	(0.047)	(0.052)	(0.047)
Panel B: Estimation Results for time-varying effects of *ERP*				
	ln (*Emissions*)		ln (*Emissions/Workers*)	
	[1]	[2]	[3]	[4]
*ERP**Time Trend	-0.016*	-0.014*	-0.018**	-0.016**
	(0.009)	(0.007)	(0.009)	(0.008)
*ERP**Time Trend^2	0.000	0.000	0.000	0.000
	(0.001)	(0.000)	(0.001)	(0.000)
F test	0.084*	0.074*	0.018**	0.0099**
Industrial dummy*year dummy	N	Y	N	Y
Observations	11,979	11,979	11,979	11,979

Robust standard errors clustered by prefecture-industry level appear in parentheses. The control variables not shown are the log of value added, log of number of offices, log of

cooling-degree days, log of heating-degree days and full set of year dummies.
* p<0.10; ** p<0.05; and ***, p<0.01.