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Promotion of Energy Efficiency Through an Energy Audit in the Industrial Sector in Japan: An Examination of Information Provision, Disclosure, Target Setting, Inspection, Reward, and Organizational Structures.[1]

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Abstract

An energy audit is a famous policy instrument to improve the energy efficiency in facilities. Although energy audits have been adopted by many countries, it is unclear whether energy audits can improve the energy efficiency, since there are several barriers to energy efficiency under energy audits. For example, the facility does not need to evaluate the net benefit of energy efficiency is greater than its cost. Another possible barrier to energy efficiency is that an energy manager may have less information to improve their energy efficiency. Moreover, even if managers can find methods to improve their energy efficiency, organizational structures may be a barrier to adopting these methods. Therefore, additional practices such as information provision, target setting, or reward by governments can make an energy audit more effective. This paper investigates the complementarity of an energy audit and these practices by focusing on the *Emission Reduction Program (ERP)*, which is a unique energy audit in Japan. Using municipality-level data, we show that target setting, inspection, and designating the department/division responsible for tackling climate change can complementarily promote the reduction in greenhouse gas emissions by facilities under the *ERP*.

Keywords: Energy audit, Greenhouse gas emissions reduction, Emissions Reduction Program, Municipality-level data

1. Introduction

Due to the increase in climate change risks, energy efficiency has received attention worldwide to tackle climate change. Many countries have adopted an aggressive target regarding energy efficiency improvement. For example, the EU and member states set their target of 32.5% improvement in energy efficiency as one of EU 2030 targets (EU Commission 2019). In Japan, it is necessary to improve the energy efficiency by 35% to satisfy the target of 2030. To achieve these targets, past energy policies may not be sufficient, and more effective energy policies are necessary.

Several policy instruments have been used to promote energy efficiency. For example, information provision has been the most popular method (Hochman and Timilsina 2017). Target setting is another popular method to promote energy efficiency (Sugino and Arimura 2011). Information disclosure can also improve energy efficiency (Hoang et al. 2018). Notably, energy audits have been widely used in recent years (Anderson and Newell 2004; Kalantzis and Revoltella, 2019).

Energy audits are defined as "a systematic, documented, periodic and objective review by regulated entities of facility operations and practices related to meeting environmental requirements" (EPA 2000) or "a process whose purpose is to assess how a building or a plant uses different forms of energy, identifying opportunities and potential consumption reductions" (Thumann and Younger 2008). In other words, the energy audit is a policy instrument that

requires facilities internally to analyze their production processes and/or energy use and improve their environmental performance.

There are more than 100 types of energy audit programs in the world (Schleich and Fleiter 2017), such as the Industrial Assessment Centers of the US Department of Energy and the German audit program. These policies encourage facilities to conduct an energy audit, enhance their environmental awareness and adopt energy efficiency practices. The nature of these programs is voluntary.

In contrast to these voluntary audit programs, some programs mandate facilities to conduct energy audit processes. One example is the *Emissions Reduction Program* (*ERP*) in Japan. This program requires regulated facilities to make *energy reports* and *energy plans,* including specific practices to improve their energy efficiency. One can expect that if the *ERP* is implemented, the regulated facilities enhance their environmental awareness, find opportunities for energy efficiency improvement, and adopt practices to improve energy efficiency through the process of making and reporting their energy efficiency plan. Therefore, the *ERP* can be considered as a *de facto* energy audit.

However, the effectiveness of energy audits may not be obvious for several reasons. First, it is unclear whether facilities/firms can find "appropriate" information through an energy audit. To improve their energy efficiency, they should seek information on specific methods to reduce their energy use or improve the energy intensity. Thus, we observe the "Energy

Efficiency Gap" (Allcott and Greenestone 2012): firms or individuals sometimes cannot make rational decisions on energy-efficient investment. Second, even if they can find the relevant methods to improve their energy efficiency through an energy audit, it remains unclear whether they engage these practices because there are no penalties for non-achievement of the target. The expected benefit of the suggested practices may also be smaller than its cost (Anderson and Newell 2004). Third, the literature argues that their organizational structures can be barriers to adopting environmentally friendly actions, including energy efficiency improvement. (Martin et al 2012; Earnhart and Leonald 2016). For example, whether the manager can proceed with his plan may depend on his supervisor and/or the priorities of energy efficiency in its firm/facility. Even if the environmental consciousness of managers in firms/facilities increases, the organizational structures of firms/facilities may become barriers for them to promote energy management.

In reality, an energy audit and other policy instruments such as information provision or target setting are concurrently used to solve the barriers of energy efficiency. For example, information provision can solve the energy efficiency gap, which is one of the potential barriers to energy audits (Allcott and Greenestone 2011; Ramos et al. 2015; Dendup and Arimura 2019). Other policy instruments such as a reward or an information disclosure also have the potential to promote energy efficiency under an energy audit. When combined with various policy instruments, an energy audit can more effectively promote energy efficiency.

However, empirical studies focusing on this topic have been limited, in contrast to the rich literature on the effectiveness or decision-making process of the energy audit itself (Anderson and Newell 2004; Earnhart and Harrington, 2014; Earnhart and Leonald, 2016; Schleich and Fleiter, 2017; Kalantzis and Revoltella 2019). Therefore, there is a gap in the literature on whether other policy instruments can make an energy audit more effective by solving the barriers of the energy audits such as energy efficiency gap.

This paper contributes to the literature by examining how other policy instruments such as an information provision, an information disclosure, and a reward contribute to the effectiveness of the energy audit on climate change mitigation. This study examines a unique policy instrument, which is a type of energy audit that has been implemented by local governments in Japan since 1995, i.e., the *Emission Reduction Program* (*ERP*).

One distinctive feature of the *ERP* is that this program consists of several elements. For example, under the *ERP*, some local governments provide incentives such as rewards for good practices in terms of energy efficiency improvement and/or greenhouse gas (GHG) reduction, while other local governments provide information to reduce GHG emissions (e.g., by replacement of standard bulbs with LED lights or setting the temperature). Prefectural governments may also require facilities to identify the department (or division or group) responsible for implementing the energy plan. These variations under the *ERP* by prefectural governments enable us to investigate the effective component of the *ERP* in promoting energy

efficiency.

However, it is challenging to examine the effectiveness of the *ERP* because the implementation of the *ERP* at the local government level may not be random. For example, local governments with considerable pollution by economic activities may not impose environmental regulations to avoid the overall macroeconomic effects of such regulations. In this case, a mere comparison of the environmental outcomes between two local governments may lead to biased estimates. To overcome this challenge, we use the Difference in Difference approach with fixed-effect models to control for time-invariant unobservable effects with a panel data set that includes all local governments across Japan. To the best of our knowledge, this paper is the first study to comprehensively examine the effectiveness of an energy audit with complementary practices such as information provision, target setting, or reward.

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 conducted analysis. Section 6 concludes by discussing the limitations of this study and directions for future studies.

2. Background

2.1. History of Japanese climate policies and the ERP

Japan is a unitary state like the UK. Its administration is divided into three levels: nation,

prefectures, and municipalities. As of April 2020, there are 47 prefectures and 1724 municipalities. Regarding climate policy, the national government, prefectures and municipalities have separately implemented their own policy instruments.

The main type of policy instruments to tackle climate change in Japan is not economic-based instruments with financial penalties but voluntary-based instruments such as the *Act on the rational use of energy* or the voluntary action plan by the Ministry of Economy, Trade and Industry (METI) (Arimura and Iwata 2015). These policy instruments mainly expect facilities/firms to voluntarily adopt environmental practices with no penalties.

One important and unique policy instrument to tackle climate change in Japan is the *Emission Reduction Planning* (hereinafter *ERP*), which is an energy audit for facilities conducted by prefectural governments. The *ERP* aims to reduce GHG emissions from large facilities by requiring a plan to reduce GHG emissions and report the results of the plan implementation. The regulated facilities are those with an energy consumption of 1,500 crude oil equivalents or more. They are expected to find relevant methods to reduce the energy consumption in the process of developing energy reduction plans and increase their environmental awareness. Thus, the *ERP* can be interpreted as a de facto energy audit.

The brief history of the *ERP* is summarized in Table 1. As shown in this table, in 1995, Ibaraki introduced the *ERP* and was the first prefectural government to do so. By the end of 2014, 30 of 47 prefectural governments had adopted the *ERP*.

Table 1 History of the *ERP* Implementation

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,
2009	Hokkaido, Yamanashi, Gifu, Okayama,
2010	Gunma, Kanagawa, Kumamoto Tottori
2011	Kagoshima
2012	Akita

2.1 Requirements and Penalties

The regulated facilities are subject to two main requirements. First, they must regularly make and submit an energy conservation plan, which should describe specific methods to reduce the GHG emissions or improve their energy efficiency. The period for the submission of the plan varies among the prefectures. Typically, prefectural governments require regulated facilities to submit a plan every 3 or 5 years. Second, they must submit an annual report on the progress of their plan implementation. In this progress report, they must report the methods that they have implemented and the achieved reduction in GHG emissions reduction using these methods.

If the regulated facilities do not submit their plan or progress report, the prefectural governments may impose two types of penalties: the prefectural governments can order noncompliant facilities to comply with the two requirements, and several prefectural

governments may publicly announce the names of facilities that refuse to comply with the order.

Almost all prefectural governments have the provision to impose these two penalties on the non-submissions of their report or plan, but most prefectural governments do not impose any penalties for bad progress in terms of GHG emission reduction. Only the Hiroshima government imposes a fine for poor progress.

Since there are no tangible penalties for progress in terms of GHG emission reduction, it is unclear whether this type of policy instrument can promote GHG emission reductions. Therefore, several prefectural governments combine additional practices under the *ERP* to more effectively promote the GHG reduction instead of imposing financial penalties when the GHG emission reduction targets are not achieved. In the next subsection, we describe the additional practices to promote GHG emission reductions adopted by prefectural governments.

2.2 Additional Requirements, Support, and Incentives

The practices in addition to the two main requirements of the *ERP* differ among prefectural governments. Table 2 shows the major additional practices adopted by the prefectural governments and indicates which government introduced each type of practice. This paper focuses on six practices: *goal setting, information disclosure, inspection of planning, information provision, design of responsible department/division, and reward for good practices*.

First, *goal setting* is an additional practice that requires regulated facilities to set a

quantitative target for GHG emission reduction. Twenty-six of 30 prefectural governments have adopted such practice[1], and there are three types of targets: "*Absolute*," "*Absolute and Intensity*," and "*Absolute or Intensity*." The first type of target implies that facilities must set an absolute target, and 13 of 26 prefectural governments adopt this requirement. The second 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 prefectural governments adopted this requirement. The third type of target permits facilities to adopt either an absolute target or an improvement in intensity; 10 of 26 prefectural governments adopt this requirement.

Sugino and Arimura (2011) studied the relationship between the setting of targets and environmental activities by firms. They showed that if an industrial association set an absolute target for emission reduction, then the firms belonging to that association tended to invest in energy efficiency. Therefore, setting a target may promote GHG emission reductions.

Second, *information disclosure* is a provision that requires regulated facilities to publish their energy saving plans and progress reports on the internet or as documents. Twenty-six of 30 prefectural governments have implemented this provision. In many cases, the governments also provide submitted plans and reports on their websites. Once the reports and plans are uploaded on the internet, anyone can see the progress of the corresponding facility.

[1] In its *ERP* guidelines, Kyoto prefectural government does not mention anything about setting goals. However, in Iwate, Tochigi and Shiga prefectures, it is optional for regulated facilities to set goals. In this paper, we do not distinguish these cases because the latter case implies that the regulated facilities are not required to set a goal.

Several studies argue that the disclosure of information on the environmental quality of facilities can encourage them to reduce pollution emissions (Tietenberg 1998; Khanna and Damon 1999; Cohen and Santhakumar 2006; Delma et al. 2010; Bi and Khanna 2012). Therefore, this provision may pressure facilities to reduce GHG emissions.

Third, *inspection of planning* is a provision that requires facilities to revise and resubmit when their plans/reports are considered insufficient or incomplete; 9 of 30 prefectural governments adopted this provision. This provision mainly aims at removing incompleteness in the contents. In addition, the governments may provide information on how to reduce GHG emissions during inspection if they consider the contents of the plan to be insufficient to reduce GHG emissions. Once the facilities fail this inspection, they must revise and resubmit their plans/reports with no financial penalties.

In other words, this provision increases the compliance cost by imposing the risk of having to revise the plan/reports. As argued in Arimura and Iwata (2015), such pressures may incentivize facilities to improve their plans.

Fourth, prefectural governments that use the *information provision* clause provide information on how facilities can achieve GHG emission reduction. Fourteen of 30 prefectural governments provide such information. In many cases, a guideline that contains various measures to achieve GHG emission reduction is available on the government websites and a form for the plan. In this manner, 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 effect of this policy instrument can be interpreted as the effect of easy-to-find information on GHG emission reductions.

Several studies mention that one barrier for success to reduce GHG emissions is a lack of information (Allcott and Greenestone 2012; Ramos et al. 2015; Dendup and Arimura 2019). Moreover, several authors mention that an information-based approach can eliminate this type of barrier (Pizer et al. 2011; Allcott and Greenstone 2012; Martin et al 2012; Dendup and Arimura 2019). Therefore, information provision may help reduce GHG emissions.

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 prefectural governments have this provision. Several studies have argued that there is a relationship between organizational structure and environmentally friendly actions. Martin et al. (2012) provided evidence on this 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 positively affect the GHG emission reduction.

Finally, prefectural governments use the *Reward for good practices* provision to reward facilities that incorporate good practices such as sufficient GHG emission reduction and the development of environmentally friendly products. Six of 30 prefectures adopt this

provision. Generally, prizes are non-monetary under the *ERP*. When the facilities receive a prize, the prefectures can provide this information on their websites. Eccles et al. (2012) and Yajima (2018) show that non-monetary prizes promote GHG emission reduction. Therefore, the provision of rewards may be an incentive for enhancing GHG emissions reduction.

These variations in the additional policy instruments by prefectural governments enable us to investigate which combination of an energy audit and these practices effectively promotes energy efficiency.

Table 2 Prefectural Differences in the Contents of 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 target”, and N denotes “Not necessary.” Designation implies a requirement of identifying departments/divisions in charge of environmental activities in the facility.

3. Empirical Strategy

This section discusses our identification strategies. The purpose of this study is to identify the causal effects of the *ERP* and various additional practices that are implemented within the *ERP* on GHG emissions. A problem to identify the causal effects is that the *ERP* implementation by prefectural governments may not be random to GHG emissions from their regions. A local government with large GHG emissions in the prefecture tends to implement the *ERP*. The local government may also implement the *ERP* under some pressure to address pollution problems from stakeholders. Then, prefecture-specific factors should be correlated with the implementation of the *ERP*.

Since the implementation of the *ERP* may not be a randomized natural experiment, a simple comparison of the outcome between a treatment group and a control group cannot provide the average treatment effects of the *ERP*. To address this issue, this study uses the difference-in-difference (DID) by regression. As argued by Bertrand et al. (2004), the fixed-effect model with the full set of time dummies can produce the DID estimator. We assume that the implementation of the *ERP* will be uncorrelated with the error term after conditioning on a set of explanatory variables and fixed effects.

Moreover, the DID by regression enables us to assume that the parallel trend assumption is valid only after conditioning our explanatory variables. Since the implementation period and prefectures are varied, it may be difficult to assume and confirm the unconditional

parallel trend assumption. Therefore, this weaker assumption may be suitable for our study.

In this study, we focus on the effect of the *ERP* and additional practices on CO_2 emissions from the manufacturing sectors. We specify our basic model as follows:

$$\ln(y_{1it}) = \alpha_0 + \boldsymbol{\beta X_{1it}} + \boldsymbol{\gamma ERP_{it}} + \lambda_t + \mu_i + \varepsilon_{i1t} \quad (1)$$

$$\ln(y_{2it}) = \alpha_0 + \boldsymbol{\beta X_{2it}} + \boldsymbol{\gamma ERP_{it}} + \lambda_t + \mu_i + \varepsilon_{i2t} \quad (2)$$

where *i* denotes the municipality, and *t* denotes the time period from 2007 to 2015.

Several prefectural governments adopted the *ERP* from the beginning of our sample period; however, to increase the sample size, we use all samples in the estimation. The definition of each variable is as follows.

y_{jit} is the dependent variable for municipality *i* at time t for its variation *j*. We use two variations of the dependent variable, since the regulated facilities may reduce CO_2 emissions by either reducing the total emissions or improving the intensity. The first variation (j=1) is measured by the log of total CO_2 emissions, and the second (j=2) is measured by the log of CO_2 emissions per worker.

Our variable of interest is represented by the vector $\boldsymbol{ERP_{it}}$. The vector contains dummy variables that indicate the implementation of the *ERP* and adoption of additional practices, as noted above. ERP_{it} is a dummy variable that takes the value of 1 when a prefectural government to which municipality *i* belongs introduces the policy during period *t*. This variable is expected to capture the effects of the main requirements of developing a plan

to reduce GHG emissions and reporting the progress, i.e., an energy audit process. $Information\ Provision_{it}$, $Designation\ of\ Responsibiliy_{it}$, $Goal\ Setting_{it}$, $Inspection\ of\ Planning_{it}$, $Information\ Disclosure_{it}$, and $Reward_{it}$ are other dummy variables incorporated in the analysis to capture the effects of additional practices under the *ERP*. These variables take a value of 1 if a prefectural government to which municipality *i* belongs has this policy instrument. For "*Goal Setting*", we focus on the requirement of setting a target as "*Absolute or Intensity*" in our analysis.

$\boldsymbol{X_{it}}$ is a vector of control variables that represent the characteristics of municipality *i*. First, to capture the effects of the economic activities in the manufacturing sectors, we include the log of outputs, log of capital stocks, and log of the number of facilities. For the equation using the log of total CO_2 as a dependent variable, we also include the log of the number of workers.

Second, we include the variable that indicates the fiscal status of the municipal and prefectural governments. Several studies argue that larger local governments tend to adopt environmentally friendly actions such as implementing the ISO14001 certification compared to smaller local governments (Miki and Miyamoto 2013; Testa et al. 2012). Their results suggest that when the local governments have larger budgets, they make greater investments to improve their environmental quality using effective environmental policies. Therefore, to minimize the possible bias caused by the fiscal status of the local governments, we include the

log of the standard financial scales and log of the financial capability indices for both prefectural and municipal governments. The standard financial scale is defined as the scale of ordinary general revenue sources, which are the sum of the standard tax revenue and ordinary local allocation tax by the national government. The financial capability index is the three-year average of standard financial revenue divided by the standard financial needs, which are equivalent to the annual estimated amount of required expenditure for reasonable municipal administrations[2]. The former denotes the amount of the total annual budgets that they can use, while the latter indicates the amount that they can afford to spend on specific purposes such as the *ERP*.

Third, other environmental policies can affect the GHG emissions from the manufacturing sectors. An important policy is the Tokyo Emissions Trading Scheme (hereinafter Tokyo-ETS), which was implemented in 2010. The Tokyo ETS requires the large facilities in Tokyo to substantially reduce the GHG emissions by imposing financial penalties for non-achievement. To control for the effects of this stringent regulation, we include $Tokyo - ETS_{it}$, which switched to the policy implemented after 2010 for the municipalities of Tokyo. Furthermore, several prefectural governments have adopted policies to reward good practices in climate change mitigation by facilities. To focus on the effectiveness of giving a

[2] For details on its definition, see p.23 of IR document issued by Budget Division, Bureau of Finance Tokyo Metropolitan Government (2019)
https://www.zaimu.metro.tokyo.lg.jp/bond/en/ir_library/ir/ir_document2019_Nov.pdf

reward as an incentive under the energy audit in this paper, we include $Other\ Reward\ Proviions_{it}$ as an additional variable to control the effects of other provisions that aim at rewarding for environmental practices[3]. This variable is assigned a value of 1 if a prefecture with municipality *i* adopts the policy instrument during period *t*.

Fourth, we control for the time-specific effects (λ_t) and municipality-specific time-constant unobserved factors (μ_i). The effects of any other national-level environmental policies such as the *Act on Rational Use of Energy* in Japan[4] can be included in the time-specific effects.

Finally, ε_{ijt} is the idiosyncratic error term. To weaken any bias corresponding to the time-varying unobserved factors, we conduct additional estimations including the prefecture-specific time trends.

[3] For detailed information, see Yajima (2018).

[4] This act was introduced in 1979 to enhance energy management in large facilities/firms. For detailed information, see Arimura and Iwata (2015).

4. Data Sources and a Description of the Data

In this study, we focus on GHG emissions from the manufacturing sector in 1741 municipalities for the period of 2007-2015. The Ministry of the Environment in Japan publicly provides information on the amount of municipality-level t-CO_2 equivalent. Economic data were obtained from the Census of Manufacturing report published by the METI, such as the outputs, number of facilities, number of workers, and capital stocks. For fiscal data, we use the Local Fiscal Status Survey by the Ministry of Internal Affairs and Communications. For information on the policies, we collected data from the website and policy guidelines of each prefectural government.

During our sample period of 2007-2015, there were changes in the structure of municipalities in Japan. For example, several towns were promoted to cities. Additionally, several municipalities were joined together to create new municipalities while dissolving the previous municipalities, and several municipalities were merged with existing municipalities.

We control for such changes in the data set in the following manner. First, when municipalities were merged with existing municipalities, we take the sum of all values of the variables for the municipalities that existed after the merger. Furthermore, we drop the individual data of the municipalities that were merged. Finally, when towns were promoted to cities, we retained the new ID of the city for the entire period. In other words, we assume that this municipality did not differ before and after the promotion during our sample period.

The summary statistics are shown in Table 3. All variables are shown in logarithmic form except the dummy variables. Table 3 shows that the log of CO_2 emissions from municipalities has a wide dispersion from -3.6 to 9.9 with a mean of 3.9. Other economic variables are also shown, such as the log of the number of workers or outputs in the manufacturing sectors. Table 3 shows that 60% of municipalities belong to prefectures that have adopted the *ERP*. The table also includes information on the ratio of the prefectures in which additional incentives, requirements, and supports have been implemented under the *ERP*. Approximately 30% or 40% of municipalities are under at least one of the provisions of goal setting, information provision, designation of responsibility, inspection of planning, or information disclosure. In contrast, only 6% of the municipalities are under the provision of rewards for good practices.

Table 3 Summary Statistics

Variables	*N*	*Mean*	*S.D.*	*Min*	*Max*
ln (*Emissions*)	16657	3.9	2.1	-3.6	9.9
ln (*Emissions/Number of Workers*)	16646	-10.5	0.6	-12.3	-8.1
ln (*Number of Workers*)	17236	7.2	1.8	1.4	11.9
ln (*Outputs*)	16649	15	2.1	8.4	21
ln (*Number of Facilities*)	17236	3.9	1.5	0	9
ln (*Capital Stocks*)	12367	14.1	1.8	2.4	18.9
ln (*Municipality Standard Financial Scale*)	17350	15.9	1.2	12.3	20.4
ln (*Municipality Financial Capability Index*)	17350	3.9	0.6	1.5	5.7
ln (*Prefecture Standard Financial Scale*)	17410	20.1	0.6	19.2	22.2
ln (*Prefecture Financial Capability Index*)	17410	-0.6	0.3	-1.5	0.3
ERP	17410	0.6	0.6		
Goal Setting	17410	0.3	0.3		
Information Provision	17410	0.3	0.6		
Designation of Responsibility	17410	0.3	0.6		
Reward	17410	0.06	0.3		
Inspection of Planning	17410	0.3	0.3		
Information Disclosure	17,410	0.4	0.5		

Year dummies, Tokyo-ETS dummies and other reward provision dummies are excluded from the table.

5. Estimation Results

5.1. Main Results

The basic results are summarized in Table 4. Table 4 shows the basic analysis, which includes only the indicator for the implementation of the *ERP* and other covariates. In this basic model, the coefficients of the *ERP* dummy can be interpreted as the overall effects of the implementation of the *ERP*. We also show the results including prefecture-specific trends in addition to the covariates in Columns 2 and 4.

Columns 1 and 2 summarize the results using the log of total CO_2 emissions as dependents. We found that the coefficients of the *ERP* dummy are negative and statistically significant at the 1% level even if we control for the prefecture-specific trends. The size of the coefficients implies that the implementation of the *ERP* can reduce CO_2 emissions by approximately 3%.

The coefficients of other covariates are consistent with the background. Brief interpretations are as follows. The coefficient of the log of outputs is positive and statistically significant at the 5% level. This finding indicates the positive effects of economic activities on CO_2 emissions. The coefficient of the log of the standard financial scale of the municipalities is negative and statistically significant at 1%. The same is true for prefectural governments.

However, the coefficient of the log of the financial capability indicator of the municipalities is not statistically significant (Column 1), while it is positive and statistically

significant at 10% (Column 2). The standard financial scale of the prefectures is also positive and statistically significant at 1% (Column 2). This contradictory result may be interpreted as follows: The positive effects of a standard financial scale reflect positive relationships between the scale of financial affairs and the level of environmental concern. In contrast, the standard financial index may strongly reflect the characteristics of a very large-scale economy. Thus, a municipal and prefectural government with a high standard financial index may also have a higher concentration of certain industries than others. Moreover, there may be pressure from those industries to avoid implementing environmental regulations.

Columns 3 and 4 in Table 4 show the results using the log of CO_2 emissions per worker as dependents. We found that the effect of the *ERP* implementation is also negative and statistically significant at the 1% level. However, the size of the coefficients, which is approximately 1-2%, is relatively smaller than that in Columns 1 and 2. The difference in size of coefficients between the models indicates that it may be easier to improve the emission intensity than the total CO_2 emissions because the former enables the facilities to expand production while reducing CO_2 emissions.

Table 5 and Table 6 show the results for the effectiveness of additional practices. All models contain the identical covariates to those in Table 4, and even-numbered columns include the prefecture-specific trends. We also conducted the F test for the null hypothesis that the coefficients of the *ERP* dummy and an additional policy variable that indicates each practice

are simultaneously zero because the latter can be interpreted as an interaction between the *ERP* dummy and itself.

We found that several practices could effectively promote the reduction of CO_2 emissions of facilities under the *ERP*. For goal setting requirements, the coefficients of the provision are negative and statistically significant at the 1% level, while the coefficients of the *ERP* are positive and statistically significant. Moreover, the sum of these coefficients is approximately 7%, which is relatively greater than the results in Table 4. For the requirement to identify the responsible department for environmental activities in the facilities, its coefficient is negative and statistically significant at the 1% level, as is the case for the *ERP* dummy. The sum of these coefficients is approximately 6%. The coefficient of the provision to inspect the contents of the plan is negative and statistically significant at 1% only for the model including the prefecture-specific trends. The sum of the coefficients of the *ERP* dummy and provision is approximately 9%. However, we cannot identify the effectiveness of the information provision, information disclosure, and reward for good practice. These results are almost consistent with the results using the log of the CO_2 amount per worker as the dependent variable (see Table 4).

Table 4 Estimation Results for the Impact of the *ERP* on CO_2 Emissions

	[1]	[2]	[3]	[4]
	ln (*Emissions*)		ln (*Emissions/Number of Workers*)	
ERP	-0.03***	-0.03***	-0.02**	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)
ln(*Number of Workers*)	0.03**	0.00		
	(0.01)	(0.01)		
ln(*Outputs*)	0.96***	0.97***	0.70***	0.71***
	(0.01)	(0.01)	(0.02)	(0.02)
ln(*Number of Facilities*)	0.01	0.00	-0.45***	-0.45***
	(0.02)	(0.01)	(0.02)	(0.02)
ln(*Capital Stocks*)	-0.00	0.00*	-0.06***	-0.06***
	(0.00)	(0.00)	(0.01)	(0.01)
ln (*Municipality*	-0.10***	-0.10***	-0.08*	-0.08**
Standard Financial Scale)	(0.04)	(0.03)	(0.04)	(0.04)
ln (*Municipality*	0.04	0.03*	-0.01	-0.04
Financial Capability Index)	(0.03)	(0.01)	(0.05)	(0.04)
ln *(Prefecture*	-0.23***	-0.32***	-0.13**	-0.27***
Standard financial scale)	(0.03)	(0.05)	(0.06)	(0.06)
ln (*Prefecture*	-0.00	0.13***	0.20***	0.20***
Financial Capability Index)	(0.04)	(0.03)	(0.05)	(0.06)
Tokyo-ETS	-0.21***	-0.11***	-0.09***	-0.09***
	(0.01)	(0.02)	(0.03)	(0.03)
Other Reward Provisions	-0.02**	-0.02***	-0.03**	-0.03***
	(0.01)	(0.01)	(0.01)	(0.01)
Municipality FE	Y	Y	Y	Y
Yearly FE	Y	Y	Y	Y
Prefecture-specific time trends	N	Y	N	Y
Sample size	12306	12306	12306	12306

Robust standard errors clustered by municipalities appear in parentheses. *** p<0.01; ** p<0.05; * p<0.1.

Table 5 Effectiveness of Additional Policy instruments under *ERP* 1

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
	ln (*Emissions*)											
ERP	0.08***	0.05***	-0.04***	-0.05***	-0.02**	-0.02***	-0.04***	-0.02***	-0.18***	-0.14***	-0.03***	-0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
Goal Setting	-0.15***	-0.13***										
	(0.011)	(0.008)										
Information Provision			0.04***	0.05***								
			(0.010)	(0.010)								
Designation of Responsibility					-0.04***	-0.04***						
					(0.008)	(0.010)						
Inspection of Planning							0.05***	-0.07***				
							(0.014)	(0.016)				
Information Disclosure									0.20***	0.14***		
									(0.006)	(0.007)		
Reward											0.03***	0.04***
											(0.010)	(0.011)
Prefecture-specific trend	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
F test	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Sample size	12306	12306	12306	12306	12306	12306	12306	12306	12306	12306	12306	12306

Robust standard errors clustered by municipalities appear in parentheses. *** p<0.01; ** p<0.05; * p<0.1. The control variables not shown include the log of the number of workers, log of outputs, log of capital stocks, log of the number of facilities, log of the standard financial scale, and log of the financial capability index of municipal and prefectural governments. The Tokyo ETS dummy, other reward provision dummy, full set of year dummies and municipality fixed effects are also included.

Table 6 The Effectiveness of Additional Policy Instruments under *ERP* 2

	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]
	ln (*Emissions/Number of Workers*)											
ERP	0.07***	0.05***	-0.01	-0.05***	-0.00	-0.02***	-0.03***	-0.02***	-0.12***	-0.14***	-0.02**	-0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Goal Setting	-0.12***	-0.13***										
	(0.016)	(0.008)										
Information Provision			-0.00	0.05***								
			(0.014)	(0.010)								
Designation of Responsibility					-0.05***	-0.04***						
					(0.014)	(0.010)						
Inspection of Planning							0.07***	-0.07***				
							(0.018)	(0.016)				
Information Disclosure									0.14***	0.14***		
									(0.015)	(0.007)		
Reward											0.04***	0.04***
											(0.017)	(0.011)
Prefecture-specific time trends	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
F test	0.00***	0.00***	0.11	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.03**	0.00***
Sample size	12306	12306	12306	12306	12306	12306	12306	12306	12306	12306	12306	12306

Robust standard errors clustered by municipalities appear in parentheses. *** p<0.01; ** p<0.05; * p<0.1. The control variables not shown include the log of the number of workers, log of outputs, log of capital stocks, log of the number of facilities, log of the standard financial scale, and log of the financial capability index of the municipal and prefectural government. The Tokyo ETS dummy, other reward provision dummy, full set of year dummies and municipality fixed effects are also included.

5.2. A possibility of the endogenous implementation of the ERP

The literature has widely discussed the endogeneity problem of models for the implementation of environmental regulations. However, in the case of multiple treatments such as the *ERP*, we cannot directly compare the trends of the outcome between the control group and the treatment groups, since the implementation periods vary among prefectures. Therefore, we conduct a placebo test to determine whether there is endogeneity.

A placebo test is often conducted using the difference-in-difference approach by the two-way fixed-effects model to test the validity of the parallel trend assumption (Dube et al 2013). The following procedure is used. First, we include t+1 or more lead terms in the policy variable. 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 the implementation.

We specify the model as:

$$\ln(y_{1it}) = \alpha_0 + \boldsymbol{\beta X_{1it}} + \sum_{k=0}^{2} \gamma_k \, ERP_{it-k} + \lambda_t + \mu_i + \varepsilon_{1it} \qquad (3)$$

$$\ln(y_{2it}) = \alpha_0 + \boldsymbol{\beta X_{2it}} + \sum_{k=0}^{2} \gamma_k \, ERP_{it-k} + \lambda_t + \mu_i + \varepsilon_{2it} \qquad (4)$$

where *i* denotes the municipality, and *t* denotes the time period.

We include three lead terms of the *ERP* dummy in addition to equations (1) and (2). To focus on the endogeneity of the implementation of the *ERP*, we exclude other policy indicators such as $Information\ Provision_{it}$ or $Designation\ of\ Responsibiliy_{it}$.

Therefore, all other covariates in equations (3) and (4) are identical to those in equations (1) and (2), respectively. We conduct the F test for the joint significance of the lead terms. Furthermore, we use the municipalities of the prefecture that implemented the *ERP* after 2007 (see Table 1) to identify the endogeneity of implementation of the *ERP*. Then, our sample size diminishes to 10,680.

Our results are summarized in Table 7. We find that the *t+1* lead of the *ERP* dummy is statistically significant at the 1% level in both model (27) and model (29). We also find that the lead terms are jointly significant at the 1% level in these models. The *t + 1* lead of the *ERP* dummy is also statistically significant at the 10% level in model (28), and all lead teams are jointly significant at the 5% level. Meanwhile, in model (27), no lead teams are jointly or individually statistically significant.

The significance level of the lead term likely increases when prefecture-specific trends are included. This result may imply that there are multi-collinearity problems between the lead terms of the *ERP* dummy and these trends. A reason is that the number of municipalities decreases.

Such mixed results do not show strong evidence of the existence of endogeneity in terms of *ERP* implementation. However, a possibility of endogeneity problems remains. To address this issue, more micro data such as facility-level data may be necessary.

Table 7 *A Placebo Test*

	[26]	[27]	[28]	[29]
	ln (*Emissions*)		ln (*Emissions/Number of Workers*)	
ERP	-0.03***	-0.05***	-0.03***	-0.03***
	(0.006)	(0.006)	(0.008)	(0.008)
ERP_{t+1}	0.01	0.02***	0.01*	0.03***
	(0.005)	(0.005)	(0.008)	(0.008)
ERP_{t+2}	0.01	0.00	0.01	0.01
	(0.004)	(0.003)	(0.008)	(0.008)
F test	0.132	0.000	0.047	0.000
Municipality FE	Y	Y	Y	Y
Yearly FE	Y	Y	Y	Y
Prefecture-specific trend	N	Y	N	Y
Sample size	6134	6134	6134	6134

Robust standard errors clustered by municipalities appear in parentheses. *** p<0.01; ** p<0.05; * p<0.1 The control variables not shown include the log of the number of workers, log of outputs, log of capital stocks, log of the number of facilities, log of the standard financial scale, and log of the financial capability index of municipalities and prefectural governments. The other reward provision dummy, full set of year dummies and municipality fixed effects are also included.

6. Discussion

We have confirmed that the *ERP* can promote the CO_2 emission reduction, even if there are no strong penalties. In addition, we have confirmed that several additional policy instruments affect the CO_2 emission reduction under the *ERP*.

Our results indicate that the *ERP* can be effective at promoting climate change mitigation by facilities, at least in the manufacturing sector. One possible reason for this effectiveness is that the *ERP* partially solves the energy-efficiency gap. The *ERP* requires regulated facilities to seek information on specific methods to reduce GHG emissions. Then, the regulated facilities may find appropriate methods to improve their energy efficiency. If so, additional information provision by prefectural governments may no longer improve their knowledge. This reason may also make the information provision not show a negative sign, which indicates that information provision may not be effective under the *ERP*.

Another possible reason for the effectiveness of the *ERP* is that some reputational effects of information disclosure may be an incentive for facilities to proceed with GHG emission reduction. As shown in Table 1, almost all prefectural governments adopt information disclosure. In other words, the effects of information disclosure may have been included in those of the *ERP*, which may explain why we

failed to detect the negative effects of information disclosure provision on CO_2 emissions; we could not separately estimate the effects of *ERP* requirements and those of information disclosure.

Under the *ERP*, we find that the goal setting requirements, requirements for identifying the department/division in charge of environmental activities, and the planning inspection provision affect the promotion of CO_2 emission reduction. Our analysis indicates that clarifying a short-term GHG emission reduction target by facilities can enhance their motivation.

The establishment of environmentally related organizations can enhance environmental activities. Once the regulated facility has identified the department/division to be in charge of environmental activities, they can smoothly proceed with their plans. One possible interpretation is that the requirement partially solves the principal-agent problem in terms of environmental activities in the facility. Even if the head of the facility has incentives to improve energy efficiency, the actual activities, such as turning off lights, may depend on the decision of each employee. The identification of the department/division may put pressure on them to perform such activity. Another possible reason for the effectiveness of this practice is that if the financial department is appointed as a department in charge of environmental activities,

the facility may become more able to invest in energy efficiency or GHG emissions reduction than before.

The planning inspection provision effectively promotes CO_2 emission reduction, which is consistent with the results of Sam et al. (2009), who showed that the experience of inspection promoted facilities to participate in the 33/50 program. An inspection can put pressure on the regulated facilities to reduce CO_2 emissions.

An important implication of our results is that the *ERP* is effective even when we control for the fiscal status of the prefectural governments. This result shows that the feasibility and effectiveness of the *ERP* may not depend on the size of the budget of the prefecture. Indeed, the *ERP* has been implemented by both urban regions such as Tokyo and Osaka and more rural regions, as shown in Table 1. Our results suggest that the *ERP* can be one of the possible policies for climate change mitigation.

Finally, we cannot find statistically significant effects for reward provision. These contradictory results may occur because only few prefectural governments adopt this practice under the *ERP*.

7. Conclusions

In this paper, we investigated the effectiveness of the combination of the *ERP*, de facto energy audit, and various policy instruments on GHG emission reduction. The *ERP* requires large facilities to make and implement a plan to reduce emissions; however, facilities that do not exert much effort are not penalized. Then, the program is characterized as a de facto energy audit. Prefectural governments provide various additional policy instruments to make the *ERP* more effective in reducing GHG emissions, such as information disclosure, information provision, and rewards for good practices. We analyzed the effect of the *ERP* and revealed the effective additional policy instruments in promoting energy efficiency.

We find that the *ERP* can promote CO_2 emission reductions. On average, municipalities of a prefecture that has implemented the *ERP* have 3% less CO_2 emissions than those in the other prefectures. However, we conducted a placebo test to check the validity of the parallel trend assumption in our analysis. We found that there might be endogenous implementation problems in our models. To solve this issue, more long panel data that can cover the entire implementation period of the *ERP* may be necessary.

Our results also show that establishing a department to oversee environmental activities and inspect the contents of the plans to reduce CO_2 emissions positively affects the CO_2 emission reduction in total and/or in intensity. However, setting a target of CO_2 emission reductions, rewarding good efforts, and publishing reports about the proceedings of each facility are not effective.

Our study has several policy implications. The results imply that as a mix of mandatory planning and mandatory reporting with no financial penalties for non-achievement, an energy audit can effectively induce large facilities to reduce their CO_2 emissions through energy efficiency improvement. Moreover, the effective policies include additional practices that address problems related to setting a target of CO_2 emission reductions, identifying a department to oversee environmental activities, and/or inspecting the plan.

In future studies, we can address the following issues. First, we could not directly account for time-varying unobserved factors such as the environmental consciousness of prefectural governments. If some governments are more concerned with pollution emissions, they may make an effort to make the *ERP* effective in reducing CO_2 emissions. Second, we do not know the exact number of facilities under the *ERP* in the municipalities. In the analysis, we used municipality-level data that

covered emissions from small facilities and large facilities. However, the *ERP* only covers large facilities. Therefore, our analysis underestimates the effects of the *ERP*. To address this issue, the facility level may be better to analyze the effects of the *ERP*.

Appendix A Dynamic Panel Specification

Fuel consumption may be adjusted by facilities in the long term, as we observe 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 lagged dependent variables. The dynamic panel specification of our model is as follows:

$$\ln(y_{it}) = \alpha_0 + \boldsymbol{\beta X_{it}} + \sum_{k=1}^{K} \gamma_k \ln(y_{i,t-k}) + \boldsymbol{\gamma ERP_{it}} + \lambda_t + \mu_i + \varepsilon_{it} \quad \text{(A.1)}$$

where *i* denotes the municipality, *t* denotes the time period, and k denotes the number of lagged dependent variables.

In this model, the presence of lagged variables makes the fixed-effect estimator biased. To address this issue, we apply a two-step first-difference generalized method of moments (FD-GMM) using Anderson-Hsiao estimator. Other variables are identical to those in the model in Section 5.

The basic results are summarized in Table A1.1. All models include the full set of year dummies. Model (2) and Model (4) include prefecture-specific time trends. First, we check the requirements for applying the FD-GMM. Then, we conduct Hansen test to overidentify the restrictions. Table B1 shows that the null hypothesis is not rejected, i.e., all instruments are valid, with the exception of Models (3) and (4). Second, we test the serial correlation in the error term. To use the FD-GMM estimator, there must be a serial correlation in t-1 but not in t-2. Table A1.1 shows that the null hypotheses, where there is no serial correlation for the first order and second order, are rejected at the 5% level for all models.

We confirm that the sign of each covariate and the *ERP* dummy is consistent with the basic results in Table 3 of Section 5. The *ERP* dummy has a negative and statistically significant impact at least at the 5% level in Model (1) and Model (3); the size of the impact is approximately 2%, which is slightly smaller than that of Section 5. However, Models (2) and (4) show that the *ERP* dummy is not statistically significant when the prefecture-specific trends are included.

For the significance level of each covariate, the lag of the positive dependent variable is statistically significant at least at the 10% level in Models (2) and (4). These results may imply that the lag of dependent variables should be controlled in the estimation. The positive sign may indicate that the municipality has larger CO_2 emissions in the past period, and the municipality tends to emit more CO2 emissions in the current

period.

Regarding the economic variables, the number of workers is not statistically significant. In contrast, the log of capital stocks and log of the number of facilities are now statistically significant in Model 1 but at the 10% level. Investment in capital stocks and the establishment of a facility may also increase CO_2 emissions in the manufacturing sector. In addition, the coefficients of both have negative signs in Models (3) and (4) at the 1% level. These results may imply that these practices can increase the total CO_2 emissions while improving the emission intensity.

Next, the log of the municipality standard financial scale is not statistically significant in Models (1) and (2), while this variable is negative and statistically significant at the 1% level in Models (3) and (4). The log of the municipality standard financial index is negative and statistically significant at the 1% level in Models (2) and (4). In contrast, the log of the prefecture standard financial scale is negative and statistically significant at the 1% level except in Model (2), while the log of the prefecture standard financial scale is negative and statistically significant at the 1% level except in Model (1). Compared with the results in Section 5, only the log of the municipality standard financial index has the opposite sign.

Finally, the other reward provision is negative and statistically significant at 1% for all models. However, the Tokyo ETS dummy is negative and statistically significant at the 1% level only in Model (1). The Tokyo ETS has been implemented since 2010; thus, it may be difficult to detect the effects on CO_2 emissions in shorter panel data.

Table A1.2 and Table A1.3 summarize the results from the estimation, including the indicator for additional incentives, requirements and supports. We confirm that the results are almost identical to those in Table 4 of Section 5. The variables have the same sign, but the size of the coefficients tends to be smaller than that in the results in Section 5. Thus, a dynamic specification can weaken the effects of the unobserved factors even if certain requirements for FD-GMM are not valid.

Table A1.1 Results of Dynamic Panel Estimation 1

	[1]	[2]	[3]	[4]
	ln (*Emissions*)		ln (*Emissions/Number of Workers*)	
ERP	-0.02***	0.01	-0.02**	-0.02
	(0.005)	(0.009)	(0.008)	(0.013)
ln (*Emissions* $_{t-1}$)	-0.018	0.092*		
	(0.028)	(0.049)		
ln (*Emissions* $_{t-1}$*/Number of Workers* $_{t-1}$)			0.026	0.695***
			(0.119)	(0.060)
ln (*Number of Workers*)	0.001	-0.002		
	(0.010)	(0.019)		
ln (*Outputs*)	0.964***	0.981***	0.658***	0.753***
	(0.007)	(0.014)	(0.031)	(0.033)
ln (*Number of Facilities*)	0.026*	-0.020	-0.464***	-0.597***
	(0.014)	(0.024)	(0.039)	(0.035)
ln (*Capital Stocks*)	0.005*	-0.002	-0.063***	-0.072***
	(0.003)	(0.004)	(0.008)	(0.010)
ln (*Municipality Standard Financial Scale*)	-0.021	-0.146	-0.402***	-0.456***
	(0.044)	(0.097)	(0.074)	(0.078)
ln (*Municipality Financial Capability Index*)	-0.034	-0.183**	-0.096	-0.297***
	(0.036)	(0.075)	(0.091)	(0.093)
ln (*Prefecture Standard Financial Scale*)	-0.341***	-0.159	-0.266***	-0.451***
	(0.036)	(0.124)	(0.068)	(0.141)
ln (*Prefecture Financial Capability Index*)	-0.036	0.203***	0.451***	0.457***
	(0.035)	(0.063)	(0.062)	(0.087)
Tokyo-ETS	-0.104***	0.042	-0.040	-0.078
	(0.009)	(0.058)	(0.025)	(0.059)
Other Reward Provisions	-0.028***	-0.073***	-0.032***	-0.065***
	(0.009)	(0.012)	(0.012)	(0.019)
Prefecture-specific Trend	N	Y	N	Y
Sample Size	10972	10972	10972	10972
AR (1)	0.00***	0.00***	0.03**	0.00***
AR (2)	0.00***	0.00***	0.03**	0.01**
Sargan Test	0.74	0.11	0.00***	0.00***
IVs for Lagged Dependent	The six lags of dependent			

The robust standard errors clustered by municipalities appear in parentheses. * p<0.10; ** p<0.05;

*** p<0.01. A full set of year dummies and municipality fixed effects is included in all models. The six lags of dependent are used as IVs for the lagged dependent in all models.

Table A1.2 Results of Dynamic Panel Estimation 2

	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
	ln (*Emissions*)											
ERP	0.043***	0.135***	-0.020***	-0.025**	-0.003	0.025***	-0.006	0.033***	-0.068***	-0.064***	-0.019***	0.004
	(0.007)	(0.015)	(0.006)	(0.010)	(0.005)	(0.009)	(0.004)	(0.008)	(0.003)	(0.008)	(0.005)	(0.009)
Goal Setting	-0.08***	-0.19***										
	(0.008)	(0.017)										
Information Provision			0.01	0.09***								
			(0.009)	(0.016)								
Designation of Responsibility					-0.05***	-0.09***						
					(0.008)	(0.021)						
Inspection of Planning							-0.05***	-0.13***				
							(0.017)	(0.021)				
Information Disclosure									0.07***	0.09***		
									(0.005)	(0.015)		
Reward											0.06***	0.03
											(0.008)	(0.022)
Prefecture-specific Trend	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
AR (1)	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
AR (2)	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Sargan Test	0.69	0.00***	0.72	0.00***	0.67	0.00***	0.70	0.00***	0.73	0.00***	0.72	0.00***
F test	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.37

The sample size is 10,972 for all models. The six lags of dependent are used as IVs for the lagged dependent in all models. * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors clustered by municipalities appear in parentheses. The control variables not shown include the log of the number of workers, log of outputs, the

log of capital stocks, log of the number of facilities, log of the standard financial scale, and log of the financial capability index of municipalities and prefectures. The Tokyo ETS dummy, other reward provisions dummy, full set of year dummies and municipality fixed effects are also included.

Table A1.3 Results of Dynamic Panel Estimation 3

	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]
	ln (*Emissions/Number of Workers*)											
ERP	0.046***	0.114***	-0.018*	-0.022	-0.004	0.001	-0.006	0.021	-0.053***	-0.044	-0.023***	-0.020
	(0.010)	(0.022)	(0.010)	(0.018)	(0.009)	(0.016)	(0.008)	(0.015)	(0.018)	(0.029)	(0.009)	(0.014)
Goal Setting	-0.09***	-0.18***										
	(0.013)	(0.028)										
Information Provision			-0.00	0.02								
			(0.015)	(0.028)								
Designation of Responsibility					-0.06***	-0.07**						
					(0.016)	(0.030)						
Inspection of Planning							-0.07***	-0.18***				
							(0.023)	(0.032)				
Information Disclosure									0.05**	0.04		
									(0.020)	(0.034)		
Reward											0.08***	0.10***
											(0.017)	(0.028)
Prefecture-specific Trend	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
AR (1)	0.06**	0.00***	0.04**	0.00***	0.03**	0.00***	0.03**	0.00***	0.04**	0.00***	0.04**	0.00***
AR (2)	0.01**	0.20	0.01**	0.16	0.02**	0.13	0.02**	0.16	0.01**	0.16	0.01**	0.16
Sargan Test	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
F test	0.00***	0.00***	0.08*	0.46	0.00***	0.04**	0.00***	0.00***	0.01**	0.31	0.00***	0.00***

The sample size is 10,972 for all models. The six lags of dependent are used as IVs for the lagged dependent in all models. * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors clustered by municipalities appear in parentheses. The control variables not shown include the log of the number of workers, log of outputs, log

of capital stocks, log of the number of facilities, log of the standard financial scale, and log of financial capability index of municipalities and prefectures. The Tokyo ETS dummy, other reward provisions dummy, full set of year dummies and municipality fixed effects are also included.

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