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Seemingly Unrelated Interventions: Environmental Management Systems in the Workplace and Energy Conservation Behaviors at Home

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Seemingly Unrelated Interventions: Environmental Management Systems in the Workplace and Energy Conservation Behaviors at Home[1]

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Abstract

To reduce their environmental impacts, a growing number of organizations worldwide have implemented environmental management systems (EMSs). In these organizations, energy conservation activities become usual behaviors for employees; thus, we hypothesize that employees continue such energy conservation behaviors at home. This hypothesis is supported by data from surveys of individuals in Japan. Specifically, we find that the probability of engaging in energy conservation practices at home is higher and that expenditures on electricity use are lower for individuals who work in organizations that implement EMSs than for individuals who do not work in organizations with EMSs. Our results suggest that beyond the original purpose of helping organizations reduce their environmental impacts, EMSs work as an intervention to promote household energy conservation.

JEL: Q40, Q50

Key Words: Conservation Behaviors, Electricity, Environmental Management System, Energy Efficiency, Household Electricity Expenditure

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1. Introduction

Global warming is one of the most serious problems that our society needs to address. The average global temperature has increased by approximately 1.4 degrees F (0.8 degrees C) since 1880, and with the current level of greenhouse gas (GHG) emissions, each successive decade is expected to become warmer than the previous one (Melillo et al., 2014). Reduction of GHG emissions is therefore an urgent need.

Like the business sector, households are responsible for a large part of GHG emissions. They represent 15-20% of primary energy use in developed countries and a higher share in developing countries (Dzioubinski and Chipman, 1999). Thus, households are an important target group for intervention (Abrahamse et al., 2005), motivating many researchers, mostly in the fields of social and environmental psychology, to investigate how to promote energy conservation among households. For an excellent review, see the study by Abrahamse et al. (2005).

In this study, we examine environmental management systems (EMSs) as a potential intervention to promote household energy conservation. This idea may sound odd to those who are familiar with EMSs, because the original purpose of an EMS is not to influence household energy conservation but to help organizations such as companies, associations, and governmental agencies reduce the environmental impacts generated by their products, services or activities. For the same reason, even organizations that currently implement EMSs are unlikely to be aware of their potential role in promoting household energy conservation. We will point out, however, that EMSs may influence household energy conservation, although EMSs and the energy consumption of households may be seemingly unrelated.

An EMS is a formal set of processes and procedures that defines how the organization will manage its potential impacts on the environment. Implementation of a typical EMS requires setting an environmental principle and a plan ("Plan"), establishing a quantifiable target to reduce the organization's environmental impacts ("Do"), and monitoring its environmental progress ("Check"). The management revisits the principle and plan and later sets a new target in a revised plan ("Act"). This repetitive cycle is known as "PDCA" (Plan-Do-Check-Act) (Coglianese and Nash, 2001). The increased control is expected to result in continuous improvement in the environmental performance of the organization (United States Environmental Protection Agency, 2014).

To manage environmental issues in a systematic manner, a growing number of organizations have implemented EMSs. The most commonly used framework for an EMS is ISO 14001, the international standard established in 1996 by the International Organization for Standardization (ISO). At least 346,147 organizations in 201 countries had been certified to ISO 14001 by the end of 2016, compared to 14,106 in 84 countries by 1999 (ISO, 2003; ISO, 2016). Likewise, 3,865 organizations and 9,140 sites were registered under Eco-Management Audit Schemes (EMAS) as of October 2017 (European Commission, 2017). EMS implementation may be even more prevalent than implied by these figures due to the presence of organizations that implement EMSs without being certified/registered under ISO 14001 or EMAS (i.e., informal EMSs or organization-specific EMSs).

Motivated by a rapid increase in the prevalence of EMSs, a number of studies have investigated the potential environmental benefits of EMS implementation, including the reduction of environmental impacts (e.g., Arimura et al., 2008; Brouwer and van Koppen, 2008; Daddi et al., 2011; Iraldo et al., 2009; Potoski and Prakash, 2005), compliance with environmental regulations (e.g., Dahlström et al., 2003; Dasgupta et al., 2000) and technological environmental innovations (e.g., Lim and Prakash, 2014; Rennings et al., 2006; Wagner, 2007; Wagner, 2008). The results are not necessarily in agreement, depending on how environmental performance is measured.

This study departs from the literature by addressing an unexplored aspect of EMSs. The point of departure is the consideration of how employees are affected by the introduction of EMSs. When an organization introduces an EMS, its objectives often include the reduction of electricity use. Therefore, employees are encouraged to engage in energy conservation activities, such as turning off lights or personal computers when not in use, to a greater extent than before. In addition, the results of these practices are periodically assessed. The employees' involvement in this process may make energy conservation behaviors become a usual act that does not require much effort. Then, it may not be surprising if the employees continue energy conservation behaviors at home.

This argument is supported by survey data on individuals in Japan. Specifically, our results show that the probability of engaging in energy conservation practices at home is higher and the expenditures on electricity use are lower when individuals' workplaces implement EMSs than when their workplaces do not. These results suggest that beyond the original purpose of helping organizations reduce the environmental impacts generated by their activities, EMSs have previously unnoticed positive spillover effects on household energy conservation.

2. Background

2.1 Environmental Management Systems

EMSs require organizations, in either the private or public sectors, to "establish programs, systems and structures for their internal operation regarding the environment"

(Prakash and Potoski, 2006). In doing so, organizations with EMSs often provide training and education, such as general awareness training (Zutshi and Sohal, 2004), to promote environmental conservation within the organization. Zutshi and Sohal (2004) claim that general awareness training should include the topic "impact of operations and individuals' actions on the environment." Through this training, employees can learn how to mitigate the environmental impact of their daily operations.

Academic literature examines environmental training as an important element of EMSs (e.g., Jabbour, 2013). However, this literature does not document in detail the content of training or education programs organizations with EMSs provide. Therefore, in this subsection, we introduce specific examples of environmental training and promotion of environmental conservation behaviors in Japanese firms with EMSs.

We begin with an example of a consulting firm with ISO 14001, *NS Solutions*. The firm provides employees with environmental education every year to enhance their understanding of the importance of environmental conservation[1]. As is typical in organizations with ISO 14001 in Japan, the firm's environmental management objectives include the reduction of electricity usage. The firm implements environmental education or training to promote energy savings. Everyone in the firm---that is, from the top managers to all the staff---is encouraged to participate in energy conservation practices: turning off lights in workspaces during lunch hours, turning off PCs when going home, turning off lights in rooms not in use, and controlling the temperature settings of air conditioners by setting the temperature at 28 degrees Celsius or higher in summer and 20 degrees Celsius or lower in winter, as advocated in the campaign by the Japanese

[1] https://www.nssol.nssmc.com/corporate/environmental.html (Accessed in April 2018)

Ministry of the Environment (the Energy Conservation Center, Japan, 2012).

As another example of a firm with an EMS, a transport company, *Geneq*, evaluates electricity usage every month in graphs so that the usage is visible and noticed[2]. Employees are provided with education as well as with notebooks that explain the company's environmental policy, the targets, the employee's obligations, and energy saving practices to engage in. Comprehension tests are regularly conducted. Some organizations further encourage workers to voluntarily participate in environmental conservation activities outside the workplace to promote their environmental awareness.

Organizations in the public sector are engaged in similar activities to promote environmental conservation through employees' behavioral changes. For example, the local government of *Kanagawa*, a prefecture next to Tokyo, has adopted an environmental management system[3]. As a part of the environmental training program, the Environmental Planning Division in Kanagawa prefectural government provides DVDs to other departments so that employees can learn about the current status of climate change issues/policy or water conservation. Moreover, the division uses posters to encourage employees to practice environmental conservation behaviors such as "turn off lights when unnecessary" not only in the workplace but also at home[4].

As shown in these cases, Japanese organizations with EMSs provide environmental education to employees. The education often focuses on energy and climate issues. Further, these organizations encourage employees to adopt the energy saving practices mentioned above.

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[2] http://www.geneq.co.jp/corporate/environment.html (Accessed in April 2018)

[3] http://www.pref.kanagawa.jp/cnt/f534419/p1016428.html (Accessed in April 2018)

[4] http://www.pref.kanagawa.jp/uploaded/attachment/818148.pdf (Accessed in April 2018)

2.2 Previous Literature on EMSs

A number of previous studies have found that EMS implementation results in better environmental performance. For example, Russo (2002) provided evidence that ISO 14001 certification helped U.S. electronics facilities reduce their toxic emissions. Potoski and Prakash (2005) found that ISO 14001 adoption results in decreased air pollutant emissions. Similarly, Iraldo et al. (2009) found that EMAS has a positive effect on the level of self-reported environmental performance perceived by the organization itself.

Similar results are obtained when technological environmental innovations are used as a specific measure for environmental performance. For example, Rennings et al. (2006) found that the maturity of the EMS has a positive influence on environmental process innovations among German EMAS-validated facilities. Likewise, Wagner (2007) examined German manufacturing firms and provided evidence that the implementation level of an EMS has a positive effect on environmental process innovation. Wagner (2008) also observed this pattern for firms in nine European countries. Lim and Prakash (2014) found that country-level ISO participation is a strong predictor of a country's environmental patent applications.

On the other hand, some studies have found little evidence that EMSs improve organizations' environmental performance. For example, Barla (2007) examined 37 plants in Quebec's pulp and paper industry and found that ISO 14001 does not result in a reduction in total suspended solid emissions. Using U.K. data, Dahlström et al. (2003) showed that neither ISO 14001 nor EMAS had a positive effect on compliance with environmental regulations, contrary to evidence found by Dasgupta et al. (2000) for facilities in Mexico. According to Darnall and Sides (2008), who conducted a metaanalysis, the evidence is inconclusive on whether adherence to ISO 14001 results in improved environmental performance.

In addition to improved environmental performance, a wide variety of potential benefits from EMSs have been listed and examined in the literature, including profitability, market expansion, competitive product/service, efficiency, improved company image, improvement in customer satisfaction and improved relations with stakeholders (e.g., Nishitani, 2011; Tan 2005; Tari et al., 2012).

As shown in the literature review, EMSs have been extensively examined in the context of organizational performance. In contrast, less attention has been paid to whether EMS implementation influences employees within the organization. According to a few studies, employee morale seems to change as a result of EMS implementation. For example, Hillary et al. (1998) found that one of the benefits perceived by registered EMAS sites is improved employee morale. According to Pan (2003), firms in Japan and Taiwan tend to perceive improved employee morale as one of the benefits from ISO 14001. Poksinska et al. (2003) provided similar evidence after examining Swedish firms that are certified to ISO 14001.

Several studies have also shown that employees become more environmentally aware when their workplaces implement EMSs. For example, Rondinelli and Vastag (2000) conducted an in-depth case study of a plant in South Carolina and found that plant managers viewed one of the benefits of ISO 14001 to be its influence on employee environmental awareness. Schylander and Martinuzzi (2007) examined Austrian firms and observed that one significant contribution of ISO 14001 is raising employee awareness of environmental issues; 85% of the firms in the survey perceived middle, strong or very strong improvements.

2.3 The Relationship between EMSs in the Workplace and Household Energy Conservation

This study extends the scope of the previous research by shedding light on an unnoticed aspect of EMSs. In particular, we argue that EMS implementation works as an intervention to promote household energy conservation, although EMSs and household energy conservation may seem to be unrelated. The idea is that an EMS induces employees to behave in a more energy-conserving way at home. To understand this idea, consider an organization that introduces an EMS. The management initially sets a target to meet, for example, a 2% reduction in electricity consumption during a certain period of time to encourage energy conservation behaviors among the employees. The person in charge regularly monitors the extent to which the employees engage in energy conservation activities, such as turning off lights when not in use, and keeps the employees aware of the target. The employees are also provided with environmental education, which is one of the basic elements of an EMS. At the end of the period, electricity consumption is compared with the target, and the report is shared with the employees. This allows them to associate the amount of reduction achieved through their behaviors. The management then sets a new target for the employees, encouraging their energy conservation behaviors again. Through this cycle, the employees may not only better understand the significance of energy conservation behaviors but also become accustomed to engaging in energy conservation behaviors in the workplace. Finally, the employees may consciously or unconsciously bring this “knowledge” and “habit” to their homes.

This argument, with the exception of the last part (i.e., bringing the knowledge and habit to their home), is in line with evidence provided by Arimura et al. (2008). Using data on facilities in Japan, they found that ISO 14001 certification is associated with reduced natural resource use. This evidence can be interpreted to indicate that when an EMS is implemented, employees behave in a more energy-conserving way in the workplace. The argument is also supported by a field experimental study by Siero et al. (1989). They developed a behavioral program to change the driving behavior of mail van drivers. Similarly to an EMS, the program was designed to provide drivers with information, task assignment, and feedback on gasoline consumption. Implemented in the Netherlands Postal and Telecommunication Services, the program resulted in energy savings of 7.3%. We conclude this section with two hypotheses: when individuals' workplaces implement EMSs, (1) the individuals become more engaged in energy conservation activities at home, and (2) their household expenditures on electricity are lower.

3. Do EMSs in the Workplace Induce Energy Conservation Activities at Home?

3.1 Data

To address the first question, we use data that are derived from an online survey conducted in February 2016. The target subjects are 20 years old or older, residing in Japan. A total of 2,618 individuals participated in the survey, recruited from 1,350,000 survey monitors registered with Market Development Research, a marketing research company in Tokyo. We requested the company to broadly divide the country into six regions and collect the subjects in such a way that the density of the respondents in each region is approximately equal to the corresponding density in the Population Census in Japan and that the distributions of age and gender in each region are matched with those in the Census. We decided to make this adjustment because we were concerned about a possible correlation between internet accessibility and residential locations; people in urban areas may be more likely to participate in an online survey than those in rural areas. After excluding non-working respondents such as students and homemakers and those with incomplete answers, the sample size was reduced to 1,723. Table 1 presents the descriptive statistics.

3.1.1 Dependent variables

We consider four energy conservation practices recommended by the Energy Conservation Center, Japan (2012), which provides an official guideline for promoting household energy conservation. Two dependent variables are related to air conditioners and are constructed from the following survey items: (w)hen you are in a living room at home, (1) "do you set the air conditioner temperature at 28 degrees Celsius or higher in summer?" (ecp_1) and (2) "do you set the air conditioner temperature at 20 degrees Celsius or lower in winter?" (ecp_2). The other two variables are constructed from the following items: (w)hen you are in a living room alone and then leave the room for 5 minutes or more, (3) "do you turn off the TV(s)?" (ecp_3) and (4) "do you turn off the light(s)?" (ecp_4). Respondents were asked to answer each question by choosing from four ordered categories: “never” (coded as 1), “rarely” (coded as 2), “occasionally” (coded as 3), and “fairly often” (coded as 4). It should be noted that some of the respondents do not use standard air conditioners in winter; instead, they use traditional Japanese-style stoves that are not equipped with temperature settings. In addition, a proportion of the respondents do not possess televisions. As a result, the number of observations differs across the practices; specifically, there are 1,435 observations for the air conditioner in summer, 923 for the air conditioner in winter, 1,641 for the TV(s), and 1,723 for the light(s).

The distribution of replies for each practice is shown in Figure 1. For each practice, respondents who answered “fairly often” occupy the largest share. For air conditioner practices, respondents are found to be engaged relatively more in summer than in winter.

3.1.2 Explanatory variables

To measure EMS implementation in respondents' workplaces, we use the following survey item: “(h)as the organization that you work for implemented an environment management system (for example, ISO 14001, Eco-Action 21[5], etc.)?” Respondents were asked to choose from “yes,” “no,” or “don't know,” and 18% of the respondents replied "yes," 39% "no," and the rest "do not know." For our analysis, we construct two dummy variables: ems that equals one if the respondent chose “yes” and ems_dk that equals one if the respondent chose “don't know.” We initially include ems in models, but not ems_dk; in other words, we treat "no" and "don't know" equally. This modeling approach assumes that when an EMS is adopted, employees are aware of it. This assumption does not seem to be unreasonable, as one of the components of an EMS is to ensure that all employees are involved in and committed to the EMS (The Commonwealth of Australia, 2017). For robustness checks, we will examine models that include both ems and ems_dk, thereby allowing for the possibility that "no" and "don't know" have differential effects.

In addition to EMSs, sociodemographic and household factors may influence energy conservation behaviors. To control for individuals’ sociodemographic characteristics, our

[5] The Eco-Action 21 is a formal certification for Japanese small and medium-scale organizations. The certification is provided by the Institute for Promoting Sustainable Societies.

models include age, a dummy variable for being male, a dummy variable for being a regular employee, dummy variables for education[6], dummy variables for occupation[7], and dummy variables for the industry the respondent works in[8]. In addition, the models incorporate two variables that represent the temperatures at which the respondents feel comfortable in summer and winter. For household and house related factors, the models include the number of household members, a dummy for home ownership, a dummy for living in a detached house, dummy variables for household income[9], and dummy variables for TV types[10]. Lastly, to control for regional differences, the models include the monthly average of the mean daily temperature in the seat of the prefectural government, in January 2016, as reported by the Japan Meteorological Agency.

As will be discussed later, we test the endogeneity of the EMSs. For this purpose, the number of employees in the organization the respondent works for is used as an instrumental variable. To obtain the corresponding variable, the survey respondents were asked the number of employees in their organization and chose from the following responses: “not more than 10,” “from 11 to 50,” “from 51 to 100,” “from 101 to 500,” “from 501 to 1,000,” “from 1,001 to 3,000,” “from 3,001 to 5,000,” “from 5,001 to 10,000,” and “10,001 or more.”

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[6] The education category consists of seven groups: “junior high school,” “high school,” “higher professional school,” “junior college,” “a bachelor’s degree,” “higher than a bachelor’s degree,” and “others.”

[7] The occupation category is classified into nine groups: “specialist/engineer,” “administrator,” “deskwork,” “sales,” “service,” “production,” “safeguard,” “agriculture/fishery,” and “transportation/ communication.”

[8] The industry category consists of ten groups: “agriculture/fishery,” “construction,” “manufacturing,” “energy,” “information and communication,” “transportation,” “wholesale/retail/restaurant,” “finance/insurance/estate,” “service,” and “public service.”

[9] The category for household income is divided by eight groups: "income < 2," "$2 \leq$ income < 3," "$3 \leq$ income < 4," "$4 \leq$ income < 5," "$5 \leq$ income < 7," "$7 \leq$ income < 10," "$10 \leq$ income < 15," and "income ≥ 15," where the unit is million yen.

[10] The TV types are arranged in three groups: “liquid crystal,” “plasma,” and “others.”

3.2 Comparison of Two Groups

To examine the relationship between EMSs and energy conservation practices, we first examine the empirical distributions of energy conservation practices $(ecp_j, j = 1, \ldots, 4)$ between two respondent groups by the EMS status of their workplaces ($ems = 1$ and $ems = 0$) in Figure 1. The green and white bars represent the respondents for $ems = 1$ and $ems = 0$, respectively. According to the figures, the distributions seem to be different from each other. For all practices, we find larger densities at "fairly often" for $ems = 1$ than for $ems = 0$. Additionally, smaller densities are observed at "never" and "rarely" in the former group than in the latter group.

We next check the mean differences of energy conservation practices by group. The first four rows in Table 2 represent the results of mean-comparison tests for all individuals, assuming normal distributions and allowing for unequal variances. It is found that respondents who work for organizations with EMSs are more likely to be engaged in all energy conservation practices at home than are those who work for organizations without EMSs. In addition, according to non-parametric Kolmogorov-Smirnov tests, the distribution of each practice differs across the groups at the one percent level of significance. These differences are consistent with the idea that EMSs in workplaces induce employees to engage in energy conservation practices at home.

Furthermore, if we inspect the data on men and women separately, gender discrepancies arise. The remaining results in Table 2 show the same pattern for men: the mean for the EMS group is significantly larger than that for the other group for all practices, whereas for women, the mean differences by EMS status group are statistically significant only for particular practices: ecp_2 and ecp_4.

3.3 The Model and Results

In the previous section, the results are found to be consistent with the positive influence of EMSs on energy conservation practices at home, especially for men. We now examine whether this is supported even after controlling for individual observed characteristics. We estimate an ordered probit model to account for the ordered categorical nature of the dependent variable (ecp_j); it takes one, two, three and four if the individual "never," "rarely," "occasionally," and "fairly often," engages in energy conservation practice j, respectively.

The underlying unobserved propensity to engage in the practice (ecp_j^*) is assumed to depend on whether the individual's workplace implements an EMS (ems), a set of other observed factors ($\boldsymbol{x}$), and a set of unobserved factors that consist in the error term (u_j):

$$ecp_j^* = \alpha_j \cdot ems + \boldsymbol{x\beta}_j + u_j, \tag{1}$$

where $(\alpha_j, \boldsymbol{\beta}'_j)$ are unknown parameters, $\boldsymbol{x}$ does not contain a constant, and u_j is standard normally distributed. The observed categorical variable is assumed to connect with the unobserved propensity in the following manner: $ecp_j = 1$ if $ecp_j^* < \mu_{1j}$, $ecp_j = 2$ if $\mu_{1j} \leq ecp_j^* < \mu_{2j}$, $ecp_j = 3$ if $\mu_{2j} \leq ecp_j^* < \mu_{3j}$, and $ecp_j = 4$ if $\mu_{3j} \leq ecp_j^*$ where $(\mu_{1j}, \mu_{2j}, \mu_{3j})$ are unknown threshold parameters. The parameters are estimated by maximum likelihood, and the corresponding standard errors are clustered at the prefecture level and robust to heteroskedasticity.

Table 3 provides the estimation results. For each practice, the coefficient on ems is positive and statistically significant at the one percent level, suggesting that individuals working for organizations with EMSs are more likely to be engaged in energy conservation practices at home than those working for organizations without EMSs. To see the extent of the effects, Figure 2 depicts the average partial effects of EMSs. For each practice, the probability of “fairly often” increases by 13-19 percentage points when ems changes from zero to one, while the probability of "never" decreases by 6-13 percentage points. According to these estimates, the effects of EMSs on energy conservation practices at home do not seem negligible in size.

We also examine whether the effects of EMSs differ across gender groups. For this purpose, we estimate equation (1) for men and women separately. The results, presented in Table 4, show that there are gender differences in the effects of EMSs. On the one hand, for men, the results are similar to those obtained before. Specifically, for all practices, the coefficients on ems are positive and significant at the one percent level, and the average partial effects on the probability of "fairly often" are 14-17 percentage points. On the other hand, women are influenced by EMSs only regarding the air conditioner practice in winter. In that case, however, the corresponding average partial effect on "fairly often" becomes larger than that obtained when we pool men and women. Overall, these results suggest that men are influenced by EMSs in a wider variety of energy conservation practices, while women are more strongly influenced by EMSs concerning a specific practice than men are.

3.4 Robustness Check 1: Treatment of "Don't Know" Responses

The results we have presented were obtained through equal treatment of the respondents who answered "no" and those who answered "don't know" to the question “(h)as the organization that you work for implemented an environment management system?.” To examine the robustness of our findings to this assumption, we now include ems_dk in the models and thereby allow for the possibility that "don't know" is not equivalent to "no."

As presented in Table 5, for all models, the inclusion of ems_dk does not change the pattern of the estimated coefficients on ems; their sign and significance remain the same as before. Although the average partial effects on the probability of "fairly often" ("never") become somewhat smaller in magnitude, they are still larger than ten (five) percentage points when significant. According to these estimates, our main findings seem to be robust to the treatment of "don't know" responses.

The results also show that "no" and "don't know" responses are not necessarily equivalent; when we examine men regarding the TV practice (ecp_3) and the light practice (ecp_4), the coefficients on ems_dk are found to be statistically significant at the five percent level. Moreover, the negative sign of the coefficients implies that men who answered "don't know" are less engaged in these practices than those who answered "no." There are two possible interpretations for these results. First, if most of those responding with "don't know" work for organizations that do not implement an EMS, then the results may be interpreted to indicate that they tend to care less about energy conservation practices than those who answered "no" (and hence are less engaged in the practices). In other words, $ems\_dk = 1$ may capture individuals who are unconcerned about energy conservation practices. Second, if most of those responding with "don't know" work for organizations that implement an EMS, the results may also imply that EMSs unnoticed by employees do not influence their energy conservation behaviors; in other words, employees should be well informed about EMSs (as is required by ISO 14001) to promote their energy conservation behavior.

3.5 Robustness Check 2: Test for Endogeneity of EMSs

In equation (1), we implicitly assumed that the key regressor, ems, is not correlated with the error term, u_j; in other words, ems is treated as an exogenous variable. This assumption does not seem to be unreasonable because it is not individuals but organizations that determine whether to implement EMSs. One might argue, however, that ems is potentially endogenous due to some omitted factors. For example, consider environmental consciousness, i.e., the extent to which an individual is environmentally conscious. This factor is expected to influence the propensity for the energy conservation practice, ecp_j^*. However, it seems difficult to completely control for this factor; a variable based on the survey question "(h)ow much are you concerned about global warming?" may be a good proxy but is unlikely to be a perfect one. For this reason, at least part of environmental consciousness is expected to be contained in the error term. Environmental consciousness may also be associated with the desire to work in an environmentally friendly organization, which would influence the probability of being employed in such an organization. Then, the error term would be correlated with whether the individual works in an organization with an EMS in place, given that environmentally friendly organizations tend to implement EMSs.

To address this issue, we test for the endogeneity of ems. We apply the method developed by Terza et al. (2008) that is a nonlinear version of the Hausman (1978) endogeneity test. To do so, we slightly modify equation (1) as follows:

$$ecp_j^* = \alpha_j \cdot ems + \boldsymbol{x\beta}_j + \rho_j \cdot \omega_j + v_j, \qquad (2)$$

where ω_j captures a set of unobserved factors that are uncorrelated with $\boldsymbol{x}$ but correlated with ems (e.g., environmental consciousness), ρ_j is the corresponding parameter, and

v_j captures a set of unobserved factors that are not correlated with ems or with ω_j and is assumed to be standard normally distributed. Conditional on ems, $\boldsymbol{x}$, and ω_j, the response probability that $ecp_j = 1$ can be derived as

$$\Pr(ecp_j = 1) = \Phi(\mu_{1j} - \alpha_j \cdot ems - \boldsymbol{x\beta}_j - \rho_j \cdot \omega_j),$$

where $\Phi(\cdot)$ is the standard normal distribution function. The other response probabilities can be derived similarly. A problem of endogeneity emerges due to the presence of ω_j; if an ordered probit model is estimated via maximum likelihood without dealing with ω_j, the estimator will be inconsistent unless $\rho_j = 0$.

We next define a reduced form equation that formalizes the relationship between ems and ω_j:

$$ems = g(\boldsymbol{x\gamma}_j + z\delta_j) + \omega_j, \tag{3}$$

where $(\boldsymbol{\gamma}_j, \delta_j)'$ are unknown parameters, $g(\cdot)$ is some function, and z is an identifying instrument. The variable z must satisfy the following conditions: (A) it is sufficiently correlated with ems, (B) it is not correlated with ω_j, and (C) it can neither have a direct influence on *ecp* nor be correlated with v_j. With a particular functional form for $g(\cdot)$, equation (3) becomes a well-known binary choice model. In this analysis, by setting $g(\cdot)$ to be the standard normal distribution function, the equation represents a probit model.

Given the response probabilities and equation (3), we can test for the endogeneity of ems by using the following two-stage procedure. In the first stage, we estimate equation (3) using maximum likelihood and compute the residual $\widehat{\omega}_j = ems - g(\boldsymbol{x}\widehat{\boldsymbol{\gamma}}_j + z\hat{\delta}_j)$. In the second stage, we estimate the ordered probit model represented by the response probabilities by substituting $\widehat{\omega}_j$ into ω_j. The null hypothesis that $\rho_j = 0$ (i.e., the exogeneity of ems) can be tested by using a conventional *t*-test.

As an instrumental variable, we use the number of employees in the organization the individual works for. There are several reasons for this variable to be a relevant instrument. First, according to previous studies (e.g., Nakamura et al., 2001), organization size (measured by the number of employees) is positively correlated with EMS certification, likely because the fixed costs of certification are less significant for large organizations than for small ones. The number of employees is therefore expected to be correlated with ems and thereby satisfies condition (A) unless a large number of organizations implement EMSs without certification. Second, it does not seem plausible that the number of employees in the individual's organization has a direct influence on whether (s)he is engaged in energy conservation practices at home. In addition, a priori, there is little reason to think that the size of the organization is systematically associated with the extent to which its employees are environmentally conscious. For these reasons, the number of employees in the organization the individual works for is unlikely to be correlated with v_j in equation (2) or ω_j in equation (3). We therefore assume that it satisfies conditions (B) and (C).

Table 6 provides the results when all individuals are examined. As Columns (1), (3), (5), and (7) show, the first stage results are as expected. In each case, dummy variables for the number of employees are positively correlated with ems. In addition, almost all the coefficients are found to be significant at the one percent level, suggesting that the instrument is not weak. These results therefore confirm that the number of employees satisfies condition (A) for a valid instrument. Columns (2), (4), (6), and (8) provide the second stage results. For each practice, the first stage residual ($\hat{\omega}_j$) is found to be far from statistically significant, with a p-value larger than 0.5. Hence, there is no strong evidence to suggest that ems is an endogenous variable. We also test for the endogeneity of ems in all the models reported in Tables 4 and 5[11]. For almost all models[12], similar results are obtained in favor of the exogeneity of ems (and ems_dk). It can therefore be concluded that our main findings are not a result of bias due to endogeneity.

4. Do EMSs Lower Household Energy Consumption?

4.1 The Model

We now address the second question: whether household expenditures on electricity use are lower for those who work in organizations with EMSs than for those who do not. We assume that the individual's monthly household expenditure on electricity use ($bill^*$) depends on ems, $\boldsymbol{x}$, and the error term (ε):

$$\ln(bill^*) = \gamma_0 + \gamma_1 \cdot ems + \boldsymbol{x\phi} + \varepsilon, \tag{4}$$

where $(\gamma_0, \gamma_1, \boldsymbol{\phi}')$ are unknown parameters and ε is normally distributed with mean zero and variance σ^2. Due to the design of the survey item used for this analysis, we do not directly observe $bill^*$; instead, interval-coded data ($bill$) are available. Specifically, $bill = 1$ if $bill^* < \tau_1$ (=2 thousand yen), $bill = 2$ if $\tau_1 \leq bill^* < \tau_2$ (=4 thousand yen),

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[11] For the models presented in Table 5 (i.e., the models that include ems_dk), we conducted endogeneity tests in a manner similar to that described in the main text. Specifically, we first extend equation (2) by including ems_dk:

$$ecp_j^* = \alpha_{1j} \cdot ems + \alpha_{2j} \cdot ems\_dk + \boldsymbol{x\beta_j} + \rho_{1j} \cdot \omega_{1j} + \rho_{2j} \cdot \omega_{2j} + v_j,$$

where ω_{1j} (ω_{2j}) captures a set of unobserved factors that are uncorrelated with $\boldsymbol{x}$ but correlated with ems(ems_dk). We also modify equation (3) as follows: $ems = g_1(\boldsymbol{x\gamma}_{1j} + z\delta_{1j}) + \omega_{1j}$ and $ems\_dk = g_2(\boldsymbol{x\gamma}_{2j} + z\delta_{2j}) + \omega_{2j}$. For $g_k(\cdot), (k = 1,2)$, we choose a multinomial logit form. Then, these equations become a multinomial logit model where the base category is "no." Given this setup, we use the following two-stage procedure. In the first stage, we estimate the multinomial logit model using maximum likelihood and compute the residuals $\widehat{\omega}_{1j} = ems - g_1(\boldsymbol{x\widehat{\gamma}_{1j}} + z\hat{\delta}_{1j})$ and $\widehat{\omega}_{2j} = ems\_dk - g_2(\boldsymbol{x\widehat{\gamma}_{2j}} + z\hat{\delta}_{2j})$. In the second stage, we estimate the ordered probit model by substituting $\widehat{\omega}_{kj}$ into ω_{kj} ($k = 1,2$). The joint null hypothesis that $\rho_{1j} = \rho_{2j} = 0$ (i.e., the exogeneity of ems and ems_dk) can be tested by using a Wald test.

[12] Only in the case of the light practice for women is *ems* endogenous and statistically significant at the one percent level. The results are available upon request.

$bill = 3$ if $\tau_2 \le bill^* < \tau_3$ (=6 thousand yen), $bill = 4$ if $\tau_3 \le bill^* < \tau_4$ (=8 thousand yen), $bill = 5$ if $\tau_4 \le bill^* < \tau_5$ (=10 thousand yen), $bill = 6$ if $\tau_5 \le bill^* < \tau_6$ (=12 thousand yen), $bill = 7$ if $\tau_6 \le bill^* < \tau_7$ (=14 thousand yen), $bill = 8$ if $\tau_7 \le bill^* < \tau_8$ (=16 thousand yen), $bill = 9$ if $\tau_8 \le bill^* < \tau_9$ (=18 thousand yen), $bill = 10$ if $\tau_9 \le bill^* < \tau_{10}$ (=20 thousand yen), and $bill = 11$ if $bill^* \ge \tau_{10}$. The response probabilities, $\Pr(bill = j|ems, \boldsymbol{x})$, $(j = 1, \dots, 11)$, resemble those of an ordered probit model, except that the threshold parameters (τ's) are all known to the researcher. The parameters $(\gamma_0, \gamma_1, \boldsymbol{\phi}', \sigma^2)$ are estimated by maximum likelihood and can be interpreted as if one had observed $bill^*$ and estimated $E(bill^*|ems, \boldsymbol{x})$ by ordinary least squares (Wooldridge, 2010, page 783).

4.2 Data

For this analysis, we use data from another online survey that was conducted in February 2014, in Japan. It included 6,500 individuals aged 20 or older. In terms of the survey procedure, we made the same geographical adjustment as explained earlier. After individuals who were unemployed or provided incomplete answers are excluded, the sample size is reduced to 2,905.

This survey is broadly similar to the one used for the previous analysis in that regarding individual characteristics, it asked about EMSs and sociodemographic and household characteristics. Unlike the previous survey, however, this survey further asked whether the individual's house is all electrified ($allelectric$) and whether it is equipped with a photovoltaic system (pv). These variables are particularly important to address the current question. Undoubtedly, home all-electric systems and photovoltaic systems are important determinants of household electricity expenditure. In addition, the installation of these systems may partly depend on ems. Therefore, without controlling for them, the regression of equation (4) would suffer from omitted variable bias[14]. For this reason, we decided to use this survey rather than the previous one for the current analysis.

While it allows us to control for the installation of all-electric and photovoltaic systems, the use of this survey comes with some cost. Specifically, this survey did not ask about the number of employees in the organization the respondent works for and therefore does not provide a relevant instrumental variable to control for potential endogeneity of ems. As a result, when estimating equation (4), we need to treat ems as an exogenous variable. Admittedly, this assumption seems to be rather strong; however, it may be less strong than it seems to be, because the results in the previous section are consistently and strongly in favor of the exogeneity of ems.

Table 7 presents the descriptive statistics of the data. For the variable of electricity expenditure, we use the following survey question: "(h)ow much money did you spend on electricity in January 2014?" Respondents were asked to choose from the eleven responses introduced previously. Figure 1(e) shows the distributions of electricity expenditures ($bill$) for $ems = 1$ and $ems = 0$. From the figure, it is somewhat unclear whether the distributions differ across the two groups in a significant manner. Indeed, although the mean of electricity expenditures for $ems = 1$ is greater than that for $ems = 0$, the mean-comparison test shows that there is no significant difference in mean values

[14] To see this, consider all-electric systems, for example. Notice first that other things being equal, expenditures on electricity are higher for households that install all-electric systems than for those that do not, as all heating and lighting are electric for the former while not for the latter. Second, to the extent that individuals are induced by EMSs to care more about electricity consumption, they may be more inclined to install all-electric systems when working for organizations with EMSs because all-electric systems are generally considered as more energy efficient than conventional electric systems. It is therefore expected that $allelectric$ and ems are positively correlated (which is indeed the case with our data). These two factors combined, the omission of $allelectric$ from a regression of household electricity expenditure will likely result in omitted variable bias, more specifically, an upwardly biased estimate of the coefficient on ems.

between the groups. In addition, the Kolmogorov-Smirnov test cannot reject the null hypothesis that the distributions are equal. At first glance, these results seem to suggest that ems is not significantly associated with $bill$. As we will see, however, the results are an artifact of not controlling for individuals' observed characteristics.

4.3 The Results

Table 8 presents the estimation results. We first estimate equation (4) without controlling for whether the individual's house is all electrified and whether a photovoltaic system has been installed. As presented in Column (1), the coefficient on ems is found to be negative and significant at the one percent level. This result does not change even after we control for $allelectric$ (i.e., whether the individual's house is all electrified), as presented in Column (2).

It should be noted that the estimated coefficient becomes larger in magnitude when we control for $allelectric$ than when we do not. This finding demonstrates the importance of controlling for $allelectric$. Specifically, the regression in Column (1) is subject to omitted variable bias; if $allelectric$ is not controlled for, the magnitude of the effect of ems will be underestimated (see footnote 14). This bias is attributed to a positive correlation between ems and $allelectric$ (a correlation coefficient of 0.07) as well as a positive conditional correlation between $allelectric$ and $\ln(bill)$ as found in Column (2) (a regression coefficient of 0.315).

We further control for pv (i.e., whether a photovoltaic system is installed). Although the estimated coefficient becomes somewhat smaller in magnitude, as presented in Column (3), it remains negative and statistically significant at the one percent level. Overall, these results are consistent with the argument that household expenditures on electricity use are lower when individuals work in organizations that implement EMSs than when they work in organizations that do not.

In addition to the statistical significance, the economic significance of the EMS effect may be noteworthy. The point estimates of the coefficient on ems range from -0.077 to -0.059, corresponding to a decrease in household electricity expenditure by approximately five to eight percent. The effect does not seem to be negligible, taking into account that it is a byproduct of EMSs whose original purpose is to help organizations reduce the environmental impacts generated by their activities.

5. Conclusion

This paper investigated whether an EMS in the workplace promotes energy conservation behaviors at home. This hypothesis is supported by data from surveys of individuals in Japan; specifically, we found that the probability that individuals will engage in energy conservation practices at home is higher when they work in organizations that implement EMSs than when they work in organizations that do not implement EMSs. We also found that there are gender differences in the effect of EMSs; men are influenced by EMSs in a wider variety of energy conservation practices than women are. We further provide evidence that expenditures on electricity use are lower for individuals who work in organizations with EMSs than for those who work in organizations without EMSs. These results are intriguing because the designers or implementers of EMSs are unlikely to be aware that EMSs play a role in promoting household energy conservation.

Our results have several important implications. First, even if EMSs do not improve the environmental performance of firms or facilities (e.g., Barla, 2007; Dahlström et al., 2003; Darnall and Sides, 2008), EMSs can be socially beneficial by reducing employees' household energy consumption. This may provide a rationale for the policies that some government authorities have already introduced, such as reduction in the frequency of inspections and provision of subsidies for organizations that implement (certified) EMSs.

Second, the effect of EMSs may be even larger than our results indicate due to green supply chain management. According to Arimura et al. (2011), facilities with certified EMSs are more likely to require that their suppliers undertake specific environmental practices, one of which is often EMS implementation. Our results, combined with those of Arimura et al. (2011), suggest that when an EMS is implemented by a downstream firm, upstream firms tend to start implementing EMSs, which in turn makes it more likely that employees in the upstream firms engage in energy conservation activities. Thus, EMSs may have a multiplier effect on household energy conservation behaviors.

Lastly, recommendations are provided for future research directions. One direction is to examine a wider variety of energy conservation practices than those this study addresses. Another and more fruitful direction may be to conduct a cross-country study and thereby examine whether findings in this study can be generalized to countries other than Japan.

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Table 1. Descriptive Statistics

Variable	Obs.	Mean	SD	Min	Max
ecp_1: Set to 28 degrees in summer	1,435	2.95	1.09	1	4
ecp_2: Set to 20 degrees in winter	923	2.66	1.15	1	4
ecp_3: Turn TV off when unnecessary	1,641	2.87	1.14	1	4
ecp_4: Turn light off when unnecessary	1,723	2.81	1.13	1	4
ems	1,723	0.18	0.38	0	1
ems_dk	1,723	0.43	0.49	0	1
Comfortable temperature in summer	1,435	25.94	2.08	16	30
Comfortable temperature in winter	923	22.80	2.82	15	30
Area-average temperature in January 2016	1,723	4.84	3.05	-9.68	19.66
Male	1,723	0.60	0.49	0	1
Age	1,723	43.61	12.30	20	69
Married	1,723	0.48	0.50	0	1
Employed regularly	1,723	0.53	0.50	0	1
Number of family members	1,723	2.81	1.32	1	9
House type					
Owned house	1,723	0.65	0.48	0	1
Detached house	1,723	0.56	0.50	0	1
TV type					
Liquid crystal	1,641	0.89	0.31	0	1
Plasma	1,641	0.08	0.27	0	1
Others	1,641	0.03	0.16	0	1
Household income					
Less than 2 million yen	1,723	0.08	0.28	0	1
Between 2 million yen and 3 million yen	1,723	0.11	0.31	0	1
Between 3 million yen and 4 million yen	1,723	0.15	0.36	0	1
Between 4 million yen and 5 million yen	1,723	0.15	0.36	0	1
Between 5 million yen and 7 million yen	1,723	0.19	0.39	0	1
Between 7 million yen and 10 million yen	1,723	0.20	0.40	0	1
Between 10 million yen and 15 million yen	1,723	0.09	0.28	0	1
More than 15 million yen	1,723	0.03	0.16	0	1
Educational status					
Junior high school	1,723	0.02	0.14	0	1
High school	1,723	0.26	0.44	0	1
Higher professional school	1,723	0.07	0.25	0	1
Junior college	1,723	0.11	0.31	0	1
University	1,723	0.46	0.50	0	1
Graduate school	1,723	0.06	0.23	0	1
Others	1,723	0.03	0.17	0	1
Occupational type					
Specialist	1,723	0.25	0.43	0	1

Administration	1,723	0.06	0.24	0	1
Desk work	1,723	0.27	0.44	0	1
Sales	1,723	0.12	0.33	0	1
Service	1,723	0.13	0.34	0	1
Production	1,723	0.13	0.33	0	1
Maintenance	1,723	0.01	0.10	0	1
Agriculture	1,723	0.01	0.10	0	1
Transportation and communication	1,723	0.02	0.15	0	1
Industry					
Agriculture and fishery	1,723	0.01	0.11	0	1
Construction	1,723	0.06	0.23	0	1
Manufacturing	1,723	0.17	0.37	0	1
Energy	1,723	0.01	0.11	0	1
Information and communication	1,723	0.08	0.26	0	1
Transportation	1,723	0.03	0.18	0	1
Wholesale, retail, and restaurant	1,723	0.14	0.34	0	1
Finance, insurance, and estate	1,723	0.06	0.23	0	1
Service	1,723	0.38	0.48	0	1
Public	1,723	0.07	0.26	0	1

Table 2. Mean-comparison Tests

	ems =0		*ems* =1		t-value	
All	Obs.	Mean	Obs.	Mean		
ecp_1: Set to 28 degrees in summer	1,161	2.90	274	3.17	-3.96	***
ecp_2: Set to 20 degrees in winter	727	2.56	196	3.03	-5.51	***
ecp_3: Turn TV off when unnecessary	1,342	2.80	299	3.14	-4.93	***
ecp_4: Turn light off when unnecessary	1,416	2.75	307	3.07	-4.69	***
Men						
ecp_1: Set to 28 degrees in summer	677	2.79	206	3.18	-4.70	***
ecp_2: Set to 20 degrees in winter	431	2.54	149	2.99	-4.32	***
ecp_3: Turn TV off when unnecessary	770	2.85	222	3.19	-4.22	***
ecp_4: Turn light off when unnecessary	811	2.78	228	3.07	-3.73	***
Women						
ecp_1: Set to 28 degrees in summer	484	3.04	68	3.15	-0.77	
ecp_2: Set to 20 degrees in winter	296	2.58	47	3.17	-3.83	***
ecp_3: Turn TV off when unnecessary	572	2.74	77	3.01	-1.90	
ecp_4: Turn light off when unnecessary	605	2.72	79	3.06	-2.50	***

Note: ***, **, and * correspond to the one, five, and ten percent levels of significance, respectively.

Table 3. Estimation Results for Energy Conservation Practices

	(1)	(2)	(3)	(4)
	ecp$_1$ (Summer)	*ecp*$_2$ (Winter)	*ecp*$_3$ (TV)	*ecp*$_4$ (Light)
ems	0.369***	0.613***	0.377***	0.356***
	(0.093)	(0.090)	(0.076)	(0.069)
Comfortable temperature in summer	0.241***			
	(0.024)			
Comfortable temperature in winter		-0.201***		
		(0.013)		
Area-average temperature in January 2016	0.0504*	0.0166	0.0229	0.0091
	(0.030)	(0.033)	(0.019)	(0.024)
Male	-0.120	0.036	0.198***	0.132**
	(0.091)	(0.107)	(0.077)	(0.053)
Age	0.008***	0.001	0.001	0.003
	(0.003)	(0.003)	(0.003)	(0.003)
Married	-0.050	-0.089	-0.024	-0.029
	(0.060)	(0.080)	(0.063)	(0.084)
Employed regularly	-0.117	-0.099	-0.114*	-0.139***
	(0.083)	(0.101)	(0.064)	(0.049)
Number of family members	-0.015	-0.004	0.034	0.034
	(0.024)	(0.034)	(0.034)	(0.027)
Owned house	-0.010	0.067	0.028	-0.031
	(0.080)	(0.103)	(0.088)	(0.106)
Detached house	0.064	0.072	0.063	0.076
	(0.072)	(0.100)	(0.073)	(0.090)
Threshold 1 (μ_1)	5.074***	-5.066***	-0.013	-0.587
	(0.683)	(0.591)	(0.749)	(0.738)
Threshold 2 (μ_2)	5.821***	-4.259***	0.597	0.093
	(0.702)	(0.579)	(0.742)	(0.739)
Threshold 3 (μ_3)	6.551***	-3.589***	1.159	0.699
	(0.716)	(0.574)	(0.736)	(0.733)
Log-likelihood	-1680.3	-1111.1	-2111.8	-2249.7
Obs.	1,435	923	1,641	1,723

Note: Standard errors clustered by prefecture are presented in parentheses. ***, **, and * correspond to the one, five, and ten percent levels of significance, respectively. Dummy variables for education, for occupation, for the industry the respondent works in, for household income, for prefectures, and for TV types are included in each model, although the results are not presented here for the sake of saving space.

Table 4. Estimation Results by Gender Groups

		(1)	(2)	(3)	(4)
		*ecp*1 (Summer)	*ecp*2 (Winter)	*ecp*3 (TV)	*ecp*4 (Light)
Men	Obs.	883	580	992	1,039
ems		0.476***	0.577***	0.447***	0.417***
		(0.104)	(0.108)	(0.079)	(0.067)
Average partial effect of *ems* on					
Pr(Never)		-0.092***	-0.136***	-0.105***	-0.099***
		(0.021)	(0.026)	(0.02)	(0.017)
Pr(Rarely)		-0.057***	-0.049***	-0.050***	-0.047***
		(0.013)	(0.008)	(0.009)	(0.007)
Pr(Occasionally)		-0.007***	0.017***	-0.011***	-0.001
		(0.002)	(0.003)	(0.002)	(0.001)
Pr(Fairly often)		0.156***	0.168***	0.166***	0.148***
		(0.034)	(0.031)	(0.029)	(0.024)
Women	Obs.	552	343	649	684
ems		0.152	1.099***	0.246	0.236
		(0.185)	(0.215)	(0.196)	(0.183)
Average partial effect of *ems* on					
Pr(Never)		-0.023	-0.235***	-0.063	-0.059
		(0.028)	(0.045)	(0.051)	(0.045)
Pr(Rarely)		-0.016	-0.072***	-0.025	-0.027
		(0.020)	(0.013)	(0.019)	(0.021)
Pr(Occasionally)		-0.007	0.032***	0.004	0.004
		(0.009)	(0.006)	(0.003)	(0.003)
Pr(Fairly often)		0.047	0.275***	0.084	0.082
		(0.057)	(0.051)	(0.067)	(0.063)

Note: The numbers in the column "*ems*" present estimates of the coefficients on *ems* in equation (1) for all practices. Standard errors clustered by prefecture are presented in parentheses. ***, **, and * correspond to the one, five, and ten percent levels of significance, respectively. The same control variables as in Table 3 are included in each model. The results for control variables are not presented here for the sake of saving space but are available upon request.

Table 5. Estimation Results When the "Don't Know" Dummy is Included

		(1)	(2)	(3)	(4)
		ecp_1 (Summer)	ecp_2 (Winter)	ecp_3 (TV)	ecp_4 (Light)
All	Obs.	1,435	923	1,641	1,723
ems		0.308***	0.540***	0.309***	0.313***
		(0.088)	(0.096)	(0.071)	(0.063)
ems_dk		-0.118	-0.160	-0.137**	-0.099*
		(0.086)	(0.121)	(0.069)	(0.059)
Average partial effect of *ems* on					
Pr(Never)		-0.057***	-0.130***	-0.078***	-0.078***
		(0.017)	(0.022)	(0.019)	(0.016)
Pr(Fairly often)		0.105***	0.159***	0.116***	0.114***
		(0.03)	(0.027)	(0.027)	(0.023)
Men	Obs.	883	580	992	1,039
ems		0.404***	0.495***	0.315***	0.339***
		(0.113)	(0.116)	(0.079)	(0.071)
ems_dk		-0.160	-0.181	-0.296***	-0.178**
		(0.120)	(0.129)	(0.069)	(0.074)
Average partial effect of *ems* on					
Pr(Never)		-0.078***	-0.116***	-0.074***	-0.080***
		(0.023)	(0.028)	(0.019)	(0.018)
Pr(Fairly often)		0.132***	0.143***	0.116***	0.120***
		(0.037)	(0.033)	(0.029)	(0.025)
Women	Obs.	552	343	649	684
ems		0.056	1.005***	0.282	0.262
		(0.161)	(0.205)	(0.177)	(0.166)
ems_dk		-0.181	-0.176	0.068	0.046
		(0.169)	(0.266)	(0.171)	(0.130)
Average partial effect of *ems* on					
Pr(Never)		-0.008	-0.215***	-0.073	-0.065
		(0.024)	(0.041)	(0.045)	(0.041)
Pr(Fairly often)		0.017	0.251***	0.097	0.091
		(0.049)	(0.048)	(0.06)	(0.057)

Note: Standard errors clustered by prefecture are presented in parentheses. ***, **, and * correspond to the one, five, and ten percent levels of significance, respectively. The same control variables as in Table 3 are included in each model. The results for control variables and the results for the average partial effects on Pr(Rarely) and Pr(Occasionally) are not presented here for the sake of saving space but are available upon request.

Table 6. Test for Endogeneity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ecp_1 (Summer)		ecp_2 (Winter)		ecp_3 (TV)		ecp_4 (Light)	
	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
Number of employees: 11~50	0.493**		0.228		0.605***		0.627***	
	(0.221)		(0.228)		(0.193)		(0.184)	
Number of employees: 51~100	1.003***		0.742**		1.004***		0.990***	
	(0.264)		(0.329)		(0.234)		(0.239)	
Number of employees: 101~500	1.320***		1.025***		1.399***		1.432***	
	(0.182)		(0.243)		(0.168)		(0.155)	
Number of employees: 501~1000	1.479***		1.310***		1.668***		1.605***	
	(0.220)		(0.243)		(0.200)		(0.192)	
Number of employees: 1001~3000	1.577***		1.588***		1.638***		1.627***	
	(0.207)		(0.264)		(0.205)		(0.183)	
Number of employees: 3001~5000	1.416***		1.398***		1.545***		1.591***	
	(0.355)		(0.370)		(0.348)		(0.328)	
Number of employees: 5001~10000	1.859***		1.947***		1.911***		1.893***	
	(0.279)		(0.345)		(0.228)		(0.219)	
Number of employees: 10001~	2.051***		1.680***		2.181***		2.112***	
	(0.270)		(0.399)		(0.211)		(0.211)	
ems		0.327		0.739**		0.252		0.339
		(0.338)		(0.376)		(0.229)		(0.226)
1st stage residual		0.0240		-0.139		0.162		0.0648
		(0.299)		(0.389)		(0.240)		(0.236)
Threshold 1 (μ_1)		4.778***		-5.453***		-0.727		-1.353**
		(0.778)		(0.886)		(0.635)		(0.678)
Threshold 2 (μ_2)		5.523***		-4.629***		-0.123		-0.672
		(0.797)		(0.859)		(0.642)		(0.685)
Threshold 3 (μ_3)		6.263***		-3.929***		0.418		-0.0713
		(0.819)		(0.848)		(0.647)		(0.685)
Constant	-8.386***		-5.474***		-7.618***		-3.461***	
	(0.914)		(1.249)		(0.705)		(0.629)	
Log-likelihood	-406.9	-1204.8	-283.0	-810.5	-449.6	-1547.0	-466.1	-1638.8
Obs.	1,042	1,042	682	682	1,210	1,210	1,264	1,264

Note: Standard errors clustered by prefecture are presented in parentheses. ***, **, and * correspond to the one, five, and ten percent levels of significance, respectively. Probit is used in the first stage estimation. The same control variables as in Table 3 are included in each model. The results for control variables are not presented here for the sake of saving space but are available upon request.

Table 7. Descriptive Statistics

Variable	Obs.	Mean	SD	Min	Max
bill	2,905	5.598	2.694	1	11
ems	2,905	0.222	0.416	0	1
Area-average temperature in January 2014	2,905	4.750	3.046	-4.1	16.8
All-electric house	2,905	0.156	0.363	0	1
Photovoltaic system	2,905	0.070	0.254	0	1
Male	2,905	0.616	0.486	0	1
Age	2,905	43.782	11.820	20	69
Married	2,905	0.610	0.488	0	1
Employed regularly	2,905	0.635	0.482	0	1
Number of family members	2,905	2.889	1.362	1	9
Owned house	2,905	0.665	0.472	0	1
Detached house	2,905	0.545	0.498	0	1
Household income (less than 2 million yen)	2,905	0.064	0.245	0	1
Household income (between 2 million yen and 3 million yen)	2,905	0.102	0.303	0	1
Household income (between 3 million yen and 4 million yen)	2,905	0.138	0.345	0	1
Household income (between 4 million yen and 5 million yen)	2,905	0.153	0.360	0	1
Household income (between 5 million yen and 7 million yen)	2,905	0.218	0.413	0	1
Household income (between 7 million yen and 10 million yen)	2,905	0.191	0.393	0	1
Household income (between 10 million yen and 15 million yen)	2,905	0.101	0.301	0	1
Household income (more than 15 million yen)	2,905	0.032	0.177	0	1
Educational status (high school)	2,905	0.282	0.450	0	1
Educational status (higher professional school)	2,905	0.090	0.287	0	1
Educational status (junior college)	2,905	0.102	0.302	0	1
Educational status (university)	2,905	0.456	0.498	0	1
Educational status (graduate school)	2,905	0.054	0.226	0	1
Educational status (others)	2,905	0.016	0.126	0	1
Occupation (company executive)	2,905	0.149	0.357	0	1
Occupation (company employee)	2,905	0.506	0.500	0	1
Occupation (public worker)	2,905	0.070	0.255	0	1
Occupation (part-time worker)	2,905	0.274	0.446	0	1

Table 8. Estimation Results for Electricity Expenditure

	(1)	(2)	(3)
ems	-0.059***	-0.077***	-0.065***
	(0.018)	(0.017)	(0.019)
Area-average temperature in January 2014	0.002	0.001	0.001
	(0.010)	(0.008)	(0.008)
All-electric house		0.315***	0.363***
		(0.033)	(0.031)
Photovoltaic system			-0.207***
			(0.049)
Male	0.045**	0.051***	0.050***
	(0.019)	(0.019)	(0.019)
Age	0.006***	0.007***	0.007***
	(0.001)	(0.001)	(0.001)
Married	0.024	0.011	0.017
	(0.020)	(0.018)	(0.018)
Employed regularly	-0.028	-0.039	-0.037
	(0.044)	(0.045)	(0.045)
Number of family members	0.143***	0.144***	0.143***
	(0.011)	(0.011)	(0.010)
Owned house	0.224***	0.201***	0.205***
	(0.027)	(0.025)	(0.025)
Detached house	0.160***	0.125***	0.142***
	(0.018)	(0.017)	(0.019)
ln(sigma)	-0.702***	-0.725***	-0.729***
	(0.017)	(0.016)	(0.016)
Constant	7.944***	7.902***	7.908***
	(0.094)	(0.0827)	(0.0842)
Log-likelihood	-5865.4	-5798.9	-5785.9
Chi-squared	9717.6***	13205.1***	13055.2***
Obs.	2,905	2,905	2,905

Note: Standard errors clustered by prefecture are presented in parentheses. ***, **, and * correspond to the one, five, and ten percent levels of significance, respectively. The results for other control variables (dummies for household income, dummies for educational status, and dummies for occupation) are not presented here for the sake of saving space but are available upon request.

Figure 1. Distributions of Energy Conservation Practices and Electricity Bills

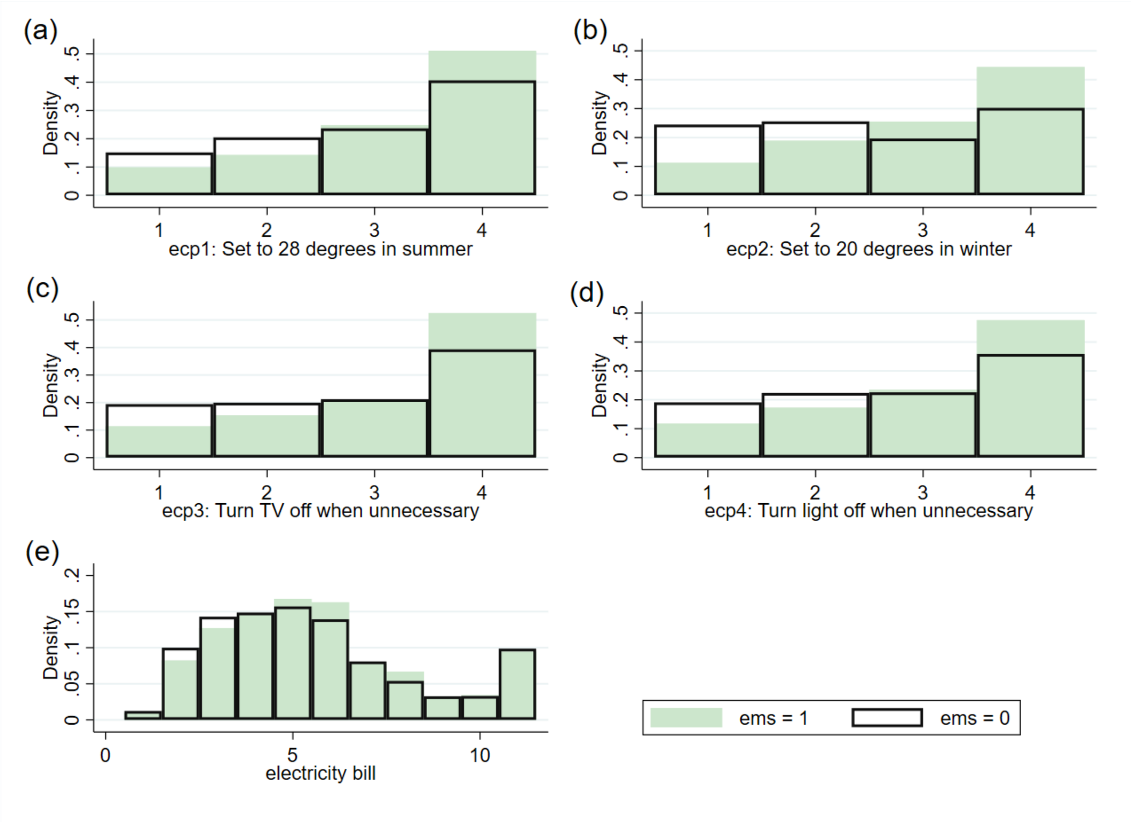

Figure 2. Average Partial Effects of EMSs on Energy Conservation Practices