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A Field Experiment on the Choice of Power Tariffs Before and After Japanese Retail Electricity Liberalization

Takunori Ishihara, Takanori Ida

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Graduate School of Economics
Kyoto University
Yoshida-Hommachi, Sakyo-ku
Kyoto City, 606-8501, Japan

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The Effect of Information Provision on Stated and Revealed Preferences:

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Takunori Ishihara[1]

Takanori Ida[2]

Abstract

This paper examines differences in attitudes towards electricity fee plans when information is provided on electricity bills based on past electricity consumption. We conducted randomized controlled trial stated preference (SP) and revealed preference (RP) experiments on the choice of electricity rates before and after liberalization. In the SP experiment, we measured participants' valuations of their electricity pricing plans. We found that providing information about the participants' benefit from switching diminished the tendency towards overconfidence. The valuation decreases substantially, when information is provided showing that a loss will be incurred from switching. The results of the RP and SP experiments differ. We found that the selection was not changed in the RP experiment, even when providing information that a loss would be incurred.

JEL classification: C93, D91, Q49.
Keywords: Randomized controlled trial (RCT), Stated preference, Revealed preference, Information provision, Power tariff, Overconfidence.

[1] Faculty of Economics and Business Administration, Kyoto University of Advanced Science, ishihara.takunori@kuas.ac.jp
[2] Graduate School of Economics, Kyoto University, ida@econ.kyoto-u.ac.jp

1. Introduction

In Japan, the complete liberalization of the electricity market, including household energy provision, began in April of 2016. As a result of this change, consumers were no longer tied to their local electricity company and became able to choose their electricity provider. In addition, before the liberalization of electricity provision, the choice of time-of-use plans was largely restricted to all-electric households, with all other consumers contracted via fixed-price contracts. However, through complete liberalization, consumers were able to freely choose both their electricity provider and the type of contract, such as fixed price or time-of-use contracts, based on their preferences. Both old and new providers began to offer these new time-of-use-based plans, and if consumers would begin to select plans that were appropriate for their lifestyles, the potential existed for an improvement in the consumer surplus and social welfare. Therefore, the central research question examined here is whether, when these time-of-use-based electricity plans were offered, consumers were able to choose the time-of-use-based plan that was appropriate for them.

As of March 2017, approximately one year after liberalization, the switching rate was approximately 8.8% (or 5.53 million households), of which the rate of switching to a new power company was approximately 4.7% (Agency for Natural Resources and Energy, 2017). In addition, the conversion rate from a regulated tariff plan to a free tariff plan within the major power companies was approximately 4.1%. Furthermore, as of February 2018, the switching rate was 15.5% (approximately 9.7 million households), of which approximately 9.5% switched to a new power company, and the rate of switching from a regulated tariff plan to a free tariff plan within major power companies was approximately 6.0% (Agency for Natural Resources and Energy, 2018). Thus, during and just after the experiment period, switching to new power companies and new rate plans remains uncommon despite liberalization.

The reason for this is “inertia” (Hartman et al., 1991); that is, consumers do not seek out alternative tariff plans or utilities (Hortaçsu et al., 2017). Consumers do not want to exert energy to search for another plan or power company, and hence even if it costs them more, they may choose to retain their current plan. In such situations, it is possible to promote consumer choice by providing information to consumers (Bertrand and Morse, 2011; Giné and Mazer, 2016).

Regarding consumer perceptions of electricity prices, Borenstein (2009) and Ito (2014) show that consumers respond to the average price, not the marginal price. Therefore, it is possible that they do not respond to the electricity price, even after correctly recognizing their own consumption patterns. Chetty et al. (2009), Finkelstein (2009), and Sexton (2015) have also shown that, in the context of taxes and power savings, the reaction to a tax becomes weak when the salience of price is low. Furthermore, those who switch may believe that they can reduce their monthly electricity bill payments by the time-of-use (TOU) tariff and may have made the switch regardless of their actual

consumption patterns. This tendency is called "overconfidence" and has been observed in attitudes towards investment (Barber and Odean, 2001) and people's expectations about their own abilities (Clark and Friesen, 2008; Eil and Rao, 2011; Ertac, 2011), and future preferences (Thunström, Nordström and Shogren, 2015). Overconfidence positively correlates with optimism (Heger and Papageorge, 2018). Therefore, even if they wish to change their power plan and the company, it is possible that consumers will not be able to select the appropriate plan and company because they have an insufficient understanding of their own consumption patterns[3].

The RECAP (read, evaluate, and compare alternative prices) approach to providing information is known for its effectiveness (Thaler and Sunstein, 2009). In the case of information asymmetry, whereby the enterprise has more information about consumers than consumers do, providing the consumers with information about their own consumption and payments will make it possible for them to identify which plan will benefit them (or not), thereby improving consumer welfare (Kamenica et al., 2010). Kling et al. (2011) empirically verified changes in consumer choice by providing such RECAP-type information. In examining the market for health insurance plans for the elderly, they found that approximately 11% of people will appropriately change their decision if provided with information on the current plan and the cheapest plan.

This paper presents an experiment that investigates whether consumers will properly select a rate plan if they are provided with RECAP-type information. Stated preference (SP) and revealed preference (RP) regarding the choice of power plan before and after power liberalization are considered. A randomized controlled trial (RCT) was conducted to verify the effect of information provision. In RCTs, subjects are randomly assigned to control groups that do not receive the intervention and treatment groups that receive the intervention. Because the assignment is random, the covariates in the treatment and control groups are considered homogeneous on average, and the difference in average outcome can be interpreted as the difference due to the intervention. Therefore, the internal validity of the average treatment effect (ATE) is ensured by performing RCTs. The intervention we performed detailed 30 minutes of electric power usage data for each subject in the summer of 2015 as RECAP-type information provision. For each subject in the treatment group, monthly electricity rates calculated by each tariff plan were provided using a flat plan that does not change the tariff rate and a TOU plan in which the day and night rates fluctuate. We also provided the price differences. We found that the tendency towards overconfidence is significantly corrected, and

[3] For the different literature, some studies on switching electricity companies and contract plans have been conducted, such as Ek and Söderhorm (2008), He and Reiner (2017), and Shin and Managi (2017). He and Reiner (2017) show that consumers' attitudes towards the costs and benefits of switching affect switching behaviour. Ek and Söderhorm (2008) show that the switching rate tends to be higher for consumers who obtain significant benefits from switching, whereas those with small benefits are less likely to switch. Shin and Managi (2017) show that the higher the intention to switch before liberalization, the higher the switching rate after liberalization.

the overall valuation decreases when consumers are given information about gaining or losing by changing their electricity rate plan in the SP experiment. In particular, we found that when consumers know that they will lose money by switching, loss aversion is evident, and the valuation is greatly reduced. Furthermore, we found that the results of the RP and SP approaches differed somewhat, and the selection was conservative in the RP experiment.

The structure of this paper is as follows. Section 2 explains the conceptual framework. Section 3 outlines the experimental design of the study. Section 4 focuses on the experimental design of the SP experiment, presents the hypothesis of the experiment, and explains the estimation method. Section 5 provides the same information for the RP experiment. Section 6 discusses the results and concludes the paper.

2. Conceptual framework

In this section, based on Kamenica et al. (2011), we consider the following model for the situation in which a consumer chooses an electricity rate plan. In this market, we assume that there are two types of consumers, with each constituting 50% of the sample. One type, ($s_i = W$), exhibits high power consumption at off-peak time ($t = 0$), and the other type, ($s_i = L$), exhibits high power consumption at peak time (t = 1). Consumer i is assumed to use power only monthly for $x_i^{s_i}$. In addition, consumers with high power consumption during off-peak hours have low power consumption during peak hours, and consumers with low power consumption during off-peak hours have high power consumption during peak hours[4]. The power used by each type of consumer is

$$x_i^{s_i=W} = \begin{cases} h & if \quad t = 0 \\ l & if \quad t = 1 \end{cases} \qquad x_i^{s_i=L} = \begin{cases} l & if \quad t = 0 \\ h & if \quad t = 1' \end{cases}$$

where $h > l > 0$.

In this market, we further assumed that all consumers are initially under a flat rate plan (FLAT). Then, the TOU plan is newly introduced to the market, and consumers have the opportunity to change plans. In FLAT, the unit price of the electricity tariff does not change depending on the time. Let this price be p. In TOU, the unit price of power fluctuates between off-peak and peak times, and we set the off-peak price as q_l and the peak price as q_h. Additionally, we set $q_h > q_l > 0$. Here, we assume revenue neutrality for TOU and let $p = \frac{1}{2}(q_h + q_l)$ hold.

[4] For example, type $s_i = W$ represents night consumption, and type $s_i = L$ represents day consumption. The peak consumption of large industrial and commercial customers occurs in the daytime, so the framework of this paper represents reality.

Under these tariff plans, if consumers choose FLAT, the monthly payments for both types of consumers are equal; $e^{FLAT} = p(h + l)$. When they select TOU, the consumer's payment of $s_i = W$ is ${e_h}^{TOU} = q_l h + q_h l$ and the consumer payment of $s_i = L$ is ${e_l}^{TOU} = q_l l + q_h h$. For consumers with $s_i = W$, because $e^{FLAT} - {e_h}^{TOU} > 0$ holds[5], TOU is cheaper than FLAT. Therefore, consumers with $s_i = W$ are expected to switch to TOU to benefit from lower monthly payments. For consumers with $s_i = L$, FLAT is cheaper than TOU because $e^{FLAT} - {e_l}^{TOU} < 0$. Therefore, it is expected that consumers with $s_i = L$ will not switch from FLAT because their monthly payment would increase if they chose TOU.

Next, we consider the case in which information asymmetry exists. In this case, consumers do not know their own consumption pattern, but the company has this knowledge. When considering switching plans, consumer i receives information $\theta_i = \{W, L\}$ about her power usage pattern. The probability that consumer i relies on this information (λ) is

$$\Pr\left(x_i^{s_i} \middle| \theta_i\right) = \begin{cases} \lambda & if \quad x_i^{s_i} = \theta_i \\ 1 - \lambda & if \quad x_i^{s_i} \neq \theta_i \end{cases},$$

where $\lambda \in [1/2, 1]$.

The conditional expected value of $x_i^{s_i}$ when consumer i receives information $\theta_i = W$ is

$$\mathrm{E}\left[x_i^{s_i} \middle| \theta_i = W\right] = \begin{cases} (h - l)\lambda + l & if \quad t = 0 \\ -(h - l)\lambda + h & if \quad t = 1 \end{cases}.$$

The conditional expected value of $x_i^{s_i}$ when consumer i receives information $\theta_i = L$ is

$$\mathrm{E}\left[x_i^{s_i} \middle| \theta_i = L\right] = \begin{cases} -(h - l)\lambda + h & if \quad t = 0 \\ (h - l)\lambda + l & if \quad t = 1 \end{cases}.$$

When consumer i receives information $\theta_i = W$, she is expected to change to TOU because TOU is

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[5] The following relationship holds for the payment of FLAT (e^{FLAT}) and the consumer's payment of $s_i = W$ (${e_h}^{TOU}$).

$$\begin{aligned} e^{FLAT} - {e_h}^{TOU} &= p(h + l) - (q_l h + q_h l) \\ &= \frac{1}{2}(q_h + q_l)(h + l) - (q_l h + q_h l) \\ &= \frac{1}{2}(q_h - q_l)(h - l) > 0 \end{aligned}$$

The first equation is derived from the definition of each payment. The second equation is derived from the assumption of revenue neutrality. For the last inequality, $h > l > 0$ and $q_h > q_l > 0$.

cheaper than FLAT when $\lambda \in (1/2,1]$. Additionally, if consumer i receives information $\theta_i = L$, she is expected to stay with FLAT because FLAT is cheaper than TOU when $\lambda \in (1/2,1]$. Furthermore, when $\lambda = 1/2$, consumer i is indifferent between the two plans[6].

In sum, when consumption information is provided, in the case of $\lambda \in (1/2,1]$, consumers who receive information $\theta_i = W$ choose TOU, and consumers who receive $\theta_i = L$ choose FLAT. In the case of $\lambda = 1/2$, consumers are indifferent between the two plans.

Based on the above, it is understood that when consumers are provided with information about their electricity usage patterns, they become able to choose an electricity plan that matches their own lifestyle patterns. If we consider the revenue neutrality that is imposed by electricity charges based on time of use, the proportions of those who gain and those who lose by switching to such a plan would be 50% each. Therefore, it should be expected that after people are provided with information, 50% of them will switch. However, the problem is that consumers are not aware in advance of whether they themselves will benefit or not. Therefore, the group of people who received information showing that they would lose out by making a switch are expected to give the plan a lower valuation when compared with the group that does not receive any information. Conversely, the group that receives information saying that they will benefit from switching should value the plan more highly when compared with the group that has not received information. In the experiment laid out below, through tests of revealed preference and stated preference, we will empirically prove whether consumer preferences change in the expected direction based on providing people with information regarding whether or not they would gain or lose from switching plans.

3. Experimental design

We conducted an SP and an RP experiment on electricity tariff plans before and after power retail liberalization in April 2016. The participants in this experiment were residents living along the Tokyu Railway Line in Aoba Ward, Yokohama City, Kanagawa Prefecture, who participated in the "large-scale HEMS information platform provision business" of the Tokyu Corporation[7]. In the target households of the experiment, a home energy management system (HEMS) was installed, and information on power consumption per 30 minutes was acquired during the summer of 2015 (June to

[6] If no information is given, then consumer i considers her type as random, so we treat this case as $\lambda = 1/2$.

[7] Table 10 in Appendix 1 shows the socio-economic attributes of the participants in each group. The average income ranged from 7.477 million yen to 7.587 million yen, which means that participants had a higher average income than Japan's national average. For this reason, it can be understood that the participants in the current survey were comparatively wealthy, even for Japan. For this reason, it is important to be careful regarding the external validity of the results of our analysis.

September). Due to the requirements for the protection of personal information, power consumption data could not be obtained outside the survey period.

First, we explain the flow of the experiment using Figure 1. A total of 1,063 households participated in the experiment[8]. We randomly divided the participants into two groups. The first group was the control group without the intervention (N = 531), and the other was the treatment group (N = 532) that received the intervention. Following the reform of the power industry in Japan, which liberalized power retailing for all consumers, an SP survey experiment was conducted from February to March 2016, just before liberalization. A total of 983 participants were contacted in the experiment, but 80 did not respond. In November 2016, after liberalization, we conducted an RP survey experiment. At that time, there were 306 non-responders, leaving a total sample size of 677 people participating in the experiment.

＜Figure 1: The flow of the experiments＞

The information provision occurred as follows. For the 532 participants in the treatment group, we enclosed the text shown in Figure 2 in a questionnaire. In this intervention text, (1) we provided the electricity bill payment per month calculated with the general electricity tariff plan (25 yen per kWh ($ 0.23 per kWh); FLAT) based on the electricity consumption measured in summer 2015. In addition, (2) we presented the electricity bill payment per month calculated using the TOU tariff plan. Furthermore, (3) we presented information on how much lower or higher the electricity cost per month would be after switching from the general electricity tariff plan to the TOU plan.

＜Figure 2: Intervention flyer＞

Here, the daytime power unit price (9:00 am to 9:00 pm) of the TOU plan is 40 yen per kWh ($ 0.36 per kWh), and the nighttime power unit price (9:00 pm to 9:00 am) is 8 yen per kWh ($ 0.07 per kWh). We assume revenue neutrality for the unit price of this TOU plan. Specifically, first, we set the unit price of daytime electricity to 40 yen per kWh. Next, we set the nighttime electricity unit price such that the monthly electricity rate payment among the participants is equal on average irrespective of whether the FLAT or TOU plan is selected.

Table 1 and Figure 3 show that revenue neutrality holds. In Table 1, for each participant, we use the HEMS data for the summer of 2015 to calculate the payments for the FLAT plan and the TOU plan and calculate the average price per month. Here, we calculate the electricity rate assuming that the price elasticity is zero. In addition, we also calculate the average difference per month between the

[8] Note that among the participants in the experiment, 33 had defects in HEMS data because of technical errors.

FLAT and TOU plans. The monthly average electricity rate was 9,428.82 yen ($85.72) using the FLAT plan and 9,428.80 yen ($85.72) using the TOU plan. The difference between them is approximately 0.02 yen, and the electricity rate per month is ± 0 as a whole on average when switching from a FLAT plan to a TOU plan.

＜Table 1: Monthly rate difference according to the tariff plan＞

Figure 3 shows the distribution of the difference between the FLAT plan and the TOU plan for each subject. The difference between plans is arranged from low to high for customers who switch on the horizontal axis. The vertical axis represents the difference. It is clear that when switching from the FLAT plan to the TOU plan, 50% of people would benefit and 50% would suffer.

＜Figure 3: The distribution of monthly payment difference＞

To assess the success of randomization for the above-mentioned control and treatment groups, we performed a balance check by t-test for average power consumption per day (kWh), average power consumption (kWh) during the day (9:00 am to 9:00 pm) and average power consumption (kWh) at night (9:00 pm to 9:00 am) (Table 2), based on power consumption in summer 2015 (July to September)[9]. The average daily power consumption was approximately 12.92 kWh for the control group and approximately 13.02 kWh for the treatment group. The difference is -0.10, which is not statistically significant (t value = -0.29). The average daytime power consumption was approximately 6.87 kWh in the control group and approximately 6.97 kWh in the treatment group. The difference is -0.10, which is not statistically significant (t value = -0.53). Finally, the average power consumption at night was approximately 6.05 kWh for the control group and approximately 6.05 kWh for the treatment group. The difference is approximately 0.002 kWh, which is not statistically significant (t value = 0.0008). From the above, there is no significant difference in the averages for daily or daytime and nighttime only power consumption, and thus the two groups can be considered well balanced.

＜Table 2: Balance check of average power consumption＞

4. Stated preference experiment

[9] The balance check of the socio-economic attributes of the consumer is detailed in Appendix 1. Regarding the number of people in the household, a statistically significant difference was observed for one portion at the 5% level; however, balance was achieved for other variables, and it can be understood that we also broadly succeeded in the randomization of socio-economic variables.

In this section, we describe the experimental design and results of the SP experiment conducted in February and March 2016 prior to liberalization.

4.1 Design

We conducted our experiments from February to March 2016 before retail liberalization in the home sector. We provided a 1,000 yen ($9.09) Quo voucher to those who participated in the experiment. A total of 983 participants participated in the experiment, while 80 potential participants did not respond. In this experiment, for the control group and the treatment group, we asked eight questions using the SP method questionnaire to select the most desirable plan from three virtual power plans (Figure 4).

＜Figure 4: Stated preference method question attribute value＞

The SP method is a type of conjoint analysis whereby good service is considered to consist of several attributes. The experimenter presented a plurality of virtual options to the subjects for which the property levels of the options were gradually changed, and the subjects then selected an option. As a result, it is possible to analyse which attribute is emphasized and to what extent based on the subject's selected option. As shown in Figure 4, the options for each plan in the question were "rate plan with new electric power company," "new rate plan with the current electric power company," and "current plan through current electric power company."

In Plan 1, the attribute of the power company is fixed as "new power company." The attributes of the rate plan are "time-of-use plan" or "flat rate plan." Furthermore, "renewable energy share" and "nuclear power share" are "0%," "20%," or "40%." Finally, "monthly electricity charges" are either "the same as the present," "10% lower," or "20% lower." For Plan 2, the attribute of the power company is fixed as "the current power company," and the other attribute items are set the same as in Plan 1. Finally, for Plan 3, all the attribute values are fixed, assuming that "current power company," "flat rate plan," a "10% renewable energy share," a "10% nuclear power share," and "monthly electricity charges" are "the same as the present."

In establishing the attributes for these inquiries, we referred to Murakami et al. (2015) with the attributes of the inquiry established around preference for nuclear power or renewable energy as the primary source of energy. In 2010, nuclear power comprised 28.8% of the total power supply, with renewable sources comprising 9.6%. However, in 2012, nuclear power comprised 1.7%, with renewables accounting for 10%. The inquiry attributes were established in plan 3 based on these proportions. The levels of attributes in plans 1 and 2 were set based on the government's plans for power supply configuration in the year 2030, by which time the renewable energy target is between 22% and 24%, and that nuclear power makes up between 20% and 22% of the total energy supply.

Combining the values of each of the inquiry attributes and employing the orthogonal factorial design method reduced the number of inquiries to 8 in the experiment.

4.2 Hypotheses

In this study, we set pricing such that revenue neutrality is established between the TOU rate plan and the FLAT rate plan. Therefore, the ratio of those who gain and those who lose by changing the rate plan is exactly half. First, how do people in the control group who do not receive RECAP information for rate plan transfers evaluate the TOU plan? Under the assumption of revenue neutrality, if the experiment participants correctly evaluate the TOU plan, the overall rating of the TOU plan will be zero. However, if people believe that they can use the TOU plan to reduce their monthly electricity bill, because humans tend to have "overconfidence," the rating of the rate plan may be positive on average.

Second, in the treatment group receiving RECAP information, the experiment participants could understand which rate plan should be selected after accurately understanding the gain and loss of the rate plans. We expect that those who are informed that they can benefit from switching will respond positively to the information and that the valuation will be high. People who receive information that they will lose money by switching are expected to have a low evaluation of the TOU plan.

Thus, when viewed across the treatment group, if the ratings of gainers and losers are symmetrical, the ratings are expected to be zero on average. However, the evaluations of people who gain or lose from switching are not necessarily symmetrical. Because humans have a tendency to exhibit "loss aversion," if the negative evaluation of the TOU plan by people who would experience a loss exceeds the positive rating of the people experiencing a gain, the evaluation of the TOU plan may be negative on average.

4.3 Estimation

Based on the response data obtained through the SP experiment, we assume a random utility model and estimate the evaluation of each attribute by the respondents by the maximum likelihood method. We assume the following random utility model:

$$U_{ni} = \beta_n x_{nit} + \gamma_n m_{nit} + \delta SQ_{nit} + \varepsilon_{ni}. \quad (1)$$

Here, the subscript n represents each individual, i represents the plan ($i \in (1,2,3)$) in each question, and t represents a question number ($t \in (1,2,\cdots,8)$).

U_{ni} is a function that represents the utility, when individual n selects rate plan i, and x_{it} is a

variable that represents each attribute level of rate plan i presented in each question t. m_{it} represents the attribute level of monthly electricity rates, and SQ_{nit} is an indicator function that takes value 1, when the responder selects the status quo (Plan 3), and 0 otherwise. Additionally, β_n represents the marginal utility for a change of one attribute level of each attribute of the respondent. Based on Bhat (2001), we used a simulated maximum likelihood estimation and assumed that β_n is a random parameter that follows a normal distribution. Next, γ_n represents the marginal utility associated with the decrease in monthly electricity charges. Some distributions can be used for random cost parameters[10]. We choose here a one-sided triangular distribution, which is a random parameter with a negatively restricted sign and a finite variation range. δ represents the fixed utility for the current rate plan. Finally, ε_{ni} is an error term and follows a type 1 extreme value distribution. Assuming that an individual n selects option i to maximize (1) above, the probability that an individual n selects option i is expressed as follows for any j($\neq$ i):

$$P_{ni} = \Pr(U_{ni} > U_{nj}). \tag{2}$$

Additionally, the log likelihood function of the above selection probability is

$$L(\beta_n, \gamma_n, \delta) = \sum_n \sum_j I_{nj} \ln P_{ni}. \tag{3}$$

Here, $I_{ni} = I(U_{ni} > U_{nj})$ is an indicator function that takes value 1 if an individual n selects option i and 0 otherwise.

We assume a mixed logit model for individual selection probabilities. In this case, we can rewrite the selection probability in (2) as

$$P_{ni} = \int \frac{exp(V_{ni})}{\sum_j exp(V_{nj})} f(\beta) d\beta. \tag{4}$$

Here, $V_{ni} = \beta_n x_{nit} + \gamma_n m_{nit} + \delta SQ_{nit}$. Because the selection probability from this mixed logit model cannot be solved algebraically, it is necessary to obtain the parameter by approximate calculation through simulation. In our research, when estimating the mixed logit model, we used the

[10] The normal distribution is a natural choice, but when estimating the WTP, we need to restrict the cost coefficient to be negative. Additionally, if the parameter takes a value close to zero, the WTP takes an extremely large value. An approach often used to specify the sign of a parameter is to assume a lognormal distribution. However, the lognormal distribution has a long and fat tail, which causes an empirical disturbance for estimating WTP (Train, 2009).

simulated maximum likelihood estimation to estimate the parameters.

Moreover, the number of simulations carried out was 100. Furthermore, since the parameters obtained from the above simulation are difficult to intuitively interpret, we calculate marginal willingness to pay (MWTP) from each random parameter (Train, 2009). Since each parameter in the random utility model represents the marginal utility of each attribute, MWTP can be obtained by dividing them by the marginal utility of money per yen. However, we cannot estimate the marginal utility of money directly from our question attributes. Therefore, we calculate the marginal utility per yen by dividing γ_n, which represents the marginal utility associated with the decrease in the monthly electricity bill, by the monthly electricity bill calculated for each individual's FLAT payment[11].

Moreover, although the parameter obtained from the above calculation is an average parameter, it is possible to calculate the conditional distribution of the parameter according to the respondent by the Bayesian theorem in the mixed logit model. By the above method, we calculate MWTP for each respondent by dividing the random parameters of each participant by the marginal utility per yen.

4.4 Estimation result: Marginal willingness to pay

Table 3 reports results for the treatment group and control group using the above-mentioned SP method[12]. First, we consider the fixed parameters. The parameters of the status quo parameter for plan 3 is -13.99 in the control group and significant at the 1% level. In the treatment group, it is -11.59 and significant at the 1% level.

Next, we consider the random parameters. The parameters of the electricity payment ratio are -10.72 in the control group and -9.53 in the treatment group; both are significant at the 1% level. The TOU parameter is 0.37 in the control group and significant at the 1% level. For the treatment group, the coefficient is 0.16, but no significant result was found. The parameters of the renewable energy share are 0.041 for the control group and 0.042 for the treatment group, both of which are significant at the 1% level. Regarding the parameters of the nuclear power share, we obtain -0.08 in the control group and -0.10 in the treatment group, and significant differences are observed at the 1% level for both.

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[11] Therefore, in estimating the selection probability, we replace the attribute value of "monthly electricity charges" with 1 if it is "the same as the present," 0.9 if it is "10% decrease," and 0.8 if it is "20% decrease."

[12] Here, we do not compare the differences between the coefficients of the treatment group and the control group but, instead, report the coefficients obtained from each model. Because the parameters obtained using the mixed logit model featured massively different scale parameters for each model, it was not possible to perform comparisons between models. For this reason, for Tables 4 and after, the WTP, which is defined by the ratios of the coefficients, is calculated to compare results without the impacts of scale parameters.

Finally, we examine the standard deviations of the random parameters. First, for the electricity payment ratio parameters, the standard deviation is 10.72 in the control group and 9.53 in the treatment group. Both groups are statistically significant at the 1% level and have sufficient variation. Next, the TOU parameters are 0.71 in the control group and 1.07 in the treatment group, both of which are significant at the 1% level. The coefficient of the renewable energy share is 0.03 in the control group and 0.04 in the treatment group, and both are statistically significant at the 1% level. Finally, the coefficient for the share of nuclear power is 0.09 in the control group and 0.10 in the treatment group, which are also statistically significant at the 1% level.

These findings demonstrate that both the fixed and the random parameters are significant for each attribute, except for the TOU parameter of the treatment group. Additionally, the standard deviations of the random parameters are all significant, indicating that the parameters vary within each group.

＜Table 3: Estimated result by stated preference method＞

Table 4 shows estimated values of the willingness to pay for each attribute based on the results in Table 3. We calculate the MWTP for each attribute. We divide the estimated results of each random parameter by the marginal utility of money, multiply it by -1 and obtain the MWTP. Regarding TOU, the MWTP is 338.13 yen ($3.07; t value = 4.28) in the control group, and this is significant at the 1% level. This value is 167.85 yen ($1.53; t value = 1.86) in the treatment group, but this result is not significant. Furthermore, there is a statistically significant difference between the two at the 1% level (t value = 5.49). The renewable energy share is valued at 37.16 yen for the control group ($0.34; t value = 9.09) and 42.51 yen for the treatment group ($0.39; t value = 8.68), and the results for both groups are significant at the 1% level. There is no significant difference in these differences (t value = 0.29). Finally, the nuclear energy share is valued at -72.45 yen for the control group ($-0.66; t value= -10.22) and -101.41 yen for the treatment group ($-0.92; t value= -9.77). Both results are statistically significant at the 1% level. There is no significant difference in these differences (t value = 0.57).

＜Table 4: Marginal willingness to pay＞

4.5 Estimation results: Average treatment effect

In this section, we estimate the treatment effects based on the MWTP. The basic estimation equation is

$$MWTP_n = \alpha + \beta \cdot Recap_n + \varepsilon_n. \quad (5)$$

Here, $MWTP_n$, which is the dependent variable, is the MWTP for TOU of individual n. The explanatory variable $Recap_n$ is a dummy variable that takes value 1 if individual n is in the treatment group and 0 if in the control group. Since the control and treatment groups are randomly assigned, the coefficient β is the ATE for receiving information. α is a constant term and can be interpreted as the average MWTP of the control group, Finally, ε_n is an error term and follows a normal distribution with zero mean.

In the following, first, only the effects of intervention are estimated using the above formula. We then estimate the effects of each intervention for those who gain and those who suffer losses by switching from the FLAT to the TOU plan[13].

Table 5 shows the estimation results of the effect of information treatment on MWTP for TOU. Here, we estimate only the presence or absence of the effect of the intervention. The effect of the intervention is -112.84 yen ($-1.03) and statistically significant at the 1% level. The constant is 385.65 yen ($3.51), which is statistically significant at the 1% level. From this, we found that the estimated value (MWTP) for TOU is higher than 0 yen when RECAP information is not given. However, this tendency is corrected, and MWTP is significantly decreased by giving RECAP information regarding changing plans. Note, however, that over-confidence is not completely addressed by giving the RECAP information.

＜Table 5: OLS estimation results-Overall treatment effect (SP)＞

Next, in result (2) of Table 6, we analyse the cases divided into loss cases/gain cases. The "Winner" part of Table 6 shows the estimation result for a person who gains by switching, and the "Loser" part shows the estimation result for a person who loses by switching. Additionally, each constant term (cons) represents the average MWTP of the corresponding control group. First, for winners, the average WTP in the control group is 413.87 yen ($3.76), which is statistically significant at the 1% level. However, the treatment effect of RECAP information for winners is not statistically significant. In contrast, for losers, the average MWTP in the control group is 360.20 yen ($3.27), which is statistically significant at the 1% level. The intervention effect by the RECAP information for losers is minus 195.30 yen ($1.78) and statistically significant at the 1% level.

＜Table 6: OLS estimation result-Treatment effect (SP) on loss/gain＞

[13] Below, regardless of whether or not those participants who have received an intervention had actually read the RECAP information, the overall effect (intention-treatment effect) of being assigned to the group that received intervention is estimated. When actually implementing a similar policy, it can be considered meaningful to estimate the ITT result because it may be assumed that some people will carefully read the information and others will not.

In result (1) of Table 5, the valuation for changing to the TOU plan decreased significantly when receiving the treatment. However, by analysing the gains and losses in Model 2 of Table 6, we found that the valuation differs depending on whether the person is in the gain or loss region. For those in the gain region, even if they are informed that they will earn by switching, we found that the valuation for the TOU plan does not change between receiving and not receiving information. For people in the loss region, the valuation is lower at 53.68 yen ($0.49) than for those in the gain region when information is not received, but this difference is not statistically significant (t value = 1.31). The valuation is further reduced when participants are informed that they will lose money. Ultimately, the valuation of changing to the TOU plan is 164.90 yen ($1.50).

From the above, by including the difference between the electricity payments of the two rate plans, we found differences in how people evaluate each plan in the loss or gain region and in response to information. A person in the loss region responds to the information that she will lose by switching and substantially reduces her valuation.

5. Revealed preference experiment

In this section, we investigate whether the same tendency with respect to preferences obtained in the SP experiment appears in the actual choice of electricity tariff plan after liberalization.

5.1 Experimental design

In November 2016, after liberalization, we surveyed the actual conditions of electricity tariff plan contracts for the 983 people who participated in the SP experiment. In this questionnaire, participants are asked about the electricity tariff plan they were enrolled in at the time of the survey. As in the SP experiment, we provided vouchers worth 1,000 yen to those who responded. The final number of respondents was 677, and 306 people did not answer. The control group had 328 people, and the treatment group had 349 people.

5.2 Estimation method

Based on the data obtained from the survey, we investigate the relationship with the presence of the RECAP information given prior to the SP experiment. Here, we use a binary variable that takes value 1 when the TOU rate plan is actually selected and 0 otherwise. As in the SP experiment, we use the RECAP dummy, which indicates the presence or absence of intervention, as an explanatory variable. We also use a Winner dummy, which takes value 1 when obtaining gain from a transition to the TOU plan, and a Loser dummy, which takes value 1 when making a loss. In the estimation, we use a probit

model to analyse the probability of choosing TOU[14].

5.3 Estimation results

Table 7 shows the estimation results on the relationship between the intervention by providing RECAP information and the choice of the TOU rate plan after liberalization. The first row of Table 7 reports the average choice probability for the control group. The second row reports the marginal effects of the coefficients obtained by the probit model. First, in result (1), we estimate only the relation between the intervention and the choice of the TOU rate plan. The intervention coefficient is -2.6% and is not statistically significant. The average choice probability of TOU for the control group is 14.6%, which is statistically significant at the 1% level. This indicates that the probability of actually selecting the TOU plan does not change according to whether information is given.

＜Table 7: Estimation result by Probit-Overall (RP)＞

Next, in result (2) of Table 8, we analyse the results divided into whether a gain or loss results from changing to the TOU plan. The first and third rows of Table 8 report selection probabilities for the control group. In addition, rows 2 and 4 report the marginal effects of the coefficients obtained by the probit model. For winners, the probability of choosing TOU in the control group is 20.3%, which is statistically significant at the 1% level. Here, a statistically significant effect of RECAP information in the treatment group is not found. In addition, for losers, the average choice probability of the control group is 9.7%, which is statistically significant at the 1% level. The effect of information provision is not found for losers in the treatment group.

＜Table 8: Probit estimation result-Treatment effect (RP) on loss or gain＞

As in result (1), even when we analyse by gain or loss in result (2), it is clear that the choice probability does not change depending on whether the person receiving the information is in the gain or loss region. The probability of switching to TOU for a loss is significantly lower at the 1% level than the probability of switching for a gain. Thus, consumers understand whether they will earn or lose regardless of the information provided, thereby deciding which tariff plan to select.

[14] As robustness checks, we also use other models, such as the linear probability model and the logit model. When estimates were made using the linear probability and logit models, the results showed a similar trend to those of the results obtained using a probit model.

6. Discussion and Conclusion

Figure 5 shows the average WTP for TOU in the SP experiment for the control and treatment groups overall, the control group winners and losers, and the treatment group winners and losers. The upper and lower bars of the bar graph in the figure indicate the standard errors. According to the analysis of the SP experiment, the average WTP of the control group was 385.65 yen ($3.51). The valuation of approximately 112.84 yen ($1.03) fell once RECAP information was received, and the average WTP of the treatment group fell to 272.80 yen ($2.48).

< Figure 5: Average MWTP by group>

From this, we found that the average WTP of the control group is larger than 0, so there is a tendency towards overconfidence when there is no information. The average WTP of the treatment group dropped after information was provided, which shows that the tendency towards overconfidence was decreased by providing information on the gain and loss from switching from FLAT to TOU.

Next, regarding whether the information given to the treatment group indicates a gain or a loss, we analysed the cases of gaining and losing by switching. In the winner case where a gain accrues, the average valuation of the control group was 413.87 yen ($3.76), and there was no significant change in the evaluation even if information was given. For the losers, the valuation of the control group was 360.20 yen ($3.27), and it decreased by 195.30 yen ($1.78) after receiving the information. Thus, the average WTP of the loser group dropped significantly to 164.90 yen ($1.50). On this basis, valuations will become smaller, and the tendency towards overconfidence will largely shrink. However, the degree of correction differs between those who received positive information and those who received negative information. People who received positive information do not change their ratings substantially compared to when they do not receive information, but when they receive negative information, they significantly reduce their valuation. The change in the valuation of losers reduced the valuation of the entire treatment group.

Asymmetric attitudes towards positive and negative information have been identified in previous studies. Ertac (2011) reports a weak response to providing positive information when a tendency towards overconfidence is observed and a strong pessimistic response to negative information. In contrast, Eil and Rao (2011), Mobius et al. (2014), and Sharot and Garrett (2016) report that when negative information was given, no response was found, while when positive information was provided, a response similar to Bayes' rule was found.

In our study, as in Ertac (2011), the valuation did not change when positive information was given, and the valuation changed substantially and pessimistically when negative information was provided. These changes in valuation can be interpreted as follows. First, if consumers do not receive

information, they will be optimistic about their lifestyle and attitude towards electricity savings and believe that they might benefit from switching to TOU. However, if it is revealed that they will pay more if they switch, the psychology of loss avoidance becomes effective, and they avoid TOU regardless of the degree of loss.

Next, Figure 6 shows the average WTP for TOU for the RP for the control group or treatment group as a whole, control group winners and losers, and treatment group winners and losers. The upper and lower bars of the bar graph in the figure indicate the standard errors. According to the RP analysis, the average probability of choosing to switch in the control group was approximately 14.6%, while it was approximately 2.6% lower when RECAP information was given, but this was not a significant result. Thus, there was no difference in the average choice probability between the treatment and control groups, and there was no change in the choice based on the information provided.

< Figure 6: Average choice probability by group>

In addition, we divided the respondents depending on whether the information conveyed a gain or loss and analysed the two cases. For the winners, the average choice probability for the control group was 20.3%, and for losers, the average choice probability for the control group was 9.7%. Neither winners nor losers showed any effect of the provision of information on the average choice probability.

It has long been known that there is a discrepancy between the results of SP data and RP data. Carson et al. (1996) report that results from SP data underestimate results from RP data. In contrast, Brown et al. (1996) and Seip and Strand (1992) have shown that SP results are inflated. In our results, unlike the estimation results based on SP data, in the RP data, there is no decline in the selection probability due to the receipt of negative information, and the reaction to a gain from switching becomes conservative due to information provision.

From the estimation results of these SP data and RP data, we found that in the SP data, the consumer is more likely to make the appropriate choice when given RECAP information. However, in the RP data, doing so did not result in an increased likelihood of making the appropriate selection. From this, we found that information such as RECAP information is insufficient to promote the adoption of TOU tariffs, and it is necessary to consider other means to improve consumer choice.

Finally, we will examine the relationship between the willingness to pay for TOU and the actual choice of the TOU rate plan. Figure 7 shows the distribution of WTP for the TOU rate plan of those who actually selected TOU and those who remained in the FLAT rate plan by control and treatment group. The red part of the figure represents the WTP of a person who selected TOU, and the blue part represents the WTP of others. For both the treatment and control groups, the distribution of WTP is on the right of the TOU selectors compared to the non-TOU selectors. People with higher WTP in advance seem more likely to actually select TOU. In addition, it can be seen that some members of the control

and treatment groups who are in the negative region of WTP actually select TOU.

<Figure 7: Distribution of TOU selection/non-selection WTP by group >

Table 9 presents the results of the analysis of this relationship using the probit model. Here, the explained variable is a binary variable that indicates TOU selection, which takes value 1 if TOU is selected and 0 otherwise. Additionally, we use the RECAP dummy, positive WTP dummy, and the interaction term of the RECAP dummy and WTP dummy as the explanatory variables. The RECAP dummy variable equals 1 for the treatment group and 0 for the control group. The WTP (+) dummy is a variable that takes value 1 if WTP (+) takes a zero or positive value and 0 otherwise. The first row of Table 9 reports the average choice probability for the control group with negative WTP. Rows 2 to 4 report the marginal effects of the coefficients obtained using the probit model. From the results in Table 9, no statistical significance is found for the RECAP dummy or the interaction term of the RECAP dummy and the WTP (+) dummy. Therefore, the presence or absence of intervention has no effect on the relationship between a positive WTP and the actual choice. Here, the average choice probability for the control group with negative WTP is 0.073 (statistically significant at the 5% level) and, thus, the TOU choice probability for people with a negative WTP is approximately 7%. Furthermore, the coefficient of the WTP (+) dummy is 0.00013 (statistically significant at the 1% level). Here, we can see that the choice probability for people with positive WTP is approximately 0.013% higher than that for people with negative WTP. Thus, the choice probability of a person who reported a high evaluation in the SP task is approximately 0.013% higher than that of a person who made a low evaluation.

<Table 9: Relationship between TOU selection probability and WTP by OLS >

The results of the SP experiment revealed that the valuation (the willingness to pay) was approximately 385.65 yen when participants did not have information on the gain or loss resulting from switching, and the valuation decreased once information was provided. In addition, those who were informed that they would lose money due to switching significantly changed their valuation. We found that providing information about the participants' benefit from switching diminished the tendency towards overconfidence. The valuation decreases substantially when information is provided showing that a loss will be incurred from switching. The results of the RP and SP experiments differ. We found that the selection was not changed in the RP experiment, even when providing information that a loss would be incurred.

References

[1] Agency for Natural Resources and Energy. (2017). Progress of full-scale liberalization of electricity retail, Electricity and Gas Basic Policy Subcommittee (Held on July 7, 2017). Last access September 3, 2019. https://www.meti.go.jp/shingikai/enecho/denryoku_gas/denryoku_gas/pdf/004_03_00.pdf

[2] Agency for Natural Resources and Energy. (2018). Progress of full-scale liberalization of electricity retail, Electricity and Gas Basic Policy Subcommittee (Held on December 19, 2018). Last access September 3, 2019. https://www.meti.go.jp/shingikai/enecho/denryoku_gas/denryoku_gas/pdf/014_04_00.pdf

[3] Bhat, C. (2001). Quasi-random maximum simulated likelihood estimation of the mixed multinomial logit model. *Transportation Research* B 35: 677-693.

[4] Barber, B.M., & Odean, T. (2001). Boys will be boys: Gender, overconfidence, and common stock investment. *The quarterly journal of economics*, 116(1), 261-292.

[5] Bertrand, M., & Morse, A. (2011). Information disclosure, cognitive biases, and payday borrowing. *The Journal of Finance*, 66(6), 1865-1893.

[6] Borenstein, S. (2009). To what electricity price do consumers respond? Residential demand elasticity under increasing-block pricing. *Working paper*.

[7] Brown, T.C., Champ, P.A., Bishop, R.C., & McCollum, D.W. (1996). Which response format reveals the truth about donations to a public good?. *Land Economics*, 152-166.

[8] Carson, R.T., Flores, N.E., Martin, K.M., & Wright, J.L. (1996). Contingent valuation and revealed preference methodologies: comparing the estimates for quasi-public goods. *Land economics*, 80-99.

[9] Chetty, R., Looney, A., & Kroft, K. (2009). Salience and taxation: Theory and evidence. *American economic review*, 99(4), 1145-77.

[10] Clark, J., & Friesen, L. (2008). Overconfidence in forecasts of own performance: An experimental study. *The Economic Journal*, 119(534), 229-251.

[11] Eil, D., & Rao, J.M. (2011). The good news-bad news effect: asymmetric processing of objective information about yourself. *American Economic Journal: Microeconomics*, 3(2), 114-38.

[12] Ek, K., & Söderholm, P. (2008). Households' switching behavior between electricity suppliers in Sweden. *Utilities Policy*, 16(4), 254-261.

[13] Ertac, S. (2011). Does self-relevance affect information processing? Experimental evidence on the response to performance and non-performance feedback. *Journal of Economic Behavior & Organization*, 80(3), 532-545.

[14] Finkelstein, A. (2009). E-ztax: Tax salience and tax rates. *The Quarterly Journal of Economics*, 124(3), 969-1010.

[15] Giné, X., & Mazer, R.K. (2016). Financial (dis-) information: Evidence from a multi-country audit study. *The World Bank*.

[16] Hartman, R.S., Doane, M.J., & Woo, C.K. (1991). Consumer rationality and the status quo. *The Quarterly Journal of Economics*, 106(1), 141-162.

[17] He, X., & Reiner, D. (2017). Why consumers switch energy suppliers: the role of individual attitudes. *The Energy Journal*, 38(6).

[18] Heger, S.A., & Papageorge, N.W. (2018). We should totally open a restaurant: How optimism and overconfidence affect beliefs. *Journal of Economic Psychology*, 67, 177-190.

[19] Hortaçsu, A., Madanizadeh, S.A., & Puller, S.L. (2017). Power to choose? An analysis of consumer inertia in the residential electricity market. *American Economic Journal: Economic Policy*, 9(4), 192-226.

[20] Ito, K. (2014). Do consumers respond to marginal or average price? Evidence from nonlinear electricity pricing. *American Economic Review*, 104(2), 537-63.

[21] Kamenica, E., Mullainathan, S., & Thaler, R. (2011). Helping consumers know themselves. *American Economic Review*, 101(3), 417-22.

[22] Kling, J.R., Mullainathan, S., Shafir, E., Vermeulen, L.C., & Wrobel, M.V. (2012). Comparison friction: Experimental evidence from Medicare drug plans. *The Quarterly Journal of Economics*, 127(1), 199-235.

[23] Mobius, M.M., Niederle, M., Niehaus, P., & Rosenblat, T.S. (2011). Managing self-confidence: Theory and experimental evidence (No. w17014). *National Bureau of Economic Research*.

[24] Murakami, K., T. Ida, M. Tanaka, and L. Friedman (2015) "Consumers' willingness to pay for renewable and nuclear energy: A comparative analysis between the US and Japan," Energy Economics vol. 50: 178-189.

[25] Seip, K., & Strand, J. (1992). Willingness to pay for environmental goods in Norway: A contingent valuation study with real payment. *Environmental and Resource Economics*, 2(1), 91-106.

[26] Sexton, S. (2015). Automatic bill payment and salience effects: Evidence from electricity consumption. *Review of Economics and Statistics*, 97(2), 229-241.

[27] Sharot, T., & Garrett, N. (2016). Forming beliefs: Why valence matters. *Trends in cognitive sciences*, 20(1), 25-33.

[28] Shin, K.J., & Managi, S. (2017). Liberalization of a retail electricity market: Consumer satisfaction and household switching behavior in Japan. *Energy Policy*, 110, 675-685.

[29] Thaler, R.H., & Sunstein, C.R. (2009). Nudge: Improving decisions about health, wealth, and happiness. *Penguin*.

[30] Thunström, L., Nordström, J., & Shogren, J. F. (2015). Certainty and overconfidence in future preferences for food. *Journal of Economic Psychology*, 51, 101-113.

[31] Train, K.E. (2009). Discrete choice methods with simulation. *Cambridge University Press*.

Appendix 1: Balance check of household attributes

Table 10 shows the average and standard deviation of participant attributes by group and the number of respondents. The third column of the table shows the difference between the average of the control group and the treatment group and the standard error. First, the proportion of females is 8.3% for the control group and 9.6% for the treatment group. The difference is 1.3% and not statistically significant (p-value = 0.431). Next, regarding the working conditions of the participants, the dummy variable equals 1 when employed (including part-time) and 0 when not. The mean is 55.0% in the control group and 52.5% in the treatment group. The difference is 2.6% and not statistically significant (p-value = 0.27). Regarding annual household income, the average value in the control group is 7,587.4 thousand yen ($68.98 thousand), and the average in the treatment group is 7,477.5 thousand yen ($67.98 thousand). The difference is 109.9 thousand yen ($0.999 thousand) and not statistically significant (p-value = 0.557). Next, regarding the characteristics of the home, we first consider whether it is a detached home or an apartment. Here, a value of 1 is assigned for single-family homes, while multi-family homes take value 0. It is 87.7% in the control group and 85.9% in the treatment group. The difference is 1.8% and not statistically significant (p-value = 0.351). Next, we examine whether the home is owned or rented. Here, the variable is coded as 1 for an owned home and 0 for a rental. The mean value is 99.6% for the control group and 99.8% for the treatment group. The difference is 0.2% and not statistically significant (p-value = 0.54). Finally, the number of people in the household is 3.24 for the control group and 3.06 for the treatment group. The difference is 0.17 and statistically significant (p-value = 0.020).

＜Table 10: Balance check of household attributes＞

Table 11 investigates the impact of the covariates on whether or not intervention is received using a linear probability model. Here, the presence or absence of the allocation of intervention (intervention = 1, no intervention =0) is used as an explained variable, while factors such as energy consumption and socio-economic data such as gender are used as explanatory variables.

The results revealed there were no significant differences in the variable attributes of energy consumption, gender, employment rate, household income, whether or not they were living in a detached house, or whether or not they owned their home, as is shown in Tables 10. Regarding the number of people in the household, a statistically significant difference was observed. It was also confirmed that the same result was found for the probit and logit models.

＜Table 11: Balance check of household attributes(OLS)＞

Appendix 2: Analysis of attrition

Here, we analyse the attrition between the SP and RP experiments. Table 12 shows the attrition rates. First, the attrition rate from the SP experiment is approximately 7% in the control group and approximately 8% in the treatment group. We observe no significant difference in attrition rates between the two groups (t value = 0.88). In addition, the attrition rate of the RP experiment is approximately 34% in both the control group and the treatment group, and again, no significance is observed (t value = 0.09).

＜Table 12: Analysis of attrition＞

In Table 13, in relation to individual attrition in the SP and RP, an analysis via a linear regression model is reported, with each attribute as an explanatory variable. A binary explained variable was used, with not participating in the SP and RP experiments being assigned 1 and a value of 0 assigned otherwise. Moreover, for both the SP or RP, the explanatory variables of the RECAP dummy, which shows whether or not intervention has occurred; daily energy consumption; and the socio-economic variables of the gender dummy, employment status dummy, household income, detached house dummy, home ownership dummy and number of people in the household were used. In addition, in this analysis, the intersection of the RECAP dummy and each variable attribute is included. Through this approach, at the same time as estimating the impact that each attribute had on attrition, we also confirm the differences in how attributes are applied between the different groups using the intervention terms.

Firstly, looking at the SP, there were no attribute variables that had a significant impact on attrition from experiments. In addition, no significant difference was observed regarding the impact of attribute variables on rates of attrition between groups. Next, regarding the RP data, when looking at the influence of attributes on attrition levels from the experiment, a statistically significant difference was found regarding living in a detached home and home ownership (significance level of 5%). However, there was no significant difference regarding the impact that variable attributes had on attrition between groups.

＜Table 13: Analysis of attrition (OLS; SP・RP data)＞

From the above, regarding the SP experiment, there was no difference in attributes among those who participated and those who dropped out and no difference based on whether or not there was intervention. Conversely, for the RP experiment, there was a difference observed in the attributes between those who dropped out of the experiment and those who participated in it. However, while

there were differences in attributes regarding the rate of attrition because there was no difference based on whether or not there was intervention, it can be considered that no bias arose from self-selection in the ultimate estimates of the intervention effects.

Appendix 3: Analysis of SP and RP including covariates

Here, the effects of intervention on both the SP and RP are estimated, inclusive of socio-economic attributes. As with the analysis reported in Table 5 regarding the SP, the WTP of TOU gained from the SP experiment is set as an explained variable. Regarding the RP, as in the analysis reported in Table 7, a binary variable is used as an explanatory variable to determine whether or not people switched to the TOU payment plan after the liberalization of electricity. In addition, the explanatory variables of both SP and RP include the RECAP dummy, which shows whether intervention was received or not as well as the socio-economic factors of the gender dummy, the employment status dummy, household income, the detached house dummy, the house ownership dummy and the number of people in the household, as shown in Table 10. Using these variables, estimates were made using OLS for the SP. In addition, estimation was performed using the probit model for the RP.

These results are shown in Table 14. For the RP results, the marginal effects are shown in the table. Firstly, regarding the SP, the intervention effect from RECAP is minus 101.19 yen, a statistically significant at 5% significance. There is no significant difference (p-value = 0.1237) in the estimated intervention effects (minus 112.84 yen) in Table 5, where the socio-economic variables are not included in the explanatory variables. Regarding the RP, the estimated intervention effect was minus 0.025, but this was not a statistically significant result. No significant difference was seen (p-value = 0.9039) in the estimated intervention effects (minus 0.026), when the explanatory variables in Table 7 regarding socio-economic variables were not included.

Moreover, looking at each socio-economic variable individually, there was no significant impact on WTP or rates of switching based on gender, employment status, home ownership or detached home ownership. Conversely, regarding family income, it was discovered that regarding the SP, when income increased by 10,000 yen, WTP increased by 0.163 yen (significance level 5%). With the RP, a similarly significant increase in the rate of selection was observed (significance level 5%). In addition, it was discovered that when the number of people in the household increased by one, the WTP increased by 38.35 yen (significance level 5%). However, for RP, the coefficient for the number of household members was not significant.

From the above, in this experiment, as was observed in Appendix 1, the balance was lost between the control group and the treatment group solely due to the number of people in the household. However, when socio-economic factors were controlled for, as well as when they were not controlled for, no significant gap was observed in the estimated results of the intervention effects; therefore, it

can be considered that the influence of the difference in attributes between groups is small.

＜Table 14: Estimation result -Overall (SP・RP)＞

Figures & Tables

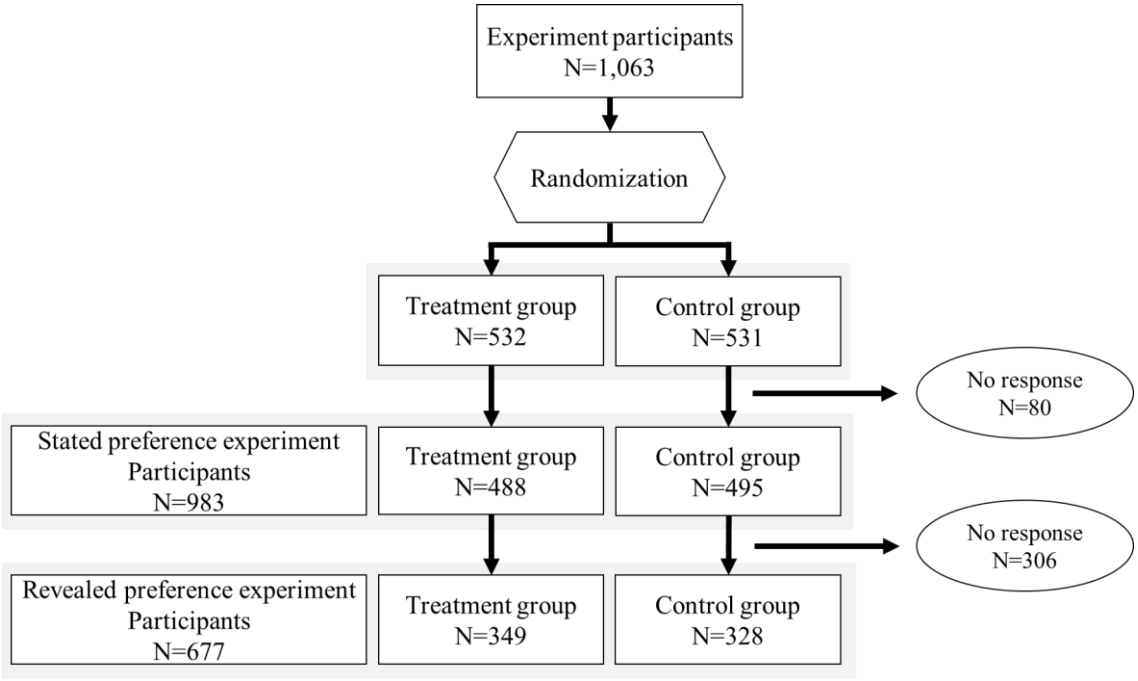
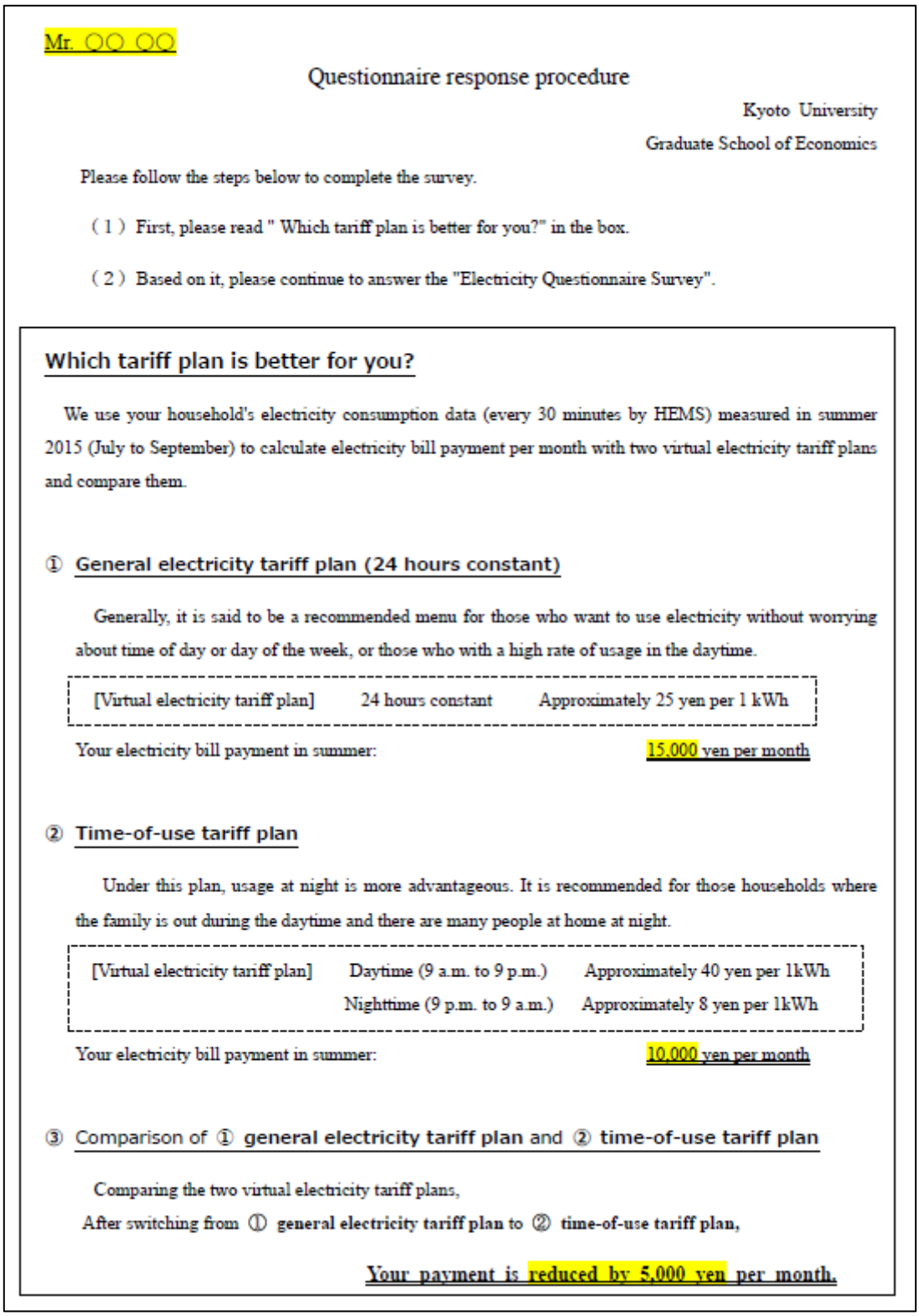


Figure 1: The flow of the experiments



Mr. QQ QQ

Questionnaire response procedure

Kyoto University

Graduate School of Economics

Please follow the steps below to complete the survey.

（1）First, please read " Which tariff plan is better for you?" in the box.

（2）Based on it, please continue to answer the "Electricity Questionnaire Survey".

Which tariff plan is better for you?

We use your household's electricity consumption data (every 30 minutes by HEMS) measured in summer 2015 (July to September) to calculate electricity bill payment per month with two virtual electricity tariff plans and compare them.

① **General electricity tariff plan (24 hours constant)**

Generally, it is said to be a recommended menu for those who want to use electricity without worrying about time of day or day of the week, or those who with a high rate of usage in the daytime.

[Virtual electricity tariff plan]	24 hours constant	Approximately 25 yen per 1 kWh

Your electricity bill payment in summer: 15,000 yen per month

② **Time-of-use tariff plan**

Under this plan, usage at night is more advantageous. It is recommended for those households where the family is out during the daytime and there are many people at home at night.

[Virtual electricity tariff plan]	Daytime (9 a.m. to 9 p.m.)	Approximately 40 yen per 1kWh
	Nighttime (9 p.m. to 9 a.m.)	Approximately 8 yen per 1kWh

Your electricity bill payment in summer: 10,000 yen per month

③ Comparison of ① **general electricity tariff plan** and ② **time-of-use tariff plan**

Comparing the two virtual electricity tariff plans,

After switching from ① **general electricity tariff plan** to ② **time-of-use tariff plan,**

Your payment is reduced by 5,000 yen per month.

Figure 2: Intervention flyer

Table 1: Monthly rate difference according to the tariff plan

(N=1,063)	FLAT plan (JPY)	TOU plan (JPY)	Difference (JPY)
Mean	9,428.819	9,428.802	0.017
s.d.	4,433.424	4,515.220	883.082
Min	0	0	-3,534
Max	39,007	37,627	6,052

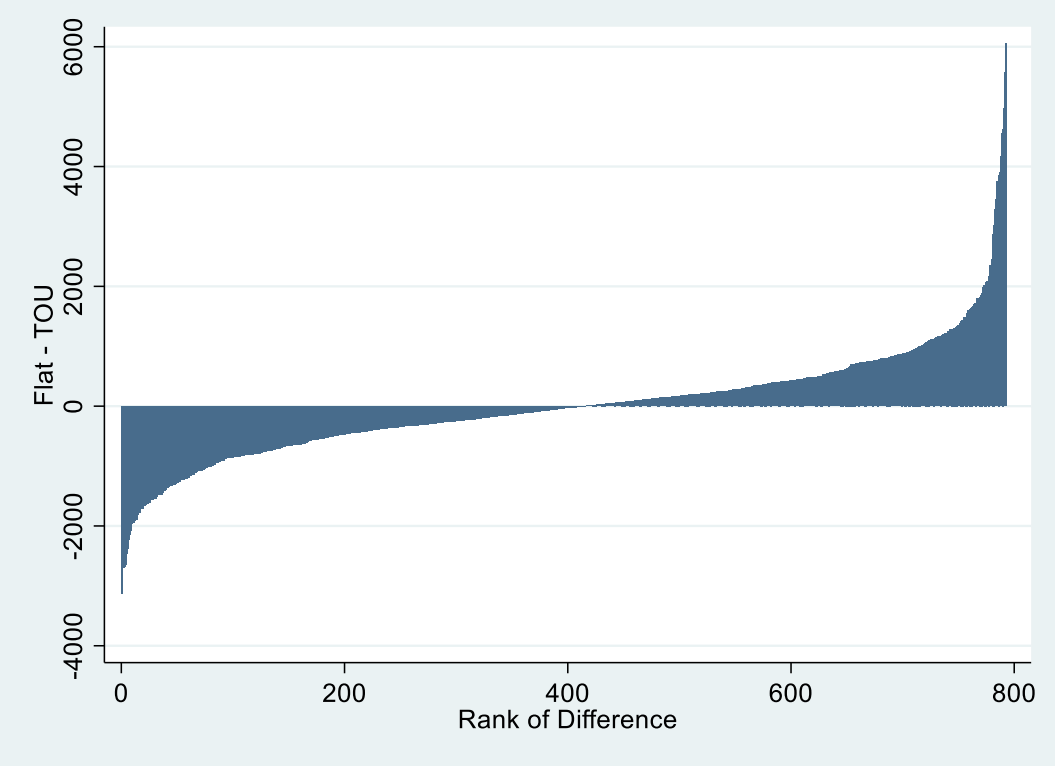


Figure 3: The distribution of monthly payment differences

Table 2: Balance check of average power consumption

	Control group	Treatment group	Difference
Daily (kWh)	12.922	13.024	-0.101
(s.d.)	(5.672)	(5.444)	(s.e. = 0.346)
Daytime only (kWh)	6.869	6.971	-0.103
(s.d.)	(3.184)	(3.019)	(s.e. = 0.193)
Nighttime only (kWh)	6.054	6.052	0.002
(s.d.)	(2.795)	(2.726)	(s.e. = 0.172)
N	531	532	

	Plan 1	Plan 2	Plan 3
Type of power company	New power company	Current power company	Current power company
Type of tariff plan	Time-of-use or Flat rate plan	Time-of-use or Flat rate plan	Flat rate plan
The ratio of renewable energy	0%, 20%, 40%	0%, 20%, 40%	10%
The ratio of nuclear energy	0%, 20%, 40%	0%, 20%, 40%	10%
Monthly electricity charge	Same as the present, 10% decrease, 20 decrease	Same as the present, 10% decrease, 20 decrease	Same as the present

Figure 4: Stated preference method question attribute values

Table 3: Estimated result by stated preference method

	Control group	Treatment group
Fixed parameters		
Status quo	-13.992**	-11.586**
	(1.042)	(0.863)
Random parameters (Mean)		
Electricity payment ratio	-10.724**	-9.532**
	(0.791)	(0.750)
TOU	0.374**	0.164
	(0.083)	(0.088)
Renewable energy share (%)	0.041**	0.042**
	(0.003)	(0.004)
Nuclear energy share (%)	-0.080**	-0.099**
	(0.005)	(0.007)
Random parameters (Standard deviation)		
Electricity payment ratio	10.724**	9.532**
	(0.791)	(0.750)
TOU	0.711**	1.070**
	(0.133)	(0.128)
Renewable energy share (%)	0.029**	0.041**
	(0.004)	(0.005)
Nuclear energy share (%)	0.086**	0.101**
	(0.005)	(0.006)
R^2	0.383	0.344
LRI	-2685.617	-2813.596
obs	3960	3904

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.

Table 4: Marginal willingness to pay

	Control group	Treatment group
Marginal willingness to pay (JPY)		
TOU	338.125**	167.853
	(78.917)	(90.322)
Renewable energy share (%)	37.161**	42.511**
	(4.087)	(4.898)
Nuclear energy share (%)	-72.449**	-101.408**
	(7.090)	(10.380)
N	464	488

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.

Table 5: OLS estimation results-Overall treatment effect (SP)

(N=952)	**(1)**
cons	385.645** (20.502)
RECAP	-112.842** (39.388)
R^2	0.0084
Adj R^2	0.007

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.

Table 6: OLS estimation result-Treatment effect (SP) on loss/gain

(N=952)		(2)
Winner	**cons**	413.872** (29.737)
	RECAP×Winner	-18.018 (60.343)
Loser	**cons**	360.195** (28.262)
	RECAP×Loser	-195.297** (50.748)
$\boldsymbol{R^2}$		0.0272
Adj $\boldsymbol{R^2}$		0.024

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.

Table 7: Estimation result by Probit-Overall (RP)

(N=677)	**(1)**
Mean probability	0.146** (0.019)
RECAP	-0.026 (0.026)
R^2	0.0019

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.

Table 8: Estimation result by Probit-Loss/gain (RP)

		(2)
Winner	**Mean probability**	0.203** (0.027)
	RECAP×Winner	-0.014 (0.034)
Loser	**Mean probability (Control group)**	0.097** (0.025)
	RECAP×Loser	-0.046 (0.040)
R^2		0.0002

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.

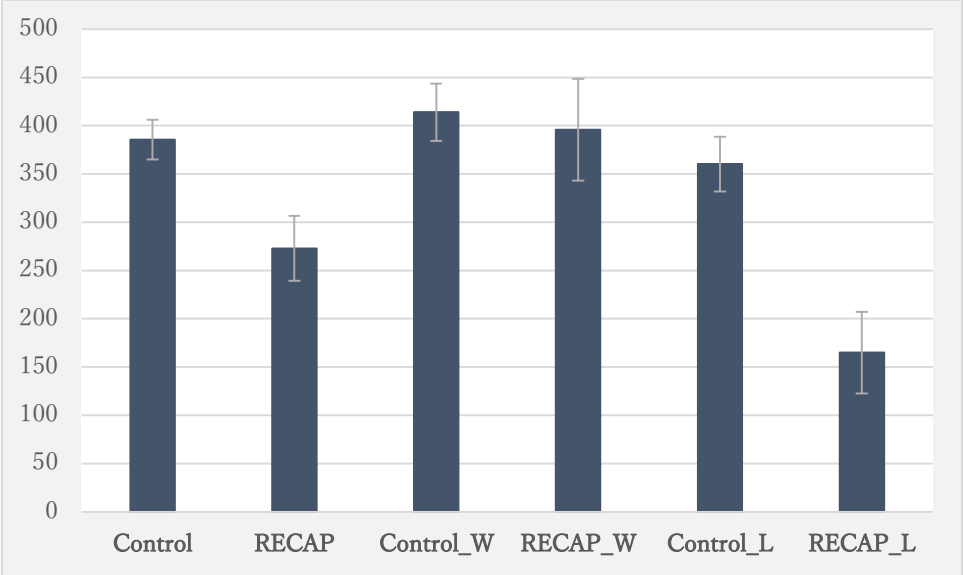


Figure 5: Average MWTP by group

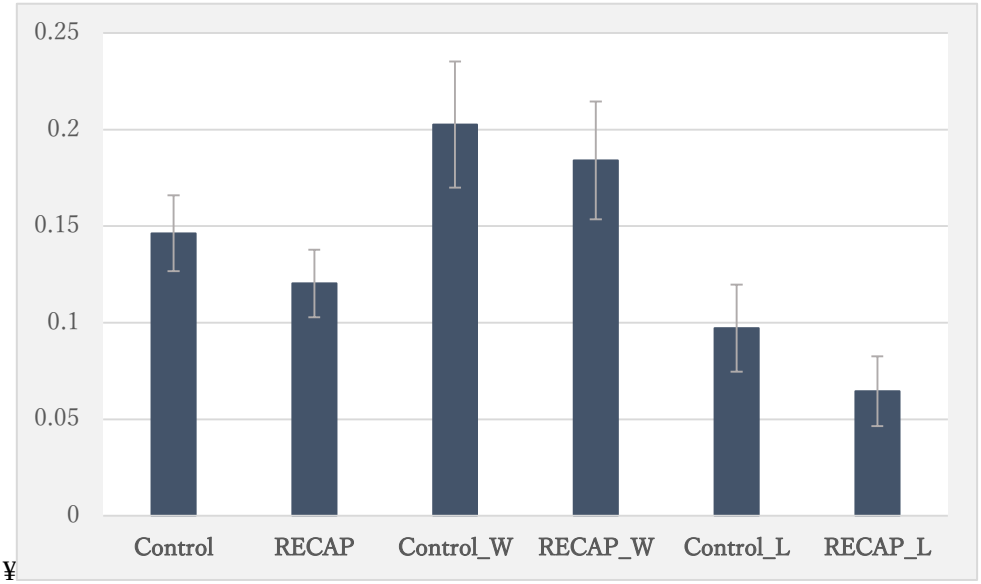


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Figure 6: Average choice probability by group

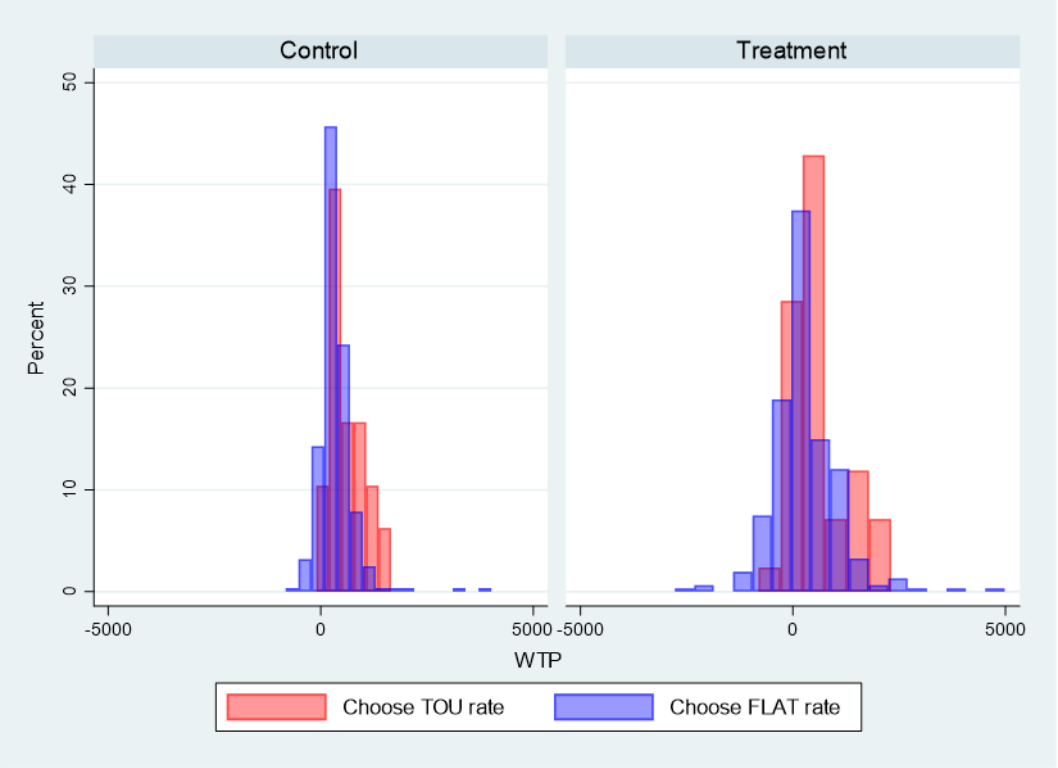

Figure 7: Distribution of TOU selection/non-selection WTP by group

Table 9: Relationship between TOU choice probability and WTP by Probit

(N=677)	(1)
Mean probability	0.073* (0.030)
RECAP	0.0111151 (0.0351294)
WTP (+)	0.0001306** (0.0000498)[依田高典1]
RECAP×WTP (+)	-0.000081 (0.0000558)
R^2	0.0316

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.

Table 10: Balance check of household attributes

	Control group	Treatment group	Difference
Sex	0.083	0.096	-0.013
(s.d.)	(0.253)	(0.280)	(s.e. = 0.016)
Employment status	0.551	0.525	0.026
(s.d.)	(0.382)	(0.391)	(s.e. = 0.024)
Household income	758.740	747.748	10.992
(s.d.)	(279.572)	(328.546)	(s.e. = 18.714)
Detached house	0.877	0.859	0.018
(s.d.)	(0.299)	(0.329)	(s.e. = 0.019)
Owned house	0.996	0.998	-0.002
(s.d.)	(0.061)	(0.043)	(s.e. = 0.003)
Number of household (persons) (s.d.)	3.235 (1.202)	3.061 (1.221)	0.173* (s.e. = 0.074)
N	531	532	

Standard errors are in parentheses. ** $p < 0.01$, * $p < 0.05$.

Table 11: **Balance check of household attributes (OLS)**

(N=1,030)	(1)
cons	0.472
	(0.271)
Daily usage (kWh)	0.002
	(0.003)
Sex	0.039
	(0.057)
Employment status	-0.030
	(0.042)
Household income	0.000
	(0.000)
Detached house	-0.050
	(0.050)
Owned house	0.164
	(0.263)
Number of household (person)	-0.028*
	(0.014)
R^2	0.0079

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.

Table 12: Analysis of attrition

	Control group	Treatment group	Difference
SPE attrition	0.068	0.083	-0.014
(s.d.)	(0.253)	(0.276)	(s.e.= 0.017)
RPE attrition	0.341	0.344	-0.003
(s.d.)	(0.475)	(0.476)	(s.e.= 0.030)
N	498	532	

Table 13: Analysis of attrition (OLS; SP・RP)

(N=1,030)	SP	RP
cons	0.075	0.971**
	(0.197)	(0.350)
Daily usage (kWh)	0.000	-0.005
	(0.002)	(0.004)
Sex	0.006	0.052
	(0.046)	(0.081)
Employment status	-0.004	-0.101
	(0.032)	(0.057)
Household income	0.000	0.000
	(0.000)	(0.000)
Detached house	-0.006	0.143*
	(0.039)	(0.070)
Owned house	0.016	-0.766*
	(0.190)	(0.337)
Number of household (person)	-0.003	0.005
	(0.010)	(0.018)
Treatment	0.034	0.116
	(0.334)	(0.593)
Daily usage × Treatment	0.000	0.008
	(0.003)	(0.005)
Sex × Treatment	-0.011	0.013
	(0.062)	(0.110)
Employment status × Treatment	0.010	0.129
	(0.045)	(0.079)
Household income × Treatment	0.000	0.000
	(0.000)	(0.000)
Detached house × Treatment	0.014	-0.019
	(0.053)	(0.095)
Owned house × Treatment	-0.064	-0.099
	(0.329)	(0.584)

Number of household × Treatment	0.008 (0.014)	-0.018 (0.025)
R^2	0.0014	0.0231

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.

Table 14: Estimation result -Overall (SP・RP)

	SP	RP
cons	39.5501 (218.5869)	-
RECAP	-101.1884* (39.8599)	-0.0246 (0.0259)
Sex	-79.8260 (56.5275)	0.0308 (0.0452)
Employment status	79.8487 (51.2190)	0.0180 (0.0323)
Household income	0.1630* (0.0679)	0.0001* (0.0000)
Detached house	-52.1371 (60.8319)	0.0528 (0.0377)
Owned house	106.0857 (198.8787)	3.3237 (15.2143)
Number of household (person)	38.3521* (16.7678)	0.0174 (0.0094)
N	952	677
R^2	0.0345	0.0293
adj R^2	0.0273	-

Standard errors are in parentheses. ** p < 0.01, * p < 0.05.