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Japanese Households' Energy Saving Behaviors Toward Social Risks by Conjoint Analysis#

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ABSTRACT

Aftermath the earthquake in March 2011, Japanese face the drastic changes in energy environment. We have been concerned about electric power shortage because nuclear power plants cease their operation. In Tokyo, people suffered from the planned power outage and even in Osaka people has been often required to save electricity use at the peak of demand. In case the shortage of electricity, we should reduce electricity use. In addition, we should promote renewable energy sources such as solar and wind power instead of nuclear power and fossil fuel such as oil and coal to reduce greenhouse gas emissions. I analyze the factors that households reduce electricity use by conjoint analysis. I find that households reduce electricity use if monthly electricity rates increase and if they recognize the possibility of outages. It might be effective to announce the possibility of outages or instability of supply to households as a nudge.

Keywords: Energy Saving, Conjoint Analysis, Outages
JEL Classifications: C25, L94, Q48

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1. INTRODUCTION

Since the Great East Japan Earthquake in March 2011, Japanese people have faced drastic changes to the energy environment. The nuclear meltdown at Fukushima was an accident of epic proportions and it is now difficult to operate nuclear power plants in the country due to shifts in public and political opinion away from supporting nuclear power. Since the earthquake, Japan has relied on natural gas (liquefied natural gas [LNG]). However, this is problematic because of greenhouse gas emissions and the increasing international momentum and resolve to mitigate anthropogenic climate change.

After the earthquake, households served by the Tokyo Electric Power Company experienced planned power outages. Even households covered by Kansai Electric Power Company have often been required to curb electricity use at the peak of demand in summer and winter while nuclear power plants remain out of operation pending the outcome of inspections.

In Japan, energy saving is an important topic because it can help prevent electric power shortages and climate change. The promotion of renewable energy sources such as solar and wind power is similarly important, instead of favoring and focusing on nuclear power and fossil fuels such as oil and coal.

Energy saving among households is important because the CO_2 emissions of households have slightly increased and the share of residential electric power in household energy consumption is large[1]. In fiscal year 2011, energy consumption in household sector is more than 2.8 times compared with 1973. The share of electricity in household sector is 50% in fiscal year 2011.

There are some approaches to prompt energy saving. Some local governments and electric power companies implement the demand response system to change the electricity demand of consumers.

1 The agency for natural resources and energy in the ministry of economy, trade and industry (2014) "White paper about energy in fiscal year 2013" Available from http://www.enecho.meti.go.jp/about/faq/001/

This system changes the patterns of consumers' behavior through an electricity rate system and an incentive payment when wholesale prices are higher and the system reliability is lower. The demand response system is divided into two types: The electricity rate type and nega-watt deal type. The time-of-day rate system, the real-time rate system and the peak load rate system are the examples of the electricity rate type. The time-of-day rate system sets higher price when electricity use is tight. The real-time rate system changes electricity rates moment by moment in response to the balance of demand and supply. The peak load rate system changes electricity rates at the peak and at the off-peak. In the nega-watt deal, an electric power company contracts with customers and if customers reduce electricity use they gain rewards from the electric power company.

The factors affecting households' energy saving is analyzed using conjoint analysis. Conjoint analysis is one of the stated preference methods and, in this context, households determine whether to save electricity use under a hypothetical situation. Monthly electricity rates, CO_2 emissions, the stability of electricity supply and energy sources are adopted as factors.

In the short-term, energy saving is justified in terms of ensuring a better match between electricity demand and supply, while in the long-term energy saving is important to reduce greenhouse gas emissions and thus militate against climate change on the one hand while also dealing with security of supply concerns. Both types of energy saving are important. Energy shortages will continue unless nuclear power plants resume operations and renewable energy sources prevail. In the short-term, electricity use should be reduced to minimize the frequency and duration of sudden power outages. After the earthquake, in the Tokyo Electric Power Company's domain, households experienced planned outages. On the other hand, in the area supplied by Kansai Electric Power Company, households have only been required to reduce electricity use. Realistically, the possibility of outages there is too small. However, if it indeed transpires that nuclear power plants do not resume operations in the future, this increases the salience of saving more electricity in case of energy shortages and planned or unplanned outages. Even if renewable energy sources prevail, electricity supply may be unstable in general because it depends on weather conditions. I analyze that households reduce electricity use if they recognize the possibility of outages and its duration lasts for many hours.

Usually, households respond to relevant prices. If electricity rates rise, households will reduce electricity use. However, we want to know whether households save electricity use to avoid climate change and outages. CO_2 emissions, the stability of electricity supply and energy sources are non-monetary factors. If they save electricity use for non-monetary reasons, this is an interesting finding. Clearly, outage costs are very high once such outages occur. Some households may save energy for non-monetary reasons that is social norm. Free-riding is also a serious problem in the context of long-term energy saving. Some people will not reduce electricity use on the assumption that others will reduce more electricity use or that any reduction on their part will be in consequential in overall, population level, terms.

The relationship between energy saving behavior and preferences for energy sources is focused. It would be suggestive if households who object to nuclear power and support renewable energy sources save electricity use.

This paper consists of the following sections. In Section 2, I introduce some related studies. In Section 3, I explain the conjoint analysis employed herein. In Section 4, I present results from a questionnaire. In Section 5, I delineate the econometric methods used to analyze the foregoing survey data and present estimation results in section 6. In section 7, I propose some policy implications.

2. RELATED LITERATURE

After the Great East Japan Earthquake in March 2011, many studies about energy saving have been published in Japan. Tanaka and Ida (2013) analyze the energy saving behavior of households in Japan after the earthquake by conjoint analysis. They found that households in the Kanto area tended to reduce electricity use because they experienced planned outages after the earthquake. Mizobuchi and Takeuchi (2013) examine which monetary factors and non-monetary factors have more effects on energy saving for households by a field experiment. They find that monetary factors have more effects on households' energy saving. Mizobuchi and Takeuchi (2012) use results from a field study to suggest that both economic and psychological factors affect energy saving in households. Among psychological factors, especially, social norms such as individual responsibility have great effects on energy saving. In a subsequent study, and by contrast, the same authors determined that monetary factors have a greater effect on energy saving in households compared to non-monetary factors. Ito et al. (2015) examined households' energy saving behaviors by a field experiment in Keihanna smart city of Kyoto prefecture. They divide their sample households into three groups: (1) Economic incentive group, (2) moral suasion group and (3) control group. In the economic incentive group, the electricity rate is raised at the peak of demand. In the moral suasion group, households are only requested to save electricity use at the peak of demand. In the control group, households are not subjected to any interventions. That study revealed that households in the economic incentive group save more electricity than those in the moral suasion group. Mizobuchi and Takeuchi (2016) analyze repurchase and additional purchase of energy saving appliances among Japanese households. Households who purchase an energy saving air conditioner can save more electricity than households who do not make such a purchase. Households who purchase an additional energy saving air conditioner can save more electricity, while households who repurchase an energy saving air conditioner do not benefit from such savings.

These foregoing studies all concern saving electricity in Japan after the earthquake. Some studies use field experiments but other studies use conjoint analysis. Poortinga, Steg, Vlek and Wiersma (2003) analyzed the effects of social and psychological factors on households' energy saving by conjoint analysis. They estimate preferences for ways of saving energy such as turning off lights in unused rooms. They find that while households exhibit preferences for different ways of saving energy, they do not concomitantly reduce their electricity consumption.

Some papers focus on the effects of nudges. Costa and Kahn (2013) find that nudges are effective. Therein, energy saving reports have effects on energy saving according to a field experiment; the ideology of individuals such as liberal or conservative also affects propensities to save energy. Allcott and Kessler (2015) estimate the consumer welfare implications of nudge effects via willingness to pay (WTP) and find that nudges do indeed increase consumer welfare. Newell and Siikamaki (2013) propose that proper information is effective for nudges. Davis and Metcalf (2014) suggest that good information leads to good consumer choices and contributes to energy saving.

Some studies focus on the effects of social norms on energy saving. Allcott (2011) showed that price and non-price interventions have the same impact on households' energy saving. Each household compares with their neighborhood. On the other hand, Arimura et al. (2014), focusing on the social interdependencies among individuals, find that social norms have little effect on households' energy saving in Japan.

From these studies, manipulation of monetary factors appears to be the most effective way to reduce household energy use. This paper focuses on both monetary and non-monetary factors. In terms of the latter, climate change, outages, and renewable energy sources are all considered. The social costs of outages and climate change are immense.

The free-rider problem is also serious in energy saving contexts. Some households might not save electricity use while others do so disproportionately. Grosche and Vance (2009) estimate WTP for free-riding in Germany. When households acquire government subsidies for energy saving interventions, free-riding is induced. Free-riding is calculated by the excess of WTP over the actual cost.

Some studies have examined the long-term effects of energy saving by households' by analyzing electricity consumption data. Allcott and Rogers (2014) compared a treatment and control group where households received a report periodically or received no such report, respectively. In addition, they compare a group where households continue to receive reports and a group where households cease to do so 2 years later in order to analyze similarities/differences between groups in the short- and long-term. They find that even where households cease to receive reports, energy saving effects continue due to the habitual effects.

Ayres et al. (2013) note that peer comparison with other households promotes energy saving at a lower cost.

3. CONJOINT ANALYSIS

Households' energy saving behavior is analyzed using a stated preference method, conjoint analysis.[2] We can estimate the preference of individuals for hypothetical goods or services which have several attributes using this technique. Households choose an option from a set of alternatives framed in terms of hypothetical goods or services. Conjoint analysis is adopted to examine households' energy saving behavior under the hypothetical situations involving changes in monthly electricity rates, CO_2 emissions and the possibility of outages. In conjoint analysis, we present profiles of goods or services which have several attributes to households. A profile which has too few attributes will not allow significant heterogeneity in preferences to be expressed, while a profile which has too many attributes places a cognitive burden on respondents. In general, we adopt five or six attributes. After we decide on attributes and their levels, we construct profiles using the orthogonal planning method to militate against multicollinearity. From various cards which we get through the orthogonal planning method, selecting cards, and their combinations, we construct profiles while removing unrealistic and dominant cards. SPSS conjoint version 17.0 is used to implement the orthogonal planning method.

The contingent valuation method (CVM) is another popular stated preference method but it is not a choice experiment. We use CVM when we evaluate users' values of non-marketable targets such as forests and coastal areas.

The following alternatives are presented to households to analyze their behavior vis-à-vis energy saving. Households choose one of the alternatives under some hypothetical situations.

- Alternative 1: Decrease by 10–20% (decrease a lot)
- Alternative 2: Decrease by 5–10% (decrease a little)
- Alternative 3: Unchanged
- Alternative 4: Increase.

An ordered logit model is used for estimation because these alternatives have a clear order. The following profile attributes are adopted: Monthly electricity rates, emissions of global greenhouse gases such as CO_2, the possibility and duration of electric power outages, and the main energy sources which are used to generate electricity.

3.1. Monthly Electricity Rates

Monthly electricity rates increase or decrease compared with current rates. The levels are −2000 JPY, −1500 JPY, −1000 JPY, −500 JPY, 0 JPY (unchanged), +500 JPY, +1000 JPY, +1500 JPY, +2000 JPY. Electricity rate are related with energy sources. Electricity generated by nuclear power might be cheaper. Electricity generated by thermal power might be higher due to the volatile fuel prices and foreign exchange rates. Electricity generated by renewable energy sources might be higher due to the feed-in tariff. The electricity rates are monetary factors.

3.2. CO_2 Emissions

CO_2 emissions will increase or decrease in 2030 compared with 1990 which is the benchmark year of the Kyoto Protocol. The levels are −20%, −10%, 0% (unchanged), +10% and +20%. CO_2 emissions are related with energy sources. Nuclear power might reduce CO_2 emissions. Coal and LNG might increase emissions while renewables might reduce emissions. Households who reduce their electricity use for concerns about climate change may be anchoring

2 Referred to Louviere et al. (2000), Kuriyama et al. (2005), Tsuge et al. (2011), Kuriyama et al. (2013) for conjoint analysis.

to a social norm. CO_2 emissions are non-monetary factors. We note a free-rider problem. Some households think that they do not need to save electricity use to reduce CO_2 emissions if others are doing so.

3.3. The Stability of Electricity Supply

The possibility of outages and their duration are presented to households. Sometimes households should reduce electricity use to avoid sudden outages. I examine whether households save electricity use or not when they recognize the possibility of outages:

1. An outage occurs once in a year and lasts for one hour or more (60 min)
2. An outage occurs once in a year and lasts for half an hour (30 min)
3. An outage occurs once in a year and lasts for a few minutes (3 min)
4. An outage occurs once in a year and lasts for a few seconds (0.05 min)
5. No outage (electricity is always supplied constantly).

Stability of supply or lack there of, is related with energy sources. In the case of nuclear power, an outage could be caused due to accidents at nuclear power plants. If nuclear power is not used, a planned outage might be experienced at the peak of demand in summer and winter to avoid one or more unplanned outages. If renewable energy sources are used, electricity supply might be unstable due to weather conditions such as short daylight hours or insufficient wind. Households who save electricity use because they are concerned about outages may be adhering to a social norm. If households save electricity use by the notice of outages, it might be effective for local governments or electric power companies to announce the possibility of outages or instability of electric power to households as a nudge. Outage is one of the non-monetary factors.

3.4. Energy Sources

An energy supply source set consisting of nuclear power, coal, natural gas (LNG), solar, and wind power are supposed. Households use one of these energy sources. Each energy source is represented by a dummy variable. Coal is the base category. Energy sources are non-monetary factors.

Each energy source has some risks. The possible risks associated with each energy source are presented to households. Households recognize these risks when they choose energy sources. Households who prefer renewable energy sources might save their electricity use because they recognize that their electricity supply is unstable due to weather conditions.

The possible risks with each energy source are as follows.

1. Nuclear power: Accidents in nuclear power plants
2. Coal: Climate change because of CO_2 emissions
3. LNG: Volatile and rising electricity rates
4. Renewable energy: The possibility of outages and instability of electricity supply due to weather conditions.

The levels of each variable are summarized in Table 1.

An example profile is shown in Table 2.

Table 1: Variables and levels

Variable	Level
Monthly electricity price (JPY)	−2000, −1500, −1000, −500, 0 (unchanged), +500, +1000, +1500, +2000
CO2 emissions	−20%, −10%, 0% (unchanged), +10%, and+20%
Outage (minutes)	60, 30, 3, 0.05, 0
Energy source	Nuclear, coal, LNG, solar, and wind power

Table 2: Example profile

Attribute	Level
Monthly electricity price (JPY)	−2000 JPY
CO_2 emissions	−20%
Outage (minutes)	No outage
Energy source	Nuclear power

Households choose one of the alternatives about energy saving under the conditions of the profiles. They answer with respect to ten choice questions. Each question has various levels of attributes. To use various profile configurations, households were divided into two groups and each group was asked to answer with respect to ten profiles. Data were collected online via a web-based questionnaire utilizing the services of the Rakuten Research company. The total sample size is 800 households: n = 400 in Kanto[3] and n = 400 Kansai[4]. Data were collected in October 16, 2015.

4. QUESTIONNAIRE RESULTS

In this section, I illustrate the results of the questionnaire. Table 3 provides attributes of the sample households.

5. ECONOMETRIC ANALYSIS

An ordered logit model is used because alternatives about energy saving have a clear order[5].

The regression model is

$$y_i^* = \sum \beta x_i + \varepsilon_i \tag{1}$$

y_i^* is the potential utility level of a household based on a random utility model, ε is the error term and β denotes parameters. The mechanisms as to how household choices dictate values of the dependent variable can be summarized as follows:

$$\begin{aligned} y_i &= 1 \text{ if } c_{-1} < y_i^* \le c_0 \\ &= 2 \text{ if } c_0 < y_i^* \le c_1 \\ &= 3 \text{ if } c_1 < y_i^* \le c_2 \\ &= 4 \text{ if } c_2 < y_i^* \le c_3 \end{aligned} \tag{2}$$

3 Kanto area is the east part of Japan around Tokyo. Saitama, Chiba, Tokyo and Kanagawa prefectures are included.

4 Kansai area is the west part of Japan around Osaka. Shiga, Kyoto, Osaka, Nara, Hyogo and Wakayama prefectures are included.

5 Greene and Hensher (2010) are referred for details concerning ordered logit models.

c is a threshold value. If the utility level of a household exists between c_1 and c_2, the household chooses alternative 3. If the utility level of a household exceeds c_2, the household chooses alternative 4. In this ordered logit context, we estimate the threshold values c as well as parameters β. We formulate the probability to choose each alternative and estimate β and c by the maximum likelihood ion method to maximize the log likelihood function.

Table 3: Households' attributes

Attributes	N=800 (%)
Occupation	
Company worker	416 (52)
Public worker	42 (5.3)
Student	1 (0.1)
Unemployed (including housewives and retirees)	193 (24.1)
Self-employed	65 (8.1)
Others	83 (10.4)
Household income (thousand JPY)	
< 2,000	169 (21.1)
2,000–3,990	152 (19)
4,000–5,990	187 (23.4)
6,000–7,990	127 (15.9)
8,000–9,990	90 (11.3)
> 10,000	75 (9.4)
Educational background	
Junior high school, high school	193 (24.1)
Technical school, junior college	170 (21.3)
University, graduate school	437 (54.6)
Family composition	
Single	147 (18.4)
Two	205 (25.6)
Three	197 (24.6)
Four	179 (22.4)
Fve	58 (7.3)
Six or more	14 (1.8)
Dwelling type	
Detached house (including two households' house)	410 (51.3)
Collective housing (condominium, apartment, housing complex etc.)	372 (46.5)
Company housing, dormitory housing etc.	18 (2.3)
Sex	
Male	523(65.4)
Female	277 (34.6)
Age (years)	
20–29	38 (4.8)
30–39	150 (18.8)
40–49	240(30.0)
50–59	240 (30.0)
60 and above	132 (16.5)
Mean	48.01
Minimum	21
Maximum	69

Table 4: Number and ratio of choices across alternatives

Alternative	Number	Ratio
1	1922	0.240
2	3180	0.398
3	2682	0.335
4	216	0.027
Total	8000	1

6. ESTIMATION RESULTS

In this section, the estimation results from the ordered logit model are explained. Table 4 shows the number of choices for each alternative.

More than half of households tend to reduce electricity use. The majority of the remainder do not change their energy use behaviors with very few opting to increase their usage.

Table 5 presents descriptive statistics of alternatives' attributes.

Table 6 illustrates the estimation results.

The coefficient of the monthly electricity rates is negative and significant at the 1% level. If the electricity rates increase, households reduce their electricity use. The coefficient of CO_2 emissions is negative but insignificant. CO_2 emissions do not have any discernable effect on energy saving. The coefficient of outage is negative and significant at the 1% level. Households reduce electricity use if they recognize the possibility of outages and its duration is long. Nuclear power is not significant. When households use electricity generated by nuclear power, they do not tend to reduce their electricity use. On the other hand, the coefficient of renewable energy resources (solar and wind) power is positive and significant at the 1% level. Households use more electricity when it is generated by renewable sources. From the results, we support the electricity rate system which raises electricity prices during peak times in order to reduce electricity use. If households are aware of the possibility of outages, they will reduce electricity use. It might be advisable for local governments or electric power companies to announce the possibility of outages or instability of electric power to households as a nudge.

Next, households' attributes are included as independent variables; the results from this estimation are presented in Table 7.

Family income and educational background are insignificant and thus do not effect energy saving. On the other hand, the coefficient of the number of family members, detached house and condominium dummy variables[6] are negative and significant at the 1% level. Households who have many family members, live in a detached house and live in a condominium tend to reduce their electricity use. Kanto dummy variable is insignificant: There is no difference between households in Kanto and Kansai vis-à-vis saving electricity. More than four years have passed since the earthquake at the time of this research. Although households in Kanto experienced planned outages after the earthquake while Kansai did not, the difference disappears over time.

Table 8 shows estimation results, including households' consciousness, as independent variables. The variables of energy saving consciousness, support for renewable energy resources and consciousness for CO_2 reduction are included as independent variables. Many households choose the same alternative of "decrease electricity use" under all conditions. The variable scale

6 Company housing and dormitory housing is the base category.

Table 5: Descriptive statistics

Alternative	Electricity rate	CO_2	Outage	Nuclear	Coal	LNG	Solar	Wind
1								
Average	531.217	0.546	15.186	0.174	0.212	0.268	0.207	0.138
Standard deviation	1458.631	14.909	21.753	0.379	0.409	0.443	0.405	0.345
2								
Average	428.774	0.316	13.611	0.174	0.221	0.259	0.205	0.141
Standard deviation	1395.248	14.576	21.165	0.379	0.415	0.438	0.404	0.348
3								
Average	61.708	−1.930	14.116	0.255	0.172	0.231	0.177	0.166
Standard deviation	1396.903	14.256	22.284	0.436	0.377	0.421	0.382	0.372
4								
Average	231.481	−4.074	17.274	0.130	0.130	0.185	0.352	0.204
Sandard deviation	1436.931	13.349	23.853	0.337	0.337	0.389	0.479	0.404

Table 6: Estimation results

Variable	Coefficient	Standard error	Z-value	P-value
Electricity rate	−0.000197	0.000017	−11.33	0
CO_2	−0.003646	0.003198	−1.14	0.25
Outage	−0.002903	0.001079	−2.69	0.01
Nuclear	0.105617	0.111215	0.95	0.34
LNG	0.117357	0.062346	1.88	0.06
Solar	0.246804	0.10591	2.33	0.02
Wind	0.442355	0.109648	4.03	0
Cut1	−1.115342	0.066002		
Cut2	0.636091	0.065097		
Cut3	3.688323	0.092296		

Log likelihood−9285.7997 Pseudo R^2 0.0107

Table 7: Estimation results (including households' attributes)

Variable	Coefficient	Standard error	Z-value	P-value
Electricity rate	−0.000197	0.000017	−11.33	0
CO_2	−0.003625	0.0032	−1.13	0.26
Outage	−0.002882	0.00108	−2.67	0.01
Nuclear	0.107942	0.111253	0.97	0.33
LNG	0.117277	0.062378	1.88	0.06
Solar	0.246738	0.105965	2.33	0.02
Wind	0.443412	0.109717	4.04	0
Income	0.00037	0.014185	0.03	0.98
Education	−0.039796	0.026232	−1.52	0.13
Family members	−0.034945	0.018054	−1.94	0.05
Detached house	−0.485616	0.1384	−3.51	0
Condominium	−0.319477	0.137544	−2.32	0.02
Kanto	0.037566	0.041916	0.9	0.37
Cut1	−1.686646	0.170928		
Cut2	0.071095	0.169804		
Cut3	3.129201	0.181399		

Log likelihood−9267.5176 Pseudo R^2 0.0126

of consciousness to save electricity use is "very conscious: 1," "a little conscious: 2," "unchanged: 3" and "not conscious: 4." The variable of support for renewable energy sources is a dummy variable. If a household chooses renewable energy sources such as solar, wind, geothermal heat, biomass, tidal, and wave power in the first or second priority, I assign 1, else 0. The variable scale of consciousness of CO_2 reduction is "reduce more: 1," "reduce a little: 2," "no need to reduce: 3" and "increase: 4."

The coefficients of consciousness to save electricity and consciousness for CO_2 are positive and significant at the 1% level. Naturally, households who have high consciousness to reduce electricity indeed do so under any conditions regarding the possibility of outages and energy sources. And households who have high consciousness for CO_2 reduce electricity. However, the coefficient of support for renewable energy sources is negative and insignificant; thus households who support renewable energy sources do not appear to be motivated to reduce their electricity use.

7. CONCLUSIONS AND POLICY IMPLICATIONS

I analyze the conditions under which households reduce, or do not reduce, their electricity use by conjoint analysis. It is necessary to reduce residential electricity consumption. Future electric power shortages are possible and plausible unless nuclear power plants resume operations and renewable energy sources prevail. Moreover, to reduce CO_2 emissions and thus mitigate climate change, residential energy demand reduction is important in the long run.

We find that households save electricity use when monthly electricity rates and the possibility of outages increase. Households are thus responding to a monetary stimulus in the case of the former and a non-monetary stimulus in the case of the latter, which can be conceived from a social norm perspective. However, CO_2 emissions and renewable energy sources are not the conditions to induce households to reduce their electricity consumption. From the results, we support the electricity rate system which raises prices at peak times to reduce demand accordingly. If households are aware of the possibility of outages, they will reduce their electricity consumption. Thus it might be effective for local governments or electric power companies to announce the possibility of outages or instability of supply to households as a nudge.

Since the 2011 earthquake there has been a shift in knowledge about and preferences for different energy sources among Japanese people. Some people are against nuclear power and for renewable energy resources. The relationship between preferences for renewable energy resources and energy saving behavior is an interesting topic. Generally, electricity supplied from renewable energy resources is unstable because of its dependence upon the requisite weather conditions. Long-term energy saving is important

Table 8: Estimation results (including consciousness variables)

Variable	Coefficient	Standard error	Z-value	P-value
Electricity rate	–0.00021	0.0000182	–11.56	0
CO_2	–0.00448	0.0033441	–1.34	0.18
Outage	–0.003259	0.0011321	–2.88	0
Nuclear	0.1015609	0.1160521	0.88	0.38
LNG	0.1221245	0.0653314	1.87	0.06
Solar	0.263804	0.1108557	2.38	0.02
Wind	0.4559248	0.1145589	3.98	0
Consciousness for saving	0.476094	0.029571	16.1	0
Support renewable energy	–0.035601	0.0461481	–0.77	0.44
Consciousness for CO_2	0.5556902	0.0329335	16.87	0
Cut1	0.6237048	0.1028449		
Cut2	2.549215	0.1070492		
Cut3	5.732475	0.1331753		

Log likelihood –8294.5046 Pseudo R^2 0.0513

to avoid climate change and to prepare energy shortages. In this paper, households respond to temporal outages caused by the tightness of electricity demand. However, they do not respond to CO_2 emissions. The system should be considered to promote long-term energy saving for households.

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