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Price Premia for Information on Local Social Impacts of Electricity Production: A Choice Experiment in Japan

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Abstract

Recent trends concerning electricity markets in developed countries are characterised by market liberalisation and an increase in electricity produced by renewable sources (REL). While electricity companies in Western society usually provide general environmental information on REL to electricity consumers, they rarely provide information regarding REL's local social impacts. This may lead to missing additional profits for REL providers if there are premia felt by consumers by providing such information. Whether the disclosure of such local social impacts by electricity facility siting has had positive marketing impacts is yet to be ascertained in the global literature and is worth analysing. Therefore, this study examined Japanese electricity consumers' preferences for different kinds of local information regarding electricity production sites using the choice experiment method. The investigation is of much interest to global REL marketing as well as policymakers. There was a positive preference for information regarding local electricity production, with the most preferred option being 100% renewable energy plus information disclosure for local vitalisation. Determinants of such preferences were also analysed. This study contributes significant implications for electricity companies' information disclosure strategy and electricity information disclosure policy.

Keywords: *information disclosure, local social impacts, renewable electricity, consumer preferences, energy marketing*

1. INTRODUCTION

Recent trends concerning electricity markets in developed countries are characterised by market liberalisation and an increase in electricity produced by renewable sources (REL). It has often been claimed in developed countries that REL produces general environmental benefits and local socio-economic benefits in areas where it is installed (Coenraads and Voogt, 2006). However, while electricity companies in Western society usually provide information regarding the general environmental impacts of REL to electricity consumers, they rarely provide information regarding the local social impacts of electricity. This may lead to missing additional profits for REL providers if there are premia felt by consumers by providing such information.

Whether the disclosure of such local social impacts by electricity facility siting has had positive marketing impacts is not clear. First, preference for such information disclosure has not been analysed much globally. The reasons for this limited analysis certainly seem to be relevant to the current information disclosure practices. Information disclosure for electricity users in Western societies mainly includes energy mix (portion of renewable energy sources and existing energy) and greenhouse gas (GHG) reduction amounts, and usually little information has been provided regarding local social impacts generated by facility siting. However, these current information disclosure practices may not be successful in achieving premia of REL felt by electricity consumers; REL's actual price premia of REL is not high when only general environmental merits such as GHS reduction are claimed (Mulder and Zomer, 2016; Raadal et al., 2012).

Second, the results of limited literature concerning preferences for information regarding the social impacts of REL are largely inconsistent. While the so-called 'NIMBY (Not In My Back Yard)' problem has been found in the literature regarding electricity facility siting if it degrades the local environment, some literature has found a premium for local electricity production (Rommel et al., 2016; Sagebiel et al., 2014). Therefore, preferences of electricity consumers for local electricity facility siting are not well understood in global literature.

This study examines how Japanese electricity consumers choose their electricity when local social impacts of electricity production are disclosed. In Japan, many 'new electricity' companies[1)], a majority of which sell REL and have social business characteristics, have been established, and they have a marketing strategy to contribute to the local socio-economy, with its REL generation being environmentally friendly in nature (Japanese new electricity companies' websites, 2019)[2)]. Analyses are conducted by examining how electricity consumers respond to the combination of different information under different assumptions using the choice experiment (CE) method. CE is useful to understand preference trade-offs among hypothetical designs regarding electricity information disclosure. Hypothetically, information is provided to electricity consumers, including not only the figures about the energy mix which is already disclosed in the existing disclosure practices, but also local socio-economic and environmental impacts of electricity production. Determinants of such preferences for local information are also analysed.

The next two sections review the relevant literature. Section 4 explains the statistical model and questionnaire design. Section 5 discusses the results, and Section 6 summarises the study. This study will have significant implications for global electricity marketing and policy by promoting an understanding of how electricity companies should utilise local social information even when information regarding the energy mix does not attract a high premium.

2. INFORMATION DISCLOSURE PRACTICES TO RETAIL ELECTRICITY CONSUMERS

How information for sustainable marketing is conveyed to consumers is vital (Kaenzig et al., 2013; Markard and Holt, 2003). To examine information disclosure strategy, it is necessary to consider the disclosure of mandatory information first, but voluntary information should be effectively chosen to communicate with consumers. Installers of Western electricity facilities are obliged to disclose certain mandatory information. However, in many cases only environmental information is provided to electricity consumers and often no social impact information is required, although there are exceptions such as in Massachusetts state where regional average labour characteristics of facilities is required (Commonwealth of Massachusetts, 2020). In particular, disclosure of information regarding fuel mix is generally required, and information regarding GHG, NOx, and SOx is often required as well. Sometimes information on suspended particulate matter, heavy metals, radioactive waste, and country of origin is also required (Markard and Holt, 2003). This information pertains to global or regional environmental impacts, and not local environmental impacts such as the reduction of local biodiversity near the facilities.

In addition to the above-mentioned mandatory information regulations, there is voluntary information disclosure in Western societies, including such information obtained by institutions as renewable energy certificates (RECs) and guarantees of origin (GoO), and eco-labels operated by voluntary groups and companies (Bröckl et al., 2011). RECs' tracking systems provide not only aggregate numbers on how many RECs have been created, but also their location, resource type, and other key statistics. GoO, a certificate of origin of renewable energy regulated by the EU renewable energy directive (Directive 2001/77/EC), certifies renewable energy sources, generation days, and sites. In Japan, the 'green electricity certification (*green denryoku shosho*)' system, which is similar to RECs and GoO, is operated and its certifications, including information on renewable sources, location and production amount, are traded. However, RECs and GoO, and their similar systems are based on the idea of 'physical detachment'; they could be traded independently of physically exchanged energy (Holt and Bird, 2005; Raadal et al., 2012; Ragwitz et al., 2009; The National Renewable Energy Laboratory, 2015). It appears that this nature of detachment has attracted little attention on local impact of electricity production and little such information has been provided to electricity end-users, although these systems have some information regarding production sites.

There are as many as 457 types of eco-labels around the world (Big Room Inc., 2020), and examination of all their cases regarding information provision to retail electricity consumers is impossible. However, in general, electricity providers selling eco-labelled electricity only seem to provide information on REL sources. Other information is sometimes provided, such as by the renewable electricity label 'EKOenergy' provided by the European EKOenergy network, which is a network comprising more than 30 environmental NGOs in more than 20 European countries. Some providers selling 'EKOenergy' disclose information not only about the renewable portion but also of local environmental information such as safeguarding of marine and bird habitats and fish migration to end-users. There are also a variety of eco-labels (in Japan they are usually called eco marks) (Japan Quality Assurance Organization, 2020), and the aforementioned green electricity certificates also include eco-labels, for example. However, eco-labelled electricity does not seem to be utilised in retail electricity marketing strategy in Japan.

Ten large existing electricity companies in Japan disclose environmental, economic, and social information regarding electricity and its production in their integrated reports ('*togohokokusho*'), CSR reports, sustainability reports, and environmental reports. However, such information does not concern the impact of the electricity that each electricity consumer utilises but is information regarding all the impacts of electricity production of those companies together. 'New electricity' companies do not issue integrated reports ('*togohokokusho*'), CSR reports, sustainability reports, and environmental reports.

In general, Western consumers mainly know the characteristics of their electricity through online marketing activities made by electricity companies (Herbes and Ramme, 2014). Herbes and Ramme (2014) analysed 600 product pages of green electricity providers' online marketing communication in Germany. They concluded that environmental protection benefits (which was mentioned in 47% of all product pages) and climate protection contributions/CO_2 emissions (44%) were the most cited items in the providers' online communication. Although not a large percentage compared to environmental information (27%), regional production was also communicated (Herbes and Ramme, 2014). In Japan, electricity companies often publish environmental friendliness of REL on their websites. 'New electricity' companies often provide information regarding local social benefits in addition to it. Kawahara and Irie (2019) analysed 25 local power producers and suppliers and found that local production and utilisation of energy ('*chisan-chisho*' in Japanese), local revitalisation, electricity cost saving, generation sites, and the fact that the electricity sources are renewables were predominantly disclosed on their websites (Kawahara and Irie, 2019).

To summarise, Western electricity consumers as well as Japanese consumers, are aware of the local social impacts of REL production either when REL is known to be produced only in certain areas, for example, it is known by the providers' names; or when information regarding REL production areas is disclosed by providers on their websites, etc., and if providers disclose local social impacts. However, if electricity users do not check such information on websites, they are not aware of local information. The following are possible reasons underlying this situation. First is providers' cost merit of obtaining environmental values. Lower cost procurement of REL is realised when the environmental values of REL are widely traded by detaching it from electricity use value in systems such as RECs, GoO, and certificates of eco-labels (Rossi and Hinrichs, 2011). These systems may currently be unaware that there may be consumers who perceive positive premia for local energy production. A second possible reason is that electricity providers may not have a reason to disclose local energy production site information when they operate in wide areas (Herbes and Ramme, 2014). Herbes and Ramme (2014) commented that many providers buy hydropower from Austria and Norway, raising the question of a provider's best use of regionality. The third reason is that physical identification of particular REL sources is technically difficult after REL is connected to electricity grids (Matsubara, 2009; Rossi and Hinrichs, 2011).

3. CONSUMER PREFERENCE FOR REL

3.1. Preference for retail electricity and general REL

Retail electricity consumers are predominantly concerned about the electricity cost, but they are also concerned about other electricity supply issues relevant to REL production. Kaenzig et al. (2013) demonstrated that the source of the energy and monthly electricity costs are the two most important decision-making attributes for the average electricity consumer. Markard and Holt (2003) found that consumers in the U.S. and Switzerland show a similar strong interest in issues relating not only to the price and reliability of service, but also environmental impacts and generation sources.

The literature suggests that when the general environmental benefits of REL, such as GHG, NOx, and SOx reduction, are recognised, electricity users pay price premia for it. Sundt and Rehdanz (2015) conducted a meta-analysis of global trends revealed by preference studies published between 2007 and 2012 and found that the willingness to pay (WTP) values were in the range of 2–6 and 1–7 U.S. cents per kWh for developed and developing countries, respectively.

In the U.S., Roe et al. (2001, p. 924) found that an increase in REL portion by 1% generates six dollars of premia per year per household consuming 1000 kWh of electricity per month. Murakami et al. (2015) also concluded that U.S. and Japanese consumers were willing to pay $0.71 and $0.31 per month for a 1% increase in the use of REL, which were $8.52 and $3.72 a year, respectively.

Comparatively, many WTP studies have been conducted in Germany, with the results varying in magnitude among studies. Grösche and Schröder (2011) found a 22% premium for moving from 0% to 100% of REL in Germany. In their 2009 study, Kaenzig et al. (2013) revealed an average WTP premium of about 16% for 100% renewable REL for German retail consumers. Studies by Sagebiel et al. (2014, p. 98) conducted in 2012 determined that German electricity consumers had a WTP value of 22.26 Euro cents per kWh for an increase from a 0% share to a 100% share of REL. Rommel et al. (2016) found that German consumers' WTP values for renewable energy range from 2.3 Euro cents per kWh to 6.8 Euro cents per kWh.

In contrast, the actual premia for REL are reportedly not as high when compared to the ranges that the previous surveys hypothetically estimated (Mulder and Zomer, 2016; Raadal et al.,2012; Roe et al., 2001), and the acceptance of REL is still low (Litvine and Wüstenhagen, 2011). Reijnders (2002) reported that there were cases where green electricity was sold cheaper than grey or default electricity by 0.46 Euro cents per kWh, or that grey and green electricity were sold at the same price, and that the maximum price difference between green and grey electricity was the equivalent of 2.3 Euro cents per kWh. Through a hedonic analysis conducted in the U.S., Roe et al. (2001) found that the average annual premium was $73.55, and the median premium was $59.40. This was equivalent to 0.5–0.6 cents per kWh when the calculation is based on the average U.S. power consumption of 13.0 MWh per person per year (1083 kWh a month) in the year 2001 (Raadal et al., 2012), and was 7.5% (mean) and 6.1% (median) of the average retail price of electricity of 7.5 cents per kWh (U.S. Energy Information Administration, 2020). World Watch magazine (2007) stated that the REC of wind power traded at $1.5–13 per 1000 kWh , and this amount was lower than the U.S. federal renewable electricity production tax credit. The above analyses suggest that actual premia for REL would be less than 20% of default electricity. The actual price premia are said to be lower than the survey results because of hypothetical bias of stated preference methods that are often utilised to analyse WTP amounts (Roe et al., 2001).

Premia for REL have also been reported to be relevant to consumers' socio-demographic variables (SDVs) and psychographic variables. According to the literature review of Herbes et al. (2015), the former includes age, gender, income, education, and household size. The latter includes environmental awareness, pro-environmental behaviour, altruism, pro-environmental attitudes, and information on renewables.

3.2. Preference for local positive/negative impacts of REL

Markard and Holt (2003) found that information about country of origin had strong positive reactions among participants in Switzerland, while generation location was not a topic of discussion in the U.S. focus groups. However, the literature on so-called 'NIMBYism' ('Not In My Back Yard') or 'YIMBYism' ('Yes In My Back Yard') suggests that various socio-economic or environmental benefits and risks of facility siting are evaluated differently by the local populace, depending on whether they are negative or positive impacts, how large and important those impacts are, and whether they are generated near a respondent's residence, or are perceived as more general benefits/risks to society. These NIMBYisms or YIMBYisms may affect retail electricity consumer preferences.

On the positive side, REL has often been argued to have effects such as diversification of power generation sources and employment, especially in regions that are economically weak (Coenraads and Voogt, 2006). Damigos et al. (2009) found that the WTP value for energy security was an average surcharge of 7.1% of the electricity charge. Hironaka and Hondo (2017) argued that half of the respondents from Nagano Prefecture in Japan would accept a monetary contribution of JPY 686 per month per household for social benefits, including 'environmentally benign locality' and 'energetically secured locality' because of the introduction of REL. In a Scottish study, Bergmann et al. (2008) found that respondents had a positive WTP value for slight improvements to wildlife in their electricity bills, which was larger for urban respondents than for rural respondents.

On the negative side, safety of REL facilities, degradation of the landscape, and power outages have been found to impact preferences for REL. Markard and Holt (2003) found that Swiss participants were concerned about the safety of electricity generating facilities. Consumers may have a mix of positive and negative impacts regarding local REL. Irie and Kawahara (2014), who analysed respondents' views towards a hypothetical project involving the construction of new photovoltaic power (PV) systems across Japan, found that PV installation and its electricity usage gained positive values overall, while electricity outages and installation areas near houses were negatively evaluated by respondents. The mean WTP values for (1) 1500 kW of local PV installation (600 tonnes of CO_2 reduction and the use of 10000 m^2 of land), (2) PV electricity usage, (3) electricity outages, and (4) areas of installation near houses (covering 1000 m^2) were estimated to be JPY 692, JPY 1229, JPY -674, and JPY -1316 per month per household, respectively. These studies suggest that the mixt of information regarding whether there are positive or negative impacts to local society and electricity consumers are required for respondents to realistically evaluate local REL.

4. MATERIALS AND METHODS

4.1. Design of the choice experiment (CE)

CE, which is evaluated by electricity consumers, is used to estimate the relative significance of characteristics electricity has. CEs are the methodologies used to ascertain the relative sizes of the utilities of two or more characteristics, or attributes, of a good (a product) or service (Lancaster, 1966; McFadden, 1977). The questionnaire asked each respondent to choose the most preferred type of electricity from three alternatives, based on the portion of REL and

Table 1: Choice experiment's attributes and levels

Attribute	Levels
Portion of REL (RE)	0% 33% 67% 100%
Portion of local production of all electricity (LE)	0% 33% 67% 100%
Statement regarding local revitalisation (IR)	No Yes
Statement regarding local production and utilisation of electricity ('*chisan-chisho*' in Japanese) (IC)	No Yes
Statement regarding the nonexistence of negative environmental impacts (IE)	No Yes
Increase of cost of electricity compared to the status-quo (CT)	-10% +0 % +10 % +20%

Notice: Information on local socio-economic impact is to qualitatively state that there is a positive local socio-economic impact of either having local revitalization (IR) or conducting '*chisan-chisho*' (IC). Information on local environmental impact is to qualitatively state that there are no negative environmental impacts on your local environment (IE).

the portion of REL that is generated in respondents' local areas, information regarding local impacts of electricity generation, and electricity costs.

The above literature provided the information regarding attributes and attribute levels, as shown in Table 1. Although fuel mix and emissions (GHG, NOx, and SOx etc.) are usually disclosed to retail electricity consumers in the U.S. and Europe, only a portion of REL ('RE') is disclosed in the attributes because the focus of this study is to measure how consumers value information that is generally not disclosed currently, namely, information regarding the localness of production ('LE') and impacts to local areas of REL generation. This information coverage seems natural in Japan where information on each retail electricity consumers' fuel mix and emissions is not explicitly disclosed to most Japanese consumers, especially when they buy electricity, while some local information is disclosed by 'new electricity' companies.

Local information was selected, which was considered to be the most often disclosed by Japanese 'new electricity' companies. As positive local socio-economic impacts, the qualitative statement regarding local revitalisation ('IR'), and local production and utilisation of energy ('*chisan-chisho*') ('IC') were either made or not made in each alternative. Assumption was made that '*chisan-chisho*' of electricity would lead to the possibility of improved stable electricity usage during disasters. Since REL facilities are known to sometimes degrade the local environment, affecting wildlife, landscape, and local people's safety, an additional environmental statement was made regarding the nonexistence of negative environmental impacts ('IE'). The cost of electricity ('CT'), defined as the average monthly cost of electricity, was also set as an attribute. Cost was at a premium between -10% to 20% of the status-quo electricity, considering that the amount would cover the actual market price of REL in Western countries.

An explanation was provided that GHG emission reduction is expected when people buy REL. Other aspects not explicitly included as attributes, such as reliability of service and electricity providers, were assumed to be the same for different alternatives. 'Local' was explained as local prefectures where the respondents lived.

All the coefficients were made generic and there was no alternative specific coefficient (namely, unlabelled experiment). The status-quo alternative, the existing one which each respondent used at the time of the survey, was not included as an alternative, which may have led to forced choices and created a bias in the responses (Dhar and Simonson, 2003; Ferrini and Scarpa, 2007). However, it was anticipated that the status-quo situation may have been erroneously remembered by the respondents, or in many cases remained undisclosed to the respondents by electricity companies, especially regarding the exact percentages of REL and the percentage of local production of electricity, which would also trigger bias. Therefore, lack of the status-quo option was not expected to lead to a more biased result overall. In fact, some researchers have suggested that the inclusion of a status-quo option may produce status-quo bias (Lancaster, 1966; McFadden, 1977; Train, 2003). While four to sixteen questions are usually asked in environmental valuation CEs, seven questions were prepared in this study to avoid overburdening the participants (Train, 2003). The last choice situation was retained for use in comparing the predictive ability of different models and methods (Train, 2003). To make choice sets natural, they were presented to respondents as natural pictures, such as Fig. 1, rather than artificial presentation. Orthogonal shifted design (Ferrini and Scarpa, 2007) was utilised for the CE design.

4.2. Questionnaire development

All the items and information in the questionnaire, except for the question regarding whether the respondent was married, were constructed with reference to the existing literature, as described above. The questionnaire included the following. First, a brief background to the survey was given and respondents were asked if they generated REL at home such as by installing PV power and did not buy electricity or did not intend to buy electricity from electricity companies within a year (screening item). Only electricity consumers who bought electricity from companies or intended to buy electricity from companies within a year were invited to the following survey. Second, the CE, as explained in Section 3.1, asked each participant six different randomised choice questions plus an additional non-randomised last question. Lastly, questions regarding participants' socio-demographic variables (SDVs) and variables relevant to psychological issues were asked. Referencing Herbes et al. (2015), SDV data including age, gender, income, education, and household size as well as psychographic variables were obtained based on the pre-test conducted in 2018 by the authors. They roughly coincide with the psychographic variables reviews in Herbes et al. (2015) that have either positive or negative impacts on WTP for REL[3)].

4.3. Data collection

The questionnaire was conducted online in October 2020 through JustSystems Co., a company providing Internet survey services. Internet surveys are much more flexible (choice situations can be tailor-made for each respondent), enable more advanced surveys, and make the data readily available without human data entry errors. Therefore, most stated choice surveys nowadays are computer-based (ChoiceMetrics, 2018).

Data were collected across Japan using proportionate stratified sampling to understand the preferences of representative Japanese electricity consumers (Table 2). Screening of the respondents was first conducted and out of 11,560 questionnaires sent, 2199 (19%) expressed their intention to participate in the survey. Of the 724 questionnaires sent to such screened people 561 (78%) were responded to. Out of these responses, 95 respondents did not complete the CEs and were excluded. In addition, 50 respondents who did not know their monthly electricity costs were excluded. A total of 416 responses were finally obtained.

A summary of statistics regarding the survey population and that of the general Japanese population is presented in Table 2. Participants were over the age of 20 and their characteristics roughly corresponded to those of the Japanese population in terms of age, sex, area of residence, marital status, number of household members, and monthly electricity consumption. The percentage of respondents with at least a bachelor's degree was higher than that of the general population (46.6% vs 23.1%, respectively), and annual household income was also higher for the sample than for the entire population (7375 thousand JPY vs 5523 thousand JPY). Having children at home was lower for the sample than that of the population (14.9% vs 24.1%, respectively).

Features of respondents' local areas, as recognised by them, are summarised in Table 3. More respondents considered that they lived in the countryside—a natural or 'environmentally good' area, rather than in a city, as indicated by the larger mean value of 'more than two features including the countryside, rich in nature, environmentally good, apply in my municipality (V6)' compared to that of 'my municipality is either a big city or an urban area (V5)'. The majority (90.1%) of respondents had not installed REL at home and, instead, bought all or some of the electricity they used. The remaining 9.8% had installed REL, such as PVs, for their own usage (including cases where some surplus electricity was sold). A summary of responses regarding respondents' lifestyle and attitudes, knowledge, values, and opinions is shown in Table 4. Many responded that they had lived in their current area for a long time and wanted to continue to do so.

Table 2: Summary of statistics regarding the survey population and the general Japanese population

	Variable	Sample	Population
Age (mean)[1]	Age	53.4	54.1
Male (mean)	sex=1	52.5	49.1
Female (mean)	sex=2	54.3	55.5
Sex[1]			
Male		49.5%	48.3%
Female		50.5%	51.7%
Area of residence[1]			
Hokkaido	HOKKAI	5.3%	4.2%
Tohoku	TOHO	6.5%	7.0%
Kanto	KAN	34.4%	34.5%
Hokuriku	HOKU		
Chubu	CHUB	15.6%	12.7%
Kinki	KIN	19.5%	17.6%
Chugoku	CHUG	6.3%	5.7%
Shikoku	SHI	2.2%	3.0%
Kyushu	KYU	10.3%	11.1%
Marital status[2]	MAR	63.9%	60.3%
Number of household members (mean)[3]	HM	2.6	2.4
Higher education[4] (Bachelor's degree or higher)	ED	46.6%	23.1%
Offspring[5] (aged 20 years or less living at home)	CHI	14.9%	24.1%
Annual household income (mean in thousand JPY)[6,7]	HI	7375	5523
Monthly electricity bill (mean in JPY)[8]	ELECOM	9365	9100

Note:
1: Age, sex, and residence composition of the general population are of people aged from 20 to 79 as of 2020, which were obtained by Basic Resident Register ('*Jumin Kihon Daicho*') (The National Statistics Center, 2020). Kyushu area includes Okinawa prefecture.
2: Marital status is the percentage of people aged 20 or over who are married. The data regarding marriage are from 2015 (Statistics Bureau, Ministry of Internal Affairs and Communications of Japan, 2015).
3: Data was as of 2019 (Ministry of Health, Labour and Welfare of Japan, 2019).
4: Data was as of 2017 (Statistics Bureau, Ministry of Internal Affairs and Communications of Japan, 2017).
5: Data was as of 2019 (Ministry of Health, Labour and Welfare of Japan, 2019).
6: Average annual household income of the population was the average annual household income of Japanese population as of 2018 (Ministry of Health, Labour and Welfare of Japan, 2019).
7: Average annual household income of respondents was calculated by averaging all respondents' annual household incomes. Each respondent's household annual income was valued as the median values of the income range in the questionnaire of that respondent.
8: Data was as of 2019 (Statistics Bureau of Japan, 2019).

Many stated that they did not participate in activities, such as public events, in their local community. There were a few respondents who considered themselves to be well-versed in terms of global environmental problems, energy, and RE. Among the many values and opinions expressed, the most significant issue for respondents was the stable supply of electricity. Many agreed with the statement that global environmental problems, local employment, and environmental conservation are important, and many also stated that they wanted to abide by local rules and societal norms.

4.4. Model specification

Multinomial logit (MNL) and mixed logit (ML) models of the CE were built to explain the variables. CEs are based on the random utility model, where the utility of goods and services is composed of deterministic or systematic and observable components (V), and stochastic components

(Hanemann, 1984). The basic behavioural model for a CE is:

$$U_{nj} = V_{nj} + \varepsilon_{nj},$$

where n is a respondent, *j* is an option, and U_{nj} $(j = 1, \dots J)$ is the utility that respondent *n* obtains from option *j*. (Hereafter, this section employs the methodology of Train (2003) unless otherwise specified.) V_{nj} is a systematic component of utility U_{nj}, a function of option *j*'s attributes and respondent *n*'s characteristics, and ε_{nj} is a random component that affects utility U_{nj}. If $U_{ni} > U_{nj}$ $\forall_j \neq I$ for respondent *n*, respondent n chooses *i*.

The simplest CE model is the MNL model. Generalized choice experiment models include the probit model, nested model, and ML model. The ML model, which approximates any discrete choice model, has the following utility function:

$$U_{nj} = \alpha' x_{nj} + \mu_n' z_{nj} + \varepsilon_{nj},$$

where x_{nj} and z_{nj} are vectors of the observable variables of option *j* (specifically, option *j*'s attributes and respondent *n*'s characteristics regarding option *j*), μ_n is a vector of a random term with zero mean, and ε_{nj} is an IID Type-I (Gumbel) distribution.

Once a suitable model is estimated, the marginal utility values and the willingness to pay (WTP) values of the attribute parameters can be calculated. The systematic terms of the utility values are:

$$V_{nj} = \beta_1 x_{1nj} + \beta_2 x_{2nj} + \beta_3 p_{nj},$$

where p_{nj} is the price of option *j*. The WTP values of the first attribute x_{1nj} and the second attribute x_{2nj} of option *j* are β_1/β_3 and β_2/β_3, respectively (Hanemann, 1984).

The models were estimated using 'R' software (v 4.0.3), specifically the 'mlogit' and 'RStan' packages. First, the MNL and ML models were estimated by maximum likelihood estimation. Due to limited prior knowledge regarding model specification, linear-in-parameter MNL, and ML models, with the main effects and cross effects, were estimated. A model including the six attributes (RE, LE, IR, IC, IE, and CT) was first generated as a base model. Second, relevant additional explanatory variables (Table 5) found in the literature were added successively to the base model depending on whether they improved the values of the Akaike information criterion (AIC). These additional explanatory variables included the second-order variables of each of the six attribute variables (RE×RE, LE×LE, IR×IR, IC×IC, IE×IE, and CT×CT), and cross effects between two attribute variables and between the attribute variables and other explanatory variables. A total of 416 explanatory variables were considered. The cross effects between the attribute variables were significant because local information (IR, IC, and IE) may be impacted by whether electricity is renewable or produced locally. Then, the adopted model was selected. Bayesian estimations were conducted to confirm the results of the maximum likelihood estimations. The models were estimated using the initial six questions and the seventh question was utilised for prediction using the model to examine the validity of the model estimation.

5. RESULTS AND DISCUSSION

The base MNL and ML models, including only six attributes, were first estimated by the maximum likelihood method (*Appendix A (a), (b)*). Some signs were as expected, cost had a negative sign, while preference for renewable electricity (RE) and local production (LE) had positive signs. Information about local utilisation of electricity (IC) earned positive preference. It was rather unexpected regarding the signs of the information about non-environmental degradation (IE), which generated negative preference. The ML model has a lower AIC value, and the random parameter of the CT variables were significant at the 1% level, suggesting that the base MNL model does not include sufficient variables to address the variability of preferences for cost.

Then, the cross effects and effects of other explanatory variables were included one by one to the base model (*Appendix B*). Many of the explanatory variables that improved AIC pertained to the cost variable (CT); among 20 most impacted variables, 16 impacted on cost. This suggests that allowance for the cost burden is significantly better explained when respondents' relevant variables are considered. In particular, electricity consumption (ELECON) and its cross effects with age (AGEELECON) most significantly impacted on preference

Table 3: Respondents' views regarding features of their local area (explanatory variables V1-V8)

	Variable	Mean Score[1]	Answer (%)				
			Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
V6	More than two features including countryside, rich in nature, environmentally good, apply in my municipality.	3.3	9%	15%	26%	35%	14%
V2	The local government is sound in my municipality.	3.3	4%	12%	43%	35%	6%
V3	There is a tendency to value local rules and social norms in my municipality.	3.2	4%	13%	47%	32%	5%
V7	Declining population and birth rate and an aging population are apparent in my municipality.	3.2	6%	22%	34%	27%	12%
V1	My local residents' association is active and there is sufficient communication and ties to the community in my municipality.	3.0	8%	22%	38%	27%	4%
V5	My municipality is either a big city or an urban area.	2.8	23%	20%	21%	23%	12%
V4	Use of natural energy and awareness of local environmental conservation issues are high in my municipality.	2.8	10%	24%	49%	14%	4%
V8	There are facilities or offices related to electricity, such as power stations, in my municipality.	2.4	23%	30%	31%	14%	2%

Note:
1: Mean Scores are calculated by the average scores of the respondents. The scores are the following. Strongly Disagree = 1, Disagree = 2, Neither Agree nor Disagree = 3, Agree = 4, Strongly Agree = 5.

for cost. From *Appendix B*, implication for information disclosure was as follows.

The best model was estimated by adding sets of variables, each one of which improved the AIC value (*Appendix B*), to the base MNL model, and determined whether the set of two or more variables also improved the base model using the criteria of the AIC values. The best MNL model was examined in terms of lower value of AIC and statistical significance of the estimates. The ML model was also estimated based on the best MNL model, and the standard error variable CT was statistically significant. The AIC value of the ML was lower than that of MNL model. This suggested that there are certain reasons that cannot be explained in the best MNL model for preferences variation regarding the CT. Therefore, the maximum simulated ML model (*Appendix C*) was adopted. Prediction was made using the adopted model and the spared sample (*Appendix D*). The choice probabilities of the prediction were remarkably similar to those of the actual choices, suggesting the validity of the model specification.

WTP values for the several situations and information disclosure were estimated (*Appendix E*). The most preferred option was when 100% of electricity was renewables and when information regarding only local vitalisation (IR) (JPY 1033) was disclosed. There was a preference for local electricity production as well as RE. RE (on average WTP JPY 797) was preferred to non-renewable (on average WTP JPY 339) and its WTP was on average higher with the amount of JPY 458. Local electricity production (on average WTP JPY 488) was preferred to outside of local electricity and was on average higher at JPY 313.

Table 4: Other explanatory variables except for variables regarding SDV and energy usage

Variable		Mean Score[1]
Lifestyle and attitudes		
V16	I or my household members make a living in the current municipality.	3.88
V14	I have lived in my current municipality for a long time.	3.85
V15	I want to live in my current municipality in the future, too.	3.79
V9	I or my household members actively participate in our local municipality (such as participation in town activities, residents' associations and activities in public halls, communicating with other local people, or experience as an officer of residents' associations).	2.64
V10	I or my household members actively participate in the activities of non-governmental or non-profit organisations.	1.99
Knowledge		
V23	I know global environmental problems well.	2.88
V25	I am familiar with renewable energy.	2.84
V24	I know energy problems well.	2.78
Value and opinions		
V28	Availability of electricity should be ensured.	4.39
V17	Solving global environmental problem is important.	4.12
V13	I want to abide by social norms or local rules.	3.97
V19	It is important to conserve the environment or landscape in my current municipality.	3.96
V30	It is a problem if power cuts happen, even if they last only 30 minutes.	3.96
V21	It is important to increase employment opportunities in my current municipality.	3.90
V20	I want my current municipality more vitalised.	3.78
V26	Renewable energy will be disseminated even more in the future.	3.73
V22	It is necessary to vitalise industries in my current municipality.	3.69
V27	I oppose nuclear energy.	3.53
V18	Many renewable energy facilities should be installed in my current municipality.	3.48
V11	I love the local community of my current municipality (e.g., I like local community, or I consider the future of the local community of my current municipality).	3.35
V12	I trust in the people and companies in my current municipality.	3.25
V29	It is dangerous if energy facilities, such as power stations, are installed in my current municipality.	3.12

Note:
1: Mean Scores are calculated by the average scores of the respondents. The scores are the following. Strongly Disagree = 1, Disagree = 2, Neither Agree nor Disagree = 3, Agree = 4, Strongly Agree = 5.

Preference for information regarding local vitalisation (IR) was positive while environmental information (IE) had a negative preference. There was no significant preference for local production and usage of electricity (IC). The preference for IR existed in every situation, while the preference for IE existed only when it was RE; environmental information was only preferred when RE was used. When RE was utilised, no information disclosure was preferred to information disclosure regarding environment (IE).

There are clear messages regarding the type of people who support RE, local production of electricity, and electricity cost burden. RE was strongly supported by older women, women who live in Tohoku area, and by people who oppose nuclear energy (V27), who think that many renewable energy facilities should be installed in the current municipality (V18), and who believe solving global environmental problems is important (V17). Local electricity production (LE) was strongly supported by older people who consume larger amounts of electricity (AGE×ELECON), those who have lived in their current municipality for a long time (V14),

Table 5: Additional explanatory variables examined in the extended MNL model

Variable		Definition	Assigned values
SDV			
	SEX	Sex	1: Male 2: Female
	AGE	Age	(Year)
	HM	Number of household members	1: One, 2: Two, 3: Three, 4: Four, 5: Five, 6: Six, 7: Seven or more
	HI	Annual household income before tax	(JPY)[1]
	II	Annual income before tax per member of household	(JPY)[2]
	ED	Level of education	1: Studied at undergraduate or graduate level 0: Not studied at university
	MAR	Marital status	1: Married 0: Not married
	CHI	Number of children aged less than 20 years old living in respondent's household	
	HOKKAI, TOHO, KAN, HOKU, CHUB, KIN, CHUG, SHI, KYU[3]	Residence or otherwise within specific regions	1: Living in one of the regions 0: Not living in one of the regions
Energy usage			
	RE	Instalment of RE device at home	1: Installed 0: Not installed
	ELECOM	Average monthly electricity payment	(JPY)[4]
Features of local areas (see Table 3)			1: Strongly Disagree 2: Disagree 3: Neither Agree nor Disagree 4: Agree 5: Strongly Agree
Lifestyle and attitudes (see Table 4),			
Knowledge (see Table 4)			
Value and opinions (see Table 4)			

Note:
1: Unit = thousand JPY. The class value was utilized. JPY 14 000 or more were assigned JPY 15 000.
2: Calculated as HI divided by HM.
3: HOKKAI=Hokkaido, TOHO=Tohoku, KAN=Kanto, HOKU=Hokuriku, CHUB=Chubu, KIN=Kinki, CHUG=Chugoku, SHI=Shikoku, KYU==Kyusyu or Okinawa.
4: Unit = JPY. The class value (middle of the range of a class) was used. JPY 40 000 or more was assigned as JPY 45 000.

and who think that 'I trust in the people and companies in my current municipality'(V12). Electricity cost burden was more accepted by larger electricity consumers, people with larger household members, installing renewable energy at home, living in the Kanto area, and who think that 'I am familiar with renewable energy', 'I oppose nuclear energy', 'I or my household members actively participate in our local municipality', and 'Solving global environmental problem is important'. In contrast, people who did not want to accept larger electricity cost burden included people who thought 'Availability of electricity should be ensured' and younger people living in the Kanto area. Significant differences between these results and those of global literature were regarding age; older people were more supportive towards bearing the cost burden of RE.

Information preference was not strongly relevant to personal characteristics; however, *Appendix B* had the following implications regarding the relationship between information disclosure and characteristics of people who had its preferences. Regarding local vitalisation (IR), it had generally positive preferences, but people having relatively lower preferences included those who installed renewable energy at home (RENEW), higher education (ED), people who think that 'many renewable energy facilities should be installed in my current municipality', 'I or my household members actively participate in the activities of non-governmental or non-profit organisations', 'It is a problem if power cuts happen, even if they last only 30 minutes', and 'I oppose nuclear energy'.

Information regarding environment (IE) usually had a negative preference, but the following people had a positive preference; high ELECON, especially older people, people living in the Kanto area and people who think that 'I am familiar with renewable energy', 'I or my household members actively participate in the activities of non-governmental or non-profit organisations', and 'I know energy problems well'. IE was only preferred by people who knew renewable energy and energy issues relatively well. While this needs further investigation, it suggested that IE was more correctly analysed only by people who are well-aware of renewable energy and energy issues; along with reminding ordinary people about the existence of potential environmental problems caused even by renewable energy. Regarding the information on local production and utilisation of electricity (IC), positive preference was evidenced for people who thought that 'I want my current municipality more vitalised', and negative preference was relevant to older people living in the Kanto area.

REL and its positive environmental values have a physically detached nature, i.e., once REL is connected to the grid system, it and its positive environmental values are no longer physically differentiable with other electricity and impacts that they create. Moreover, general environmental benefits that REL generates, such as the reduction of GHG and other environmentally degrading gases, have positive impacts not only on the local community but also on wider society and global society. Therefore, it is of social interest to reduce the additional costs of REL by trading detached environmental values among wider society, thus decreasing the total cost to society (Ragwitz et al., 2009; Del Rio, 2005). This is, in fact, in line with the current certificate schemes such as RES, GoO, and Japanese green energy certificates, where physically detached positive environmental values are traded.

However, if there are premia for locally favourable impacts felt by local residents, electricity providers may obtain benefits through this avenue. If REL generates local vitalisation effects of those facilities, and if the origin of production of particular REL can be effortlessly confirmed to link to particular local electricity consumers, electricity companies that sell such electricity may obtain additional price premia by disclosing such information. If the premia obtained by such information disclosure outweigh the cost of information disclosure, electricity companies can obtain additional profits. Such information disclosure is more easily attainable by electricity companies that produce certain sources of electricity in certain local places, which may often be the case for REL production (Vetter and Karantininis, 2002), but information provision would in principle be possible for large electricity companies that produce electricity, even including non-REL, in multiples areas far away from electricity usage. This can be possible by using novel state-of-the-art technologies such as block-chain technology, as it would enable direct electricity trade between electricity production sites and electricity consumers, and premia felt by consumers may be given back to the electricity generation sites. These results would have significant implications for state-of-the-art electricity marketing and policy.

6. CONCLUSIONS

This study examined electricity consumers' preferences for different kinds of local information regarding electricity production sites. This kind of analysis has not been conducted much globally, and it will have significant implications for electricity marketing and policy.

The study using the CE method was conducted in Japan. There was a positive preference for local electricity production, as well as renewable electricity (REL). The most preferred option was 100% renewable energy implementation plus information disclosure regarding local vitalisation. Preference for information regarding local vitalisation (IR) was positive while environmental information (IE) had a negative preference.

The preference for information regarding local vitalisation existed in every situation, while the preference for environmental information existed only when electricity was renewable. There was no significant preference for information regarding local production and usage of electricity (IC).

If electricity generates local vitalisation effects of those facilities, and if the origin of particular electricity production can be linked to local electricity consumers, electricity companies that sell such electricity may obtain additional price premia by disclosing such information. Such cases may be more usual for REL, but non-REL may also be linked to such cases. The results would have significant implications for state-of-the-art electricity marketing and policy.

NOTES

1) 'New electricity' companies take up 19.2% of the share of power sales in 2020 (Agency for Natural Resources and Energy, 2020).
2) Larger renewable energy facilities tend to be installed in remote rural areas rather than in urban areas because of land value and siting difficulties in Japan. This is often lauded in remote rural areas where ageing and under-population is more pronounced. Against this background, renewable energy has been promoted in Japan mainly in the context of rural vitalisation (Ministry of Agriculture, Forestry and Fisheries of Japan, 2020; Rossi and Hinrichs, 2011), and 'new electricity' has also claimed it (Japanese new electricity companies' websites, 2019; Kawahara and Irie, 2019).
3) Our psychographic variables include environmental awareness, pro-environmental behaviour, pro-environmental attitude, and information information on renewables, while altruism was not included in ours.

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Appendix A: Base Model

(a) MNL model

	Estimate	Std. Error	z-value	Pr(>|z|)	
RE	0.299	0.073	4.096	0.000	***
LE	0.224	0.072	3.110	0.002	**
IR	0.045	0.050	0.897	0.370	
IC	0.224	0.049	4.544	0.000	***
IE	-0.112	0.048	-2.320	0.020	*
CT	-69.810	2.747	-25.416	< 2.2e-16	***
Log-Likelihood:	-2216.3				
AIC:	4444.6				
Significance: *** p<0.001, ** p<0.01.					

(b) ML model

	Estimate	Std. Error	z-value	Pr(>|z|)	
RE	0.299	0.078	3.841	0.000	***
LE	0.225	0.075	2.999	0.003	**
IR	0.045	0.053	0.858	0.391	
IC	0.224	0.053	4.203	0.000	***
IE	-0.112	0.050	-2.237	0.025	*
CT	-69.832	3.395	-20.570	< 2.2e-16	***
sd.CT	11.074	7.637	1.450	0.147	***
Log-Likelihood:	-2212.3				
AIC:	4438.6				
Significance: *** p<0.001, ** p<0.01.					

Appendix B: Variables with Significant Effects on AIC Values

(a) Variables with significant effects on RE			
Variable	AIC order[1]	AIC	Coefficients
V27	13	4420	0.294
V18	15	4424	0.341
V17	18	4425	0.363
SEXCHI	26	4432	0.561
V19	27	4432	0.289
V26	28	4432	0.299
SEXAGE	31	4433	0.869
AGEELECON	37	4435	8.527

(b) Variables with significant effects on LE			
Variable	AIC order[1]	AIC	Coefficients
V14	20	4427	0.269
AGEELECON	24	4431	9.650
V12	32	4433	0.268
V11	34	4434	0.235
V15	36	4435	0.230
ELECON	39	4437	4.953
V17	48	4438	0.223
V13	52	4438	0.222

SEXTOHO	38	4435	1.361
V3	42	4437	0.238
AGECHI	43	4437	0.676
V6	46	4438	0.172
AGE	47	4438	1.330
SEX	49	4438	0.400
SEXELECON	50	4438	4.140
V28	51	4438	0.220
V15	62	4440	0.177
ELECON	66	4440	4.104
V13	69	4440	0.197
CHI	71	4441	0.336
V21	77	4441	0.180
V16	78	4441	0.157
V14	79	4442	0.139
V12	83	4442	0.159
4389	85	4442	0.292
SEXHOKKAI	93	4443	0.665
AGETOHO	94	4443	0.948
TOHO	97	4443	0.549
V20	100	4443	0.143
CHUG	102	4443	-0.544
SEXII	104	4443	0.442
V8	105	4443	-0.118
AGECHUG	115	4444	-0.957
V11	133	4444	0.100
RE	141	4444	0.329
V4	144	4445	0.105
ED	157	4445	-0.180
V9	162	4445	0.074
SEXCHUG	166	4445	-0.526
AGEHOKKAI	176	4445	0.543
HOKKAI	179	4445	0.338
SEXSHI	189	4445	0.772
AGESHI	191	4445	0.889
V25	195	4445	0.069
V23	197	4445	0.076
SEXKIN	204	4446	0.216
V7	216	4446	0.058
V22	221	4446	0.069
SHI	223	4446	0.420
V5	229	4446	-0.043
KAN	254	4446	-0.099
V29	266	4446	-0.041
V10	279	4446	0.038

V1	53	4439	0.185
V16	54	4439	0.186
V26	57	4440	0.202
SEXTOHO	59	4440	0.980
V2	61	4440	0.199
SEXCHI	63	4440	0.364
V23	64	4440	0.175
V6	70	4441	0.140
SEXELECON	75	4441	3.246
V27	76	4441	0.129
AGE	80	4442	0.963
SEX	86	4442	0.272
V5	87	4443	-0.100
V3	88	4443	0.156
SEXAGE	89	4443	0.461
V25	90	4443	0.125
TOHO	92	4443	0.549
AGECHI	101	4443	0.403
KIN	109	4443	-0.293
AGETOHO	118	4444	0.809
II	123	4444	-0.340
V19	124	4444	0.120
SEXED	129	4444	0.290
V20	147	4445	0.105
V4	150	4445	0.100
ED	152	4445	-0.180
CHI	153	4445	0.182
V28	170	4445	0.090
V7	171	4445	0.076
V9	182	4445	0.064
AGEKAN	186	4445	0.294
AGEKIN	187	4445	-0.322
V21	211	4446	0.073
SEXCHUB	214	4446	0.228
AGEED	230	4446	-0.204
AGEII	237	4446	-0.305
AGEHOKKAI	274	4446	0.277
HOKKAI	276	4446	0.175
CHUG	287	4446	0.154
AGECHUG	288	4446	0.287
V24	291	4446	0.036
RE	297	4446	-0.115
V10	300	4446	0.031
SHI	301	4446	-0.225
SEXKAN	306	4446	0.087

AGEKIN	280	4446	0.172
AGEII	281	4446	0.230
AGEKYU	293	4446	0.207
CHUB	294	4446	-0.098
SEXED	296	4446	0.093
SEXKYU	298	4446	0.136
V2	302	4446	0.038
AGECHUB	314	4446	-0.156
V1	317	4446	0.029
V30	322	4446	0.026
AGEED	325	4446	-0.095
SEXKAN	327	4446	0.070
KYU	343	4446	0.065
II	352	4446	-0.055
V24	381	4447	0.011
SEXCHUB	384	4447	0.039
HI	399	4447	0.016
HM	403	4447	0.006
AGEKAN	419	4447	-0.015
KIN	435	4447	0.003

HI	307	4446	-0.062
SEXSHI	316	4446	-0.299
V29	318	4446	-0.027
V22	328	4446	0.028
SEXKYU	329	4446	0.101
AGESHI	332	4446	-0.275
V18	337	4446	0.022
SEXKIN	339	4446	0.064
4389	365	4447	-0.029
AGECHUB	368	4447	-0.069
KYU	377	4447	0.040
AGEKYU	378	4447	-0.070
HM	383	4447	0.009
CHUB	411	4447	0.014
KAN	414	4447	-0.010
SEXII	424	4447	-0.011
V8	427	4447	-0.002
SEXHOKKAI	432	4447	0.008
V30	434	4447	0.001
SEXCHUG	438	4447	-0.001

(c) Variables with significant effects on IR			
Variable	AIC order[1]	AIC	Coefficients
RE	56	4439	-0.431
V18	91	4443	-0.095
V10	108	4443	-0.078
V30	110	4443	-0.080
ED	111	4443	-0.166
V27	120	4444	-0.066
SEXED	137	4444	-0.189
V3	146	4445	-0.076
AGEED	155	4445	-0.229
CHUG	161	4445	0.253
4389	168	4445	-0.120
AGE	178	4445	0.358
HM	194	4445	-0.044
ELECON	203	4446	-0.999
SEXII	215	4446	-0.152
V8	218	4446	-0.040
V17	225	4446	-0.046
AGECHUG	227	4446	0.307
KAN	232	4446	-0.082
V1	233	4446	0.038
V16	235	4446	0.038
SEXCHUG	239	4446	0.225

(d) Variables with significant effects on IC			
Variable	AIC order[1]	AIC	Coefficients
V27	107	4443	-0.070
V20	114	4444	0.092
AGEKAN	130	4444	-0.286
SEXKAN	134	4444	-0.193
KAN	138	4444	-0.146
V10	140	4444	-0.063
V17	145	4445	0.075
4389	149	4445	-0.133
V16	160	4445	0.062
SEXCHUB	163	4445	0.226
V28	164	4445	0.065
V8	165	4445	-0.055
V9	173	4445	0.047
SEXHOKKAI	174	4445	0.280
V22	180	4445	0.061
ELECON	183	4445	-1.129
ED	184	4445	-0.106
AGEHOKKAI	188	4445	0.363
AGECHUB	193	4445	0.258
AGEII	196	4445	0.292
SEXED	198	4445	-0.134
HOKKAI	199	4445	0.216

V9	242	4446	0.030
V7	245	4446	-0.033
V5	250	4446	-0.025
AGEKAN	258	4446	-0.124
HI	259	4446	-0.062
AGETOHO	262	4446	0.215
SEXKAN	268	4446	-0.081
V13	289	4446	-0.030
SEXELECON	290	4446	-0.501
AGECHI	292	4446	0.081
V23	309	4446	-0.022
TOHO	312	4446	0.086
SEXSHI	319	4446	0.201
AGESHI	321	4446	0.225
SHI	323	4446	0.125
AGEKYU	324	4446	0.111
CHI	330	4446	-0.034
V6	331	4446	0.014
V15	333	4446	0.016
SEXCHI	334	4446	-0.033
V22	335	4446	-0.018
AGECHUB	336	4446	0.077
V2	340	4446	0.016
KYU	341	4446	0.049
V11	350	4446	0.013
SEX	354	4447	-0.024
KIN	356	4447	-0.029
V14	359	4447	0.010
SEXCHUB	362	4447	-0.041
SEXKIN	367	4447	-0.032
SEXTOHO	369	4447	0.051
V28	371	4447	0.010
HOKKAI	372	4447	-0.038
V19	376	4447	0.009
V29	385	4447	-0.007
SEXKYU	388	4447	0.028
V21	390	4447	-0.008
V20	391	4447	-0.007
V4	395	4447	0.006
AGEHOKKAI	405	4447	-0.029
CHUB	406	4447	-0.011
V12	408	4447	0.004
AGEII	409	4447	0.022
SEXHOKKAI	410	4447	-0.018
V24	415	4447	-0.003

V21	201	4445	0.055
AGESHI	202	4446	0.567
SEXSHI	205	4446	0.470
V2	208	4446	-0.052
CHUB	209	4446	0.123
V23	213	4446	-0.044
SHI	224	4446	0.277
AGEED	228	4446	-0.144
II	231	4446	0.122
HM	234	4446	-0.033
SEXTOHO	236	4446	-0.201
V6	238	4446	0.032
V30	240	4446	-0.035
V15	247	4446	-0.034
V19	248	4446	0.037
V4	249	4446	0.036
CHI	251	4446	-0.066
V7	257	4446	0.030
KIN	267	4446	0.073
V26	269	4446	0.033
SEXELECON	271	4446	-0.561
SEXCHI	273	4446	-0.061
AGECHUG	277	4446	-0.214
RE	278	4446	-0.096
AGEKIN	282	4446	0.116
AGE	284	4446	0.176
AGEELECON	299	4446	-0.766
SEXII	304	4446	0.081
CHUG	305	4446	-0.092
V14	311	4446	-0.019
KYU	326	4446	-0.061
V13	342	4446	-0.017
V25	344	4446	-0.013
SEXKYU	345	4446	-0.057
V24	346	4446	0.013
HI	351	4446	0.025
V1	358	4447	0.011
V18	361	4447	-0.011
V11	363	4447	-0.010
V12	364	4447	0.012
TOHO	373	4447	-0.035
V29	382	4447	-0.007
AGECHI	393	4447	0.020
V5	397	4447	-0.004
SEXKIN	398	4447	0.018

SEXAGE	420	4447	0.009
V25	421	4447	-0.002
II	422	4447	-0.007
AGEELECON	425	4447	0.069
AGEKIN	431	4447	-0.005
V26	436	4447	-0.001

AGEKYU	400	4447	-0.032
AGETOHO	407	4447	-0.029
SEXAGE	412	4447	0.011
V3	416	4447	-0.003
SEX	417	4447	-0.006
SEXCHUG	428	4447	0.011

(e) Variables with significant effects on IE			
Variable	AIC order[1]	AIC	Coefficients
ELECON	65	4440	2.513
V25	74	4441	0.103
AGEELECON	81	4442	3.351
V28	98	4443	-0.097
KAN	99	4443	0.185
AGEKAN	116	4444	0.316
V10	117	4444	0.075
V24	119	4444	0.080
AGECHUG	121	4444	-0.611
SEXCHI	122	4444	0.165
HI	125	4444	0.149
V9	131	4444	0.059
HM	132	4444	0.062
V23	139	4444	0.070
CHUG	148	4445	-0.268
SEXELECON	156	4445	1.224
SEXCHUG	158	4445	-0.381
V15	159	4445	0.063
AGEKYU	167	4445	0.356
KYU	169	4445	0.198
V1	172	4445	0.057
V11	175	4445	0.054
4389	177	4445	0.112
CHUB	181	4445	-0.146
RE	190	4445	0.178
V29	200	4445	-0.046
V8	207	4446	0.043
AGECHUB	220	4446	-0.211
V27	222	4446	0.034
SEXAGE	226	4446	0.137
AGEHOKKAI	241	4446	-0.251
SEXKAN	243	4446	0.100
AGECHI	244	4446	0.117
KIN	246	4446	-0.086
SEX	252	4446	0.065
HOKKAI	253	4446	-0.142

(f) Variables with significant effects on CT			
Variable	AIC order[1]	AIC	Coefficients
ELECON	1	4348	327.005
AGEELECON	2	4373	446.589
V1	3	4392	19.539
V24	4	4392	19.273
V10	5	4402	15.049
V25	6	4402	16.883
V27	7	4408	13.538
V23	8	4408	17.160
HM	9	4413	11.322
V28	10	4413	-15.341
V4	11	4417	14.906
V9	12	4418	11.194
V8	14	4422	11.846
HI	16	4424	21.978
KIN	17	4425	-36.042
AGEKIN	19	4427	-59.610
V12	21	4429	11.803
RE	22	4430	30.277
V6	23	4431	8.971
4389	25	4432	23.506
V7	29	4433	8.760
AGEKAN	30	4433	34.359
KAN	33	4433	19.213
SEXKIN	35	4434	-37.769
V17	40	4437	9.824
V20	41	4437	-8.628
V3	44	4438	9.046
SEXELECON	45	4438	102.505
CHI	55	4439	15.505
V22	58	4440	-7.504
V11	60	4440	6.950
SEXCHI	67	4440	13.542
AGECHUB	68	4440	-36.088
AGECHI	72	4441	21.677
V2	73	4441	6.932
CHUB	82	4442	-16.679

V20	264	4446	-0.034
CHI	265	4446	0.061
V26	270	4446	0.033
II	272	4446	-0.089
V18	283	4446	0.027
SEXED	285	4446	0.073
SEXSHI	286	4446	0.266
AGEKIN	303	4446	-0.098
SEXCHUB	310	4446	0.081
V12	320	4446	0.021
V2	347	4446	0.015
V3	348	4446	0.015
V5	349	4446	-0.010
AGEII	353	4447	-0.071
SEXKIN	355	4447	0.038
SEXKYU	357	4447	0.049
V7	360	4447	-0.010
V14	366	4447	0.009
V21	374	4447	-0.010
V17	375	4447	-0.010
SEXHOKKAI	379	4447	-0.040
SEXII	380	4447	-0.028
SHI	386	4447	-0.049
V30	387	4447	0.006
ED	392	4447	0.013
V13	394	4447	0.007
V16	396	4447	-0.006
AGE	401	4447	0.034
AGETOHO	404	4447	-0.032
AGEED	413	4447	-0.012
V6	418	4447	-0.002
AGESHI	423	4447	0.027
V4	426	4447	-0.002
V22	429	4447	-0.002
TOHO	430	4447	-0.006
SEXTOHO	433	4447	0.005
V19	437	4447	0.001

AGEKYU	84	4442	28.204
SEXCHUB	95	4443	-21.833
SEXKAN	96	4443	13.020
V15	103	4443	4.844
HOKKAI	106	4443	20.853
KYU	112	4444	13.618
V30	113	4444	-4.747
V18	126	4444	4.197
SEXSHI	127	4444	-48.153
V26	128	4444	4.834
AGEII	135	4444	24.851
AGEHOKKAI	136	4444	26.745
SHI	142	4444	-27.113
SEXTOHO	143	4444	17.329
SEXHOKKAI	151	4445	17.461
V16	154	4445	-3.610
V21	185	4445	-3.475
V13	192	4445	3.292
SEXCHUG	206	4446	-20.410
AGESHI	210	4446	-31.521
CHUG	212	4446	-10.781
V14	217	4446	2.220
SEXKYU	219	4446	9.633
V19	255	4446	2.043
AGE	256	4446	12.600
V5	260	4446	-1.283
II	261	4446	6.395
SEXED	263	4446	-4.852
ED	275	4446	3.145
AGEED	295	4446	4.785
TOHO	308	4446	4.376
AGECHUG	313	4446	-8.413
SEXII	315	4446	-4.296
SEX	338	4446	-1.620
SEXAGE	370	4447	-1.689
V29	389	4447	-0.334
AGETOHO	402	4447	1.845

1: AIC order is the overall order which improved AIC values among all the additional variables.

Appendix C: Adopted ML Model

<u>(a) Maximum simulated likelihood estimation</u>

Variable	Estimate	Std. Error	z-value	Pr(>|z|)	
RE (renewable 100%)	1.380	0.364	3.794	0.000	***
LE	1.065	0.410	2.597	0.009	**
IR	0.890	0.133	6.672	0.000	***

CT (100 thousand JPY)	-108.391	10.439	-10.384	< 2.2e-16	***
RE×RE	-0.853	0.339	-2.518	0.012	*
LE×LE	-0.841	0.330	-2.549	0.011	*
RE×IR	-0.948	0.192	-4.943	0.000	***
RE×IE	-0.609	0.109	-5.592	0.000	***
LE×IC	-0.622	0.209	-2.982	0.003	**
V17×RE	0.331	0.112	2.944	0.003	**
SEX×AGE×RE	1.144	0.299	3.824	0.000	***
SEX×TOHO×RE	1.053	0.503	2.092	0.036	*
V27×RE	0.169	0.081	2.096	0.036	*
V18×RE	0.239	0.096	2.479	0.013	*
V14×LE	0.307	0.078	3.917	0.000	***
V12×LE	0.217	0.089	2.449	0.014	*
AGE×ELCON×LE	5.572	2.874	1.939	0.052	.
ELECON×CT	237.227	63.525	3.734	0.000	***
V25×CT	14.732	3.485	4.227	0.000	***
V27×CT	12.582	3.268	3.851	0.000	***
V28×CT	-31.724	4.265	-7.438	0.000	***
V9×CT	8.152	2.815	2.896	0.004	**
AGE×KAN×CT	114.327	34.294	3.334	0.001	***
KAN×CT	-44.419	19.560	-2.271	0.023	*
V17×CT	15.452	5.393	2.865	0.004	**
HM×CT	7.377	3.204	2.302	0.021	*
V20×CT	-8.929	4.085	-2.186	0.029	*
RENEW×CT	26.557	10.298	2.579	0.010	**
sd. CT	-51.132	8.217	-6.223	0.000	***
Log-Likelihood:		-1972			
AIC:		4002			
Significance: *** p<0.001; ** p<0.01; * p<0.05					

(b) Bayesian estimation

	mean	se_ mean	sd	X2.5.	X25.	X50.	X75.	X97.5.	n_eff	Rhat
RE (renewable 100%)	1.227	0.004	0.345	0.563	0.997	1.226	1.457	1.918	8576.29	1.0005
LE	1.013	0.004	0.370	0.293	0.761	1.015	1.260	1.727	8139.16	1.0003
IR	0.922	0.001	0.126	0.677	0.836	0.921	1.006	1.169	11947.77	1.0002
CT (100 thousand JPY)	-93.503	0.070	8.089	-109.572	-98.877	-93.487	-87.991	-77.818	13481.59	1.0003
LE×LE	-0.710	0.003	0.292	-1.288	-0.907	-0.710	-0.512	-0.139	9868.47	1.0003
RE×RE	-0.678	0.003	0.309	-1.288	-0.881	-0.679	-0.468	-0.084	8795.51	1.0005
RE×IR	-0.958	0.002	0.185	-1.327	-1.083	-0.958	-0.832	-0.599	11961.22	1.0002
RE×IE	-0.544	0.001	0.096	-0.732	-0.610	-0.544	-0.480	-0.354	22871.57	0.9999
LE×IR	-0.687	0.002	0.191	-1.061	-0.816	-0.687	-0.558	-0.314	9564.01	1.0003
SEX×AGE×RE	0.980	0.002	0.272	0.448	0.792	0.980	1.160	1.519	23782.36	1.0001
V17×RE	0.301	0.001	0.096	0.112	0.237	0.302	0.366	0.486	22262.22	0.9999

V27×RE	0.160	0.000	0.070	0.023	0.113	0.160	0.208	0.298	25176.18	1.0001
SEX×TOHO×RE	0.952	0.003	0.478	0.022	0.631	0.951	1.274	1.889	27956.23	0.9999
V18×RE	0.222	0.001	0.086	0.052	0.165	0.222	0.280	0.389	21010.09	0.9999
V14×LE	0.288	0.000	0.073	0.145	0.239	0.288	0.337	0.432	23452.05	1.0000
V12×LE	0.206	0.001	0.085	0.040	0.148	0.206	0.264	0.369	23781.06	0.9999
AGE×ELECON×LE	4.303	0.016	2.408	-0.370	2.654	4.281	5.916	9.031	23268.95	0.9999
V28×CT	-27.720	0.026	3.297	-34.264	-29.928	-27.716	-25.508	-21.357	15483.22	1.0001
V25×CT	11.686	0.018	2.753	6.302	9.837	11.693	13.515	17.167	23077.24	0.9999
V27×CT	10.787	0.015	2.418	6.113	9.176	10.775	12.379	15.590	25190.96	1.0001
ELECON×CT	227.624	0.355	39.204	149.418	201.543	227.874	253.835	304.031	12203.18	1.0002
AGE×KAN×CT	119.446	0.267	29.311	62.175	99.471	119.598	139.230	177.414	12082.41	1.0007
RENEW×CT	22.758	0.054	8.180	6.486	17.213	22.848	28.382	38.565	22782.20	1.0000
V9×CT	7.166	0.018	2.314	2.577	5.618	7.195	8.720	11.687	17298.57	1.0000
V17×CT	13.199	0.032	4.325	4.742	10.307	13.115	16.045	21.870	18616.42	0.9999
HM×CT	6.403	0.019	2.374	1.708	4.806	6.421	8.001	11.036	15178.62	1.0003
KAN×CT	-50.228	0.154	16.907	-83.693	-61.537	-50.319	-38.682	-17.445	12066.13	1.0006
V20×CT	-7.524	0.021	3.109	-13.614	-9.623	-7.518	-5.443	-1.408	22069.64	1.0000
mu_beta (CT)	4.258	0.105	13.038	-23.363	-2.340	4.367	10.829	32.136	15413.01	0.9999
sigma_beta (CT)	26.785	0.376	43.454	1.207	7.633	16.281	30.914	118.281	13348.61	1.0001
lp__	-2000.6	0.0	3.921	-2009.3	-2003.1	-2000.3	-1997.8	-1994.0	7864.5	1.0005

Appendix D: Prediction of Choice Probability and Comparison with the Actual Choice

Alternative	1	2	3
Prediction	72.0%	19.3%	8.7%
Actual choice	75.0%	17.5%	7.5%

Appendix E: WTP Values for Several Situations and Information Disclosure

		Local electricity	Outside of local electricity	Average
Renewable electricity 100%	Information regarding IR and IE	917	677	797
	Information regarding IR	1033	793	
	Information regarding IE	874	488	
	No information	990	604	
Nonrenewable electricity	Information regarding IR	605	365	339
	No information	386	0	
Average		801	488	

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