実践論文

リスク・安定性・規模を考慮した電源開発に関する選択モデリングのパイロットスタディ

Pilot Study for Eliciting Preferences for Electricity Supply in Japan while Simultaneously Considering Risk, Fluctuations, and Size with Choice Modeling

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keywords: choice experiment; electricity supply; energy related risk; fluctuation of electricity

We conducted a pilot study using an energy option choice experiment (CE) survey with undergraduate samples, which is one of the choice modeling approaches. Our CE questions relate to risk increase, supply stability, power utility/facility size, and fee increase regarding a hypothetical electricity generation project in the Tokyo metropolitan area. As a result, the respondents accepted increases in climate-change and ecosystem risks. On the other hand, they were reluctant to accept health risk increases related to electricity generation and supply. We could not find any significant parameter with regard to stable electricity supply and utility/facility size.

首都圏の電源開発について，選択モデリングの一種である選択型実験（choice experiment: CE）に関するパイロット調査を実施した．サンプルは学部学生を用いた．CE を構成する属性として，電源開発に起因する様々なリスクの上昇，供給の安定性，電源施設・設備の規模と，電力料金の値上がりを採用し，首都圏における仮想的な電源開発プロジェクトを設定した．分析の結果，電源開発に起因する気候変動および生態系リスクの上昇が回答者に受け入れられた一方で，健康リスクの上昇は忌避される傾向にあることを確認した．また，安定的な電力供給や，電源施設・設備規模については選好抽出にいたらなかった．

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1. Introduction

Japan has considered a host of issues since the Great East Japan Earthquake and Tsunami on March 11, 2011, including electricity supply. The rolling blackouts in East Japan including the Tokyo metropolitan area are still vivid in the memories of many Japanese, and were the first rolling blackouts since World War II. As the Fukushima I nuclear power plant disaster occurred because of an earthquake and tsunami, all nuclear power plants were shut down, apart from the Ooi nuclear power plant which was operated from July 2012 to September 2013[i]. It is a matter of urgency that we consider how best to assure the electricity supply in Japan, especially in the Tokyo metropolitan area where the electricity supply from other districts including the Fukushima nuclear power plant have been utilized.

When considering the issue of electricity supply, certain trade-offs with regard to risk and stability along with fiscal cost are inevitable, because risk and/or stability issues exist for all electricity generation options. For example, risk exists with wind power generation related to landscape disturbance or reduction of residential tranquility. Large-scale solar power plants may suffer from low stability because of seasonally fluctuating electricity generation. Large-scale geothermal plants may disturb the ecosystem to some extent. Natural gas power generation may accelerate climate change or global warming. Coal power plants may increase health risks related to local air pollution. Therefore, we should understand public preferences related to the trade-off structure in order to discuss appropriate scientific methodology and cost effectiveness and efficiency.

In order to elicit preferences, there are two approaches: revealed preference method and stated preference method (Louviere et al. 2000). The revealed preference method, which includes a hedonic price function approach, has high reliability because it utilizes behavioral data in existing markets. However, it does suffer from multicollinearity between covariates, relatively low flexibility because it analyzes existing alternatives, and relatively low data availability frequency. On the other hand, the stated preference method, which includes choice modeling (CM), describes hypothetical behavior. Therefore, it has relatively high flexibility, and can cope with multicollinearity using certain experimental design procedures; it also "seems to be reliable when respondents understand, are committed to and can respond to tasks" (Louviere et al. 2000). In order to include most electricity options in our research scenario, we should consider options that do not exist yet, and are thus hypothetical. Therefore, we decided to utilize the stated preference method.

To evaluate several components of the trade-off structure simultaneously using stated preference methods, CM is one promising approach. CM is able to assess several variables simultaneously (Louviere et al. 2000) and usually involves choosing preferred types through a choice experiment (CE), or ranking different types using a contingent ranking, in such a way that clarifies the preferences for options that consist of several attributes.

Indeed, previous studies employed CM to evaluate preferences for electricity supply stability. In the US, Moeltner and Layton (2002) conducted a CE survey that included attributes on power outage (outage duration hours, whether outage occurs on weekdays or weekends, and outage time schedule). In Sweden, Söderberg (2008) considered the willingness to pay (WTP) of distribution utilities and industrial customers for a reduction in electricity outages, and Carlsson and Martinsson (2008) investigated WTP in households. Using the attributes duration of announced and unannounced outages, voltage stability, perceived customer service, and price, Söderberg (2008) also employed a CE. Carlsson and Martinsson (2008) applied a CE to the number and duration of outages. Ohdoko et al. (2013) conducted contingent ranking surveys in China, which included the number and duration of electricity outages, including health-risk reduction-related air pollution caused by fossil fuel energy and monthly electricity fee increases. To the extent of our knowledge, there are no studies that consider electricity supplies that fluctuate daily or seasonally because of renewable energy resources.

Several CE studies highlighted renewable energy resources. In Scotland, Bergmann et al. (2006, 2008) used a CE consisting of landscape impact, wildlife impact, air pollution increases, new local long-term employment created by renewable energy projects, and annual increases in household electric bills resulting from expansion of renewable energy projects. In Norway, Navrud and Bråten (2007) implemented a CE survey, which consists of type of energy source (wind power, hydropower, natural gas-fired power plant), along with size of power plant (a few large, more medium-sized, many small power plants) and annual fee on the electricity bill. In the UK, Longo et al. (2008) created hypothetical renewable energy policy CE questions with annual reductions in greenhouse gas emissions because of renewable energy increases, annual length of electricity shortages, change in number of employees in the electricity sector, and increases in electricity bills. Scarpa and Wills (2010) implemented a discretionary CE survey consisting of household-level energy-generating technologies in the UK: solar hot water, wind turbines, and solar electricity. However, it is more realistic in the current situation in Japan to take both renewable and exhaustive energy resources into consideration. To the extent of our knowledge, there are no other CM studies in this field.

If we conduct a CM survey related to both renewable and exhaustive energy resources, several 'neutral' attributes should be created in order to ensure fairness between electricity-generation technologies, and to encourage dispassionate discussion of electricity supply. Here, the term 'neutral' attributes denotes characteristics not present in certain technologies such as photovoltaic power generation, but present in technologies such as seasonally fluctuating power generation. For example, Scarpa and Willis (2010) conducted a CE survey on micro-generation electricity technologies with regard to primary heating in the UK. To evaluate several household-level technologies (photovoltaic, micro-wind, solar thermal, ground source heat pumps, biomass boilers, micro-hydro, air source heat pumps, fuel cells), they created some 'neutral' attributes in a primary heating choice experiment: inconvenience of system, which requires digging of the garden during installation, refueling of and space for fuel storage, and cupboard space for boiler. To ensure a fair and dispassionate discussion on technology choice between renewable and exhaustive energy resources, even if it consists of nuclear power, we must create several 'neutral' attributes of energy-generating technologies and conduct CM surveys in Japan.

This article proceeds as follows. In Section 2, we summarize our survey design and our adopted econometric method. Subsequently, we present the estimation results in Section 3, and provide discussion and topics for future research in Section 4.

2. Material and Method

We administered our survey at Dokkyo University from June 3 to 13, 2014. Before implementation, we conducted preliminary discussions with 21 undergraduates at Taro Ohdoko Laboratory at Dokkyo University to improve the design of the questionnaire. We conducted an in-person CE survey to elicit the preferences for electricity supply, simultaneously taking into consideration environmental and health risks, supply fluctuations, and plant or facility size. It is clear that CE performance depends on respondents interpreting the questionnaire precisely, and that CE involves a certain burden on undergraduate respondents compared with members of the public. Thus, we simplified our questionnaire as much as possible. Undergraduates at Dokkyo University were sampled as much as possible using convenience sampling. As detailed in Table 1, we obtained 127 useful samples.

We eliminated any possible correlation in the attributes in the experimental design methodology, primarily by using the main effects of a fractional factorial design along with the attributes and levels given in Table 2 in order to reduce the number of combinations below the maximum factorial 3^4=81 (Lorenzen and Anderson 1993). We created 16 profiles, and randomly selected two of these to create our choice sets. Including an opt-out option makes it possible to mimic real-world situations (Ryan and Skåtun 2004).

Table 1: Demographics

Item	Subitem	No. of respondents
Gender	Male	68
	Female	59
Faculty	Foreign languages	25
	International liberal arts	7
	Economics	73
	Law	22
Having public fee payment experience	Yes	17
	No	110
Having previous general knowledge on topics related to electricity generation		
Climate-change risk	Yes	86
	No	41
Ecosystem risk	Yes	81
	No	46
Health risk	Yes	91
	No	36
Stable annual electricity supply	Yes	83
	No	44
Seasonally fluctuating electricity supply	Yes	75
	No	52
Daily fluctuating electricity supply	Yes	79
	No	48

Item	Subitem	Stats
Age	Mean	19.803
	SD	1.141
No. of family members	Mean	3.465
	SD	0.342

Note: SD is standard deviation.

Table 2: Attributes and levels of CE

Attribute	Levels
Risk increase	Climate-change risk increase, health risk increase, ecosystem risk increase
Supply stability	Daily fluctuating electricity supply, seasonally fluctuating electricity supply, stable annual electricity supply
Utility/facility size	A few large-sized utilities/facilities, several medium-sized utilities/facilities, many small-sized utilities/facilities
Electricity fee increase (JPY/month)	+1000, +2000, +3000

Thus, we provided two alternatives and one opt-out option for each of the CE questions, which represented eight choices per respondent. In addition, because Japanese Energy and Environment Council forecasted the projections of energy cost scenario through to 2030 on December 21st 2011[ii], we set our hypothetical project through 2030 (see Appendix).

To analyze the CE data, we employ a random utility model where we define the utility of the respondent choosing alternative i as:

$$U_i = V_i + \varepsilon_i = \beta' x_i + \varepsilon_i, \quad \text{(Eq.1)}$$

where V_i denotes the observable component, ε_i is the unobservable error component, and x_i is the attribute vector of alternative i, which has the marginal utility vector β (Louviere et al. 2000). Previous studies have frequently employed an additively separable form for the observable component, which we also utilize.[iii]

McFadden (1974) showed that the choice probability of i among J alternatives becomes a conditional logit (CL) with random utility maximization given a Type I extreme value distribution for the error component, as follows:[iv]

$$P_i = \exp(V_i)/\sum_j \exp(V_j). \quad \text{(Eq.2)}$$

Revelt and Train (1998) demonstrated that a random parameter logit (RPL) with the use of repeat data to estimate the choice probability with preference heterogeneities could relax the assumptions of CL, i.e., preference homogeneity and the independence of irrelevant alternatives (IIA).[v] The choice probability of respondent $n\ (n = 1, \cdots, N)$ is given as follows within the parameter space Ω:

$$\pi_{ni} = \int \prod_t P_{nit}\, f(\beta|\Omega) d\beta, \quad \text{(Eq.3)}$$

where $t\ (t = 1, \cdots, T)$ denotes the number of times the respondent answers, P_{nit} is the form of CL, and $f(\beta|\Omega)$ is known as a mixing distribution. Previous studies have frequently employed the normal distribution for $f(\beta|\Omega)$, which we also utilize.

We estimate the implicit price (IP) or marginal WTP using the marginal utility parameter estimate, β, where the subscripts bid and q, respectively, denote the price attribute and the remaining attributes:

$$IP_q = -\beta_q(\cdot)/\beta_{bid}(\cdot). \quad \text{(Eq.4)}$$

$\beta_q(\cdot)$ and $\beta_{bid}(\cdot)$ become functions when a cross term is incorporated for the population characteristics and attribute q. For simplicity in estimating the IP, we set β_{bid} as the fixed parameter (cf. Revelt and Train 1998).

We employ R 3.0.3 (CRAN: http://cran.r-project.org/) and the procedure 'mlogit[vi]' when estimating RPL, with 10,000 Monte Carlo simulations of the mean and the variance matrix of the mean parameters to estimate confidence intervals (CIs) for the IP (Krinsky and Robb 1986, 1990). We set alternative specific constants (ASCs) for the leftmost and middle option in the choice set to test for alternative positional effects, as pointed out by Chrzan (1994). As the rightmost option in the choice set denotes the opt-out option, this option is not preferred when every ASC is positively and significantly estimated. To estimate IPs for every level of every single attribute, we employed effects coding for the variables in our choice sets in accordance with Bech and Gyrd-Hansen (2005), except for the price attribute.

In searching for the best-fit model for RPL, we give high priority to the significance of the standard deviation parameters in order to grasp the structure of the preference heterogeneities, and we try every combination of the various covariates listed in Table 1. We decided to employ the likelihood-related information criteria when seeking a best-fit model. We employed several measures of goodness-of-fit, including McFadden's ρ, and the Akaike information criterion and the Bayesian information criterion.

3. Result

Our variables are presented in Table 3, and the RPL results in Table 4. Model 1 consists of only the attributes of the choice sets and Model 2 of both the attributes and cross terms of the attributes and covariates. The likelihood ratio test statistics are substantially larger than the critical value ($2*(940.750 - 913.310) = 54.880 > Chi^2_{0.01}(5) = 15.090$), such that we concentrate only on the interpretation of Model 2 below.

As Model 2 shows, there are alternative positional effects because every positive ASC is significant. Thus, we can assume the ASCs effectively represent the positional effects while the estimates of the remaining parameters denote the unbiased marginal utilities. In addition, we conclude that respondents were reluctant to choose the opt-out option.

With regard to the risk increase attribute, climate-change risk increase (Clim in mean parameter) and ecosystem risk increase (Eco in mean parameter) were significantly and positively estimated, while health risk increase (Heal in mean parameter) was significantly negative. There are three relevant cross terms related to the climate-change risk increase that are significant: the cross terms with the number of family members (Clim*Fam) were positive, and those with the male dummy variable (Clim*Male) and those with the dummy variable relating to having public fee payment experience (Clim*Pub) were negative. Additionally, the standard deviation parameters were significant for both climate-change and health risk increase (Clim and Heal in SD parameter).

Table 3: List of variables

Variable	Content	Description
ASC_M	Alternative specific constant of option M	Takes value of 1 if the chosen alternative is the leftmost option M; 0 otherwise.
ASC_N	Alternative specific constant of option N	Takes value of 1 if the chosen alternative is the middle option N; 0 otherwise.
Clim	Climate-change risk increase	Takes value of 1 if the chosen alternative contains this level of the risk attribute; –1 if it contains the level 'ecosystem risk increase', which is an omitted variable; 0 otherwise.
Heal	Health risk increase	Takes value of 1 if the chosen alternative contains this level of the risk attribute; –1 if it contains the level 'ecosystem risk increase', which is an omitted variable; 0 otherwise.
Eco	Ecosystem risk increase	Estimated value from other-effect coded variable estimates.
Day	Daily fluctuating electricity supply	Takes value of 1 if the chosen alternative contains this level of the risk attribute; –1 if it contains the level 'yearly stable electricity supply', which is an omitted variable; 0 otherwise.
Seas	Seasonally fluctuating electricity supply	Takes value of 1 if the chosen alternative contains this level of the risk attribute; –1 if it contains the level 'yearly stable electricity supply', which is an omitted variable; 0 otherwise.
Year	Stable annual electricity supply	Estimated value from other-effect coded variable estimates.
Larg	A few large-sized utilities/facilities	Takes value of 1 if the chosen alternative contains this level of the risk attribute; –1 if it contains the level 'many small-sized utilities/facilities', which is an omitted variable; 0 otherwise.
Med	Several medium-sized utilities/facilities	Takes value of 1 if the chosen alternative contains this level of the risk attribute; –1 if it contains the level 'many small-sized utilities/facilities', which is an omitted variable; 0 otherwise.
Smal	Many small-sized utilities/facilities	Estimated value from other-effect coded variable estimates.
Fee	Electricity fee increase	Numerical value.
Male	Male	Takes value of 1 if the respondent is male; 0 otherwise.
Fam	Number of family members	Numerical value.
Pub	Has public fee payment experience	Takes value of 1 if the respondent has public fee payment experience; 0 otherwise.

Therefore, first, the respondents are adverse to health risk, while they are willing to accept or bear increases in climate-change and ecosystem risk. Second, it suggests that these respondents, who are male, having fewer family members, have public fee payment experience, and place less importance on climate-change risk increases. Finally, there is preference heterogeneity about the risk increase attribute as a whole. With regard to the supply stability attribute, there are no mean parameters that are significant (Day, Seas, and Year in mean parameter). On the other hand, the standard deviation parameters are significant with respect to daily fluctuating electricity supply (Day in SD parameter). Therefore, respondents have no preference for fluctuations in electricity supply, although there is preference heterogeneity for daily fluctuations. With regard to utility/facility size, there are no significant parameters (Larg, Med, and Smal). The price attribute is negative and significant (Fee), along with positive cross terms with respect to the male dummy variable (Fee*Male), and negative with respect to having public fee payment experience (Fee*Pub). Therefore, respondents do not have any preference about size of power plant or facility. Respondents who are male are less reluctant to pay for an electricity fee increase in our scenario, while those who have public fee payment experience are more reluctant to pay.

When estimating the IP of each attribute level, we assumed insignificant coefficients in the Table 4 set the value of 0. Additionally in effects coding, the reference point or the omitted level of the attribute is defined as the negative sum of the coefficients with regard to the levels of attributes incorporated into estimation (Bech and Gyrd-Hansen 2005). With regard to the coefficients of the cross term, the mean value of each characteristic was employed. As shown in Table 5, we estimated only the mean IP with respect to risk increase attribute levels.

4. Discussion and Concusion

Considering both marginal utility coefficients and IP estimates, there are certain differences between the evaluations of males and females, and between those who have experience with public fee payment and those who do not. For Japanese undergraduates, those who live on their own frequently have experience with public fee payments, while those who live at their parents' house have less experience. Thus, experience can be interpreted as a proxy of the respondents' living situation.

Climate-change risk increase is less preferable or less bearable for those who are male with fewer family members and have experience of public fee payment (Clim in mean parameter, Clim*Male, Clim*Fam, and Clim*Pub in Table 4, and Clim in Table 5). Although Jacobson and Delucchi (2011) and Delucchi and Jacobson (2011) pointed out the possibility of replacing exhaustive energy with renewable energy, we can assume that it is inevitable to incorporate fossil fuel power generation into the electricity mix in the Tokyo metropolitan area.

Table 4: RPL results

	Model 1			Model 2		
Variable	Coefficient	t-value		Coefficient	t-value	
Mean parameter						
ASC_M	1.659	7.260	***	1.693	7.265	***
ASC_N	1.720	9.726	***	1.804	9.819	***
Clim	0.498	6.895	***	0.435	2.789	***
Heal	–0.501	–4.819	***	–0.568	–5.268	***
Eco	3.240E-03			0.133		
Day	–0.191	–1.695	*	–0.118	–0.978	
Seas	–0.043	–0.408		–0.032	–0.291	
Year	0.235			0.150		
Larg	0.102	1.028		0.093	0.909	
Med	0.014	0.193		7.674E-03	0.106	
Smal	–0.116			–0.101		
Fee	–6.874E-04	–7.772	***	–9.648E-04	–9.147	***
Cross Term						
Clim*Male				–0.396	–3.188	***
Clim*Fam				0.088	2.531	**
Clim*Pub				–0.702	–2.609	***
Fee*Male				5.502E-04	6.219	***
Fee*Pub				–2.075E-04	–1.871	*
SD Parameter						
Clim	0.896	8.525	***	0.876	8.311	***
Heal	0.533	3.091	***	0.568	3.355	***
Day	0.434	2.109	**	0.445	2.223	**
No. of samples	127			127		
No. of observations	1014			1014		
Halton replication	100			100		
Log-likelihood	–940.750			–913.310		
McFadden R^2	0.116			0.141		

Note: ***, **, * indicate significance at the 1, 5, and 10% levels, respectively. SD is standard deviation.

Table 5: IP estimates

	Mean IP	95% Lower bound	95% Upper bound
Clim	724.668	530.933	920.224
Heal	–729.380	–1013.530	–462.975
Eco	4.712	na	

Note: na, not applicable.

Our result suggests that males who live on their own in the Tokyo metropolitan area tend to be reluctant to increase their use of fossil fuel.

With regard to the other risk increase, it is not acceptable to employ the power generation which increases health risk, while it is marginally acceptable to adopt the technology which increases ecosystem risk (Heal and Eco in mean parameter in Table 4, and Heal and Eco in Table 5). Thus, the results support the development and implementation of technologies that reduce the residential health risk from power generation in the future in the Tokyo metropolitan area, while ecosystem managers around Tokyo should pay more attention to ecosystem risk communication.

As for supply stability, the respondents have no particular preference at the mean level (Day, Seas, and Year in mean parameter in Table 4), while they heterogeneously prefer reductions of daily fluctuations (Day in SD parameter in Table 4). This is partly because fluctuations are not their major concern, and partly because they may misinterpret the term 'stability'. The respondents are undergraduates at Dokkyo University, and we assume a certain number of them have experience of rolling blackouts from the Great East Japan Earthquake and Tsunami. For this reason, those who answered our CE questions seem sensitive to electricity blackout as the stability, not as the reduction of fluctuation. Although there is no significant preference for a reduction of fluctuations at the mean level in our samples, many more efforts should be made by renewable energy advocates to achieve stable electricity generation and supply with reference to, say, what Zubi (2011) or Santos-Alamillos et al. (2014) studied in the context of wind power generation in Spain, because some preference heterogeneity is observed in the respondents. Alternatively, tractable energy resources should be used to cover supply shortages to meet demand.

Finally, we could not identify preferences for the size of power utility/facility (Larg, Med, and Smal in mean parameter in Table 4). If we incorporate the attribute of distance from the residential location to the power plant, or if we include the attribute of the electric generation capacity or the electricity output, we could elicit IPs on the size of power utility/facility.

This research is a pilot study designed to improve survey design. We need to improve the definition of attributes: risk increase should be measurable numerically, such as by deaths by cancer related to air pollution from fossil fuel use; stability should be associated with blackout risk; utility/facility size should be associated with the distance from place of residence in order to identify not-in-my-back-yard preference structures, or with the electric generation capacity or the electricity output in order to clarify the meaning of the size. These topics are left for future research.

Acknowledgement

This research was supported by the Information Science Research Institute and a personal research grant from Dokkyo University. The author gratefully acknowledges the comments and advice of anonymous reviewers, the efforts of Ms. Nozomi Takiguchi, Mr. Tetsuya Sato, Ms. Ami Kumura, Mr. Shion Iizuka, Mr. Shun Ubukata, Ms. Yuri Takishima, Mr. Kimitaka Okawa, and the other staff at the Taro Ohdoko Laboratory at Dokkyo University, and the survey respondents.

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Appendix: Scenario of Choice Modeling

"Suppose we implement an electricity utility development project in the Tokyo metropolitan area. The project occurs from January 1, 2015 to December 31, 2030; thus, the project will last for 15 years. The project involves the construction of power plants and facilities to manage households' electricity usage in the area. The project cost is covered by increasing the monthly electricity fee for the 15 years. In addition, certain risks are increased as a result of the project. Please choose your most preferred option from the following choice set. When choosing alternatives, please consider the cost of the option. Meanwhile, assume everything else remains constant."

Q1. How about the following combinations?

	M	N	L
Risk increase	Climate risk increase	Ecosystem risk increase	I cannot choose between the two alternatives.
Supply stability	Seasonally fluctuating electricity supply	Seasonally fluctuating electricity supply	
Utility/facility size	Many small-sized facilities	Several medium-sized utilities/facilities	
Electricity fee increase (JPY/month)	+3,000	+2,000	
	□	□	□

Q2. How about the subsequent combinations?

	M	N	L
Risk increase	Ecosystem risk increase	Climate risk increase	I cannot choose between the two alternatives.
Supply stability	Yearly stable electricity supply	Stable annual electricity supply	
Utility/facility size	A few large-sized utilities/facilities	Several medium-sized utilities/facilities	
Electricity fee increase (JPY/month)	+2,000	+3,000	
	□	□	□

Q3. How about the subsequent combinations?

	M	N	L
Risk increase	Ecosystem risk increase	Climate risk increase	I cannot choose between the two alternatives.
Supply stability	Seasonally fluctuating electricity supply	Stable annual electricity supply	
Utility/facility size	Many small-sized utilities/facilities	Several medium-sized utilities/facilities	
Electricity fee increase (JPY/month)	+1,000	+3,000	
	□	□	□

Q4. How about the subsequent combinations?

	M	N	L
Risk increase	Climate risk increase	Health risk increase	I cannot choose between the two alternatives.
Supply stability	Stable annual electricity supply	Stable annual electricity supply	
Utility/facility size	Many small-sized utilities/facilities	Several medium-sized utilities/facilities	
Electricity fee increase (JPY/month)	＋2,000	＋1,000	
	□	□	□

Q5. How about the subsequent combinations?

	M	N	L
Risk increase	Climate risk increase	Health risk increase	I cannot choose between the two alternatives.
Supply stability	Seasonally fluctuating electricity supply	Daily fluctuating electricity supply	
Utility/facility size	Several medium-sized utilities/facilities	Many small-sized utilities/facilities	
Electricity fee increase (JPY/month)	＋2,000	＋2,000	
	□	□	□

Q6. How about the subsequent combinations?

	M	N	L
Risk increase	Health risk increase	Climate risk increase	I cannot choose between the two alternatives.
Supply stability	Seasonally fluctuating electricity supply	Stable annual electricity supply	
Utility/facility size	Several medium-sized utilities/facilities	A few large-sized utilities/facilities	
Electricity fee increase (JPY/month)	＋2,000	＋1,000	
	□	□	□

Q7. How about the subsequent combinations?

	M	N	L
Risk increase	Ecosystem risk increase	Climate risk increase	I cannot choose between the two alternatives.
Supply stability	Daily fluctuating electricity supply	Daily fluctuating electricity supply	
Utility/facility size	Several medium-sized utilities/facilities	A few large-sized utilities/facilities	
Electricity fee increase (JPY/month)	＋3,000	＋2,000	
	□	□	□

Q8. How about the subsequent combination?

	M	N	L
Risk increase	Health risk increase	Climate risk increase	I cannot choose between the two alternatives.
Supply stability	Seasonally fluctuating electricity supply	Daily fluctuating electricity supply	
Utility/facility size	A few large-sized utilities/facilities	Several medium-sized utilities/facilities	
Electricity fee increase (JPY/month)	＋3,000	＋1,000	
	□	□	□

(2014年9月30日受付)
(2014年12月3日採録)

[i] Citizens' Nuclear Information Center (http://www.cnic.jp/english/)
[ii] http://www.cas.go.jp/jp/seisaku/npu/policy09/archive01_05.html [Japanese only].
[iii] We also employed a linear form of the utility function with regard to attributes in the choice set.
[iv] This assumes a strictly increasing, continuous, and strictly quasi-concave utility function.
[v] For any two alternatives i and k, the IIA property of CL in equation 2 is equivalent to the ratio of the probabilities not depending on any alternatives other than i and k ($P_i/P_k = \exp(V_i)/\exp(V_k)$, see e.g. Train (2009)). When it comes to RPL, the ratio of the probabilities becomes:
$P_{nit}/P_{nkt} = \int \prod_t \exp(V_{nit})/\sum_j \exp\left(V_{njt}\right) f(\beta|\Omega)d\beta / \int \prod_t \exp(V_{nkt})/\sum_j \exp\left(V_{njt}\right) f(\beta|\Omega)d\beta$. Then, the ratio depends on all alternatives other than i and k, and IIA is totally relaxed by RPL.
[vi] http://cran.r-project.org/web/packages/mlogit/mlogit.pdf