Kyoto University,
Graduate School of Economics
Research Project Center Discussion Paper Series

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Discussion Paper No. E-14-003

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April, 2014

Inner Conflict between Nuclear Power Generation and Electricity Rates: A Japanese Case Study

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Abstract: Since the March 11 earthquake, Japanese households have been facing a trade-off problem between decreasing dependency on nuclear power generation and avoiding an increase in electricity rates. We analyze this inner conflict quantitatively, adopting two economic-psychological approaches: First, we note that the trade-off causes cognitive dissonance after making a choice that results in a wider desirability gap between the chosen alternative and the rejected alternative. Second, the consumer surplus improves by 11.2% with a no-choice option for suspending judgment in the presence of cognitive dissonance. Third, individual characteristics such as gender and annual household income are significantly correlated with both cognitive dissonance and a preference for the no-choice option.

JEL classification codes: D3, D12, L94, Q41
Keywords: Nuclear power, Cognitive dissonance, No-choice option, Discrete choice experiment, Random parameter logit model

1. INTRODUCTION

A radical reconsideration of the Japanese energy policy is under way in light of the March 11 earthquake and the Fukushima crisis. Before the disaster, the Japanese government had planned to increase the ratio of nuclear power generation from the then-existing level of 20–25% to 45% around 2030. The electricity rate was around ¢20/kWh for an average residential household. However, after the disaster, the general public is opposed to an increase in the ratio of nuclear power generation.

In July 2012, the Democratic Party government announced the *Options for Energy and Environment*, where three scenarios were presented for 2030.

- Scenario 1: Nuclear power generation ratio, 0%; household electric bill, monthly increase by US$40–110 (given that USD1=JPY100 hereafter)
- Scenario 2: Nuclear power generation ratio, 15%; household electric bill, monthly increase by US$40–80
- Scenario 3: Nuclear power generation ratio, 20–25% ; household electric bill, monthly increase by US$20–80

Consequently, citizens are tormented by a trade-off problem between a reduced nuclear power generation ratio and a higher electricity bill. Presently, they are divided between endorsing one of the scenarios. It should be noted here that there are various evidences that indicate the change of citizens' attitudes toward the mixture of electric sources including nuclear and the other alternative powers. In the previous papers, they tried to explain the factors which effect on citizen's attitude toward nuclear power plants by the perception of benefit and economic incentives with reference to the local industrial structure (Kato et al. 2013), by the safety perception which is recognized by the knowledge and information offered by the public sector (Stoutenborough et al. 2013), and by the risk perception and emotional fear (Siegrist et al. 2014, Hartmann et al. 2013).

Relative to the previous papers, the present paper aims more on the quantitative analysis of psychological effects on the profession of the people toward nuclear power plants: cognitive dissonance and suspension of judgment.

As pointed out by Tversky & Shafir (1992), psychological conflict has been considered to play no role in the economic theory of rational choice. However, the previous studies suggested that the presence of conflict not only influences the psychological state of a decision maker but can also affect the actual choice. Luce (1998) suggested that choosing an avoidant option (e.g., no-choice option to maintain status quo) could satisfy coping goals by minimizing the explicit confrontation of negative consequences of a potential decision. Further, Dhar & Simonson (2003) argued that when consumers are uncertain about their preferences but are forced to make a choice, they tend to select options that are easy to justify and are associated with a lower likelihood of error and regret.

The psychological literature of decision-making has also shown that making a difficult choice affects the decision-maker's psychological state, and subsequently changes his or her preferences. Thus, though the economic theory of rational choice assumes that individuals behave according to their preferences (e.g., “I choose it because I like it”), their choice behavior (especially a difficult choice between similarly attractive alternatives) also affects their preference (e.g., “I like it because I chose it”). This process of choice-induced preference change has been explained by the “cognitive dissonance” theory (Festinger, 1957). An inconsistency between preference and behavior (i.e., "I might have chosen something I don't like") causes an uncomfortable feeling called *cognitive dissonance*, which in turn motivates a person to modulate his or her preference in order to restore the consistency. After choosing between options, people tend to value the chosen alternative more and the rejected alternative less (Brehm, 1956; see also Izuma, Matsumoto, Murayama, Samejima, Sadato, & Matsumoto, 2010; Sharot, Fleming, Yu, Koster, & Dolan 2012, for recent works).

Second, the no-choice option provides an alternative route to reduce the psychological discomfort associated with forced choice. The option to delay choice or seek new alternatives is more likely to be selected in the case of a high rather than low conflict or when the available alternatives are slightly rather than substantially different in their attractiveness.[1]. If an option not to choose is unavailable, consumers resolve the forced-choice problem by selecting other available options that are associated with the

[1] The three viewpoints differ in the potential situations that result in the decision to defer a choice (Dhar, 1997). First, the no-choice option may be chosen when a decision maker expects to find better alternatives by continuing the search (rational search). Second, inaction allows one to maintain flexibility of future choice by doing nothing and to avoid regret associated with making a poor choice (trade-off problem). Third, adding a new alternative could increase or decrease the no-choice preference by influencing the commitment to any one option (preference uncertainty).

least potential for a significant error (Tversky & Shafir, 1992).

The present study investigates, using the cognitive dissonance and no-choice option framework, the Japanese people's psychological conflict, after the March 11 disaster, between a reduction in the nuclear power generation ratio and a rise in the electricity bill. In February 2013, we conducted a web-based survey among 2,000 individuals, randomly selected from the panel members of a Japanese research agency, My Voice Communications, Inc. First, we carried out four preliminary surveys regarding nuclear power generation and electricity bills. Second, we examined consumer preferences based on the cognitive dissonance paradigm. Third, we conducted a discrete choice experiments (DCE) based on the stated preference method with respect to the no-choice option.[2]

The main conclusions of this study can be summarized as follows. In the first place, the difference between a chosen alternative and a rejected alternative increased after the decision, indicating that forcing people to make a difficult decision regarding, for example, dependency on nuclear power generation and electricity rates, causes their post-choice preference change to remove their psychological conflict. Therefore, they may take a harsher line as a result of their preference change caused by their own choices. Second, investigating the willingness to pay (WTP) for electricity, given a 1% decrease in the nuclear power generation ratio, we see that the WTP value increases by 20.5%, and existence of no-choice option improves the consumer surplus by 11.2%. Third, regressing individual characteristics on the variables related to cognitive dissonance and the no-choice option, we see that gender and household income are statistically significant predictors in both models. That is to say, female and low-income households tend to fall into cognitive dissonance and, as a result, choose the no-choice option.

The remainder of this paper is structured as follows. Section 2 explains the preliminary survey results. Section 3 investigates the preference survey on cognitive dissonance and discusses the results. Section 4 elucidates the preference for the no-choice option. Section 5 discusses the relationship of individual characteristics with

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[2] In many DCEs, a no-choice option is provided as one of the alternatives in the choice sets to make the choice more realistic. This option can entail a real no-choice alternative (Haaijer, Kamakura, & Wedel 2001). Not including this option leads to reduced fit and biased estimates of linear attributes.

cognitive dissonance and the no-choice option. Section 6 provides the concluding remarks.

2. SURVEY SUMMARY

We conducted a web-based survey in February 2013. The survey was administered to 2,000 individuals by stratified random sampling from the registered respondents of MyVoice Communications, Inc., a Japanese research agency. They were paid $5 for their participation. We set the following conditions for data collection: (a) 1,000 respondents for each gender; (b) participants' age from 20 to 69 years; (c) approximately 20% of respondents from each age group. The actual number of respondents from each age group was as follows: 333 respondents in their 20s, 435 respondents in their 30s, 405 respondents in their 40s, 391 respondents in their 50s, and 436 respondents in their 60s. Their average age was 45.4 years. Table 1 provides other information on the respondents. Of the respondents, 62% were married, and 47% indicated a bachelor's degree as their highest educational qualification. The average household size was 2.9.

<Insert Table 1 around here>

A preliminary survey was conducted before the two detailed surveys for cognitive dissonance (Section 3) and the no-choice option (Section 4). This first survey consisted of four questions on nuclear power generation and electricity rates. The respondents visited the survey website and answered the questions. Table 2 presents the questions and the frequency distribution of the responses to each question.

<Insert Table 2 around here>

The first question was whether their opinions about nuclear-generated electric power had changed since the Fukushima crisis. Among the respondents, 75.4% indicated their opinions had changed. The second question was about future nuclear power generation plans—whether they thought that more plants should be set up, the status quo should continue, or the plants should be abandoned. The results showed that 67% of the respondents thought the plants should be abandoned (immediately or in the future). The third question was about resuming nuclear power plants. The respondents were asked if they thought the plants that were being shut down should be resumed. Results showed that 56% of the respondents thought the plants should be resumed once their safety was ensured. The fourth question was about the increase in electricity rates. The respondents were asked how tolerant they were about the increase in electricity rates for household use, which resulted from the shutdowns of nuclear power plants and the increase in fuel costs to heat the power plants. Results showed that 61.3% of the respondents wanted no increase in electricity rates.

Overall, respondents experienced substantial changes in their opinions after the Fukushima crisis and thought the nuclear plants should be abandoned at some time. They, however, favored the resumption of the nuclear plants once their safety was ensured and objected to an increase in the electricity rate from reduced dependency on nuclear power generation. Thus, they experienced a psychological conflict.

3. COGNITIVE DISSONANCE

After the preliminary survey, the same 2,000 respondents participated in the second survey, which was designed to assess preference changes after making a choice regarding nuclear power generation and electricity rates. We followed the basic procedures of the free-choice paradigm. In this paradigm, participants are first asked to rate several items (e.g., music albums, political candidates) according to their preference (first rating task). Second, they are asked to choose between two of the items that had similar preference ratings in the first rating task (choice task). Finally, they are asked to rate their preference for the same items one more time (second rating task). Studies found that after making a difficult choice between two equally preferred items, the participant’s preference for the chosen item increases while the preference for the rejected item decreases (in what is called the “spreading of alternatives”; e.g., Brehm, 1956; Steele, Spencer, & Lynch, 1993; see Chen & Risen, 2010, and Izuma & Murayama, 2013, for potential methodological issues of the free-choice paradigm).

First rating task

Table 3 shows eight alternatives that were presented to the respondents. The eight alternatives represented eight different combinations of dependency on nuclear power generation and electricity rates. The alternatives used in the second survey were among 16 alternatives that were initially prepared for the third survey (Section 4). The respondents rated how desirable each alternative was by using a 7-point scale ranging from 1 (*Not desirable at all*) to 7 (*Very desirable*). Then, they ranked the alternatives according to their preference (from the first to eighth).

The presentation order of the eight alternatives was randomized (but was the same across respondents), and was changed when they appeared again at the second rating task. However, each alternative was presented under the same label (e.g., Alternative A) across the two rating tasks. This procedure was used to help the respondents not confuse the alternatives when they appeared in a different order at the second rating task.

<Insert Table 3 around here>

Choice task

After the first rating task, two alternatives among the eight were presented to the respondents. No information was given to the respondents as to why these two were selected. These two were, in fact, the ones that the respondents had ranked as their fourth and fifth best in terms of desirability. The presented alternatives were thus different across respondents (Alternatives E [15%, ¢50] and D [25%, ¢40] were most frequently ranked as the fourth and fifth best, respectively). The respondents were then instructed to imagine that they were supposed to vote one of them and to indicate which they chose. To ensure a serious decision, the respondents were informed as follows: “Results of the poll will be open to the respondents of the next survey.”

Second rating task

After making a choice, the respondents were asked to answer a series of questions (42 items in total) that are irrelevant to the current study. This procedure (i.e., having an interval between the choice and the second rating task) was also a part of the standard free-choice paradigm.

After completing the filler items, Alternatives A to H were again presented to the respondents. The respondents indicated their preferences by using the same 7-point scale once again. However, the presentation order was, as mentioned above, different from the first rating task. In addition, the respondents were clearly instructed as follows: "Ignore the answers you gave earlier; please indicate what you feel right now."

We examined choice-induced preference change by employing the same method as in previous studies (e.g., Brehm, 1956; Steele, Spencer, & Lynch, 1993; also see Chen & Risen, 2010; Izuma & Murayama, 2013). First, we calculated the difference between the first and second rating (second rating – first rating) for the alternative that was chosen (voted) at the choice task. We also calculated the difference between the first and second rating (first rating – second rating) for the alternative rejected at the choice task. The former difference score represents how much the respondent's preference for the chosen item *increased* after the choice task, while the latter difference score represents how much the respondent's preference for the rejected item *decreased* after the choice task. Then, we simply added the two difference scores to obtain an overall measure of the spread of alternatives (hereafter, SA) for each participant. A positive SA indicates that the difference between the chosen item and the rejected item increased after the choice task. On the other hand, a negative SA indicates that the difference between the two items shrank after the choice task.

The average SA of the current study was 0.23 (standard deviation = 1.45). A t-test revealed that the SA was significantly greater than zero, $t(1999) = 7.16$, $p < .001$. This suggests that the respondents changed their preferences to justify their choices.

In addition, the respondent's first ratings were found to be associated with their choices. While 1,417 (70.85%) participants voted the alternative ranked as the fourth best at the first rating, only 583 respondents (29.15%) voted their fifth-best alternative; $\chi^2(d.f.=1) = 347.78$, $p < .001$. This suggests that pre-choice preferences were actually associated with the choices: the alternatives that had been preferred more was more likely to be chosen.

The findings presented so far are summarized as follows: First, as expected from the theory of rational choice, pre-choice preferences were related to choices. At the same time, however, the choices affected post-choice preferences. The difference between the chosen alternative and the rejected alternative increased after the decision. Thus, the current study suggests that forcing people to make a difficult decision, for example, regarding dependency on nuclear power generation and electricity rates, causes their post-choice preference change to remove their psychological conflict. Thus, people take a harsher line as a result of their preference change caused by their own choices.

4. NO-CHOICE OPTION

We now explain the discrete choice experiment (DCE) analysis with/without a no-choice option, the estimation models, and the estimation results. We conducted a DCE for 2,000 respondents to analyze factors addressing the inner-manual conflict between dependency on nuclear power generation and electricity rates. The DCE analysis assumes that a service is a profile composed of attributes. In the literature of this paper, the attributes are electricity rate and dependency on nuclear power generation. If an excessive number of attributes and levels is included in the hypothetical choice situations, respondents would find it difficult to answer the questions. In order to design efficient choice questions, we adopted an orthogonal planning method (see Louviere et al. 2000, Ch. 4, for details).[34]

We give respondents eight kinds of choice question that are composed of the dependency on nuclear power generation and the electricity rate (per kWh) and let them choose an alternative that they like. The attribute levels for dependency on nuclear power generation are set at 0%, 15%, 25%, or 50%. The attribute levels for the electricity rate are set at ¢20 (status quo), ¢30, ¢40, or ¢50. We made 16 profiles using the orthogonal planning method and divided them into alternatives 1 and 2. Note that we use in the DCE the same attribute levels that the Democratic Party government determined for the *Options for Energy and Environment* in July 2012. Thus, the

[3] The major advantage of including a no-choice option in a DCE is that a more realistic experiment is obtained (Vermeulena et al. 2008). The experiment therefore leads to better estimates of the model parameters and to better predictions of market penetrations. As a matter of fact, forcing a respondent to make a choice in a DCE might lead to biased parameters when analyzing the choice data (Dhar, 1997; Dhar & Simonson, 2003).

[4] When the no-choice option is selected, no information is obtained on the relative attractiveness of the available alternatives. One potential solution to this problem is to use a dual response format in which respondents choose first among a set of available alternatives without the no-choice option and then among the available alternatives and the no-choice option (Brazell, et al., 2006; Anderson & Wiley, 1992).

respondents are familiar with those values.

<Insert Table 4 around here>

We repeatedly present eight questions to the respondents without the no-choice option in the first wave and with the no-choice option in the second wave. Representative questionnaires are shown in Table 5.

<Insert Table 5 around here>

Estimation Model

We then explain the estimation models. Conditional logit (CL) models, which assume independent and identical distribution (IID) of random terms, have been widely used in past studies. However, the property of independency from the irrelevant alternatives (IIA) derived from the IID assumption of the CL model is too strict to allow flexible substitution patterns.[5] The most prominent scheme is a mixed logit (ML) model that accommodates differences in the variance of random components (or unobserved heterogeneity). ML models have sufficient flexibility to overcome the limitations of CL models by allowing random taste variation, unrestricted substitution patterns, and the correlation of random terms over time (McFadden and Train 2000).

Accordingly, by setting 100 Halton draws, we can demonstrate variety in the parameters at the individual level through the maximum simulated likelihood method.[6] Furthermore, since a respondent answers eight questions in the questionnaire for the conjoint analysis, the data thus obtained form a panel, and we can apply a standard

[5] An implicit assumption in DCE studies of forced choice is that the no-choice option would take a proportionate share from the various available alternatives, consistent with the assumption of IIA, such that the qualitative conclusions in understanding the trade-offs consumers make among options are unaffected (Dhar & Simonson, 2003). However, if this assumption does not hold, any experimental findings may be systematically biased and lead to incorrect predictions about relative shares when consumers have the option not to choose.

[6] The adoption of Halton draws is an important problem that should be examined further (Halton, 1960). Bhat (2001) found that 100 Halton sequence draws are more efficient than 1,000 random draws for simulating an ML model (Train, 2003).

random effect estimation. Thus, we can calculate the estimator of the conditional mean of the random parameters.

Assuming that parameter vector β_n is distributed with density function $f(\beta_n)$ (Revelt and Train, 1998), the ML specification allows for repeated choices by each decision maker in such a way that the coefficients vary with people but are constant across choice situations for each person. Based on the traditional CL model, the repeated choice logit probability of decision maker *n* choosing alternative *i* in choice situation *t* is expressed as

$$L_{nit}(\beta_n) = \prod_{t=1}^{T} [\exp(V_{nit}(\beta_n)) / \sum_{j=1}^{J} \exp(V_{njt}(\beta_n))], \quad (1)$$

which is the product of normal logit formulas, given parameter β_n, the observable portion of utility function V_{nit}, and alternatives *j=1, …, J* in choice situations *t = 1, …, T*. Therefore, the ML choice probability is the weighted average of logit probability $L_{nit}(\beta_n)$ evaluated at parameter β_n with density function $f(\beta_n)$, which can be written as

$$P_{nit} = \int L_{nit}(\beta_n) f(\beta_n) d\beta_n. \quad (2)$$

In a linear-in-parameter form with our specification, the utility function can be written as

$$U_{nit} = V_{nit} + \varepsilon_{nit}$$
$$V_{nit} = \alpha_n + \beta_{1n} \times \textit{nuclear dependency}_{nit} + \beta_{2n} \times \textit{electric rate}_{nit}, \quad (2)$$

where α_n, β_{1n}, and β_{2n} denote random preference parameters for the attributes and ε_{nit} denotes an independently and identically distributed extreme value (IIDEV) term.[7]

The parameters α and β_{1n} are assumed to be normally distributed. The problem is to choose the distribution of β_{2n}. Recall that the WTP value for an attribute is the ratio of the attribute's coefficient to the price coefficient. If the price coefficient is held fixed, the WTP distribution is simply a scaled distribution of the attribute's coefficient. On the other hand, the WTP distribution is more complex when the price is zero or positive.

A common device used to fix the sign of a price parameter is to specify that it has a

[7] Note that α_n denotes the alternative-specific constant term for the no-choice option.

lognormal distribution. However, the lognormal distribution has a long, thick tail, which could imply an implausible empirical distribution of parameter values. An alternative is to use a random parameter with a finite range of variation; here, we used what is called the beta distribution. This specifies that the mean of the distribution is a free parameter, but the two endpoints of the distribution are fixed at zero and at double the mean value. We used NLOGIT 5 for the estimation.

Estimation Results

We start by explaining the estimation results of the two-alternative model, given in Table 6a. The total number of observations is 16,000 considering that 2,000 respondents answer 8 questions. McFadden's pseudo R^2 is 0.537. The estimation results indicate both means and standard deviations (s.d.) for two random parameters. We have assumed a normal distribution for nuclear power generation, and the mean is significant at 1% with the expected sign. We have also assumed a non-positive β distribution for electricity rate, and the mean is significant at 1% with the expected sign. Note that equality for mean and s.d. values is assumed by the beta distribution. The s.d. estimates are also significant at 1% for both random parameters, indicating that the respondents have diverse preferences. We calculate the WTP values showing the electricity rate (per kWh) they are willing to pay given that the dependency on nuclear power generation decreases by 1%. The WTP value is 0.1170.200 = 0.583 cent on average.

<Insert Table 6 around here>

Next, we explain the estimation results of the three-alternative model, given in Table 6b. Given 16,000 observations, the selection ratio of the no-choice option is 2,093/16,000 = 0.13. McFadden's pseudo R^2 is 0.536. Estimates (mean and s.d.) are reported for three random parameters (nuclear power generation, electricity rate, and no-choice option). Having assumed the normal distribution for dependency on nuclear power generation, the mean value is significant at 1% with the expected sign. Having also assumed a non-positive beta distribution for the electricity rate, the mean value is significant at 1% with the expected sign. The constant term for the no-choice option is negative and significant at 1%, indicating that the third alternative is less popular than alternatives 1 and 2. All s.d. values are significant at 1%. The WTP value is 0.1270.177 = 0.716 cent on average.

We then compare the estimation results obtained with the two- and three-alternative models. The WTP value for 1% decrease of nuclear dependency is ¢ 0.583 for the two-alternative model and ¢ 0.716 for the three-alternative model; thus, the WTP value increases by 20.5% with the no-choice option. That is to say, a respondent is willing to pay 20.5% more for electricity with the no-choice option given that the dependency on the nuclear power generation ratio decreases. The reason for this is that under potential cognitive dissonance, the numerator of WTP (the estimate of the dependency on nuclear power generation in modulus) increases by 8.5%, while the denominator (the estimate of the electricity rate in modulus) decreases by 12.0% with the no-choice option. The addition of the no-choice option causes the respondents to avoid ambiguous and irresponsible answers and evade the trade-off problem, resulting in an increase in the WTP values.

Let us next calculate the improvement in consumer surplus by comparing the two- and three-alternative models. Under the random utility assumptions in the logit model, the expected consumer surplus in a choice situation is calculated as

$$E(CS_n) = (1/\alpha_n) \times \ln(\sum_{j=1}^{J} e^{V_{nj}}) + C \qquad (3)$$

where C is an unknown constant, which will be ignored when we consider the change in consumer surplus, and α_n denotes a constant with respect to income, usually the negative of the negative price coefficient, which implies the marginal utility in income. Taking the difference between the two results gives the change in consumer surplus as follows:

$$\Delta E(CS_n) = (1/\alpha_n) \times [\ln(\sum_{j=1}^{J_1} e^{V_{nj}^1}) - \ln(\sum_{j=1}^{J_0} e^{V_{nj}^0})] \qquad (4)$$

where the superscripts 0 and 1 refer to before and after the change, respectively (McConnell, 1995; Train 2003, pp.59-61).

When we calculate the improvement in consumer surplus between the two- and three-alternative models, given the actually chosen alternatives' profiles, we obtain the following:

$$\Delta E(CS_n) / E(CS_n) = (36.7 - 32.8) / [(32.8 + 36.7)/2] = 0.112 \qquad (5)$$

That is to say, the consumer surplus improves by 11.2% with the no-choice option.

Under a psychological conflict such as cognitive dissonance, a respondent defers a decisive choice and gets a temporary utility gain by choosing the no-choice option. In other words, if a respondent is forced to make a choice from a very difficult trade-off, he or she experiences a psychological conflict, and the utility decreases.

5. FURTHER DISCUSSIONS

From the previous discussions, we conclude as follows: First, a cognitive dissonance occurs between dependency on nuclear power generation and a rise in the electricity rate; second, the consumer surplus improves with the no-choice option. Here, we analyze the relationship of cognitive dissonance and the no-choice option with individual characteristics such as gender, age, academic career, family composition, and household income. We aim to detect which individual characteristics influence cognitive dissonance and the preference for the no-choice option.

From the cognitive dissonance framework, we define SA as the explained variable, where a positive SA indicates that the difference between the chosen item and the rejected item increased after the choice task, whereas a negative SA indicates that the difference between the two items shrank after the choice task. The SA takes a discrete value ranging from -7 to +8. Negative values account for 22.1%, zero values 45.1%, and positive values 33.2%.

In the no-choice option model, we define the number of times that a respondent chooses the third alternative from eight conjoint questions as the explained variable. Therefore, the value takes a discrete value ranging from 0 to +8. Zero values account for 60.5% and positive values, 39.5%.

We set gender (female), age, family composition (size), final academic degree (1 = graduate school, 2 = undergraduate, 3 = two-year college/higher professional school, 4 = vocational school, 5 = high school, 6 = junior high school), and annual household income ($100) as explanatory variables for both models.

Estimation Model

We now describe the estimation model: the two-sided censored Tobit regression model. Censored regression models are suitable in cases where the variable of interest is observable only under certain conditions. At this point, let y* be normally distributed with mean μ and variance σ^2. An observed variable y is censored if

$$
\begin{aligned}
y &= c_L \quad if \quad y^* \le c_L \\
&= c_H \quad if \quad y^* \ge c_H \qquad (6)\\
&= y^* \quad otherwise,
\end{aligned}
$$

where c_L and c_H are given constants.[8] Next, consider estimating the regression equation

$$y^* = a + \sum_i b_i \times X_i + \varepsilon \qquad (6)$$

where α denotes a constant term, b_i denotes the regression coefficients, and ε is assumed to be normally distributed and censored on both sides. Parameters can be estimated by maximum likelihood, and the maximum likelihood estimates are unbiased in large samples. However, the maximum likelihood estimates in censored regression models are inconsistent in the presence of heteroscedasticity. Therefore, we let the variance term to be cluster corrected, such that robust covariance matrices are obtained with the Tobit estimator.

Estimation Results

We start by showing the estimation results of the cognitive dissonance model in Table 7a. The total number of observations is 2,000. As has already been explained, the explained variable is SA (the difference between the chosen item and the rejected item after the choice task), which ranged from -7 to +8. The explanatory variables are gender, age, family composition, final academic degree, and household income. The estimation results show that the female dummy and household income are statistically significant (at the 5% and 10% levels). As for the marginal effects, the female dummy increases the relative desirability of a chosen alternative by 1.6 points, and a US$100 increase in household income decreases the relative desirability of a chosen alternative by 0.14 points.

[8] Note that c_L and c_H denote -7 and 8 levels for the cognitive dissonance model and 0 and 7 levels for the no-choice option model.

<Insert Table 7 around here>

We next present the estimation results of the no-choice option model in Table 7b. The total number of observations is 2,000. The explained variable is the number that a respondent chooses the third alternative from the eight questions, which ranges from 0 to +8. Explanatory variables are again gender, age, family composition, final academic degree, and household income. The estimation results show that female dummy, age, and household income are statistically significant (at the 5%, 1%, and 1% levels). As regards the marginal effects, the number of times the no-choice option is selected increases 0.42 times with the female dummy and 0.02 times with a one-year increase in age; it decreases 0.41 times with a US$100 increase in household income.

From what has been stated, the female dummy and household income are statistically significant predictors for both cognitive dissonance and no-choice option models. That is to say, if a respondent is female and if the household income is low, cognitive dissonance occurs with a trade-off problem; consequently, the no-choice option is more likely to be selected. The lesson here is that we should not force female and low-income households to make a choice with a trade-off problem, causing inner conflict, but, rather, allow them to defer the final choice, such that the no-choice option improves consumer surplus. In other words, compulsory choice causes severe pain to respondents. As long as it has the time, the government should provide a reconciled third way, and not enforce a two-alternative choice on the people.

It should be noted, however, that recent discussion in behavioral economics suggests that time inconsistency happens because of a decreasing discount rate, such as in hyperbolic discounting (Frederick et al., 2002). Therefore, a decision maker knows that he or she should choose a later-higher reward rather than a sooner-lower reward, but actually chooses the latter. It is practically difficult for policy practitioners to discern between a good and a bad choice delay. It would be a good idea for the government to give a no-choice option to a decision maker, at least temporarily, to reach a final decision within a determined deadline.

6. CONCLUSIONS

This study investigated the trade-off problem, after the March 11 disaster, between the reduction in the nuclear power generation ratio and a rise in the electricity rate on the basis of cognitive dissonance and no-choice option theories. Our findings were as follows. First, the difference between the chosen alternative and the rejected alternative increased after the decision, indicating that forcing people to make a difficult decision causes their post-choice preferences to remove their psychological conflict. Second, we see that the WTP value for the electricity rate, given a 1% decrease in the nuclear power generation ratio, increases by 20.5% with an introduced no-choice option. Furthermore, the consumer surplus increases by 11.2% with the introduced no-choice option. Third, female and low-income households are likely to feel cognitive dissonance and select the no-choice option. Such a psychological investigation is important in analyzing the inner conflict between the reduction in the nuclear power generation ratio and the rise in the electricity rate.

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Table 1 Summary of respondent characteristics

N = 2,000	Min.	Max.	Mean	SD
Gender (female)	0	1	0.50	0.50
Age	20	69	45.39	13.44
Marital status (married)	0	1	0.62	0.49
Household size	1	7	2.91	1.32
Final degree (*)	1	6	3.16	1.38
Household income ($100)	150	1750	577	356

* 1 = Graduate school, 2 = Undergraduate, 3 = Two-year college/Higher professional school, 4 = Vocational school, 5 = High school, 6 = Junior high school

Table 2 Results of the survey on opinion changes after the Great Earthquake

(a) Opinion changes after the Great Earthquake

Are there any changes in your opinions on nuclear-generated electric power before and after the Fukushima nuclear disaster on March 11, 2011?

	Frequency	Percent
1 = Definitely yes	665	33.3
2 = Yes	841	42.1
3 = Neither	290	14.5
4 = No	135	6.8
5 = Definitely no	69	3.5
Total	2000	100

(b) Opinions about plans of nuclear power generation

What do you think about the future of nuclear power generation in Japan?

	Frequency	Percent
1 = We should definitely increase the number of plants	32	1.6
2 = We should be careful in increasing the number of plants	207	10.4
3 = We should continue the status quo	321	16.1
4 = We should abandon them in the future	1023	51.2
5 = We should abandon them immediately	316	15.8
6 = Don’t know	101	5.1
Total	2000	100

(c) Opinions about resuming nuclear power plants

What do you think about resuming the nuclear power plants that are currently being shut down for regular inspection?

	Frequency	Percent
1=They should be resumed immediately after the regular inspection	139	7.0
2 = They should be resumed after the regular inspection and additional safety assessment	980	49.0
3 = They should not be resumed	688	34.4
4 = Don't know	193	9.7
Total	2000	100

(d) Opinions about an increase in the electricity rate

Due to a spate of shutdowns of nuclear power plants, fuel cost for heat power plants has increased. The current electricity rate for household use is ¢20 per kWh. What is your upper limit for the electricity rate for household use?

	Frequency	Percent
1 = ¢20 (current rate)	1226	61.3
2 = ¢30	589	29.5
3 = ¢40	79	4.0
4 = ¢50	50	2.5
5 = Don’t know	56	2.8
Total	2000	100

Table 3 Eight alternative combinations of the degree of dependency on nuclear power generation and electricity rates

		The degree of dependency on nuclear power generation	**Electricity rates （per kWh）**	**Average score in the first rating task**
(1)	Alt. H	50%	¢20	3.57
(2)	Alt. E	15%	¢50	2.95
(3)	Alt. A	15%	¢40	3.50
(4)	Alt. G	25%	¢50	2.67
(5)	Alt. D	25%	¢40	3.16
(6)	Alt. F	0%	¢30	5.20
(7)	Alt. C	50%	¢30	3.05
(8)	Alt. B	0%	¢20	5.99

Table 4 Attributes and levels used in DCE

Attributes	Levels
Dependency on nuclear power generation (%)	0%
	15%
	25%
	50%
Electricity rate /kWh (¢)	¢20
	¢30
	¢40
	¢50

Table 5 Representative questionnaire

(a) Two-alternative DCE

	Alt 1	Alt 2
Dependency on Nuclear Power Generation (%)	50%	0%
Electric Rate / kWh (¢)	¢20	¢50
Choose one		

(b) Three-alternative DCE

	Alt 1	Alt 2	Alt 3
Dependency on Nuclear Power Generation (%)	50%	0%	No choice
Electric Rate / kWh (¢)	¢20	¢50	
Choose one			

Table 6 Estimation results of random parameter logit model

(a) Two-alternatives model

2 Alternatives	
No. of Sample	2000*8
Max LL	-5135.3
Initial LL	-11090.4
McFadden R2	0.537

		Estimates	S.E.	
Nuclear	MEAN	-0.117	0.004	***
(Normal)	S.D.	0.117	0.004	***
Electric Price	MEAN	-0.200	0.006	***
(Beta)	S.D.	0.200	0.006	***

Note: ***1% significance level, **5% significance level, *10% significance level

(b) Three-alternatives model

3 Alternatives	
No. of Sample	2000*8
Max LL	-8148.2
Initial LL	-17577.8
McFadden R2	0.536

		Estimates	S.E.	
Nuclear	MEAN	-0.127	0.003	***
(Normal)	S.D.	0.120	0.003	***
Electric Price	MEAN	-0.177	0.003	***
(Beta)	S.D.	0.177	0.003	***
No Chioce	MEAN	-11.037	0.180	***
(Normal)	S.D.	2.434	0.083	***

Note: ***1% significance level, **5% significance level, *10% significance level

Table 7 Estimation results of two-sided censored Tobit model

(a) Cognitive dissonance model

Cognitive Dissonance	
No. of Sample	2000
Max LL	-3546.8
Minimum (Left)	-7
Maximum (Right)	8

	Estimates	Marginal Effects	S.E.	
Constant	0.013	NA	0.172	
Gender (Female)	0.159	0.159	0.064	**
Age	0.002	0.002	0.002	
School	-0.009	-0.009	0.025	
Family Size	0.000	0.000	0.000	
Household Income	-0.140	-0.140	0.009	*

Note: ***1% significance level, **5% significance level, *10% significance level

Note 2: As the explained variable is almost symmetrically distributed, the estimates are almost equal to the marginal effects.

(b) No-choice option model

No-choice Option	
No. of Sample	2000
Max LL	-1289.2
Minimum (Left)	0
Maximum (Right)	8

	Estimates	Marginal Effects	S.E.	
Constant	0.563	NA	0.466	
Gender (Female)	0.419	0.272	0.167	**
Age	0.021	0.013	0.006	***
School	0.041	0.027	0.064	
Family Size	0.000	0.000	0.001	
Household Income	-0.630	-0.410	0.022	***

Note: ***1% significance level, **5% significance level, *10% significance level