Japanese Acceptance of Nuclear and Radiation Technologies after Fukushima Diichi Nuclear Disaster

Review of Integrative Business & Economics Research

Hiroshi, Arikawa
Department of Informatics, Nara Sangyo University
3-12-1 Tatsunokita, Sango-cho, Ikoma-gun, Nara 636-8503, Japan.
E-mail: hiro-ari@pglab.org

Yang, Cao
Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences
4A Datun Road, Chaoyang District, Beijing 100101, China.
E-mail: caoy@psych.ac.cn

Shigeru, Matsumoto*
Department of Economics, Aoyama Gakuin University
Room 828, Building 8, 4-4-25 Shibuya, Shibuya-ku, Tokyo 150-8366, Japan.
E-mail: t71092@aoyamagakuin.jp

ABSTRACT

We conducted an Internet survey to evaluate Japanese acceptance of nuclear and radiation technologies after the Fukushima Daiichi Nuclear Disaster. Our empirical results demonstrate that aged and female subjects have a more negative image about technology use. Both education and familiarity with science increase the likelihood of acceptance. Although raising questions about the country's energy requirements enhances acceptance of nuclear technology, actual knowledge is not correlated with acceptance. This suggests that people accept or reject the use of nuclear and radiation technologies without conducting a cost-benefit analysis.

Keywords: Fulushima Daiichi Nuclear Disaster, Internet Survey, Nuclear and Radiation Technologies.

1. INTRODUCTION

On Friday, March 11, 2011, the Great Tohoku Earthquake hit off the east coast of Japan. It triggered a major tsunami, causing nearly 20,000 deaths. The tsunami further disabled the power supply and cooling systems of three Fukushima Daiichi nuclear reactors. All three cores largely melted, and the reactors released radioactive materials.

This serious accident has sparked a huge debate on the use of nuclear power, and a wide variety of opinions has been expressed on the subject. To reduce dependence on

nuclear power, local and national governments have undertaken various policy measures. Firms and households have also taken voluntary measures such as installation of energy-saving applications and solar panels.

The purpose of this research is to evaluate Japanese acceptance of nuclear and radioactive technologies after the experience of the recent nuclear accident. We identify the characteristics of the person who opposes or supports the use of these technologies. We also examine how acceptance has been altered after the accident.

The structure of the remaining paper is as follows. Section 2 explains our survey methodology and summarizes Japanese acceptance of nuclear and radioactive technologies after the experience of the recent nuclear accident. In Section 3, we present our empirical model and identify the characteristics of the opponents as well as supporters of technology use. Section 4 concludes the paper.

2. SURVEY METHODOLOGY

We recruited our subjects from the consumer testers of *Cross Marketing* and asked them to access our original PC server. Our subjects are aged from 20 to 60 years old and live in either the Kanto or Kansai region. The Kanto region is closer to the Fukushima prefecture. We conducted an Internet survey from March 11–15, 2012. In total, 830 consumer testers accessed the server. After removing incomplete observations, the number of observations was reduced to 805.

To evaluate subjects' acceptance of nuclear and radioactive technologies, we asked them the same questions utilized in the public opinion survey carried out by the Japan Atomic Energy Relations Organization (2008). Specifically, we asked subjects to respond to the following two questions on the basis of a 5-point Likert scale (ranging from 1 = strongly agree to 5 = strongly disagree).

(1) Do you think that nuclear power is necessary for the prevention of global warming?

(2) Do you think that radiation technology is necessary for agricultural species improvement?

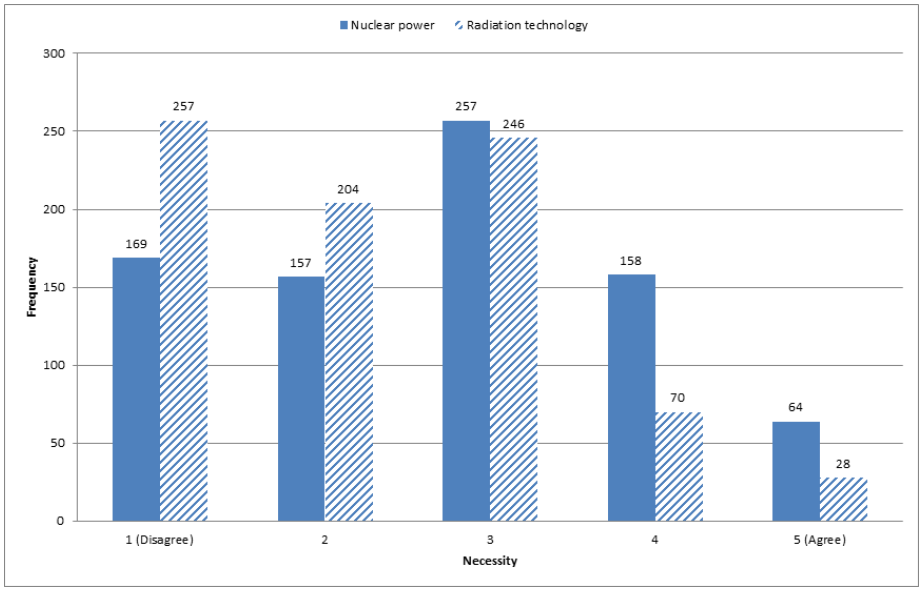

Figure 1. Demand for nuclear and radiation technologies

Figure 1 presents the responses of our subjects. It shows that the average subject has a negative image of both nuclear and radiation technologies. The mean score for nuclear power is 2.74 while that for radiation technology is 2.26. The acceptance of radiation technology use to improve agricultural species is lower than that of nuclear power use to prevent global warming although the latter carries higher risk than the former.

To examine how sociodemographic characteristics affect the acceptance of nuclear and radiation technologies, we asked the subjects to indicate their gender, age, number of children, education, and monthly income.

Figure 2 compares public acceptance of nuclear power in the present survey with that in the original survey by the Japan Atomic Energy Relations Organization. The figure shows that public acceptance has dropped drastically since the nuclear accident. The mean score dropped from 4.02 to 2.74. The figure further demonstrates that the rate of decline among the senior generation is larger than that among the younger generation. The rate of decline among females is greater than that among males.

We asked the subjects about their familiarity with science. Specifically, we asked whether they prefer science subjects (mathematics and science) to art subjects (history and literature). To examine the subject's knowledge about the energy status of Japan, we asked questions on (1) the proportion of Japan's oil consumption met by imports, (2) the minable years of petroleum reserves in the world, and (3) the ratio of nuclear power to total power generation in Japan prior to the Great Tohoku Earthquake.

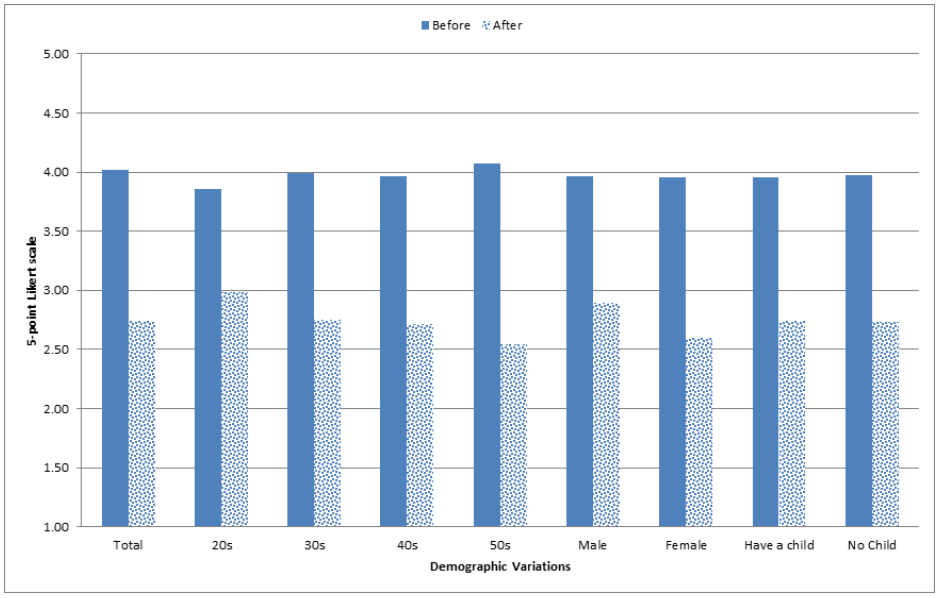

Figure 2. Change in public acceptance of nuclear power

Public opinion researchers such as McFarland (1981) and Benton and Daly (1991, 1993) have found that subjects' responses are influenced by the order of the questions. In the current analysis, we expect that raising questions about energy status will enhance the acceptance of nuclear power. To examine whether the order of questions influences subjects' opinions on nuclear power, we divided our subjects into two groups. Subjects in Group 1 were first asked about the energy status and then about their opinions on nuclear and radiation technologies. For the subjects in Group 2, we reversed the order of questions.

We also asked subjects whether they felt that the Japanese government allocated an adequate budget for environmental policies. If the subject stated that the government allocated an adequate budget, then the dummy variable of environmental policy takes the value of 1. Otherwise, it takes the value of 0.

Table 1 presents the descriptive statistics of our subjects. The number of female subjects is slightly larger than that of male subjects. Subjects are equally distributed between Kanto and Kansai region. The average age of our subjects is 40.77 years old. The table shows that 77% of subjects have children and 55.5% of them have a job. The average monthly income of the worker-subject is 431,096 yen. The table shows that more than half of the subjects stated that the government had allocated an insufficient budget for environmental policies.

With regard to energy status questions, 77% of the subjects answered the first question correctly. However, less than half of the subjects answered the second and third questions correctly. These results imply that the average person has poor

knowledge about the country's energy status.

Table 1. Descriptive Statistics

Variable	Unit	Mean	St. Dev.	Share	Cases
Age	Years Old	40.77	10.54		805
Education	Years	14.70	1.90		805
Familiarity with Science	Level (0–3)	1.27	1.10		805
Female	Dummy			0.51	805
Have a Child	Dummy			0.77	805
Kanto Area	Dummy			0.50	805
Energy Condition Knowledge 1	Dummy			0.77	805
Energy Condition Knowledge 2	Dummy			0.24	805
Energy Condition Knowledge 3	Dummy			0.35	805
Opinion on Environmental Policies	Dummy			0.42	805
Group 1	Dummy			0.52	805
Income	10,000 yen	43.11	26.03		447

3. EMPIRICAL RESULTS

The purpose of this empirical analysis is to identify the type of person who supports or opposes the use of nuclear and radiation technologies. We employ ordered probit models for the empirical analysis. Although we asked questions based on the 5-point Likert scale, only a few respondents selected choice 5 in the survey. Thus, the 5-level model did not provide a sufficient variation. Therefore, we reclassified the categories into three levels as follows.

Censoring in the analysis of nuclear power use:

$E_{Ni} = 0$ if $E^*_{Ni} \leq \theta_1$ (Protester: choices 1 and 2)

$= 1$ if $\theta_1 < E^*_{Ni} \leq \theta_2$ (Neutral: choice 3)

$= 2$ if $\theta_2 > E^*_{Ni}$ (Supporter: choices 4 and 5)

Censoring in the analysis of radiation technology use:

$E_{Ai} = 0$ if $E^*_{Ai} \leq \theta_1$ (Strong Protester: choice 1)

$= 1$ if $\theta_1 < E^*_{Ai} \leq \theta_2$ (Moderate Protester: choice 2)

$= 2$ if $\theta_2 > E^*_{Ai}$ (Non-protester: choices 3, 4, and 5)

Based on the maximum likelihood estimation by LIMDEP (Version 9.0), we arrive at the determinants of the acceptance of nuclear and radiation technologies. The results of ordered probit models are presented in Table 2.[1]

Table 2. Opinion on Nuclear Power and Radiation Technology

Variable	Nuclear Power		Radiation Technology	
	Model 1	Model 2	Model 1	Model 2
Number of Observations	805	447	805	447
Female	−0.240***	−0.177	−0.414***	−0.319*
	(0.082)	(0.155)	(0.087)	(0.165)
Have a Child	0.080	0.039	−0.107	−0.071
	(0.097)	(0.132)	(0.100)	(0.133)
Age	−0.008***	−0.008	−0.013***	−0.015***
	(0.004)	(0.005)	(0.004)	(0.005)
Education	0.039***	0.031***	0.040***	0.032**
	(0.012)	(0.016)	(0.012)	(0.016)
Kanto Area	−0.077	−0.071	−0.032	−0.071
	(0.081)	(0.112)	(0.085)	(0.113)
Energy Condition Knowledge 1	0.091	0.084	−0.017	−0.020
	(0.097)	(0.136)	(0.102)	(0.139)
Energy Condition Knowledge 2	−0.026	−0.070	−0.014	0.030
	(0.096)	(0.128)	(0.101)	(0.129)
Energy Condition Knowledge 3	−0.100	−0.034	0.041	0.026
	(0.090)	(0.115)	(0.093)	(0.116)
Opinion on Environmental Policies	−0.335***	−0.366***	−0.282***	−0.243**
	(0.084)	(0.113)	(0.088)	(0.114)
Group 1	0.142*	0.302***	0.087	0.089
	(0.080)	(0.110)	(0.084)	(0.111)
Familiarity with Science	0.105***	0.085*	0.122***	0.140***
	(0.039)	(0.050)	(0.041)	(0.051)
Income		0.000		0.001
		(0.002)		(0.002)
Threshold parameters for index μ	0.871***	0.691***	1.066***	0.972***
	(0.047)	(0.057)	(0.060)	(0.071)
Chi squared	53.687***	29.048***	82.951***	32.453***

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses show standard errors.

[1] We estimated multivariate ordered probit models in order to take account of unobserved heterogeneity of subjects. They do not improve the estimation efficiency.

Model 1 includes full observations. The results demonstrate that aged and female subjects have a more negative image of both nuclear and radiation technologies. There are a substantial number of empirical studies showing that risk aversion is positively correlated with age and that females are more risk averse. Our results are consistent with those empirical findings.

Subjects who felt that the government should allocate more funds to environmental protection expressed a negative opinion about both nuclear and radiation technologies. This implies that there is a negative correlation between environmental consciousness and the acceptance of nuclear and radiation technologies.

Both formal education and familiarity with science enhance the acceptance of nuclear and radiation technologies. College graduates in the sciences are more likely to support the use of nuclear power for the prevention of global warming. High school-educated clerical workers are more likely to oppose it. By contrast, the actual knowledge of the country's energy conditions is not correlated with the acceptance of nuclear and radiation technologies. This suggests that people base their acceptance primarily on taste and that they do not conduct a cost-benefit analysis.

Finally, as in previous studies, we find that the order of questions influences subjects' responses. Specifically, we find that the subjects in Group 1, who were first asked questions about energy status, respond more positively to the use of nuclear power than those in Group 2, who were asked those questions at the end of the survey. The empirical results suggest that the acceptance of nuclear power is enhanced when subjects are questioned about the energy status before their opinion on nuclear power is elicited.

In Model 2, we used only subjects with a positive income. The results reveal that income is not correlated with the acceptance of nuclear and radiation technologies. The inclusion of income as a variable does not substantially change the results of the remaining variables.

4. DISCUSSION

In this paper, we conducted an original Internet survey to evaluate Japanese acceptance of nuclear and radiation technologies after Fukushima Daiichi Nuclear Disaster. Before the disaster, aged and female subjects had a more negative image of the technologies than other subjects. The results demonstrate that they turned more negative after the disaster. Although many studies show that parents avoid risky behavior, we find that the presence or absence of children does not affect the acceptance of the technologies.

Actual knowledge about the country's energy condition does not have an impact on

acceptance. People thus accept or reject nuclear and radiation technologies without calculating the costs and benefits. Public acceptance will not be altered by the provision of energy information.

As in the previous studies, we find that the order of questions affects subjects' responses. The empirical results suggest that subjects lacking adequate knowledge may be influenced by questions used to evaluate subject knowledge. It would therefore be desirable to place such questions at the end of a public opinion survey.

ACKNOWLEDGEMENTS

This research was supported by a Promotion Project for Distinctive Joint Research" from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), April 2012 - March 2013. We would like to express our gratitude to the Research Institute for Socionetwork Strategies, Kansai University.

REFERENCES

[1] Benton, J.E. and Daly, J.L. (1991) A question order effect in a local government survey. *Public Opinion Quarterly* Vol. 55, No. 4, pp. 640-642.

[2] Benton, J.E. and Daly, J.L. (1993) Measuring citizen evaluations: the question of question order effects. *Public Administration Quarterly* Vol. 16, No. 4, pp. 492-508.

[3] Japan Atomic Energy Relations Organization (2008) Opinion survey about the spread of nuclear power use knowledge, No. 3.

[4] McFarland, S.G. (1981) Effects of Question Order on Survey Response. *The Public Opinion Quarterly* Vol. 45, No. 2, pp. 208-215.

.