

How Scientific Discourses Affect Risk Perception: Evidence from Japan *

Midori Aoyagi[†] Ikuma Ogura[‡]

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How do scientific discourses affect individuals' attitudes toward and concerns about policies that involve health and environmental risks? We explore this research question by focusing on public opinion toward nuclear power among Japanese residents. Radiation and nuclear risks have been a major issue in Japan since the disaster at the Fukushima Daiichi Nuclear Power Plant in 2011, and the issue became particularly salient in 2023, when the Japanese government and Tokyo Electric Power Company (TEPCO) began releasing treated water stored at the power station into the ocean. We conducted a survey experiment with individuals living in Japan (n = 2,315), where random subsets of participants were asked to read short vignettes describing either the safety or the hazardousness of the treated water release to human health and the environment. Analyses of the experimental data reveal that the vignette emphasizing the hazardousness of the treated water release increased the opposition to and concern about the policy. On the other hand, the vignette emphasizing the safety of the treated water release did not affect respondents' attitudes toward the policy, while it increased the concerns about the health and environmental risks of the policy. These findings carry theoretical as well as practical implications, suggesting the need for different approaches to garnering support for and reducing concerns about policies that pose health and environmental risks.

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[†] Senior Research Associate, National Institute for Environmental Studies. Email: aoyagi@nies.go.jp

[‡] Assistant Professor, Graduate School of Social Sciences, Hitotsubashi University. Email: ikuma.ogura@r.hit-u.ac.jp

1 Introduction

In democratic societies, it is crucial that the enacted policies reflect the will of the people, either indirectly—through holding elected politicians accountable—or directly—through measures such as referendums. This is especially true for policies related to nuclear power issues, in which citizen participation is particularly important for two reasons. First, as nuclear policy issues can pose health and environmental risks, they involve trans-science—an issue described in scientific terms but cannot be solved by science (Weinberg 1972). Since scientists cannot use their expertise to solve trans-scientific problems, it is important not only for scientists but also for citizens to be involved in the policy-making process. Second, in politically handling the risks associated with the nuclear energy issue, it is crucial for policymakers to understand the questions and concerns that policy stakeholders have about the issue and to communicate with them so that they can make informed choices about the policy. Thus, citizens play an important role in the risk governance framework, especially in the risk assessment and risk communication phases (Renn 2008).

To effectively engage citizens in the nuclear energy policy-making process, it is crucial that we understand the sources and the mechanisms of individuals' attitudes toward and concerns about the issues. However, as we discuss in more detail in the next section, while previous research has devoted much effort to investigating the factors associated with individuals' attitudes toward nuclear energy issues, there are few studies that examine the drivers of citizens' concerns about the risks associated with nuclear power. In addition, because most of the previous studies have used observational data, they can only show whether the factors they focus on are correlated with individuals' attitudes toward nuclear energy issues, but are not able to examine the causal effects of the alleged explanatory factors. The current state of the field is unsatisfactory because, without knowing their driving forces, we cannot persuade people to support the nuclear power policies nor can we allay the concerns that people have about these policies.

To fill these gaps in the literature, this paper reports the results of our original pre-registered survey experiment with Japanese residents, which examines the sources of citizens' attitudes toward and concerns about the risks associated with the nuclear energy issue, using the case of the offshore

discharge of ALPS-treated water from the Fukushima Daiichi Nuclear Power Plant. Focusing particularly on the scientific discourses surrounding the issue as the driving forces of citizens' attitudes and concerns, our survey experiment asked random subsets of respondents to read a short vignette emphasizing either the safety or the hazardousness of the treated water discharge before answering their opinions about the treated water discharge and their concerns about the associated health and environmental risks. The analysis of the experimental data demonstrates that the scientific argument emphasizing the danger of the treated water discharge increased the opposition to and concern about the policy. In contrast, the experimental vignette emphasizing the safety of the treated water discharge did not affect respondents' attitudes toward the policy, while it increased the concerns about the health and environmental risks of the policy. These findings have theoretical as well as policy implications, as they suggest that factors making individuals more (less) supportive of nuclear energy policies may not necessarily reduce (increase) their concerns about the associated risks, or vice versa, thus requiring different approaches to garnering support for and mitigating concerns about the policies.

The remainder of this paper proceeds as follows. The next section describes the case used in this paper—the discharge of ALPS-treated water from the Fukushima Daiichi Power Plant—and the related literature, and explains why we focus on scientific discourses as the driving forces of citizens' attitudes and concerns. The following two sections describe the design of the survey experiment and report the analysis results of the experimental data. The final section concludes the paper.

2 Background and Literature

2.1 Background: ALPS-treated water discharge from Fukushima Daiichi Power Plant

Issues related to nuclear power have been one of the major political issues in Japan since the disaster at the Fukushima Daiichi Power Plant, which occurred after the 2011 Great East Japan

Earthquake. The issue became particularly salient in 2023, when the Japanese government and the Tokyo Electric Power Company (TEPCO) started releasing the water stored at the power plant into the ocean on August 24. The government and TEPCO have said that the health and environmental impact of the discharged water is minimal because the radioactive materials contained in the water have been either removed or diluted as much as possible using the purification system called the Advanced Liquid Processing System (ALPS). The International Atomic Energy Agency (IAEA) has also announced that the discharge of ALPS-treated water is “consistent with relevant international safety standards.”¹

However, the offshore discharge of ALPS-treated water raised concerns among the Japanese mass public. According to the probability-based public opinion survey that we conducted with Japanese residents in April 2023, about 51% of the respondents said that they were either “concerned” or “somewhat concerned” about the health and environmental impact of the ALPS-treated water discharge. The number slightly declined but still remained at 42.6% in the August survey, which was conducted approximately two weeks before the treated water discharge started.²

Concerns were particularly expressed by the people working in the fishing industry in the Fukushima Prefecture, as the discharge of ALPS-treated water could lead to harmful rumors that the seafood products in the areas were contaminated with radioactive materials (Mabon and Kawabe 2022). In addition, some journalists and environmental groups, such as FoE Japan, have argued that the treated water discharged into the ocean is not safe because the treated water still contains hazardous material, tritium, and the data on the measurement of radioactive materials provided

¹https://www.iaea.org/sites/default/files/23/07/alps_executive_report.pdf (Accessed on July 12, 2024).

²The Central Research Services regularly conducts omnibus public opinion surveys using three-stage stratified sampling and face-to-face interviews. We added our rider question on people’s concerns about the health and environmental risks associated with the treated water discharge in the April and August surveys. The item was reviewed and approved by the institutional review board of the National Institute for Environmental Studies (protocol ID: 2022-005R3).

by the government and TEPCO are not trustworthy. Such concerns and criticisms have also been raised by the surrounding countries, and countries/regions such as China and Hong Kong have imposed embargo on the seafood products from some or all areas of Japan.

2.2 Related Literature

Numerous previous studies have examined the factors that correlate with and/or influence people's attitudes toward nuclear energy issues, both at the individual and aggregate level. The factors identified include: demographic and political characteristics of individuals, such as gender (Sundström and McCright 2016) and ideology (Besley and Oh 2014), relative price and scarcity of fossil fuels (Gupta et al. 2019), nuclear energy-related incidents, such as the disaster at the Fukushima Daiichi Power Plant (e.g., Kim, Kim and Kim 2013; Soni 2018), perceptions of health benefits (Uji, Prakash and Song 2021), concerns about climate change (e.g., Konisky, Ansolabehere and Carley 2020; but see Sonnberger et al. 2021), not-in-my-backyard (NIMBY) sentiments (Carley et al. 2020), and attitudes toward nuclear weapons (Baron and Herzog 2020). As these studies collect and analyze public opinion survey data from countries of various regions, ranging from North America and Western Europe to East Asia and Southeast Asia, we can also examine the generalizability of the findings they report.

While these works have their own merits, we point out two limitations in the literature. First, in contrast to research on people's attitudes toward nuclear energy issues, previous studies have not examined the driving forces behind people's concerns about the health and environmental risks associated with these policies. This is unfortunate because supporting (opposing) a nuclear energy issue does not necessarily mean feeling unconcerned (concerned) about the associated risks. For instance, several Japanese newspaper companies reported that public opinion polls conducted in August 2023 showed that over 50% of the respondents supported the discharge of ALPS-treated water.³ Considering that nearly half of the respondents to our survey expressed concern about the associated risks, this indicates that there were a certain number of Japanese citizens who supported

³*Asahi Shimbun*, August 21, 2023, p.3; *Yomiuri Shimbun*, August 28, 2023, p.9

the treated water discharge but also felt concerned about it, suggesting the need to examine the drivers of concern as well as those of attitudes.

Moreover, previous studies in the field tend to treat people's concerns about health and environmental risks as a component of "perceived risk" to the associated policy and examine its causes or its effect on attitudes toward the policy. For example, [Ryu and Kim \(2015\)](#) asked Korean people about their concerns about the Fukushima disaster as one of the items to measure the "perceived risk" of the accident and examined the causes of perceived risk based on the heuristic/systematic information processing model. However, being aware of the risks associated with a nuclear energy policy does not necessarily mean being concerned about these risks. Thus, it is important to examine the causes of people's concern about the health and environmental risks associated with nuclear power policies separately from the perceived risks of the policies.

Second, with a few exceptions (e.g., [Baron and Herzog 2020](#); [Uji, Prakash and Song 2021](#)), the vast majority of previous studies use observational data to examine the drivers of citizens' attitudes toward nuclear energy issues. However, while observational public opinion survey data, especially those based on probability samples, are superior in that they provide descriptive estimates of the characteristics of the target population, they are not suitable for testing causal hypotheses. This is because the presence of unobserved confounding factors (i.e., factors that affect both the explanatory and the outcome variables) makes it difficult to empirically determine whether the alleged explanatory factors or other unobserved factors impact the outcome of interest. Thus, unless the survey includes items for all the confounding factors, causal estimates based on its data will inevitably be biased. Experimental studies, on the other hand, can overcome this problem by randomly assigning the values of the alleged explanatory variables, thus preventing potential confounding factors from affecting the relationships between the treatment and the outcome variables ([Imbens and Rubin 2015](#)). In order to persuade citizens to support a nuclear energy policy and allay their concerns about the associated risks, we need to know whether the factors under examination not only correlate with, but also influence, individuals' attitudes and concerns. Therefore, since our goal in this paper is to identify factors that *cause* people's attitudes and concerns about nuclear

energy issues, it is important to use a research design suitable for analyzing causal relationships.

2.3 Hard v. Easy Issue

In examining the driving force behind people's attitudes and concerns about the health and environmental risks associated with the discharge of ALPS-treated water, this paper focuses particularly on the scientific discourses surrounding the issue. This is because the offshore discharge of treated water can be considered as a “hard” issue. [Carmines and Stimson \(1980\)](#) distinguish “hard” and “easy” issues based on whether they are (i) technical or symbolic, (ii) about policy means or policy goals, and (iii) on the political agenda for a short or long time. According to [Carmines and Stimson \(1980\)](#), while people can use their “gut responses” and thus do not need to have much knowledge or motivation to form attitudes, individuals must make informed reasoning to form opinions on “hard” issues.

The discharge of ALPS-treated water can be considered a “hard issue” for Japanese citizens. First, the issue is quite technical; it is impossible to explain the issue without using scientific jargon such as “tritium” and “radiation.” Second, the issue deals with policy means. Both proponents and opponents of the treated water discharge agree that the nuclear reactors at the Fukushima Daiichi Power Plant must be decommissioned. However, they disagree on how the decommissioning process should be carried out; while the proponents of the treated water discharge emphasize its necessity and safety, the opponents point to other policy options, potential health and environmental risks, and insufficient effort by the Japanese government and TEPCO to obtain the consent of stakeholders, especially those working in the fishing industry in Fukushima Prefecture. Third, the issue has only been on the Japanese political agenda for a short time. The offshore discharge of water stored at the power plant has been discussed among policy experts since 2013, but the issue was not widely covered in the mass media until 2021, when the government officially decided on the policy. This suggests that Japanese individuals cannot use their “gut responses” to form their opinions about this issue. Thus, we can expect that the scientific arguments presented by both proponents—the Japanese government and TEPCO—and opponents—some journalists and environmental groups—

of offshore discharge of treated water have room for influencing individuals' attitudes toward as well as their concerns about the issue.

3 Study Design

We conducted an online survey experiment with Japanese residents from December 21-25, 2023.⁴ We recruited participants from the non-probability respondent pool provided by Rakuten Insight. A total of 2,315 respondents who passed the simple attention checks completed the survey.

We consider our use of a convenience sample does not seriously affect the results of the survey experiment. One concern about using non-probability samples is that individuals who are willing to participate in surveys—especially those who are registered in the respondent panels of survey companies—will respond differently from those who are reluctant to participate in surveys. However, a recent study by [Moniz et al. \(n.d.\)](#) demonstrates that results from survey experiments tend not to differ systematically by respondents' eagerness to participate in the surveys. In addition, to make the respondents representative of the Japanese population, we set quotas for gender (men or women), age (18-29, 30-39, 40-49, 50-59, 60-69, or 70-79), and region (Hokkaido/Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, or Kyuhu/Okinawa) based on the 2020 census.

In the experimental part of the survey, we randomly divided the respondents into three groups. Respondents assigned to the “Control” condition directly proceeded to the outcome question items. Participants in the other two groups were asked to read a short vignette about the ALPS-treated water discharge before answering the outcome questions.

The vignette for both groups contained the same leading sentences explaining basic knowledge about the ALPS-treated water discharge.

Since late August, the Japanese government and TEPCO have begun discharging the

⁴The survey was reviewed and approved by the institutional review board of Ibaraki University (protocol ID: 23L1300). We pre-registered the study design at AsPredicted, which can be found at https://aspredicted.org/NG8_K97 (Accessed on July 12, 2024).

ALPS-treated water stored at the Fukushima Daiichi Nuclear Power Plant into the ocean. The discharge is planned to take place about every two weeks for over 30 years. ALPS-treated water refers to water containing radioactive materials stored in tanks at the Fukushima Daiichi power plant that has been purified to meet international safety standards other than tritium using the equipment called APLS (Advanced Liquid Processing System). As tritium cannot be removed with current technology, it is diluted as much as possible.

For respondents assigned to the “Pro-discharge treatment” condition, we additionally presented sentences arguing that the ALPS-treated water discharge poses no risks to the environment and human bodies.

Therefore, it is believed that the discharge of ALPS-treated water into the ocean will have no impact on the environment or human health. A report by the International Atomic Energy Agency (IAEA), an agency of the United Nations, also concluded that the discharge of ALPS-treated water “will have a negligible radiological impact on people and the environment.” In addition, the discharge of the ALPS-treated water is conducted in consideration of safety, including periodic monitoring to ensure that there are no significant changes in the concentration of radioactive materials in the sea and fish.

In contrast, participants in the “Anti-discharge treatment” condition additionally read sentences claiming that the discharge of treated water is potentially hazardous to human health and environment.

Although radioactive materials contained in the ALPS-treated water are considered to be below international safety standards, there are media reports that some radioactive materials remain in excess of safety standards. In addition, some experts have pointed out that the safety of radioactive materials such as tritium has not been clarified with regard to their effects when taken into the human body and the cumulative effects when

their amount in the environment increases over time. Some experts also point out that, although a report by the International Atomic Energy Agency (IAEA), an agency of the United Nations, states that the release of the ALPS-treated water is in line with international standards, it cannot be considered neutral because it is basically based on information provided by the Japanese government and TEPCO.

We created these vignettes with reference to the arguments offered by the Japanese government/TEPCO⁵ and FoE Japan⁶, respectively. Therefore, we believe that the vignettes reflect the scientific discourses that have actually existed in the Japanese society, ensuring the ecological validity of the findings.

We asked respondents two outcome questions. First, we asked whether they approved or disapproved of the discharge of ALPS-treated water on a five-point scale ranging from “approve,” “somewhat approve,” “neither approve nor disapprove,” “somewhat disapprove,” and “disapprove.” In addition to respondents’ attitudes toward the treated water discharge, we also asked whether they were concerned about the environmental and health risks associated with the policy on a five-point scale ranging from “not concerned,” “somewhat not concerned,” “can’t say either,” “somewhat concerned,” to “concerned.” In analyzing the data, we rescaled these variables so that larger values indicate that respondents were more strongly supportive of the policy and less concerned with the associated risks, respectively.

4 Results

In this section, we first show how the scientific arguments presented to the pro- and anti-discharge conditions affected the respondents’ attitudes toward and concerns about the discharge of ALPS-treated water. We then examine whether the treatment effects are systematically different between

⁵<https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/atw.html> (Accessed on July 12, 2024)

⁶<https://foejapan.org/en/issue/20230820/13971/> (Accessed on July 12, 2024)

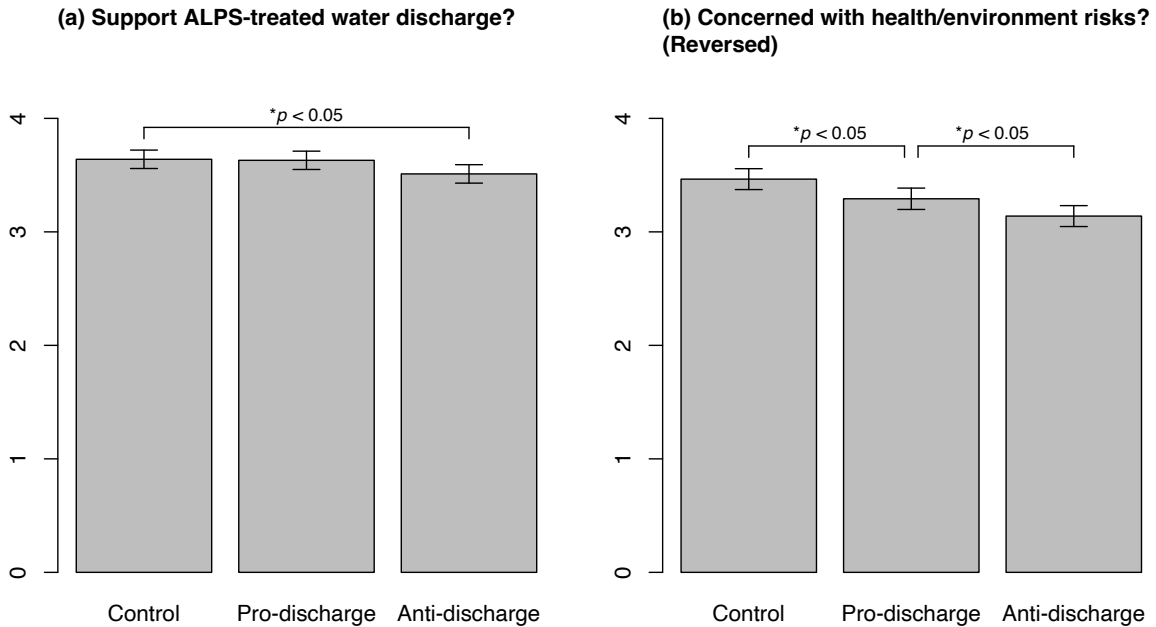


Figure 1: Summary of Experimental Results

respondents.

4.1 Average Treatment Effects

Figure 1 visually summarizes the results from the survey experiment. Panel (a) on the left side of the figure depicts the respondents' average support of the ALPS-treated water discharge by experimental conditions, and panel (b) on the right describes the mean concerns (reversed) about the health and environmental risks associated with the treated water discharge. Arrows on the bars represent the corresponding 95% confidence intervals.

The figure reveals that the scientific discourses for and against the ALPS-treated water discharge affected the respondents' attitudes toward and concerns about the issue differently. According to the figure, arguments emphasizing the hazardousness of the treated water discharge reduced support for the policy and increased the concerns about the associated health and environmental risks (both $p < 0.05$). In contrast, while respondents assigned to the pro-discharge treatment condition supported the policy at the same rate as those in the control condition, they were on average more

concerned about the risks associated with the policy than those in the control condition ($p < 0.05$), although the effect was smaller than that of the anti-discharge condition. This means that simply being exposed to the description of the policy increased concern about the risks associated with it, regardless of the direction of the scientific arguments.

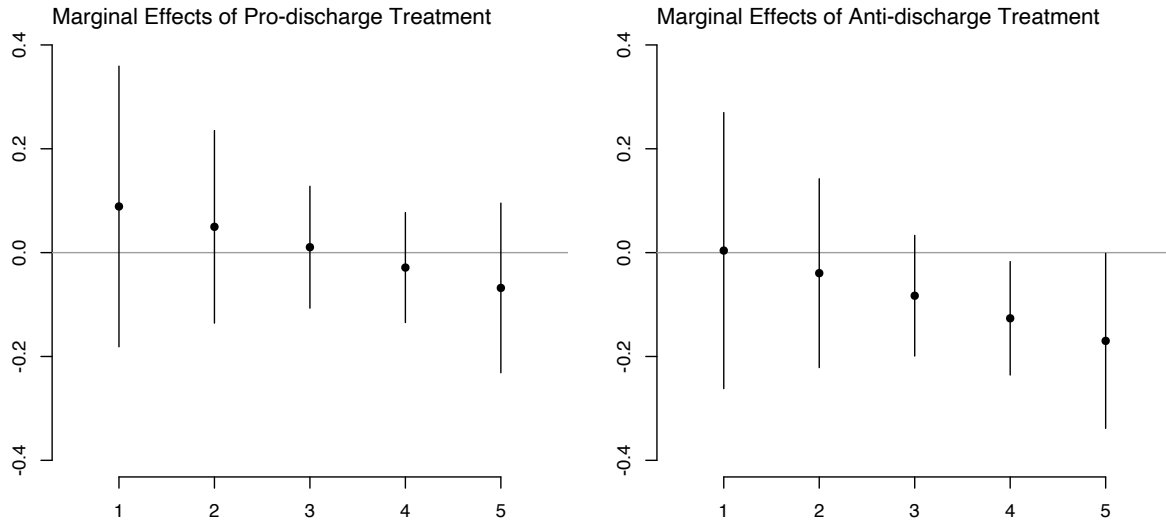
4.2 Treatment Effect Heterogeneity

To examine the heterogeneous treatment effects, we focus on the respondents' pre-treatment attitudes toward nuclear power. According to the theory of motivated reasoning, when processing information, people are motivated not only to make correct judgments but also to reach conclusions consistent with their pre-existing beliefs (Kunda 1990; Taber and Lodge 2006). If this is the case, the pro-discharge treatment should increase support for and decrease concern about the discharge of ALPS-treated water among respondents who support the use of nuclear power in the first place, whereas the vignette for the anti-discharge condition should decrease support and increase concern among those who hold negative opinions about nuclear power.

To test this expectation, we asked respondents about their attitudes toward nuclear power before the experimental part of the survey. Specifically, we asked respondents how much they agreed with the opinion that “nuclear power should be maintained as one of the sources of electricity supply in the future” on a 5-point Likert scale. We recoded the answers so that larger values indicate stronger agreement with the presented statement. We then used this variable as a moderator and estimated linear regression models of respondents' opinions and concerns about the treated water discharge on the indicator variables for the two treatment conditions, their attitudes toward nuclear power, and their interaction terms.

Figure 2 illustrates how the estimated marginal effects of pro- and anti-discharge treatments change with the respondents' pre-treatment attitudes toward nuclear power (Brambor, Clark and Golder 2006). The upper pane of the figure summarizes the marginal effects of pro- and anti-discharge conditions on respondents' attitudes toward the offshore discharge, and the lower pane depicts the marginal effects on respondents' concerns about the associated risks. The solid dots

(a) Outcome: Attitude toward ALPS-treated Water Discharge



(b) Outcome: Concern about Health/Environmental Risk

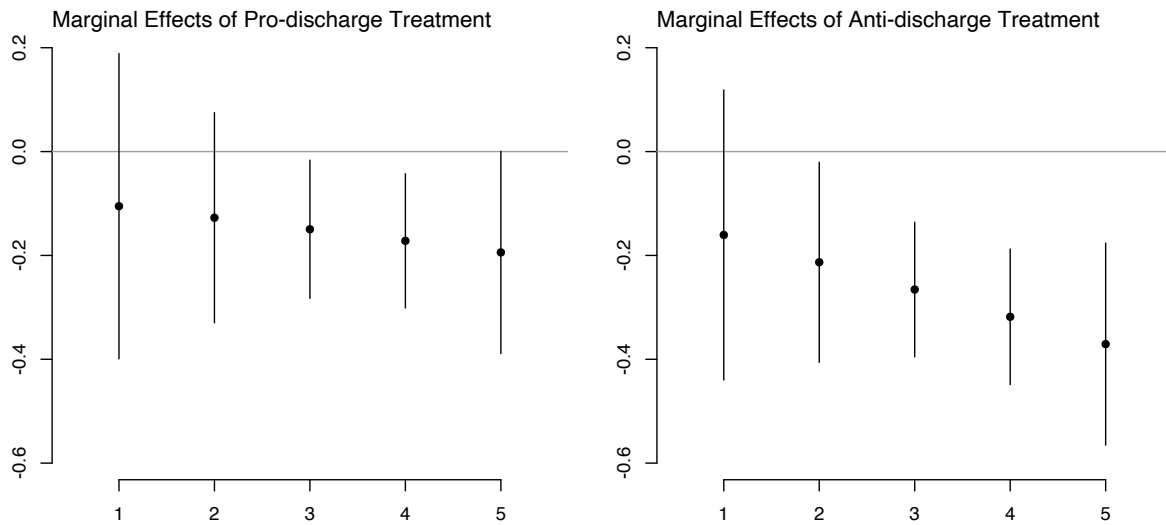


Figure 2: Marginal Effects of Pro-/Anti-discharge Treatments by Respondents' Opinions about Nuclear Power

represent the point estimate of the marginal effects, and the segments represent the corresponding 95% confidence intervals.

The figure shows that, contrary to our expectations, the pro-discharge treatment increased respondents' concerns about the health and environmental risks of the treated water discharge among those who were either neutral or supportive of nuclear power, whereas it had no statistically significant effects on respondents' attitudes regardless of their pre-treatment opinions about nuclear power. Similarly, the effect of anti-discharge treatment on decreasing support for/increasing concern about the offshore discharge was stronger among respondents with positive attitudes toward nuclear power. Thus, motivated reasoning does not seem to explain any heterogeneity in the treatment effects; in fact, both the pro- and anti-discharge treatment affected individuals who were supportive of nuclear power, especially with respect to concerns about the health and environmental risks of the treated water discharge.

5 Conclusion

This paper has presented the results of a survey experiment we conducted with Japanese residents on the impact of scientific discourses on their attitudes toward and concerns about the discharge of ALPS-treated water. Analysis of the experimental data reveals that scientific arguments affected respondents' opinions and concerns differently. Another notable finding is that not only the experimental vignette emphasizing the hazardousness of the treated water discharge but also the vignette claiming the safety of the policy led to an increase in concerns. These results have both theoretical and practical implications. On the theoretical side, as we discussed in section 2.2, our study underscores the importance of examining the driving force behind people's attitudes toward and concerns about nuclear energy issues separately. Future research on this topic should not only add more empirical evidence on the drivers of individuals' concerns about the associated risks but also build theories on what makes individuals more/less concerned and how. On the practical side, the findings of this paper indicate that an intervention to gain people's support for a nuclear energy

issue may actually increase concerns about the health and environmental risks associated with the policy. Therefore, we should take different approaches to garnering support for nuclear energy issues and mitigating concerns about the associated health and environmental risks.

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