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Framing Effects in Surveys for the Acceptance Toward Nuclear Power Generation

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Does framing alter the results of surveys concerning nuclear energy and nuclear power plant? Even though the importance of framing effects in the actual survey questionnaires has received wide academic attention, the framing effects concerning nuclear power generation have not been thoroughly examined. This article investigates the influence of negative framed questionnaires on public opinions toward nuclear power generation. Based on surveys on 576 respondents in South Korea, we estimating ordered logistic regressions conduct an empirical analysis. We demonstrated that the influence of negative framing on respondents' opinions toward nuclear power generation is statistically and substantially meaningful. At the same time, we based on the theory on information-processing styles show that men are more susceptible toward negatively framed questionnaires compared to women.

Key words: framing effects, public acceptance, nuclear power generation, nuclear energy

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Ⅰ. Introduction

Does the framing effect alter the results of surveys concerning nuclear energy and nuclear power plant? In March 2011, a tsunami struck the eastern coast of Japan and more than 23,000 people were killed or went missing. After the Fukushima nuclear disaster, public acceptance of nuclear energy and power plants has decreased significantly and has even been seen as irrecoverable (Holt et al. 2012; Jang & Park 2020; Kim et al. 2013). At the same time, the Fukushima nuclear disaster accelerates academic attempts to restore and recuperate the acceptance of nuclear energy (Hu et al. 2021; Kim & Byrne 2020; Wang et al. 2020). Concerning the potential factors behind the acceptance of nuclear energy and power plants, several factors have received academic attention: safety and risk evaluations (Cvetković et al. 2021; Lee & Harrison 2000), knowledge on nuclear energy and power plants (Huang et al. 2018; Kivimäki & Kalimo 1993; Woo & Bae 2022), and comprehension of economic benefits (Reddy & Painuly 2004).

Given that the above-mentioned studies on the acceptance have relied on the survey approach heavily (Nguyen & Yim 2018; Tsujikawa et al. 2016; Visschers & Wallquist 2013), it is very important to double-check that the questionnaires used in the survey are properly structured and fulfill their role in accurately capturing public opinions toward nuclear energy and nuclear power plants. Especially, regarding the survey approach, the importance of framing effects in the actual survey questionnaires has received wide academic attention (Chyung et al. 2018; Johnson et al. 2004; Lietz 2010). It is revealed that even a simple word or a term affects respondents' answers and causes survey errors (Deming 1944; Semin 2008). However, the framing effects concerning nuclear energy and power plants have not been thoroughly examined. Given that the results of the surveys on nuclear power have a nonnegligible influence on the government's nuclear policy stance and are used as important reference data, this academic void is unexpected.

Moreover, the absence of a study on the framing effects in surveys on nuclear energy can hinder us from fully recognizing the variations in the acceptance. Therefore, we aiming to unveil the influence of framing effects in nuclear energy surveys conduct a survey experiment on 576 respondents in South Korea.

This article investigates the influence of the ways of framing in the survey questionnaires on the acceptance of nuclear power generation. This article proceeds with the following orders. First, we review previous works especially dealing with potential factors determining the public acceptance of nuclear energy and nuclear power plants. In the Theories and Hypotheses section, we introduce how the framing effects can affect the results of surveys concerning nuclear power plants and power. Then, the following Empirical Analysis section shows the results of ordered logistic regression models about the acceptance. Lastly, we conclude with a discussion of the potential limitations and contributions of this article.

Ⅱ. Literature Review

The global electricity consumption tends to increase faster than the estimated global demand (Cvetković et al. 2021). However, nuclear power plants that take a large proportion of energy production enjoy lower public acceptance compared to other sources of energy including wind and hydrogen. The growing attention on global warming, climate change, and the adverse impacts of anthropogenic activities including fossil fuel consumption leads scholars to focus on how to improve public acceptance of nuclear energy. Although nuclear power generation has been evaluated as safe, efficient, and clean rather than other thermal power generation (Chung & Kim 2018; Wu 2017; Xia et al. 2019; Zhu et al. 2022), both Chornobyl and Fukushima nuclear disasters contribute to the low public acceptance toward nuclear energy (Roh & Kim 2022).

Along with the consensus that nuclear energy is the most important source to overcome the global electricity consumption crisis and environmental hazards (Han

et al. 2017; Tang et al. 2012; Wang et al. 2016), potential factors of the public acceptance of nuclear energy and nuclear power plants have been thoroughly examined. Some studies emphasize the role of safety perceptions on the acceptance (Cvetković et al. 2021; Lee & Harrison 2000), while others shed light on the importance of knowledge on nuclear energy (Kim et al. 2014; Wang et al. 2019; Woo & Bae 2022). For instance, Cvetković et al. (2021) examining the case of Serbia demonstrates that public doubt about the safety of nuclear energy is one of the most important factors of public denial against the nuclear power plant. A more recent study from Woo and Bae (2022) shows that any knowledge about nuclear energy can increase acceptance of nuclear energy.

Along with the safety perceptions and the role of knowledge, perceived benefits have received academic attention (Tsujikawa et al. 2016; Visschers et al. 2011; Visschers & Siegrist 2013; Wang et al. 2019). Especially, Visschers et al. (2011) demonstrate that the perceived benefits of a secure energy supply and environmental protection are driving factors of the acceptance. In addition, regarding the influence of trust in the managing bodies on the acceptance of nuclear power plants, many previous studies have shown that people with little knowledge about nuclear technology tend to rely on their trust in the managing bodies when they determine whether they will support nuclear energy or not (Bronfman et al. 2012; Ho et al. 2019; Kim et al. 2014; Siegrist & Cvetkovich 2000). Also, some previous studies argue that pro-environmental orientation positively affects people's attitudes toward nuclear energy (Corner et al. 2011; Spence et al. 2010).

Largely relying on a survey approach (Nguyen & Yim 2018; Tsujikawa et al. 2016; Visschers & Wallquist 2013), the previous studies on the public acceptance of nuclear energy and power plant have broadened our understanding of attitudes toward nuclear energy. However, as mentioned earlier, there is a relative lack of studies on the role of framing in the surveys for the acceptance of nuclear energy (Nguyen & Yim 2018; Wang et al. 2013). Considering the crucial role of the survey approach in the studies for public acceptance toward nuclear power generation, scrutinizing the impacts of framing on survey questionnaires is important to prevent survey results from being errored. Thus, we will examine the framing

effects on public opinions toward nuclear power generation.

Ⅲ. Theories and Hypotheses

Framing effects have been analyzed thoroughly in various social science domains including sociology, political science, and journalism (Amsalem & Zoizner 2022; Druckman 2001). It has been revealed that a framing effect tends to occur when illustrating the same issue and problem differently and affects people's attitudes or behavior (Björnehed & Erikson 2018; Entman et al. 2009; Scheufele & Iyengar 2012). The framing effects have received intensive attention from scholars when public perception and acceptance of new policies or technologies including negative emission technologies (Wenger et al. 2021) spatial planning policies (Pleger et al. 2018), cultured meat (Bryant & Dillard 2019), etc. In terms of energy policies, the framing effects in surveys about energy transitions or renewable energies have been regarded as an important factor in determining public attitudes (Cacciatore et al. 2012; Demski et al. 2019).

Most studies have relied on the framing theory. Framing theorists have argued that different types of frames lead to "different underlying mechanisms and consequences" (Levin et al. 1998). Related to the survey approach, broad literature has demonstrated that the context of the questionnaires and the expression of those can influence the answers from respondents (Cullis et al. 2006; Galesic & Tourangeau 2007; Tourangeau et al. 2000; Wang et al. 2022). Even though several exceptions exist (Presser et al. 1992), most of the studies on the context in surveys have focused on examining the influence of framing in the actual questionnaires. The non-neglectable impacts of framing have been empirically supported by previous studies (Glaser et al. 2007; Lecheler & De Vreese 2011; Ubel et al. 2001; Watanabe & Shibutani 2010). For instance, some studies show that negatively framed compared to positively framed questionnaires have greater impacts on respondents (Baumeister et al. 2001), while others demonstrate that negatively framed ques-

tionnaires strengthen respondents' original attitudes (Bizer & Petty 2005). The cognitive evaluation theory supports those findings by theorizing that negative emotions or words describing subjects tend to cause negatively biased attention on the subjects (Small & Lerner 2008).

Based on the findings from the previous studies, we will see whether the negative framing alters the patterns of answers in the surveys related to nuclear energy and nuclear power plant. In addition to the independent influence of the negative framing, we also expect that the negative framing can reinforce the respondents' original attitude toward nuclear energy and power plants.

Hypothesis 1: Negative framing affects respondents to negatively respond to the questionnaires about the acceptance of nuclear energy and power plants, while all other things being equal (Ceteris Paribus).

Rather than only testing the existence of framing effects in nuclear energy surveys, we further examine whether the framing effects weakened or augmented based on the gender of respondents. Except for safety and risk perceptions, one of the most well-known determinants of the acceptance of nuclear energy is gender (Keller et al. 2012; Solomon et al. 1989). Women's low-level support for nuclear energy has been empirically supported around the world (Sundström & McCright 2016). The "awareness theory" largely developed by Griffin (1978) maintains that females generally tend to have less awareness of technical issues and it connects to lower support for the acceptance of nuclear technology. Many studies have provided evidence for this argument (Visschers & Wallquist 2013).

In this study, we also examine whether the influence of framing occurs heterogenous according to gender. The difference that gender can make in framing effects has been studied for decades (Hannah & Cafferty 2006; Kivivuori et al. 2012; Mayer & Tormala 2010; Rooney et al. 2005; Teigen & Karlsen 2020). For instance, Mayer and Tormala (2010) argue that

"[…] men and women responded differently to think- versus fell-framed

> messages. Men were more persuaded when the critics' reviews were framed in think terms, whereas women were more persuaded when the critics' reviews were framed in feel terms." (451p)

In addition, gender is regarded as one of the factors influencing the patterns of framing effects (Cullis et al. 2006; Huang & Wang 2010). More recently, the study by Huang and Wang (2010) demonstrates that females tend to be more susceptible to negative frames compared to their male counterparts. Those works showing the gender gap in susceptibility to framing are primarily based on the differences in information-processing styles between males and females (Putrevu 2004). The information-processing styles are divided into two types of styles: relational processing and item-specific processing. Relational processing emphasizes the shared themes among diverse pieces of information, while item-specific processing pivots the target words or messages (Putrevu 2010). It is unveiled that male tends to have item-specific processing and female to have relational processing when they face new information (Senkova & Otani 2021).

The gender difference is rooted in the differences in socialization. According to the Social Role Theory, both males and females acquire attributes befitting for their gender-role expectations. Historically, men should be more aggressive to get positions of power. Conversely, women do not have to play this role (Eagly 1987). Men and women tend to receive education for those different roles from a series of socialization agents including peers and mass media (Moschis 1985). According to Putrevu (2010), women are likely to have feminine characteristics (nurturance and relationship harmony), while men are prone to equip masculine attributes (competitiveness and assertiveness) due to the different socialization. With those characteristics, men are likely to predispose toward item-specific processing, but women are prone to rely on relational processing. In terms of surveys, it means that men tend to focus on individual survey questions rather than women, while women tend to access survey questions with their previous knowledge and opinions based on relations. Therefore, the differences in information-processing make men more susceptible to negatively framed messages or words than women.

Borrowing the theory about information-processing styles developed by Putrevu (2004) and given that previous literature on framing effects has found that gender conditions the degree of framing effects on public attitudes and behaviors, we expect that gender can influence the susceptibility to negative framing about nuclear energy and power plants.

Hypothesis 2: The gender of respondents influences the susceptibility to the negative framing of nuclear energy and power plants, while all other things being equal (Ceteris Paribus).

Ⅳ. Empirical Analysis

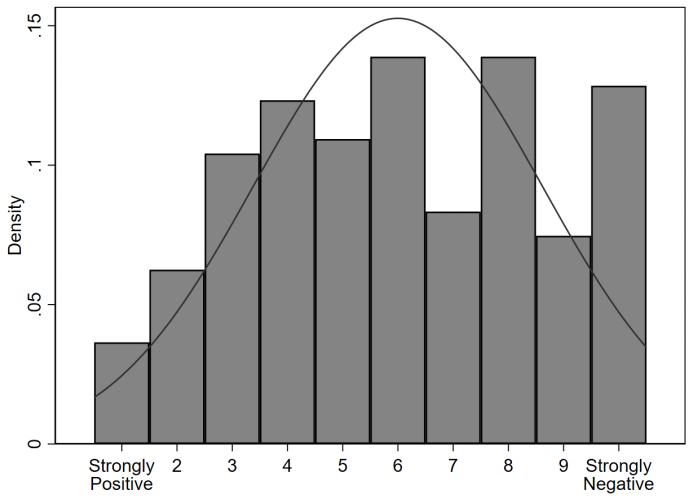
In this section, we will introduce variables, data, modeling strategies, and empirical results about how the framing effects can affect the response to the questionnaires about nuclear energy and power plants. To test whether the framing effect can substantially alter the respondents' reactions to the questions about nuclear power plants, we take advantage of survey experiments. Our sample is composed of 576 respondents. The respondents are divided into two samples: neutral framing samples (N=291) and negative framing samples (N=285). Both groups are asked to answer a series of questionnaires about nuclear energy and power plants with neutral and negative framing respectively.

1. Variables and Data

1) Dependent Variable

To measure the public acceptance of nuclear energy and power plants, we use the answers to the questionnaire that 'How do you think about nuclear power in South Korea?' Respondents can select their answers among the ten options ranging

from 1(Strongly Positive) to 10 (Strongly Negative). <Figure 1> illustrates the distribution of the dependent variable. As presented, the density roughly follows the normal distribution.



<Figure 1> Distribution of the Dependent Variable

2) Independent Variable

As an independent variable, we use a binary variable named Negative Framing indicating whether the questionnaires used in surveys are asked in a negative way or not. We divide neutral and negative framing samples based on survey questionnaires with different word choices and expressions related to nuclear energy and nuclear power plant. This strategy is based on the previous studies on the questionnaire design. It has been regarded that unclear terms and emotional words are highly correlated with survey errors (Deming 1944), which remains an important issue of survey research (Biemer 2010; Markmann et al. 2021; Schober & Conrad 1997). The influence of words and terms on survey results is based on the fact that those are the main source of meaning that respondents rely on when they answer a survey question. Given that words or terms can never be perfectly neutral, they tend to drive respondents' reactions, opinions, and perspectives toward

survey questionnaires (Semin 2008; Wenneker et al. 2005). Relying on the existing research on the questionnaire design, we using different words and terms related to nuclear energy and nuclear power plant construct neutrally and negatively framed questionnaires.

In the neutrally framed surveys, the respondents were asked to respond to questionnaires including the four neutral questionnaires related to safety and benefit perceptions which have been regarded as determinants of the acceptance toward nuclear power plants: 'How safe do you feel about nuclear power plants?', 'How do you feel about living near a nuclear power plant?', 'Are you aware that electricity tax relief or exemption has been made in exchange for installing a radioactive waste disposal facility for people living around the facility?', and 'In your opinion, it is reasonable to give additional points to residents when they apply for jobs from the Korea Hydro & Nuclear Power (KHNP) Cooperation?'

Conversely, in the negatively framed surveys, the four questionnaires were framed negatively: 'How safe do you feel about nuclear power plants which is one of the representative hate facilities?', 'How do you feel about living near a nuclear power plant with is one of the representative hate facilities?', 'Are you aware that electricity tax relief or exemption has been made in exchange for installing a radioactive waste disposal facility for people living around the hate facilities?', and 'In your opinion, it is reasonable to give additional points to residents living nuclear power plants which is one of the representative hate facilities when they apply for jobs from the Korea Hydro & Nuclear Power (KHNP) Cooperation?' We assign 1 if questions are framed in negative ways. otherwise, 0 is assigned.

3) Control Variables

Based on the previous findings that respondents with much knowledge of nuclear energy and power plant are more likely to support nuclear power generation (Huang et al. 2018; Woo & Bae 2022), we include some knowledge variables: Knowledge on Nuclear Power, Knowledge on the Locations of NPPs, and Knowledge on KHNP.[1)] To measure respondents' knowledge of nuclear power, we

employ an index developed by Woo and Bae (2022). They using three specific items[2] conduct the principal component analysis (PCA) to build an index for Knowledge on Nuclear Power. We assign 1 to Knowledge on the Locations of NPPs if respondents say 'Yes' to the question that 'Do you know the exact locations of the four nuclear power plants in South Korea?' Also, 1 is assigned to Knowledge on KHNP if respondents say 'Yes' to the question that 'Do you know about the Korea Hydro & Nuclear Power (HKNP)?' In addition, basic individual features including Age and Gender are included. Age is categorized into 1 (aged less than 31) and 2 (aged over 31). We assign 0 to Gender if respondents are male. Otherwise, 0 is assigned.

<Table 1> Descriptive Statistics

Variable	Mean	Std. dev.	Min	Max
Dependent Variable				
Acceptance of Nuclear Energy and Power Plants	5.002	2.613	1	10
Independent Variable				
Negative Framing	0.495	0.250	0.000	1.000
Control Variables				
Female	0.492	0.500	0.000	1.000
Knowledge on Nuclear Power	0.000	1.680	-3.303	4.287
Knowledge on KHNP	0.896	0.306	0.000	1.000
Knowledge on the Locations of NPPs	0.403	0.491	0.000	1.000
Age	1.596	0.491	1.000	2.000

1) KHNP operates South Korea's 21 NPPs along with 27 hydro-electric power plants. We assume that if a respondent knows about the KHNP, the respondent has much knowledge on nuclear power and power plant compared to the respondent who hasn't.

2) 'Do you know that you are exposed to radiation during X-ray and CT scans, which are essential to health checkups?', 'Do you know that radioactive waste is also present in waste from hospitals?', and 'Do you know that most of the low and medium level radioactive waste is used daily, such as clothes and gloves worn during radiation work?'. Respondents can answer whether they know about the information in each question by selecting 1 (absolutely I do not know) to 10 (absolutely I know).

<Table 1> introduces the descriptive statistics of all variables employed in this article. To test whether there is a multicollinearity problem among the independent and control variables included in models, we conduct variance inflation factors (VIFs) tests. The individual and mean VIFs are all less than 4, indicating that there is no problematic collinearity among the explanatory variables. It should be noted that respondents' jobs and regions are also controlled with fixed effects even if not presented.

<Table 2> Balance Test

Explanatory Variables	Neutral Frame	Negative Frame	Mean Diff.	95% C. I.	
Female	0.515 (0.029)	0.467 (0.030)	0.049	-0.033	0.131
Knowledge on Nuclear Power	0.008 (0.097)	-0.008 (0.101)	0.015	-0.259	.290
Knowledge on KHNP	0.910 (0.017)	0.017 (0.019)	0.030	-0.020	0.080
Knowledge on the Locations of NPPs	0.395 (0.029)	0.411 (0.029)	-0.015	-0.095	0.065
Age	1.581 (0.029)	1.611 (0.029)	-0.030	-0.110	0.051

Note: Standard errors are in parentheses.

To examine whether the respondent's group received negatively framed surveys and the group received neutrally framed surveys are balanced or not, we conduct Welch's t-tests which have been widely employed rather than Student's t-tests. It is based on previous research demonstrating that Student's t-tests can be severely biased and lead to invalid statistical inferences (Delacre et al. 2017; Fay & Proschan 2010). As presented in <Table 2>, the independent variables are not statistically different between the two groups, indicating that the variables are statistically indistinguishable between the groups. However, given that respondents' information regarding regions and jobs is not balanced between the two groups, and the small number of observations is employed in this study, we employ ordered

logistic regression to examine the impacts of negative framing on public opinions toward nuclear energy and nuclear power plant.

2. Empirical Results

<Table 3> Empirical Results from the Ordered Logistic Regression Model

Variables	Coefficient	Robust Std. Err.	Z-Score	$P>\|z\|$	95% C. I.	
Independent Variable						
Negative Framing	0.446***	0.148	3.010	0.003	0.156	0.737
Control Variables						
Female	0.437*	0.230	1.900	0.057	-0.014	0.888
Knowledge on Nuclear Power	-1.106***	0.065	17.060	0.000	-1.234	-0.979
Knowledge on KHNP	-0.658***	0.224	2.940	0.003	-1.096	-0.219
Knowledge on the Locations of NPPs	-0.033	0.165	-0.200	0.842	-0.355	0.290
Age	0.082	0.171	0.480	0.631	-0.253	0.418
Cut1	-2.907	0.472			-3.832	-1.983
Cut2	-1.699	0.446			-2.572	-0.825
Cut3	-0.626	0.426			-1.461	0.209
Cut4	0.301	0.425			-0.531	1.133
Cut5	1.023	0.428			0.184	1.861
Cut6	1.939	0.433			1.091	2.788
Cut7	2.545	0.444			1.675	3.415
Cut8	3.787	0.457			2.892	4.683
Cut9	4.688	0.484			3.739	5.637

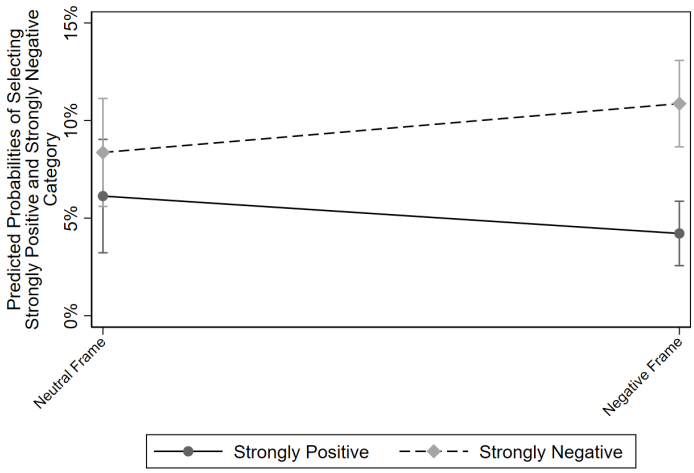
Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. The Akaike's Information Criteria (AIC) and the Bayesian Information Criteria (BIC) are 2196.906 and 2275.316. Fixed Effects for respondents' jobs and regions are included.

Given that our dependent variable is an ordinal variable, the application of ordinary least squares regression gives non-sensical predictions and statistical hypothesis tests will be unsound (Menard 2002). Therefore, we estimate ordered logistic regression models. <Table 3> presents the empirical results from the ordered logistic regression model. As presented, it is revealed that the Negative Framing is statistically significant at the level of $p < 0.01$ in a positive direction. It means that the negative questionnaires related to nuclear energy and power plant increase the probability for respondents to provide negative opinions toward nuclear power generation. These empirical results provide support for the previous argument that the framing effect is an influential determinant of people's attitudes and behavior (Björnehed & Erikson 2018; Entman et al. 2009). At the same time, it also emphasizes the need to pay attention to survey framing to estimate public acceptance toward nuclear power generation.

The ordered logistic regression also demonstrates that the knowledge related to nuclear energy and nuclear power plants tends to decrease the probability for respondents to expose negative attitudes toward nuclear power generation. This finding resonates with the argument from Woo and Bae (2022) that there is a conducive influence of the knowledge on radiation and radioactive waste on the public acceptance of nuclear power generation. Furthermore, Female is statistically significant at the level of $p < 0.1$ with a positive sign, indicating that females are more likely to show negative attitudes toward nuclear power generation. It is in the line with previous studies demonstrating that women are significantly less supportive of nuclear power generation (Ansolabehere & Konisky 2009; Corner et al. 2011; Sundström & McCright 2016).

To evaluate the substantial influence of the survey frames, we estimate predicted probabilities for respondents to select strongly positive and strongly negative categories in the questionnaire used to build the dependent variable. <Figure 2> shows the predicted probabilities of selecting each category along with 95% confidence intervals. In the neutrally framed surveys, the probabilities of selecting strongly positive and strong negative categories are 6.131% and 8.364% respectively and they are not statistically different from each other. However, in the negatively

framed surveys, the predicted probabilities of selecting the two categories are changed to 4.216% and 10.867% each to each. In other words, the probability of selecting a strongly negative category decreases by 1.915% and that of selecting a strongly positive category increases by 2.503%, meaning that the negative frame has a substantial influence on the observed opinions toward nuclear power generation. These gaps also indicate the potential bias rooted in the survey frames.



<Figure 2> Predicted Probabilities of Selecting Strongly Positive and Strongly Negative Categories Based on the Survey Frames

Note: The predicted probabilities are estimated based on the results presented in <Table 3>, while all other variables are held at constant values. 95% confidence intervals are presented together.

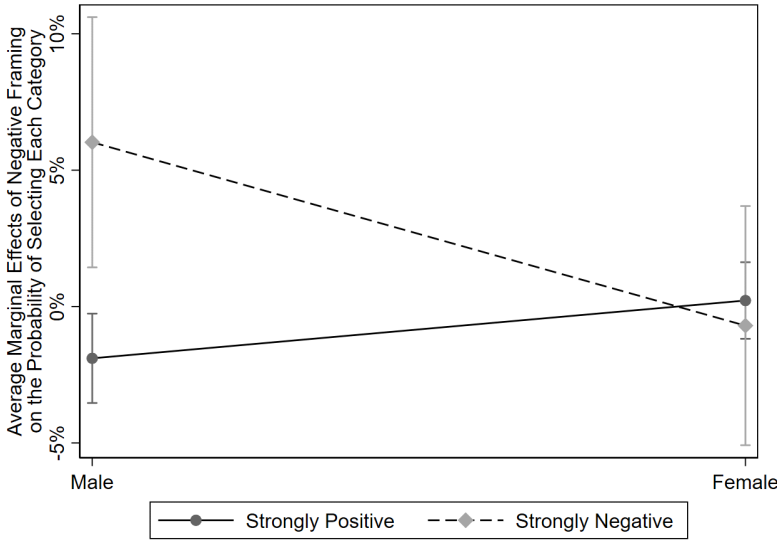
To test the hypothesis concerning the heterogenous impacts of negative frames according to the gender of respondents, we re-estimate the ordered logistic regression model with the interaction term between Negative Framing and Female. The AIC and BIC from the model presented in <Table 4> are less than those in <Table 3>, which means that the model estimated with the interaction term has greater explanatory power. The interaction term is statistically significant at the level of $p < 0.05$ with a negative sign, indicating that the impacts of the two variables are conditioned by each other. It provides a clue for hypothesis 2 that the

gender of respondents influences the susceptibility to negative framing. Moreover, the results on other control variables including Female, Knowledge on Nuclear Power, Knowledge on KHNP, and Knowledge on the Locations of NPPs are also statistically significant as those presented in <Table 3>.

<Table 4> Empirical Results on the Interaction Term from Ordered Logistic Regression Model

Variables	Coefficient	Robust Std. Err.	Z-Score	$P>\|z\|$	95% C. I.	
Interaction Term						
Negative Framing X Female	-0.608**	0.295	-2.060	0.039	-1.186	-0.029
Independent Variable						
Negative Framing	0.544***	0.211	2.580	0.010	0.131	0.957
Control Variables						
Female	0.350*	0.204	1.720	0.086	-0.050	0.750
Knowledge on Nuclear Power	-1.102***	0.062	17.690	0.000	-1.223	-0.979
Knowledge on KHNP	-0.632***	0.213	2.970	0.003	-1.049	-0.216
Knowledge on the Locations of NPPs	-0.565***	0.167	3.380	0.001	-0.892	-0.237
Age	0.033	0.166	0.200	0.841	-0.292	0.358
Cut1	-2.742	0.278			-3.286	-2.198
Cut2	-1.678	0.225			-2.119	-1.237
Cut3	-0.835	0.212			-1.251	-0.419
Cut4	-0.186	0.208			-0.593	0.221
Cut5	0.288	0.207			-0.119	0.694
Cut6	0.865	0.208			0.458	1.272
Cut7	1.234	0.212			0.818	1.650
Cut8	1.971	0.226			1.529	2.414
Cut9	2.531	0.238			2.064	2.998

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. The Akaike's Information Criteria (AIC) and the Bayesian Information Criteria (BIC) are 2195.905 and 2260.316. Fixed effects for respondents' jobs and regions are included.



<Figure 3> Average Marginal Effects of Negative Framing on Respondents' Answers

Note: The predicted probability is estimated based on the results presented in <Table 4>, while all other variables are held at constant values. 95% confidence intervals are presented together.

<Figure 3> illustrates the average marginal effects of negative framing on respondents' answers to the questionnaires for nuclear power generation. Related to females, the average marginal effects of negative framing on the probabilities of selecting strongly positive and strongly negative categories are 0.222% and -0.700% respectively. Even though the gap between the point estimates is more than 0.5%, the 95% confidence intervals overlap. It indicates that the point estimates are not statistically different, meaning that female respondents are not susceptible to negatively framed questionnaires about nuclear energy and nuclear power plants. In terms of male respondents, the average marginal effects of negative framing on the probabilities of selecting each category are -1.898% and 6.024% each to each. To be specific, negative framing increases the probability of selecting the strongly negative category in the questionnaire used to build the de-

pendent variable by 6.024%, while the framing decreases that of selecting the strongly positive category by 1.898%. To sum up, the empirical results from <Table 4> and <Figure 3> support the argument that gender influences the susceptibility to the negative framing of nuclear energy and power plants. Also, even not presented, the empirical results are robust in OLS regression models.

Ⅴ. Conclusion and Discussion

To put it in a nutshell, we relying on ordered logistic regression models demonstrate that the influence of negative framing on respondents' opinions toward nuclear power generation is statistically and substantially meaningful in terms of predicted probabilities. At the same time, the results indicate that females are more likely to oppose nuclear power generation, while respondents with much knowledge on nuclear power and on KHNP are prone to support it. More interestingly, the interaction term between the gender of respondents and negative framing is also statistically significant, providing empirical support for the hypothesis about the heterogenous impacts of framing according to gender. In the subsequent analysis based on average marginal effects, it is revealed that male respondents are susceptible to negative framing, while females are not.

These empirical findings contribute to the literature on the potential factors of public acceptance. Previous studies on the public acceptance of nuclear energy have been largely based on the survey approach (Ansolabehere & Konisky 2009; Ho et al. 2019; Jang & Park 2020), but they relatively pay less attention to the effect of different framing of the surveys. The results presented in this article urge scholars to beware of how they frame the actual questionnaires to investigate the public acceptance of nuclear energy. Second, concerning the literature on framing itself, this article sheds light on the heterogeneity of the framing effects according to the subjects of the surveys. For instance, it has been revealed that framing ef-

fects are stronger for females when the survey is related to crime victims (Kivivuori et al. 2012) and health (Updegraff et al. 2015). The findings that female is more prone to be affected by the negative framing toward nuclear energy and power plants provide a clue that the framing effects might be heterogenous according to the survey subjects.

In addition to the academic contribution of this article, the findings also alert researchers to carefully examine the public acceptance of nuclear energy and power plants. With the increase in the importance of nuclear energy in the circumstance of energy crisis around the globe (Amjed et al. 2022; He et al. 2023; Nisa 2023), accurate analyses of the potential determinants of the public acceptance toward nuclear energy are getting progressively crucial for the sustainable development of countries and to maximize national benefits. Hands-on workers and questionnaire organizers concerning surveys on nuclear energy should always pay attention to whether they construct neutral question wordings or not. In addition, if they encounter problems with framing, researchers must check the validity of the surveys in terms of framing and have to consider implementing weights such as propensity weighting.

Despite the potential contributions of this article, this work is not free from limitations. First of all, the number of respondents is limited. Theoretically, the small number of respondents does not affect the representativeness. However, a larger sample size will increase the explanatory power of the models. Second, this article only focuses on the statistical approach which is an innately limited methodology to make causal inferences. Thus, analyzing the causal mechanisms behind the link between negative framing and respondents' attitudes toward nuclear energy and power plants with qualitative approaches such as interviews will be promising. Moreover, conducting robustness checks on the empirical results presented in this article with additional control variables such as education level, income, and political ideology will be also meaningful.

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