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Analyzing Attitude Change towards Nuclear Energy after the Fukushima Accident

- An Application of Multilevel Modeling -

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Abstract

The Fukushima nuclear accident had a significant impact on the attitude change toward nuclear energy. This attitude change critically influences the energy transition, in particular, phaseout of nuclear energy. The purpose of this study is to analyze the determinants of attitude change toward nuclear energy after the Fukushima accident. Since the attitude change is influenced not only by the individual variables but also by the contextual variables, it is necessary to set both the macro country-level variables and the micro individual-level variables as the causal variables of the attitude change. Empirical findings summarize that male, education, religion, risk perception, and trust at the individual level, and operation of nuclear power plant, GDP per capita at the country level had a crucial impact on attitude change from supporting to opposing.

Key words: Fukushima accident, attitude change, individual-level, country level, multilevel modeling

Ⅰ. Research Background & Question

After Fukushima nuclear accident broke out, several countries around the world have changed their energy policy toward de-nuclear energy. Germany accelerates the energy transition from nuclear energy to renewable energy. Germany announces that she performs energy transition fully (or almost entirely) to renewable energy sources by 2050, and that the country's share of energy derived from nuclear sources should be eliminated incrementally by 2022. In May 2017, 48% of the Swiss people supported for the proposed Energy Strategy 2050 which starts in 2018. When the law takes effect, Switzerland will begin a phaseout of nuclear energy and a transition to renewable (Morris, 2017). In France, the government decides to cap the nuclear energy generating capacity to the current level of 63.2 GWe, limiting it to the 50% of total energy output by 2025 (Vercelli, 2014).

Such policy turns at country level reflect on the

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people's opinions which would have probably changed after Fukushima accident. In 2005, the GlobeScan, commissioned by International Atomic Energy Agency (IAEA), conducted surveys in 18 countries to determine how many people favor or oppose the construction of nuclear power plants. In 2011, the GlobeScan, commissioned by BBC, also conducted similar surveys in 23 countries. Compared to these two sets of data, the opposition to the construction of new nuclear power plants has dramatically increased: it was up from 73% in 2005 to 90% in 2011 in Germany, 66% to 83% in France, and 61% to 83% in Russia. It is also observed in a rise of 76% to 84% in Japan (Black, 2011). Moreover, according to Kessides (2012)'s survey on the people in 24 countries, 62% of respondents oppose nuclear energy. Besides, 27% of the opponents express that they have changed their attitude after the Fukushima accident. This indicates that the Fukushima nuclear accident has a serious negative impact on public attitudes.

It is remarkable that, in the United States and France, where dependence on the nuclear energy and the support for it are high, there is an attitude change toward nuclear energy after the Fukushima accident. According to Gallup research, Americans' support for nuclear energy as a power generation method fell from 62% in 2010 to 57% in 2013. In Jammal (2012)'s survey of French people, the percentage of people pointing out that nuclear energy is the most dangerous of the six existing risks increases from 8% to 18% after the accident. Based on three consecutive follow-up surveys conducted in autumn of 2010, in March of 2011, and in October of 2011, Siegrist & Visschers (2013) also show that Fukushima accident has a negative impact on the Swiss people's acceptance of nuclear energy. In a study by Bird, *et. al*. (2013), a survey of Australian citizens shows that support for nuclear energy is dropped from 30.9% in 2010 to 26.9% after Fukushima accident. The proportion of supporting responses to the question – the risk of nuclear energy outweighs benefits – increased from 23.9% in 2010 to 32.8% in 2012. The changes in attitude toward nuclear energy in each country after the Fukushima nuclear accident have a significant impact on the transition of energy policy. However, there have been few pieces of research on attitude change caused by Fukushima accident.

In this context, it is necessary to study attitude changes related to nuclear energy systematically. In particular, the analysis of the structural causes affecting attitude change toward nuclear energy is a significant work in terms of theory and practical policy making. However, this topic is incredibly complex because not only individual but also contextual factors should be considered to explain the variance of attitude change. To investigate the effects of both individual and contextual factors on attitude change about nuclear energy, we will adopt the multilevel modeling. This method will include perceived risk, knowledge, trust, and type of mass media at the individual level and dependence on nuclear energy, distance from Fukushima, GDP, and quality of environment at the country level. We expect that our analysis shows the structure of attitude change caused by the Fukushima accident.

II. Theoretical Background

1. Previous Studies after the Fukushima Accident

After the Fukushima accident, there have been several studies over attitude change toward nuclear energy. According to Prati & Zani (2012), since the Fukushima nuclear accident, trust in nuclear energy and pro-attitude toward nuclear energy have declined whereas the intention to the opposition and perceived risk toward nuclear energy has been increasing. Siegrist, *et. al.* (2014) observe that there are changes in the perception of the benefits of nuclear energy after the Fukushima accident, which strongly influences the attitude of people accepting nuclear energy. In addition, Kitada (2016) points out that, over the past 30 years, only 20 to 30% of people have a negative attitude toward nuclear energy, supporting abolition or reduction of nuclear power generation (NPG). However, in four to six months after the Fukushima accident, the proportion of people with negative attitudes towards nuclear energy has been increased to 70%.

These previous studies heavily rely on psychometric paradigms. The psychometric paradigm refers to a research approach used in explaining how laymen (nonexperts) perceive various hazards (Siegrist, 2010: 600). To show expressed preference, this paradigm has developed various methods for estimating and scaling risks at the individual level. It accepts following assumptions: 1) risk is inherently subjective, not objective, 2) criteria for risk refers to not only technological, physical sides but also social, psychological aspects, 3) main research concern is about public opinion and 4) it emphasizes the importance of cognitive structure in risk judgment (Rohrmann & Renn, 2000). Moreover, psychometric paradigm accepts that when making the risk assessments, people use not only statistical information such as probability, but also qualitative information such as perceptions of dreadfulness and newness. The "cognitive map" that results from studies utilizing the psychometric paradigm became the icon of risk perception research (Siegrist, 2010: 600).

This paradigm has contributed to understanding the risk in terms of theory and practice. Slovic, *et. al.* (1982) argue that psychometric paradigm contributes risk analysis and decision making by (1) improving methods for eliciting opinion about risk, (2) providing a basis for understanding and anticipating public responses to hazards, and (3) improving the communication of risk information among laypeople, technical experts, and policymakers(1982: 83).

However, this paradigm has several limits. According to Sjöberg (2006: 3), a closer look at several decades' works of psychometric paradigm shows that (a) novelty carries little weight in risk perception, (b) "dread" has not been measured appropriately and is little powerful, and (c) social trust has a marginal influence as compared to trust in science, epistemological trust. All of those comments are reduced to the bias of methodology to which this paradigm adopts. Moreover, Douglas (1997) argues that this "psychometric" approach naively attempts to "depoliticize" risk conflicts by attributing social-structural issues to cognitive work at the individual level. Douglas & Wildavsky (1982) stress the role of sociality which consists of grid and group, assuming that people's thought is inherently not solipsism but social and contextual dependence.

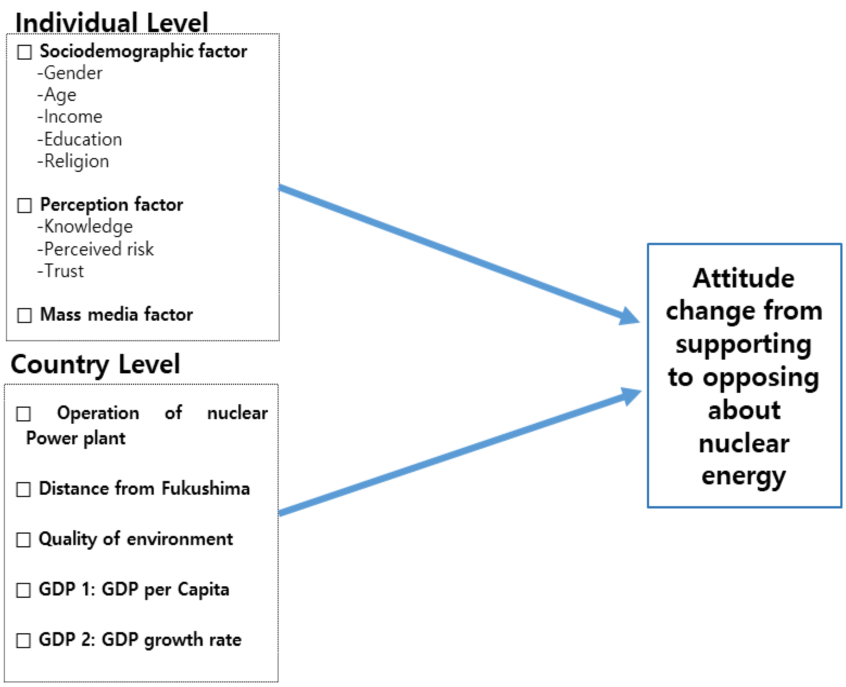

Figure 1. Research Framework

In this context, it is necessary to consider the structural variables at the contextual level as well as the psychological variables at the individual level for the sake of explaining the attitude toward risk. To explain attitude change after the Fukushima nuclear accident, this study adopts the multilevel approach which considers the psychological variables such as risk perception, trust, and knowledge at the individual level as well as dependence on nuclear energy, distance from Fukushima, quality of environment, and GDP at the country level. This multilevel approach will contribute to understanding the structure of attitude change in risk perception.

2. Research Framework

A series of multilevel models are fitted including the individual-level variables such as knowledge, risk perception, trust, and mass media. In addition, multilevel models permit the introduction of country-level variables such as dependence on nuclear energy (i.e., number of operating nuclear power plant), distance from Fukushima, quality of the environment (i.e., EPI(Environmental Performance Indicator)), and GDP into the model. The dependent variable is the attitude change after Fukushima nuclear energy. 〈Figure 1〉 shows our research framework.

3. Research Hypothesis

1) Sociodemograhic Variable

(1) Gender

Differences in risk perception between females and males in risk studies are one of the most controversial research topics. Since females are more likely to be sensitive to the risks, they are generally more risk-averse than males and tend to oppose nuclear energy. After analyzing the differences in perceived risk, both Slovic (1999) and Flynn, *et. al.* (1994) show that in judging risk, women tend to perceive the risk object more dangerously than men do. Men express less opposition to natural gas-fired power plant and nuclear power plant than women do (Ansolabehere & Konisky, 2009). Also, Brody (1984) demonstrates that compared to men, women have lower level of safety and seriously assesses the risk of nuclear power plants. Passino & Lounsbury (1976) show that women are more opposed to building a nuclear power station than men do. Roh & Jin (2017) demonstrate that compared with males, females are less likely to accept nuclear power generation, both at the national level and in their residential areas. Why they differ? Gustafsod (1998) argues that gender structures, reflected in gendered ideology and gendered practice, bring out systematic gender differences in the perception of risk. Based on previous findings, we provide the hypothesis about the attitude change according to gender difference.

H1: The women show in attitude change from positive to negative toward nuclear energy more than the men after Fukushima accident.

(2) Age

It has been generally accepted that the higher the age, the higher the acceptance of nuclear energy. Webber (1982) and Roh & Jin (2017) show that age is found to exert a positive effect on the acceptance of nuclear energy at the national level. The reason why the higher the age is, the higher the acceptability is as follows: First, the higher the age, the more resources people hold. These resources serve as means to reduce risks when disasters occur. Second, the older the age, the stronger the conservative. Nuclear energy is a valuable asset which should be protected since it gives various benefits in terms of economy. Economic value is one of the dominant values that conservatives advocate. According to Corn*er, et. al.* (2011)'s empirical study, men, older individuals, those in higher social classes and people with a voting preference for the Conservative party rate nuclear energy more favorably.

H2: The old bring out less attitude change from supporting to opposing about nuclear energy after Fukushima accident than the young do.

(3) Income

Income has been known to play a crucial role in defending against risk. Therefore, it is reasonable that the higher the income, the lower the risk perception toward nuclear energy, and the higher the acceptability of nuclear energy. Flynn, *et. al.* (1994) find that higher income groups show less resistance to nuclear energy than lower income groups, implying that more income has a positive impact on the acceptance of nuclear energy. Huang, *et. al.* (2013) find that low-income workers respond to the danger more after the Fukushima accident. However, Whitfield, *et. al.* (2009) demonstrate that the higher income has a direct negative impact on the acceptance of nuclear energy. Moreover, according to Ansolabehere & Konisky (2009), income does not influence on the acceptance of a new nuclear power plant.

H3: Higher incomes decrease the probability of attitude change from positive to negative toward nuclear energy after Fukushima accident

(4) Education

If education provides more knowledge about the negative impact of nuclear energy, it reduces support for nuclear energy. After examining the residents in California, Webber (1982) shows that the higher level of education has a negative impact on the acceptance of nuclear energy. Wang & Kim (2018) show that the education effect depends on the national context: Out of 27 European countries, education has a negative impact on the acceptance of nuclear energy only in France.

However, similar to income, education is regarded as a resource which can be used against risks. In this case, higher education increases the acceptance of nuclear energy. Cha (2004) demonstrates that the higher the education level, the lower the nuclear risk perception. Greenberg (2009) finds that wealthy white people who are university educated are supporters of concentrating locations at major plants (CLAMP). On the other hand, Ansolabehere & Konisky (2009) demonstrate that education does not show a significant impact on the acceptance of a new nuclear power plant. For making hypothesis, we follow the previous research in the first part.

H4: Higher education level increases the attitude change from positive to negative toward nuclear energy after Fukushima accident

(5) Religion

Religion has a significant impact on the way of life and values. One of the most significant characteristics of religion is the conservatism for which economic value is essential. From this point of view, the high economic benefits of nuclear energy would lead to support for nuclear energy.

However, Balžekienė (2007) shows that religious piety positively affects concerns about the environment, human health, and personal safety associated with nuclear power plants. According to de Lima (1993), the people in earthquake-prone regions, have expressed higher trust in religious or political institutions. It implies that those who have religion may show more sensitive to risk, which links to the opposition toward nuclear energy. For making hypothesis, we follow the previous research in the first part.

H5: The religion reduces the attitude change from positive to negative toward nuclear energy after Fukushima accident

2) Perception Factor

(1) Risk perception

Generally, perceived risk reduces the acceptance of nuclear energy whereas the perceived benefit increases it (De Groot & Steg, 2010). Therefore, more highly perceived risks about nuclear energy increase attitude change from positive to negative one after the Fukushima accident.

In the post-Fukushima accident research, both perceived risks and benefits are essential variables in determining the acceptability of nuclear energy. According to Yamamura (2012), perceived risks to nuclear accidents are positively related to experience with technical disasters. Siegrist & Visschers (2013) show that perceived benefits have a significant impact on the acceptance of nuclear energy. Moreover, Ho, *et. al.* (2013) demonstrate that risk perception about nuclear energy is an essential determinant in planning new nuclear power plants. Also, Tanaka (2004) shows that the impact of perceived risk on acceptance of nuclear power depends on the type of acceptability. Both perceived risks and benefits have an equal impact on the acceptance of nuclear energy in a general situation. However, if both perceived risks and benefits are related to the area where respondents live, perceived risks have a more significant impact on the acceptance of nuclear power than benefits.

H6: The perceived risks increase the attitude change from positive to negative toward nuclear energy after Fukushima accident whereas the perceived benefits decease it

(2) Knowledge

More knowledge about nuclear energy increases the acceptance of nuclear energy (Kunreuther, 2002; Wang & Kim, 2018) since it increases the perceived benefit of nuclear energy (Huang, *et. al.*, 2013). Kuklinski, *et. al.* (1982) show that groups with higher knowledge have a lower rate of opposition to nuclear power operation and its construction than groups with lower one. In particular, in the process of judgement about acceptance, the two groups show differences in thinking logic; high-knowledge groups tend to rely on calculation of cost-benefit, while low-knowledge groups do on both a general view of technology and information provided by the group involved in the dispute. However, few studies show that knowledge appears to have no statistically significant impact on the acceptance of nuclear energy (Stoutenborough, *et. al.*, 2013).

H7: Better knowledge reduces the attitude change from positive to negative toward nuclear energy after Fukushima accident.

(3) Trust

Trust matters because people depend on trust when they do not have information for judgment (Siegrist, 2000). Trust will increase the acceptance of nuclear energy. Siegrist, *et. al.* (2000) analyze the influence of trust on both perceived risks and benefits of nuclear energy. According to Whitefield, *et. al.* (2009), increased trust in nuclear governance institutions lowers perceived risk of nuclear energy, and both higher trust and lower risk perceptions have contributed to the public's positive attitude toward nuclear energy. Frewer, *et. al.* (1998) show that lack of confidence in nuclear regulatory agencies leads to negative perceptions and attitudes toward nuclear energy and reduces the acceptance of nuclear energy. Katsuya (2011) demonstrates that trust in utilities and government has a significant impact on acceptance of nuclear power regardless of before and after the Fukushima nuclear accident. Visschers & Siegrist (2013) show that, before the Fukushima accident, trust is a crucial factor affecting both perceived risks and benefits of nuclear energy. However, in the post-Fukushima era, the relationship between trust and perceived risks/benefits of nuclear energy is disappeared.

H8: Trust switches the attitude change from positive to negative toward nuclear energy after Fukushima accident.

3) Mass Media Effect

Today, societies highly depend on the media. It applies to risk judgment about nuclear energy because, first, if the media reports a risk, many people suddenly become aware of it and start to worry about it. Second, if a risk topic appears in the media (news), then the risk must be real (Schmidt, 2004). Moreover, mass media plays a crucial role in distributing information about issues related to Fukushima accidents. As most information may contain negative information, the people with more contact with mass media would have a negative attitude toward nuclear energy.

Different media types play different roles in influencing risk perception. Coleman (1993) shows that television exposure is related to personal-level risk perception, while many newspapers do societal-risk perceptions of voluntary health and risk issues (e.g. AIDS, heart disease, smoking). Moreover, Combs & Slovic (1979) show that the frequency of newspaper, which reported about causes of death, correlated more closely with laymen's estimates than with the actual mortality statistics. According to Slovic (1993), people trust the news about more negative event than positive ones. Those who are anchored to negative images of nuclear energy have greater confidence in the negative information about the risk of nuclear energy.

H9: More exposure to mass media increases the attitude change from positive to negative toward nuclear energy after Fukushima accident.

Additionally, we check the impact of not only exposure to mass media but also kind of mass media such as TV, radio, newspaper, and internet. Today, since the internet becomes main source for information, it could have more influential power on the attitude change.

4) Country-Level Factor

(1) Operation of Nuclear Power Plant (NPP)

The path dependence has the power to sustain the existing state of something. The dependence on nuclear energy gives the benefit to countries: cheaper energy price and more clean air. Hence, if the country already depends on the nuclear power, people in this country will accept the nuclear energy. Moreover, those who live in the country depending on the nuclear power do not change the attitude from acceptance to denial of nuclear energy after Fukushima accident. Pampel (2011) shows that the existing nuclear power plants in a country increase the public support for nuclear energy. Wiegman, *et. al.* (1995) indicate that because of a high proportion of nuclear energy, French people have both high-risk and benefit perception relatively, compared to Dutch citizens. According to Wang & Kim (2018), the dependence on nuclear power, i.e. the share of nuclear power, amount of energy supply, and net import of energy, has a positive impact on the acceptance of nuclear energy at the country level. According to Kim, *et. al.* (2013), the country's level of dependence on nuclear energy for electricity has positive impact on the acceptance of nuclear energy. They show that a country's acceptance of nuclear energy is influenced by the number and density of nuclear power reactors, the proportion of nuclear energy, and the history of the operating experience of nuclear power generation. Recently, Nguyen & Yim (2018) show that people in countries depending on nuclear power tend to have more approval of nuclear energy than people in states without that type of energy.

H10: Dependence on nuclear power decreases the attitude change from positive to negative toward nuclear energy after Fukushima accident.

(2) Distance from Fukushima

Physical state influences the acceptance of nuclear energy. If people live far away from the nuclear power station or accident, they do not perceive the risk about them. Litmanen (1999) compares the acceptability of people living far away from nuclear power plants with that of people living around nuclear power plants. He shows that the former shows more acceptance of nuclear power than the latter. In the United States, negative perceptions of nuclear-related facilities (high-level radioactive waste repositories) are prevalent among residents living around nuclear power plants (Jenkins-Smith & Bassett, 1994). In the case of the Fukushima accident, Latré, *et. al.* (2017) demonstrate that the decrease in support for nuclear energy is stronger in countries closer to Fukushima. Also, conditional support for nuclear power in Japan is dropped from just over 30% in 2007 to only over 20% in 2011 (Poortinga, *et. al.*, 2013).

However, He, *et. al.* (2012) show that respondents living far away from nuclear facilities have a more critical attitude toward nuclear power. On the other hand, Sjöberg (2004) finds that the residents in the two adjacent areas of the nuclear power plant are positive about nuclear energy and have low perceptions of the risks.

In this study, we assume that more distance from Fukushima would induce fewer changes in acceptance of nuclear energy.

H11: The longer distance decreases the attitude change from positive to negative toward nuclear energy after Fukushima accident.

(3) Quality of environment (EPI: Environmental performance Index)

Nuclear power is environmentally friendly energy because it does not emit the carbon dioxide. However, it has been regarded as a risky object to the environment because of the high possibility of risk destroying the environment if a nuclear accident occurs. Ansolabehere & Konisky (2009) show that perceived environmental harm has a negative impact on the acceptance of a nuclear power plant. Moreover, good environment induces the more environmentalism. Even though there have been debates over the role of environmentalism, it has related to the opposition to the nuclear energy. According to Corner, *et. al.* (2011), Spence, *et. al.* (2010), environmental values have a negative impact on unconditional support for nuclear power. Kim & Wang (2018) show that the environmentalism at the country level negatively influences the acceptance of nuclear power at the individual level.

Therefore, we hypothesize that the people in the better quality of the environment will show more change from acceptance to denial of nuclear energy after Fukushima accident.

H12: Better quality of environment will increase the attitude change from positive to negative toward nuclear energy after Fukushima accident.

(4) GDP

Alhakami & Slovic (1994) argue that higher income has a negative relationship with the perceived risk about specific risky objects. Since higher income increases the education level which brings out more knowledge about the benefit of nuclear energy, finally it reduces the risk perception of nuclear energy. However, Nguyen & Yim (2018) demonstrated that GDP per capita has a negative impact on public acceptance of nuclear power. Kim, *et. al.* (2013) show that GDP reduces public acceptance of nuclear energy after the Fukushima accident. After Wang & Kim (2018) also research the relationship between GDP and the "pros and cons" of nuclear energy by people, they do not find any statistically significant evidence of an positive effect of GDP on public acceptance of nuclear energy. Based on the results of previous empirical studies, we set the following hypothesis.

H13: GDP decreases the attitude change from positive to negative toward nuclear energy after Fukushima accident.

To examine the effect of GDP on people's attitude change carefully, we consider two types of GDP variables: GDP per capita and GDP growth rate. GDP per capita measures the nation's level of income while GDP growth rate measures how fast the economy is growing. We expect these variables to have associations with the attitude change from "supporting" to "opposing" nuclear energy.

Ⅲ. Data & Measures

1. Data Construction

This study analyzed the survey data based on 36,122 randomly selected people from 47 countries after Fukushima accident in 2001. This survey was carried by Gallup International. To make dependent variable which measures supporting and opposing about nuclear energy at the individual level, we use two consecutive questions: First, ask a person about his/her "supporting" for or "opposing" to nuclear energy as of today. The person who participated in the first question is also asked what was his/her view before the Fukushima accident in Japan. We compare the responses about these two questions. If view is changed from "supporting" to "opposing" after Fukushima accident, one is coded for respondents who change their views, zero otherwise. We use this binary variable as the dependent variable.

Concerning explanatory variables, we consider sociodemographic, individual perception, types of mass media as the primary information source, and country-level variables. First of all, five sociodemographic variables are employed for our hypothesis tests such as gender, age, income, education, and religion. For testing hypothesis 1, gender is introduced in the empirical test model, coded one for Male and zero for Female. Age30 is also derived from Gallup survey to test hypothesis 2 that the old are more reluctant to change their view from supporting to opposing about nuclear energy. Age30 is a dummy variable constructed as; (0)≤30 years old, and (1)≥31 years old. Income is included in the model to test hypothesis 3, and in education hypothesis 4. Education is a dummy variable, coded one if the respondent was a college graduate or above, and zero otherwise. Religion is also a dummy variable to test hypothesis 5, coded as one if the respondent has faith, and zero otherwise.

Besides, factors influencing individual perception are included in our hypothesis tests. Knowledge is introduced in the model to test hypothesis 5, risk perception hypothesis 6, and trust hypothesis 8.

Table 1. Descriptive statistics

Variable	N	Mean	SD	Min	Max
Dependent variable(supporting → opposing)	8485	0.2	0.4	0	1
Individual-level factors					
Gender(male=1, female=0)	8485	0.59	0.49	0	1
Age30	8485	0.44	0.5	0	1
Income	8485	2.99	1.34	1	5
Education(1=high education, above college)	8485	0.41	0.49	0	1
Religion	8485	0.84	0.37	0	1
Knowledge	8485	3.9	0.35	1	4
Risk perception	8485	3.01	1.3	1	5
Trust	8485	1.83	0.71	1	3
Source of getting information about Fukushima disaster					
TV	8485	0.75	0.43	0	1
Radio	8485	0.03	0.18	0	1
Newspaper	8485	0.07	0.25	0	1
Internet	8485	0.13	0.33	0	1
Country-level factors					
Number of operating NPP	31	7.84	19.66	0	104
Distance from Fukushima	31	8254	2842	1215	13636
EPI(Environmental Performance Index)	31	51.79	11.48	25.32	68.92
GDP per capita	31	1.69	1.8	0.07	5.03
GDP growth rate	31	3.4	3.2	-7.1	9.9

Note: SD=Standard deviation

In hypothesis 9, it is assumed that the perceived risk depends on not only how much exposure to the media but also what media people are exposed to. For testing hypothesis 9, four dummy variables are employed such as TV, Radio, Newspaper, and Internet. These variables are expected to examine the effect of media types on people's changing attitude from positive to negative toward nuclear energy after Fukushima accident.

Country-level variables as well as individual variables play an essential role in changing people's view. As predictors at the country level, we consider the dependence on nuclear energy (i.e. number of operating nuclear power plant), distance from Fukushima, quality of the environment (i.e. EPI (Environmental Performance Indicator)), and GDP.

2. Descriptive Statistics

Summary statistics of both individual and country level factors are presented in 〈Table 1〉. The summary of the dependent variable shows that, after the Fukushima accident, 20% of interviewees change his/her opinion on nuclear power from positive to negative.

〈Table 2〉 presents descriptive information on all of the explanatory variables, broken down by the dependent variable. A series of chi-square tests show that there are significant differences among groups in gender, income, education, religion, knowledge, risk perception, and the forms of media getting information about Fukushima accident.

The lower the income, the lower the education level, the more religious, women rather than men, change the attitude from positive to negative

Table 2. Characteristics of variables

	Variable	Change attitude	Not change attitudes	χ^2
Gender	Female = 0	830(24%)	2626(76%)	
	Male = 1	837(17%)	4192(83%)	70.5***
Age30	Age ≤ 30	926(19%)	3868(81%)	
	Age 〉 30	741(20%)	2950(80%)	0.8
Income	≤ 20%	273(20%)	1083(80%)	
	20-40%	455(23%)	1531(77%)	35.7***
	40-60%	441(21%)	1669(79%)	
	60-80%	235(16%)	1196(84%)	
	≥ 80%	263(16%)	1339(84%)	
Education	lower than college graduate	1060(21%)	3951(79%)	
	above college graduate	607(17%)	2867(83%)	17.6***
Religion	No Religion	175(13%)	1196(87%)	
	Have religion	1492	5622(79%)	49.1***
Knowledge	Lower level	8(53%)	7(47%)	
	Middle level	25(34%)	49(66%)	27.3***
	Higher level	159(23%)	523(77%)	
Risk perception	1(very low)	148(11%)	1210(89%)	
	2	274(16%)	1406(84%)	117.2***
	3	503(22%)	1821(78%)	
	4	415(24%)	1311(76%)	
	5(very high)	327(23%)	1070(77%)	
Trust	1(low)	672(22%)	2325(78%)	
	2	697(18%)	3267(82%)	25.3***
	3(high)	298(20%)	1226(80%)	
TV	0(No)	378(18%)	1748(82%)	
	1(Yes)	1289(20%)	5070(80%)	6.3**
Radio	0(No)	1614(20%)	6581(80%)	
	1(Yes)	53(18%)	237(82%)	0.4
Newspaper	0(No)	1561(20%)	6372(80%)	
	1(Yes)	106(19%)	446(81%)	0.1
Internet	0(No)	1488(20%)	5909(80%)	
	1(Yes	179(16%)	909(84%)	8.1***

Note: *,**, and, *** are 10%., 5%, and 1% levels of significance, respectively.

toward nuclear power. The lower the level of knowledge and trust and the higher the perceived risk increase the negative attitude toward nuclear power. The more the TV application and the less the internet raise the negative-oriented attitude change.

Ⅳ. Empirical Methodology

There are very few studies that cover both individual- and country-level variables. However, an individual's moving from "supporting" to "opposing" nuclear energy depends not only on the individual-level variables but also on more structural-related factors such as group, organization, and country. Paxton and Knack (2008) argue that, since previous research remains at the individual level, it does not consider the broader social and institutional structures in which public opinion is embedded. It is self-evident that any research focusing only on unilateral effect suffers from difficulty in explaining the contradictory findings. Various studies suggest that structural factors at the country level affect individual attitudes and need to be considered as explanatory ones.

Considering the importance of structural factors in individual attitude, we adopt multilevel modeling that analyzes how both individual and country level factors influence his/her moving from "supporting" to "opposing" nuclear energy. Since the design of the present study assumes that the country level factors affect individuals who live in the country in question, an analytical method is necessary to demonstrate the country-level effects beyond any individual factors. Hierarchical linear modeling (henceforth, HLM) is a useful estimation method when analyzing data collected from various countries. To investigate the effects of both individual and country level variables on the dependent variable, we employe the HLM method, which is expected to control the country level effects on individuals (Raudenbush & Bryk, 2002).

To examine what factors influence an individual's moving from "supporting" to "opposing" nuclear energy, we use a logit model. Following equation is a logit model using HLM approach. All individual and country level variables are recomputed by subtracting the grand mean from every score to interpret the interception for all variables.

〈Model 1 : Unconditional model〉

Level 1 : $\log[\varphi/(1-\varphi)] = \beta_{0j}$

Level 2 : $\beta_{0j} = \gamma_{00} + u_{0j}$

〈Model 2 : Unconditional slope model〉

Level 1 : $\log[\varphi/(1-\varphi)] = \beta_{0j} + \beta_{1j}\text{Gender} + \beta_{2j}\text{Age30} + \beta_{3j}\text{Income} + \beta_{4j}\text{Education} + \beta_{5j}\text{Religion} + \beta_{6j}\text{Knowledge} + \beta_{7j}\text{Risk Perception} + \beta_{8j}\text{Trust} + \beta_{9j}\text{TV} + \beta_{10j}\text{Radio} + \beta_{11j}\text{Newspaper} + \beta_{12j}\text{Internet}$

Level 2 : $\beta_{qj} = \gamma_{q0} + u_{qj}$ (q=0,1, … , 12)

〈Model 3 : Conditional model〉

Level 1 : $\log[\varphi/(1-\varphi)] = \beta_{0j} + \beta_{1j}\text{Gender} + \beta_{2j}\text{Age30} + \beta_{3j}\text{Income} + \beta_{4j}\text{Education} + \beta_{5j}\text{Religion} + \beta_{6j}\text{Knowledge} + \beta_{7j}\text{Risk Perception} + \beta_{8j}\text{Trust} + \beta_{9j}\text{TV} + \beta_{10j}\text{Radio} + \beta_{11j}\text{Newspaper} + \beta_{12j}\text{Internet}$

Level 2 : $\beta_{0j} = \gamma_{00} + \gamma_{01}\text{Number of operating NPP} + \gamma_{02}\text{Distance from Fukushima} + \gamma_{03}\text{Environmental performance index} + \gamma_{04}\text{Per Capita GDP} + \gamma_{05}\text{GDP growth rate} + u_{0j}$

$\beta_{qj} = \gamma_{q0}$ (q=1,2,3,4, and q=9,10,11,12),

$\beta_{qj} = \gamma_{q0} + u_{qj}$ (q=5,6,7,8)

V. Analysis and Findings

The unconditional model in 〈Table 3〉, that is Model 1, analyzes the change of his/her support the nuclear energy without independent variable. If we analyze the variance of level 2 through the unconditional model, we could confirm how much the other independent variables have explanatory power in the subsequent model. In 〈Table 3〉, the result of

Table 3 : Multilevel analysis of moving from supporting nuclear power to opposing it

		Unconditional model(Model 1)			Unconditional slope model(Model 2)			Conditional model(Model 3)		
	Variable	Coef.	S.E.	Odds	Coef.	S.E.	Odds	Coef.	S.E.	Odds
Individual −level factors	Intercept	−1.243	0.114***	0.288	−1.406	0.140***	0.245	−1.348	0.182***	0.260
	Gender				−0.277	0.053***	0.758	−0.306	0.087***	0.736
	Age 30				0.027	0.030	1.028	0.055	0.038	1.057
	Income				−0.015	0.018	0.985	−0.023	0.018	0.978
	Education				−0.120	0.046**	0.887	−0.139	0.059**	0.871
	Religion				0.341	0.099***	1.407	0.419	0.154**	1.520
	Knowledge				−0.095	0.109	0.910	−0.116	0.122	0.890
	Risk perception				0.133	0.030***	1.143	0.187	0.036***	1.206
	Trust				−0.075	0.037**	0.927	−0.100	0.043**	0.905
	TV				0.193	0.124	1.213	−0.016	0.123	0.984
	Radio				0.070	0.195	1.073	−0.217	0.216	0.805
	Newspaper				0.237	0.164	1.267	−0.001	0.175	0.999
	Internet				0.145	0.186	1.156	0.0120	0.156	1.012
Country−level factors	Operation of NPP							−0.006	0.002***	0.994
	Distance from Fukushima							0.000	0.000	1.000
	Quality of Environment(EPI)							−0.016	0.012	0.984
	GDP1: Per capita GDP							0.134	0.055**	1.143
	GDP2: GDP growth rate							0.015	0.030	1.015
	Random effect	SD	σ^2	χ^2	SD	σ^2	χ^2	SD	σ^2	χ^2
	Level2, u_0	0.680	0.462	378.656***	0.872	0.761	16.849	0.360	0.130	21.484**
	ICC	0.123			0.188			0.038		

Note: 1. ***p〈.01, **p〈.05, *p〈.1
2. NPP=Nuclear power plant, SD=Standard deviation, S.E.=Standard error

Model 1 shows that the mean of the odds ratio is −1.243, implying that an individual has a 0.224=(exp(−1.243)/(1+exp(−1.243)) chance of reversing the affirmative opinion on the use of nuclear power.

In Model 1, the variance of level 2 denotes whether or not country−level variables are useful to be included in the estimated model. The variance of level 2 is statistically significant (χ^2 = 378.656, p〈.01) so that country−level factors need to be considered in the model. In addition, the intraclass correlation coefficient (ICC) of the HLM model is 0.123=(.761/(.761+π^2/3)), implying that the variability in “changing his view from positive to negative” could be found between countries by 12.3 percent. It is worthy to note that there is no rule for what ICC would make HLM necessary. However, values higher than 0.05 may be sufficient (Heck & Thomas, 2009).

In Model 2, we include various individual−level variables to explain his/her reversing the positive opinion on nuclear power. Above all, the intraclass correlation is calculated first. The ICC of the HLM model is 0.188, implying that the differences of country−level characteristics explain 18.8% of the variation of reversing his/her opinion. Since the value of ICC is high in Model 2, it is reasonable for us to employ the HLM method by including country-level factors. Following country-level factors are considered in Model 3: the number of operating nuclear power plant in the country, physical distance from Fukushima, EPI (Environmental Performance Indicator), GDP per capita, and GDP growth rate.

The ICC of Model 3 is 0.038, which is much less than that the value based on Model 2. The change of ICC – including country-level factors lowers the ICC – leads us to focus on the results of Model 3 rather than those of Model 2. Moreover, since the coefficients of variables in Model 2 are similar to those in Model 3, it will be better for us to interpret the results of Model 3 instead of interpreting both results of Model 1 and Model 2.

In Model 3, variables at the individual level include demographic characteristics (gender, age, income, education, religion); knowledge and risk perception (knowledge about nuclear power, nuclear risk perception, and trust in nuclear power); and media source of getting information on Fukushima disaster. Gender is statistically significant (β = –.306, $p < .01$), denoting women perceive the risk object as more dangerous than men do. The education dummy variable is also statistically significant (β = –.139, $p < .05$). This result is consistent with the findings from previous studies (Cha, 2004). Similar to research on risk perception, those with high levels of education are more reluctant to reverse their positive opinion on the use of nuclear than those who are not. Religion has statistically significant influences on changing his/her opinion, too. Persons with religion are more likely to move from "supporting" to "opposing" nuclear power than any of the others with no religion.

We hypothesize that more highly perceived risk about nuclear power increases the attitude change from positive to negative one after Fukushima disaster. The statistical significance of risk perception (β = .187) is consistent with our hypothesis so that persons with highly perceived risk are apt to move from "supporting" to "opposing" nuclear energy after the Fukushima accident. The coefficient of trust is –.100 and statistically significant at 5 percent level. It seems that trust in nuclear energy lowers the perceived risk to it, which makes people reluctant to change their views on nuclear energy.

Both age and income variables are statistically insignificant, implying that age and income have no substantial effect on his/her reversing the favorable opinion on the use of nuclear energy. Besides, four media variables – including TV, radio, newspaper, and internet – do not show any significance so that the sources of getting information do not matter for his/her moving from "supporting" to "opposing" nuclear energy.

Concerning country-level variables, five variables are included at level 2: the number of operating nuclear power plant, physical distance from Fukushima, and quality of environment estimated by EPI (Environmental Performance Indicator), GDP per capita, and GDP growth rate. Among the five country-level variables, both the number of operating the nuclear power plant and GDP per capita are statistically significant. It means that people living in a country with high levels of GDP are more apt to move from supporting nuclear power to opposing it than a country with a lower level. However, unlike the effect of GDP per capita, the coefficient of "the number of operating nuclear plant" shows a negative sign (-.016), indicating the probability to change his/her view is lesser for people living in a country with a large number of nuclear plants. It is interpreted that, people living in countries with many nuclear power plants have been accustomed to nuclear power so that they do not change their views on nuclear energy easily.

V. Conclusion and Implication

This study aims to analyze the determinants of attitude change after the Fukushima nuclear accident. Since the attitude change was influenced not only by the individual dimension variables but also by the contextual dimension variables, we investigate the relationship between attitude change and individual as well as societal variables with the HLM method. For this work, we adopt the attitude change from positive to negative as predicted variables while the socio-demographic variables, knowledge, risk perception, trust, mass media at the individual level and operation of NPP, distance from Fukushima, quality of environment, and GDP at the country level as predictors.

In general, empirical test results show that people change their views on nuclear energy, from positive to negative, due to both individual and country level factors. Influential individual-level factors are gender, education level, religion, risk perception, and trust. The analysis shows the findings as follows:

First, men rather than women or highly educated persons are more reluctant to move their view from "supporting" to "opposing" nuclear energy after the Japanese Fukushima disaster. In addition, people with trust in government's controlling risky facilities also hesitate to change their perception from "supporting" to "opposing them." However, persons who have a high level of risk perception or persons with religion are apt to change their opinion from positive to negative.

Second, it is also found that country-level factors, such as GDP per capita and the number of operating nuclear plant, are crucial ones giving influences on public opinion from positive to a negative attitude toward nuclear power.

Based upon the empirical findings a few important implication can be summarized as follows: First, there is a change in attitude after the Fukushima nuclear accident. Second, such an attitude change is influenced not only by individual-level variables but also by country level variables. Third, the causal variable's impact on attitude change is also variant. At the individual level, religion and perceived risk have a decisive influence on attitude change whereas GDP per capita has an impact on the attitude change at the country level.

This study is meaningful in the sense that it systematically analyze the degree of attitude change after Fukushima nuclear accident and its cause. However, there are some limitations in this study as well. First, since secondary data are used for the study, the key variables, often used at the individual level, are omitted. Second, although various variables affect the attitude change at the national level, our study adopt only five variables. In the follow-up study, it needs to analyze additional variables which were not adopted in this study.

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References

Alhakami, A. S. and P. Slovic. 1994. A Psychological Study of the Inverse Relationship Between Perceived Risk and Perceived Benefits. *Risk Analysis*. 14(6): 1085-1096.

Ansolabehere, S. and D. M. Konisky 2009. Public Attitudes toward Construction of New Power Plants. *Public Opinion Quarterly*. 73: 1-12.

Balžekienė, A. 2007. A*n Integration of Sociological Risk Theories Explaining the Nuclear Risk Perception in Lithuania*. Paper to be presented at the conference Risk and Rationalities Queens' College. Cambridge Thursday 29- Saturday 31 March 2007.

Bird, D. K., K. Haynes, R. van den Honert, J. McAneney, and W. Poortinga. 2014. Nuclear Power in Australia: A Comparative Analysis of Public Opinion Regarding Climate Change and The Fukushima Disaster. *Energy Policy*. 65: 644-653.

Black, R. 2011. Nuclear Power 'Gets Little Public Support Worldwide. http://www.bbc.co.uk/news/science-environment-15864806.

Brody, C. J. 1984. Differences by Sex in Support for Nuclear Power. *Social Forces*. 63(1): 209-228.

Cha, Y. Y. 2004. An Analysis of Nuclear Risk Perception: With Focus on Developing Effective Policy Alternative. *International Review of Public Administration.* 8(2): 33~47.

Coleman, C. L. 1993. The Influence of Mass Media and Interpersonal Communication on Societal and Personal Risk Judgments. *Communication Research*. 20: 611–628.

Combs, B. and P. Slovic. 1979. Newspaper Coverage of Causes of Death. *Journalism & Mass Communication Quarterly*. 56: 837–849.

Corner, A., D. Venables, A. Spence, W. Poortinga, C. Demski, and N. Pidgeon. 2011. Nuclear Power, Climate Change And Energy Security: Exploring British Public Attitudes. *Energy Policy*. 39: 4823-4833.

Morris, C. 2017. *Swiss Referendum Adopts Energy Transition with Nuclear Phaseout*. https://energytransition.org/2017/05/swiss-referendum-adopts-energy-transition-with-nuclear-phaseout/

De Groot, J. I. M. and L. Steg. 2010. Relationships between Value Orientations, Self-determined Motivational Types and Pro-environmental Behavioral Intentions. *Journal of Environmental Psychology*. 30(4): 368-378.

Douglas, M. 1997. The depoliticization of risk. In R. J. Ellis and M. Thompson. (eds.), *Culture Matters*: Essays in Honor of Aaron Wildavsky(pp. 121–132). Boulder, Colo.: Westview Press.

Douglas, M. and A. Wildavsky. B. 1982. *Risk and Culture: An Essay on The Selection of Technical And Environmental Dangers*. Berkeley: University of California Press.

Flynn, J., P. Slovic and C. K. Mertz. 1994. Gender, Race, and Perception of Environmental Health Risks. *Risk Analysis*. 14(6): 1101-1108.

Frewer, L. J., C. Howard and R. Shepherd. 1998. Understanding Public Attitudes to Technology. *Journal of Risk Research.* 1(3): 221-235.

Greenberg, R. 2009. NIMBY, CLAMP, and the Location of New Nuclear-related Facilities: U.S. National and 11 Site-specific Survey. *Risk Analysis.* 29(9): 1242-1254.

De Groot, J. I. M., L. Steg, and W. Poortinga. 2013. Values, Perceived Risk and Benefits, and Acceptability of Nuclear Energy. *Risk Analysis*. 33(2): 307-317.

Gustafsod, P. E. 1998. Gender Differences in Risk Perception: Theoretical and Methodological Perspectives. *Risk Analysis.* 18: 805-811.

He, G., A. P. J., Mol, L. Zhang, and Y. Lu. 2012. Nuclear Power in China after Fukushima: Understanding Public Knowledge, Attitudes, and Trust. *Journal of Risk Research*. 17(4): 435-451.

Heck, R. and S. Thomas. 2009. *An Introduction to Multilevel Modeling Techniques(2nd ed.)*. New York: Routledge.

Huang, L., Y. Zhou, Y. Han, J. K. Hammitt, J. Bi, and L. Yang. 2013. *Effect of the Fukushima Nuclear Accident on The Risk Perception of Residents Near A Nuclear Power Plant* *in China*. Proceeding of Notational Academy Science. U S A, 110(49): 19742-19747.

Huebner. Christian. 2013. Accelerated Energy transition in Germany after Fukushima: An Overview of the German Energiewende. *Facts & Findings*, 104: 1-9.

Jenkins-Smith, H. and Jr. G. W. Bassett. 1994. Perceived Risk and Uncertainty of Nuclear Waste: Differences Among Science, Business and Environmental Group Members. *Risk Analysis*. 14(5): 851-856.

Katsuya, E. 2011. *Self-motivated Accident Prevention Activities at Enterprises in Japan*. First International Seminar, SAFE '99, on Safety & Fire Engineering, Cochin, India, November: 417-427.

Kessides, Ioannis N. 2012. The Future of the Nuclear Industry Reconsidered: Risks, Uncertainties, and Continued Promise. *Energy Policy*. 48: 185-208.

Kim, Young Hwan, Min Ki Kim, and Won Joon Kim. 2013. Effect of the Fukushima Nuclear Disaster on Global Public Acceptance of Nuclear Energy. *Energy Policy*, 61: 822-828.

Kitada, A. 2016. Public Opinion Changes after the Fukushima Daiichi Nuclear Power Plant Accident to Nuclear Power Generation as Seen in Continuous Polls Over the Past 30 Years. *Journal of Nuclear Science and Technology*. 53(11): 1686-1700.

Kuklinski, J. H., D. S. Metlay, and W. D. Kay. 1982. Citizen Knowledge and Choices on the Complex Issue of Nuclear Energy. *AJPS*. 26: 615-642.

Latre, E., T. Perko, and P. Thijssen. 2017. The Public Opinion Change after the Fukushima Nuclear Accident: The Role of National Context Revisited. *Energy Policy*. 104: 124-133.

Litmanen, T. 1999. Cultural Approach to the Perception of Risk: Analysing Concern about the Siting of a High-Level Nuclear Waste Facility in Finland. *Waste Management Research*. 17: 212-219.

Newport, F. 2014. *Americans Still Favor Nuclear Power a Year After Fukushima*. http://www.gallup.com/poll/153452/americans-favor-nuclear-power-year-fukushima.aspx.

Nguyen, V. P. and Man Sung Yim. 2018. Examination of Different Socioeconomic Factors that Contribute to the Public Acceptance of Nuclear Energy. *Nuclear Engineering and Technology*. 50(5): 767-772.

Pedroso de Lima M. L. 1993. *Percepcao do Risco Sismico*. Ph.D. Dissertation. Social and Organizational Psychology, University of Lisbon, Portugal.

Poortinga, W., M. Aoyagi, and N. Pidgeon. 2013. Public Perceptions of Climate Change and Energy Futures before and after The Fukushima Accident: A Comparison between Britain and Japan. *Energy Policy*. 62: 1204-1211.

Prati, G. and B. Zani. 2012. The Effect of the Fukushima Nuclear Accident on Risk Perception, Antinuclear Behavioral Intentions, Attitude, Trust, Environmental Beliefs, and Values. *Environment and Behavior*. 45(6): 782-798.

Roh, S. and J. W. Lee. 2017. Differentiated Influences Of Risk Perceptions On Nuclear Power Acceptance According To Acceptance Targets: Evidence from Korea. *Nuclear Engineering and Technology*. 49(5): 1090-1094.

Rohrmann, B. and O. Renn. 2000. Risk Perception Research. In Bernd Rohrmann and Ortwin Renn (eds.). *Cross-Cultural Risk Perception: A Survey of Empirical Studies*. Dordrecht: Kluwer Academic Publishers.

Schmidt, M. 2004. *Loss of Agro-Biodiversity in Vavilov Centers, with a Special Focus on the Risks of Genetically Modified Organisms(GMOs)*. Ph.D. Dissertation. Vienna, Austria.

Siegrist, M. 2000. The Influence of Trust and Perceptions of Risks and Benefits on the Acceptance of Gene Technology. *Risk Analysis*. 20(2): 195-203.

Siegrist. M. 2010. Psychometric Paradigm. In Susanna Hornig Priest. (ed.). *Encyclopedia of Science and Technology Communication*. 600–601. New York: Sage.

Siegrist, M. and V. Visschers. 2013. Acceptance of Nuclear Power: The Fukushima Effect. Energy Policy. 59: 112-119.

Siegrist, M., G. Cvetkovich and C. Roth. 2000. Salient Value Similarity, Social Trust, and Risk/Benefit Perception. *Risk Analysis*. 20(3): 353-362.

Siegrist, M., C. Keller, and H. A. L. Kiers. 2005. A New Look At The Psychometric Paradigm Of Perception Of Hazards. *Risk Analysis*. 25(1): 211–222.

Michael Siegrist, M., B. Sutterlin and C. Keller. 2014. Why Have Some People Changed their Attitudes Toward Nuclear Power After The Accident in Fukushima?. *Energy Policy*. 69:

356-363.

Sjöberg, L. 2004. Local Acceptance of a High-Level Waste Repository. *Risk Analysis*. 24(3): 737-749.

Sjöberg, L. 2006. *Myths of The Psychometric Paradigm and How They Can Misinform Risk Communication*. SSE/EFI Working Paper Series in Business Administration No. 2006:10

Slovic, P. 1999. Trust, Emotion, Sex, Politics, and Science: Surveying the Risk-Assessment Battlefield. *Risk Analysis*. 19(4): 689-701.

Slovic, P. 1993. Perceived Risk, Trust, and Democracy. *Risk Analysis*. 13(6): 675-682.

Slovic, P. B. Fischohoff and S. Lichtenstein. 1982. Why Study Risk Perception? *Risk Analysis*. 2(2): 83-93.

Slovic, P., J. Flynn, C. Mertz, M. Poumadere, and C. Mays. 2000. Nuclear Power And The Public: A Comparative Study Of Risk Perception in France and the United States. In O. Renn and B. Rohrmann(eds.). *Cross-cultural Risk Perception*. Springer, Boston, MA. pp: 55-102.

Spence, A., W. Poortinga, N. Pidgeon, and I. Lorenzoni. 2010. Public Perceptions of Energy Choices: The Influence of Beliefs about Climate Change and the Environment. *Environment and Energy*. 21 (5): 384–407.

Stoutenborough, J. W., S. G. Sturgess, and A. Vedlitz. 2013. Knowledge, Risk, and Policy Support: Public Perceptions of Nuclear Power. *Energy Policy*. 62: 176-184.

Tanaka, Y. 2004. Major Psychological Factors Determining Public Acceptance of The Siting of Nuclear Facilities. *Journal of Applied Social Psychology*. 34(6): 1147-1165.

Tsujikawa, N., S. Tsuchida, and T. Shiotani. 2016. Changes in the Factors Influencing Public Acceptance of Nuclear Power Generation in Japan Since the 2011 Fukushima Daiichi. Nuclear Disaster. *Risk Analysis*. 36(1): 98-113.

Vercelli, A. 2014. Nuclear and Financial Meltdowns: The Impact of The Fukushima Accident on The Transition to a Low-Carbon Economy. FESSUD(Financialisation, Economy, Society And Sustainable Development). 76: 1-42.

Visschers, V. H. and M. Siegrist. 2013. How a Nuclear Power Plant Accident Influences Acceptance of Nuclear Power: Results of a Longitudinal Study Before and after the Fukushima Disaster. *Risk Analysis*. 33: 333-347.

Visschers, V. H. M. and L. Wallquist. 2013. Nuclear Power Before and After Fukushima: The Relations Between Acceptance, Ambivalence and Knowledge. *Journal of Environmental Psychology*. 36: 77-86.

Wang, J. and Seoyong Kim. 2018. Comparative Analysis of Public Attitudes toward Nuclear Power Energy across 27 European Countries by Applying the Multilevel Model. *Sustainability*. 10(5): 1518-1538.

Webber. D. J. 1982. Is Nuclear Power Just Another Environmental Issue? An Analysis of California voters. *Environment and Behavior*. 14: 72-83

Whitefield, S. C., E. A. Roas, A. Dan, and T. Dietz. 2009. The Future of Nuclear Power: Value Orientations and Risk Perception. *Risk Analysis*. 29(3): 425-437.

Wiegman, O., J. M. Gutteling, and B. Cadet. 1995. Perception of Nuclear Energy and Coal in France and the Netherland. *Risk Analysis*. 15(4): 513-521.

Yamamura, E. 2012. Experience of Technological and Natural Disaster and their Impact on the Perceived Risk of Nuclear Accidents After the Fukushima Nuclear Disaster in Japan 2011: A Cross-country Analysis. *The Journal of Socio-Economics*. 41: 360-363.

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후쿠시마 원전사고 이후 원자력 에너지에 대한 태도변화 분석

– 다수준 모델링의 적용을 통해 –

국문초록 후쿠시마 원전사고는 원자력 에너지에 대한 태도변화에 매우 큰 영향을 미쳤다. 이러한 태도변화는 탈원자력이라는 에너지전환에 영향을 미친다. 본 연구의 목적은 후쿠시마 원전사고 이후 태도변화의 결정요인을 분석하는데 있다. 태도변화는 단순히 개인적 차원의 변수뿐만 아니라 맥락적 차원의 변수들로부터 영향을 받기 때문에 미시적인 개인적 수준의 변수뿐만 아니라 거시적인 국가수준의 변수를 태도변화의 원인변수로 설정할 필요가 있다. 본 연구에서는 후쿠시마 원전사고 이후 태도변화를 종속변수로 설정하였으며, 개인수준에서 인구학적 변수, 매스미디어 변수, 지각변수 등, 국가수준에서는 원전의존성, GDP, 후쿠시마 원전으로부터의 거리, 환경의 질 등을 독립변수로 설정하여 다수준 분석을 실시하였다. 분석결과 개인적 수준에서는 남성(-), 교육수준(+), 종교(+), 위험지각(+), 신뢰(-) 등이 원자력에 대한 지지에서 반대로의 태도변화에 유의하게 영향을 미치고 있었으며, 국가수준에서는 원전운영(-), GDP(+)이 영향을 미치고 있었다.

주제어 : 후쿠시마 원전사고, 태도변화, 개인수준/국가수준, 다수준 모델링

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