

Communication

Extending the Coverage of the Trust–Acceptability Model: The Negative Effect of Trust in Government on Nuclear Power Acceptance in South Korea under a Nuclear Phase-Out Policy

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Abstract: This article extends the coverage of the trust–acceptability model to a new situation of nuclear phase-out by investigating the effect of trust on the public acceptance of nuclear power, with South Korea as the research setting. Through the structural equation modeling of a nationwide survey dataset from South Korea, we examined the effects of the public’s trust in the various actors related to nuclear power on their perceptions of the benefits and risks of nuclear power and their acceptance of nuclear power. Contrary to previous studies’ findings, in South Korea, under a nuclear phase-out policy by the government, trust in government revealed a negative impact on the public acceptance of nuclear power. Trust in environmental non-governmental groups also showed a negative effect on nuclear power acceptance. In contrast, trust in nuclear energy authority and trust in nuclear academia both had positive effects. In all cases, the effect of a trust variable on nuclear power acceptance was at least partially accounted for by the trust’s indirect effects through benefit perception and risk perception. These findings strengthen the external validity of the trust–acceptability model and provide implications for both researchers and practitioners.

Keywords: trust–acceptability model; public acceptance; nuclear power; trust; trust in government; benefit perception; risk perception



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1. Introduction

1.1. Research Motivation: Extending the Coverage of the Trust–Acceptability Model

Public acceptance of an electricity generation source/technology—the public’s perception of an electricity generation source/technology as something worth accepting—is an important social factor in the country’s development of energy infrastructure. This is because, depending on such acceptance, both policy-making on energy infrastructure and the implementation of such policy can be supported or impeded [1–5].

As a determinant of acceptance of a generation source, trust has received considerable research attention. First, studies have demonstrated that an individual’s trust in authorities or institutions that regulate a generation source (typically governments and energy-related organizations) influences their acceptance of that generation source. Second, this influence of trust may occur as it influences the individual’s perceptions of the benefits and risks of that generation source, which in turn determine the acceptance [6]. This trust–acceptability model for generation sources [2] and analogous frameworks have been verified by several studies (e.g., [6–13]).

However, the verification of the trust–acceptability model for generation sources has been limited to cases in which trust in government has a positive effect on the perceived benefits of a generation source while negatively affecting perceived risks, and positively influences the acceptance of that generation source as a result. Thus, such verification is not

well covered in cases where a government is explicitly implementing a phase-out policy for a generation source. Particularly, to the best of our knowledge, it is difficult to find a study that demonstrates that trust in government has a negative impact on the public acceptance of nuclear power when the government attempts to phase out nuclear power. As long as this research gap exists, the trust–acceptability model regarding generation sources will remain verified in only limited conditions.

By filling this research gap, we contribute to the trust–acceptability model’s external validity. Findings from a study with a different context strengthen the external validity of a theory or model [14,15]. A country under a nuclear phase-out policy is a new context that is difficult to find among existing studies adopting the trust–acceptability model. Thus, the verification of the model in such a country will strengthen the external validity of the model.

Our secondary interest is whether the effects of trust in nuclear energy authority will be synchronized with those of trust in government. Nuclear energy authorities (i.e., nuclear power corporations) are usually under the significant influence of their country’s government or are even directly controlled when they take the form of government-owned enterprises [16]. Considering this, in a country under a nuclear phase-out policy, will trust in nuclear energy authority influence acceptance of nuclear power in a similar manner as trust in government does? On the contrary, will trust in nuclear energy authority have different signs of effects since that authority is not responsible for the nuclear phase-out policy and the satisfactory operation of the authority means nuclear power is being well managed? Answering this question will provide a practical implication regarding whether the public’s trust in nuclear energy authority helps or harms the deployment of a nuclear phase-out policy.

Prompted by these research needs, the present study aims to extend the coverage of the trust–acceptability model by investigating the effect of trust on public acceptance of a generation source, with a country whose government is pushing the phase-out of that generation source as the research setting. We posit that, in such a country, trust in government will have a negative impact on the public acceptance of the generation source, along with a negative effect on perceived benefits of the generation source and a positive effect on perceived risks, contrary to what previous studies have shown.

1.2. Research Setting: South Korea under a Nuclear Phase-Out Policy

We chose South Korea (hereafter, Korea) as our research setting, because it is a country that is dramatically being pushed toward the phasing-out of a generation source on which the country has heavily relied—nuclear power. As of 2016, which is a year before the launch of the current government headed by President Moon Jae-in, Korea ranked sixth in the world in terms of the number of nuclear power plants and 13th in its proportion of nuclear power in the national electricity production [17]. However, the Moon government initiated a major reform regarding Korea’s electricity mix, which refers to the combination of various primary sources used to generate electricity [18–20]. This reform is largely characterized in two ways: (1) the phasing-out of coal and nuclear power and (2) the expansion of natural gas and new renewable energy [21–24].

This government reform policy, particularly the phasing out of nuclear power, has been driving Korean society into a fierce controversy in which various actors including politicians, scholars, and activists are engaged [25,26]. The pro-nuclear factions, represented by nuclear academia such as the Korean Nuclear Society, are concerned about the government’s nuclear phase-out policy. They are concerned that phasing out nuclear power will cause Korea to fail to catch two rabbits: meeting the country’s electricity demands and reducing environmental pollution. Furthermore, they stress that the safety of Korean nuclear power plants is world-class and that the possibility of a nuclear disaster such as the Fukushima accident is slim in Korea. On the other hand, anti-nuclear factions such as environmental NGOs are raising strong questions about the claims regarding economic feasibility and safety of nuclear power made by the pro-nuclear factions [25,27,28].

1.3. Research Agenda: Applying the Trust–Acceptability Model to Korea under a Nuclear Phase-Out Policy

Prompted by the aforementioned research needs and recent situation in Korea, the present study extends the coverage of the trust–acceptability model by applying the model to Korea, whose current government is pushing the phasing-out of nuclear power. In particular, it demonstrates the following:

- The negative effect of people’s trust in government on their acceptance of nuclear power;
- The negative and positive effects of such trust on the perceptions of benefits and risks from nuclear power, respectively, which are other determinants of nuclear power acceptance;
- The impacts of trust in other actors related to nuclear power, such as the nuclear energy authority, nuclear academia, and environmental non-governmental organizations.

Consistent with this research agenda, we used a nationwide Korean sample from 2018, the year after the launch of the current Korean government, and its nuclear phase-out policy. We organized the remainder of this study as follows. In the Theoretical Background section, we detail the importance of public acceptance of generation source/technology and trust as a determinant of such acceptance, thereby providing our research model based on the trust–acceptability model. The Methodology section describes our sample and measurements. In the Results section, we adopt structural equation modeling (SEM) and demonstrate that trust in government negatively influences nuclear power acceptance, while also showing the effects of trust in other actors. The Conclusions section provides implications for researchers and practitioners in nuclear and energy-related fields.

2. Theoretical Background

2.1. Importance of Public Acceptance in Energy Policy

The public is an important actor group that impacts a country’s policies regarding energy infrastructure. The public significantly influences political decision-making on (1) whether to support the development of specific generation sources or technologies and (2) whether to sanction the construction of infrastructure for such sources/technologies. Furthermore, public opposition can prevent such decisions from being put into practice, or at least impede such implementation [1–3]. For example, in the 1970s, public opposition to nuclear power in Germany cancelled the proposed construction of a nuclear power plant in Wyhl [29]. Italy abandoned the use of nuclear power after a public vote in 1987; another public vote in 2011, whose results were also against nuclear power, has made the re-introduction of nuclear power to Italy difficult [30]. In the US, anti-nuclear movements among the public and other actors contributed to significant cost overruns during construction of nuclear power plants and even to the cancellation of some of the projects whose investment was already in progress [31]. There have also been cases in which the lack of the local community’s acceptance, which is a part of public acceptance, delayed, or derailed proposed wind power projects [32–34].

In line with this significance of public acceptance of a generation source or technology, the determinants of this acceptance have received considerable research attention. One of the widely adopted approaches for these determinants is the benefit–risk framework [2,35–38]. Studies have found that the benefits and risks individuals perceive regarding a generation source predict their acceptance of that generation source positively and negatively, respectively. In addition, several factors, such as trust [2,6,7,10,11,39], affective feelings [6], values [40], and political orientations [41,42], have been found to significantly influence acceptance of a generation source.

2.2. Trust as a Determinant of Public Acceptance of a Generation Source

The importance of trust is in line with the diversification and specialization of roles in societies. Because of such diversification and specialization, individuals cannot achieve well-being based on their own abilities and activities alone; thus, they become greatly

dependent on other individuals or even groups [43,44]. Therefore, when evaluating an object that is beyond their direct knowledge or control, individuals rely on authorities that have regulatory powers or expertise regarding that object. Trust is a tightly intertwined set of beliefs that the trust target has integrity and competence. Thus, when an individual has trust in a certain authority, their perception and evaluation of an object are influenced by the authority's claims about that object, becoming synchronized with such claims [45–47]. For example, people with trust in gene technology enterprises that advocate gene technology should perceive such technology as more beneficial and less risky than those without such trust [45].

This role of trust has received significant research attention in the public sector, as individuals (and their collective, a society) rely on public authorities with regard to whether to accept or oppose scientific/technological developments that entail both benefits and risks. Individuals frequently lack sufficient knowledge, time, or resources to make their own assessments of benefits and risks from complex scientific/technological development; therefore, they may rely on a trustworthy authority's claims regarding such development [45–47]. Thus, one of the most recognized explanations of the role of trust is that (1) an individual's trust in an authority relevant to a technology influences their perceptions of the benefits and risks of that technology, (2) such benefit and risk perceptions influence their acceptance of that technology, and (3) such trust thereby influences the acceptance [10,45,48]. This causal trust–acceptability model (in short, the trust–acceptability model [2]) or analogous frameworks have been verified for various kinds of technologies [39,49], including generation sources such as biomass [10], fossil fuel [2], nuclear power [2,6,7,10,11], and solar energy [39].

Despite the abundant research on the effect of trust on the public acceptance of technologies including generation sources, a research gap is found. That is, existing studies adopting the trust–acceptability model or analogous frameworks for generation sources are limited to phenomena in which trust in government has a positive effect on perceived benefits of a generation source or a negative effect on perceived risks, thus positively influencing the acceptance of that generation source. This limitation can be attributed to the fact that the relevant studies were set in countries where a specific generation source was being newly introduced, expanded, or at least maintained, for the trust–acceptability model itself began as efforts to explain the determinants of public acceptance of new technologies that entail risks. Thus, any examination of the effect of trust in government on the acceptance of a generation source in a country under a phase-out policy for that generation source is currently difficult to find.

Filling this research gap is significant in that it contributes to improving the external validity of the trust–acceptability model. External validity refers to the generalizability of research findings across contexts. A study in a different context, in particular, contributes to the confirmatory status, which refers to the extent to which the proposition has been supported in numerous tests in diverse settings [14]. Since the confirmatory status is one of the five factors that make up the external validity, findings from a study with a different context can strengthen the external validity of a theory or model [15]. A country where the government is attempting to phase out nuclear power is a new setting that is difficult to find among existing studies adopting the trust–acceptability model. Thus, the verification of such a model in a country under a nuclear phase-out policy will strengthen the external validity of the trust–acceptability model, which will in turn strengthen our confidence in that model [14].

2.3. Hypotheses and Research Model

We posit that, in a country where the government is pushing the phasing-out of a generation source, trust in the government will have negative impacts on the public acceptance of that generation source and on the perceived benefits of that generation source and a positive effect on the perceived risks, contrary to what previous studies have shown. To validate our postulation, we develop hypotheses by combining the above-described

theoretical background with the recent situation in Korea, whose government is pushing for nuclear phase-out.

In addition, we develop hypotheses on the effects of trust in actors other than government. In studies adopting or consistent with the trust–acceptability model, the target of trust tended to focus on actors who have the direct authority to make decisions about the introduction and regulation of a technology (i.e., government [2,6]). However, as modern societies have diversified, many other actors have also become involved in the construction of the public’s perceptions of the benefits and risks of technology, which has affected their acceptance of said technology. In line with this, several studies have expanded the range of targets of trust to various actors in societies such as industry players, scientist/researcher groups, and non-governmental organizations (environmental groups) [50–52]. Thus, we also consider the effects of trust in these actors.

To focus on our novel findings, we do not propose explicit hypotheses on the following two effects, which have been well-established by numerous studies: (1) the perception of benefits of nuclear power has a positive effect on nuclear power acceptance, while (2) the perception of risks from nuclear power has a negative effect on nuclear power acceptance [2,6,13,38,53–56]. Instead, we will examine these basic assumptions in our data analysis.

2.3.1. The Effects of Trust in Government

As we described in Section 2.2, when an individual has trust in a certain authority regarding an object, they will likely follow the authority’s claims about that object. This in turn will influence the acceptance of policies being advocated by the trusted authority. For example, individuals who highly trust an authority responsible for a certain policy may perceive the benefits of such a policy as greater and the risks/costs of the policy as lower, which in turn leads to a more favorable response to the policy [45]. In Korea, Oh and Hong [57] found a positive association between individuals’ trust in government and their willingness to pay for public environmental projects. A Canadian study by Rhodes et al. [58] found that trust in government is positively associated with support for the government’s climate policies. An Irish study by Rodriguez-Sanchez et al. [59] found that individuals’ general trust in government affects their acceptance of a water charge policy by affecting their emotions toward such a policy and evaluations of expected benefits and costs. Using a nationwide survey of India, Thaker et al. [60] found that individuals with a higher level of trust in government are more likely to support the government’s water conservation policies. In this light, in Korea under a nuclear phase-out policy [22,25,28,61], individuals with a higher level of trust in the government will likely agree with the government’s claim that nuclear power should be phased out and are thus less accepting of the use of nuclear power for electricity generation. Therefore, we derive the following hypothesis:

Hypothesis 1 (H1). *Trust in government, in Korea under a nuclear phase-out policy, has a negative effect on nuclear power acceptance.*

We predict that this negative effect of trust in government on nuclear power acceptance will be at least partially accounted for by the mediating roles of the perception of the benefits of and risks from nuclear power, as in the following. In modern societies where the public is an important group, a major change in policy requires public persuasion and publicity. Korea is no exception. Since its launch in 2017, the current Korean government has been deploying public communications for its nuclear phase-out policy, consistently emphasizing the risks from nuclear power while devaluing or avoiding commenting on the benefits of nuclear power [22,25,28,61]. Thus, individuals with a higher level of trust in the Korean government will likely perceive the benefits of nuclear power lower and the risks from such power higher, both of which lead to a decreased level of nuclear power acceptance. Thus:

Hypothesis 2 (H2). *Trust in government, in Korea under a nuclear phase-out policy, has a negative effect on the perception of benefits of nuclear power, thereby having a negative indirect effect on nuclear power acceptance through decreased benefit perception.*

Hypothesis 3 (H3). *Trust in government, in Korea under a nuclear phase-out policy, has a positive effect on the perception of risks from nuclear power, thereby having a negative indirect effect on nuclear power acceptance through increased risk perception.*

2.3.2. The Effects of Trust in Nuclear Energy Authority

Nuclear energy authorities, which usually take the form of nuclear power corporations, are involved in the actual ownership and operation of nuclear power plants. Korea Hydro and Nuclear Power (KHNP) [62], a Korean government-owned enterprise, is not the main agent of nuclear energy policy-making but is the exclusive agent of the actual ownership, operation, and management of nuclear power plants in Korea [16]. Thus, believing that this nuclear energy authority is working well means believing that nuclear power plants in Korea are being operated well so that country can make good use of nuclear power for public welfare. In this light, individuals with a higher level of trust in KHNP are likely to think that nuclear power in Korea is contributing to the country and therefore more accepting of the use of nuclear power. Therefore:

Hypothesis 4 (H4). *Trust in KHNP (the main nuclear energy authority in Korea) has a positive effect on nuclear power acceptance.*

If KHNP is operating well, it means that the country is able to benefit more sufficiently from nuclear power while reducing the associated risks. In this light, a higher trust in KHNP will lead to a higher perception of the benefits of nuclear power but a lower perception of risks from such power, both of which lead to greater acceptance of nuclear power. Thus:

Hypothesis 5 (H5). *Trust in KHNP has a positive effect on the perception of the benefits of nuclear power, thereby having a positive indirect effect on nuclear power acceptance through increased benefit perception.*

Hypothesis 6 (H6). *Trust in KHNP has a negative effect on the perception of risks from nuclear power, thereby having a positive indirect effect on nuclear power acceptance through decreased risk perception.*

2.3.3. The Effects of Trust in Nuclear Academia

The nuclear academia (the nuclear science academic community) is the group of professors and researchers at nuclear-related institutes. Regarding the public's judgment of a scientific or technical issue, the academia engaged with that issue is an influential group with knowledge and expertise that the public cannot possess. Although academia is not a homogeneous group with consensus, the nuclear academia in Korea has generally and consistently expressed concerns and opposition to the current Korean government's nuclear phase-out policy [25,27,28,63]. Thus, those who trust nuclear academia are likely to think that nuclear power should not be phased out, and thus they are more accepting the use of nuclear power. Therefore:

Hypothesis 7 (H7). *Trust in nuclear academia has a positive effect on nuclear power acceptance.*

Based on a wealth of research, nuclear academia has emphasized the benefits of nuclear power as a feasible and reliable solution for the reduction of greenhouse-gas and fine-dust emissions while meeting electricity demand. Academia has also emphasized the safety of Korea's nuclear power plants [25,27,28,63]. Thus, individuals with a higher level of trust in nuclear academia are likely to perceive the benefits of nuclear power as higher

and the risks from such power as lower, both of which lead to an increased level of nuclear power acceptance. Thus:

Hypothesis 8 (H8). *Trust in nuclear academia has a positive effect on the perception of the benefits of nuclear power, thereby having a positive indirect effect on nuclear power acceptance through increased benefit perception.*

Hypothesis 9 (H9). *Trust in nuclear academia has a negative effect on the perception of risks from nuclear power, thereby having a positive indirect effect on nuclear power acceptance through decreased risk perception.*

2.3.4. The Effects of Trust in Environmental Non-Governmental Organizations

Environmental non-governmental organizations (NGOs), a term that encompasses NGOs in the field of environmentalism, are largely negative toward nuclear power plants [64], although there are some exceptional NGOs that call for policies to support nuclear energy. This is because nuclear power entails the risk of nuclear accidents or disasters [65], which are critical to public safety and environmental protection—the core values pursued by environmental NGOs. In Korea, environmental NGOs deployed nuclear phase-out movements even before the current government [66]. Thus, individuals with a higher level of trust in environmental NGOs are likely to be less accepting of nuclear power. As such, we propose the following hypothesis.

Hypothesis 10 (H10). *Trust in environmental NGOs has a negative effect on nuclear power acceptance.*

In deploying nuclear phase-out movements, environmental NGOs also utilize the benefit–risk framework. They particularly argue that the economics of nuclear power, as claimed by the nuclear academia and other pro-nuclear factions, are exaggerated. Their point is that nuclear power will lose its economic feasibility if the costs of decommissioning nuclear power plants and the disposal of nuclear waste are included in the levelized cost of electricity (LCOE) of nuclear power. That is, environmental NGOs devalue the economic benefits of nuclear power [67,68]. Regarding the risk aspect, they raise strong questions about the safety of nuclear power [64]. Thus, individuals who trust environmental NGOs are likely to perceive the benefits of nuclear power lower and the risks from such power higher and are thus less accepting of the use of nuclear power. Thus:

Hypothesis 11 (H11). *Trust in environmental NGOs has a negative effect on the perception of benefits of nuclear power, thereby having a negative indirect effect on nuclear power acceptance through decreased benefit perception.*

Hypothesis 12 (H12). *Trust in environmental NGOs has a positive effect on the perception of risks from nuclear power, thereby having a negative indirect effect on nuclear power acceptance through increased risk perception.*

2.3.5. Research Model

Based on the hypotheses and other effects we discussed, we propose a causal model in which an individual's trust in various actors are set to influence their perceptions and acceptance of nuclear power, as shown in Figure 1. The total effects are not explicitly drawn here but will be estimated from the corresponding direct and indirect effects.

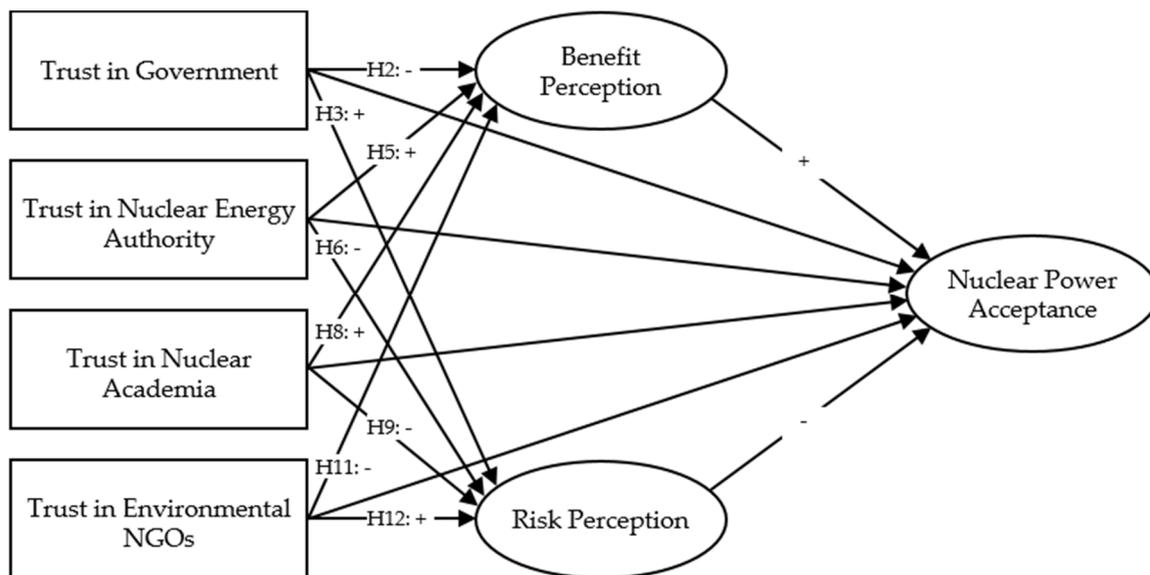


Figure 1. Our research model based on the trust–acceptability model. The total effect of each trust variable (H1, H4, H7 and H10) is not explicitly drawn here but we consider it. +: a positive effect hypothesized; −: a negative effect hypothesized.

Our model is consistent with the trust–acceptability model [2]. However, whereas the existing studies adopting or consistent with this model showed positive effects of trust in government on the acceptance of generation sources, our model hypothesizes that such trust will have a negative effect on nuclear power acceptance in Korea under a nuclear phase-out policy.

3. Methodology

3.1. Sample and Data Collection

The study used the dataset compiled by the Korean Nuclear Society (KNS) [69] in November 2018, the year after the launch of nuclear phase-out policy by the Moon government. The first author of the present study participated in KNS’s project group that was in charge of the general processes of the survey. The survey targeted the Korean population 19 years old and older. A professional opinion research firm—Gallup—conducted the data collection using computer-assisted telephone interviews. The sampling adopted proportionated quota sampling based on the population sizes by region, gender, and age as of October 2018. The respondents were contacted through landlines (20%) and wireless (80%) random digit dialing. In order to prevent exposure to the name of the survey committee (i.e., KNS) from affecting respondents’ participation in the survey or their responses, respondents were only told the names of the research company and the interviewer: “Hello, I’m OOO, an interviewer at Gallup Korea”. The survey collected data were from 1006 respondents: the confidence level was 95% and the margin of error was $\pm 3.1\%$ points.

Among this original sample, we adopted 692 respondents who had no missing values in our key variables as our study sample. We considered non-response bias [70] as follows. First, no score of the 11 key measurement items except one was different at the 0.05 level between the respondents in the study sample and the others. Second, the analyses to be described in the remainder were performed on both the study sample and the original sample (i.e., SEM can analyze a dataset including missing values). The analysis results for the hypotheses showed no essential difference between the two samples. As such, the threat of non-response bias appeared to be not a serious concern. Thus, we report our analysis results using the study sample. Table 1 shows the profiles of the study sample.

Table 1. Study sample profile.

Demographic Characteristic	Distribution	
Gender	Male	56.07%
	Female	43.93%
Age (measured in specific age)	19–29	19.08%
	30–39	15.61%
	40–49	21.39%
	50–59	22.83%
	60+	21.10%
Residential area	Seoul	20.09%
	Busan	7.51%
	Daegu	4.48%
	Incheon	5.20%
	Gwangju	3.03%
	Daejeon	3.18%
	Ulsan	2.17%
	Sejong	0.29%
	Gyeonggi Province	24.13%
	Gangwon Province	2.60%
	Chungcheongbuk Province	3.03%
	Chungcheongnam Province	4.05%
	Jeollabuk Province	3.90%
	Jeollanam Province	3.32%
Gyeongsangbuk Province	5.20%	
Gyeongsangnam Province	6.79%	
Jeju Province	1.01%	

Note: $N = 692$.

3.2. Measures

Table 2 shows the measurement items of our key variables.

Table 2. Measures.

Variable and Measurement Item	Standardized Loading
Trust: "How much do you trust information or messages about nuclear power from the following agencies?" (each is measured by a single item)	
"Government"	
"KHNP" (nuclear energy authority)	
"Nuclear academia"	
"Environmental NGOs"	
Perception of benefits of nuclear power ($\alpha = 0.81$, AVE = 0.60, CR = 0.85)	
Benefit 1: "The unit cost of nuclear power generation is relatively low, which helps reduce electricity bills."	0.79
Benefit 2: "Nuclear power emits almost no fine dust or greenhouse gases."	0.71
Benefit 3: "Nuclear power is an easy way to store fuel for the long-term, which brings advantages to energy security."	0.81
Perception of risks from nuclear power ($\alpha = 0.67$, AVE = 0.56, CR = 0.78)	
Risk 1: "A nuclear power plant can have a serious accident that greatly damages people's lives and property."	0.89
Risk 2: "Radioactive waste generated by nuclear power, such as spent nuclear fuel, is difficult to manage safely."	0.57

Table 2. Cont.

Variable and Measurement Item	Standardized Loading
Acceptance of nuclear power ($\alpha = 0.83$, AVE = 0.71, CR = 0.80)	
Acceptance 1: “What do you think about using nuclear power as a means of producing electricity in our country?”	0.86
Acceptance 2: “Currently, nuclear power is responsible for about 30% of our country’s electricity generation. What do you think we should do about this share of electricity generation in the future?”	0.83
Model Fit: $\chi^2 (27) = 43.67$, normed $\chi^2 = 1.62$, $p < 0.05$; confirmatory fit index = 0.994; Tucker–Lewis index = 0.989, root-mean-square error of approximation = 0.030	

Note: All items were measured on four-point Likert-type scales, except for Acceptance 2, which was assessed on a five-point Likert-type scale. All items were reverse-coded so that a higher score indicates a higher value for that item. α = Cronbach’s α ; AVE = average variance extracted; CR = composite reliability.

3.2.1. Trust Variables

Regarding the measure of trust in the various actors related to nuclear power, two points were considered. First, while trust is a complex construct with multiple dimensions such as competence and integrity [10,46], the limitation in survey length made it difficult to ask the respondents multiple questions regarding each trust target. Second, the item about trust in an actor should ask the respondents about their trust in that actor or ‘in relation to’ or ‘regarding’ nuclear power, not their trust in the general aspects of that actor: for example, “How much do you trust the government in relation to nuclear power?” However, the words ‘in relation to’ and ‘regarding’ in the Korean language may sound less intuitive and thus may not adequately reach the survey target—ordinary Korean citizens.

For these reasons, a single proxy item that could represent the concept of trust in a condensed and intuitive manner was necessary for the survey. In the sense that trusting information from an actor is in line with trusting that actor, the survey adopted trust in nuclear-related information or messages provided by an actor as a proxy for trust in that actor related to nuclear power. Thus, the respondents were asked: “How much do you trust information or messages about ‘nuclear power’ from the following agencies?” For each actor—the government, KHNP (the nuclear energy authority), the nuclear academia, and environmental NGOs—the respondent rated their trust in that actor on a four-point scale (1 = trust a lot; 2 = generally trust; 3 = generally do not trust; 4 = do not trust at all). The responses were reverse-coded.

3.2.2. Benefit and Risk Perception Variables

The respondents’ perception of the benefits of nuclear power was measured using three items—Benefits 1–3—as in Table 2. According to Kim et al. [71], the perceived benefits of nuclear power frequently explored by researchers are three-folds: low cost economies, climate change mitigation effect, and supply security (e.g., [6,72–75]). Consistent with this, item Benefit 1 measures respondents’ perception of nuclear power’s benefit to low-cost economies. Benefit 2 measures the perception of the environmental benefits (including the climate change mitigation effect) of nuclear power. Benefit 3 measures the perception of the energy security benefit of nuclear power.

The respondents’ perception of the risks from nuclear power was measured using two items—Risks 1 and 2. Existing survey items regarding these risks largely include two kinds of risks: the risk of nuclear accidents and that of spent radioactive waste (please refer to Table 1 of Roh and Lee [76]). Consistent with this, Risk 1 measures the respondents’ perception of the risk of nuclear power accidents. Risk 2 measures the perception of nuclear power’s risk in terms of radioactive waste management. All items for the benefit and risk perceptions used a four-point Likert-type scale (1 = strongly agree; 2 = generally agree; 3 = generally disagree; 4 = strongly disagree). The responses were reverse-coded.

3.2.3. Acceptance of Nuclear Power

Acceptance of nuclear power was measured by the items Acceptance 1 and 2. Acceptance 1 measures the degree to which respondents agree with the use of nuclear power for the country's electricity generation [76,77]. The item used a four-point Likert-type scale (1 = strongly agree; 2 = generally agree; 3 = generally disagree; and 4 = strongly disagree).

Acceptance 2 measures respondents' opinions on the desirable portion of nuclear power in the country's electricity generation [38,53]. This is also a significant indicator of nuclear power acceptance in Korea, which is already operating nuclear power plants. While the other key variables were measured using four-point scales, Acceptance 2 used a five-point Likert-type scale (1 = should be increased greatly above the current level; 2 = should be increased slightly above the current level; 3 = should be maintained at the current level; 4 = should be decreased slightly below the current level; 5 = should be decreased greatly below the current level) so that the intermediate value of the scale (i.e., 3) explicitly corresponded to the respondent's preference for the status quo. The responses were reverse-coded.

3.3. Reliability and Validity

For the variables that used multiple items, the Cronbach's α was as follows: α for benefit perception = 0.81; α for risk perception = 0.67; α for acceptance = 0.83. Although the α for risk perception does not reach the 0.7 threshold, it is notable that this variable used a small number of items (i.e., 2), which can cause downward bias in Cronbach's α . Thus, we conducted a confirmatory factor analysis (CFA). The measurement model fit the data greatly: χ^2 (27) = 43.67, normed χ^2 = 1.62, $p < 0.05$; confirmatory fit index (CFI) = 0.994; Tucker–Lewis index (TLI) = 0.989, root-mean-square error of approximation (RMSEA) = 0.030 [78]. As shown in Table 2, all standardized factor loadings exceeded the threshold of 0.40 [79] and were highly significant ($p < 0.001$). The composite reliability (CR) of each multiple-item construct well exceeded the 0.70 criterion and the average variances extracted (AVEs) were greater than 0.5 [80–83]. These support convergent validity. As shown in Table 3, the square root of each multiple-item construct's AVE was greater than the construct's correlations with other variables [84], in support of discriminant validity.

Table 3. Correlations and descriptive statistics of key variables.

Variable	a	b	c	d	e	f	g
a. Trust in government							
b. Trust in nuclear energy authority	0.27 ***						
c. Trust in nuclear academia	0.16 ***	0.51 ***					
d. Trust in environmental NGOs	0.43 ***	0.11 **	−0.03				
e. Perception of benefits	−0.08 *	0.29 ***	0.44 ***	−0.26 ***	(0.78)		
f. Perception of risks	0.20 ***	−0.16 ***	−0.34 ***	0.29 ***	−0.42 ***	(0.75)	
g. Nuclear power acceptance	−0.20 ***	0.24 ***	0.40 ***	−0.35 ***	0.73 ***	−0.53 ***	(0.84)
Mean	2.40	2.67	2.72	2.48	3.00	3.23	2.74
Standard deviation	0.82	0.73	0.75	0.81	0.76	0.74	0.88

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Below the diagonals are the correlations among the scores of the variables; diagonal elements are the square roots of the average variances extracted of multiple-item variables. For the score for nuclear power acceptance, the item score of Acceptance 2 (1–5) was re-scaled to 1–4 so that the scales of Acceptance 1 and 2 match. For the other variables, the item scores range from 1 to 4. A higher score indicates a higher value for the variable.

4. Results

4.1. Estimates of the Structural Equation Model

Although it is not presented for readability, in every SEM we ran, we allowed the independent variables (the trust variables) to covary with each other, following the standard procedure in an SEM. The initial model presented in Figure 1 proved an excellent fit (χ^2 (28) = 103.93; normed χ^2 = 3.71, $p < 0.001$; CFI = 0.975; TLI = 0.950; RMSEA = 0.063). However, some paths were not significant. After making model revisions by deleting insignificant paths, we obtained the model shown in Figure 2 with an excellent fit: χ^2 (30) = 105.27;

normed $\chi^2 = 3.51, p < 0.001$; CFI = 0.975; TLI = 0.954; RMSEA = 0.060). The χ^2 difference between the two models ($\Delta\chi^2(2) = 1.34$) was not sufficient to offset the difference in degrees of freedom ($\chi^2_{0.05}(2) = 5.99$). Thus, we selected the revision, which is more parsimonious and does not include any insignificant path, as our final model [78].

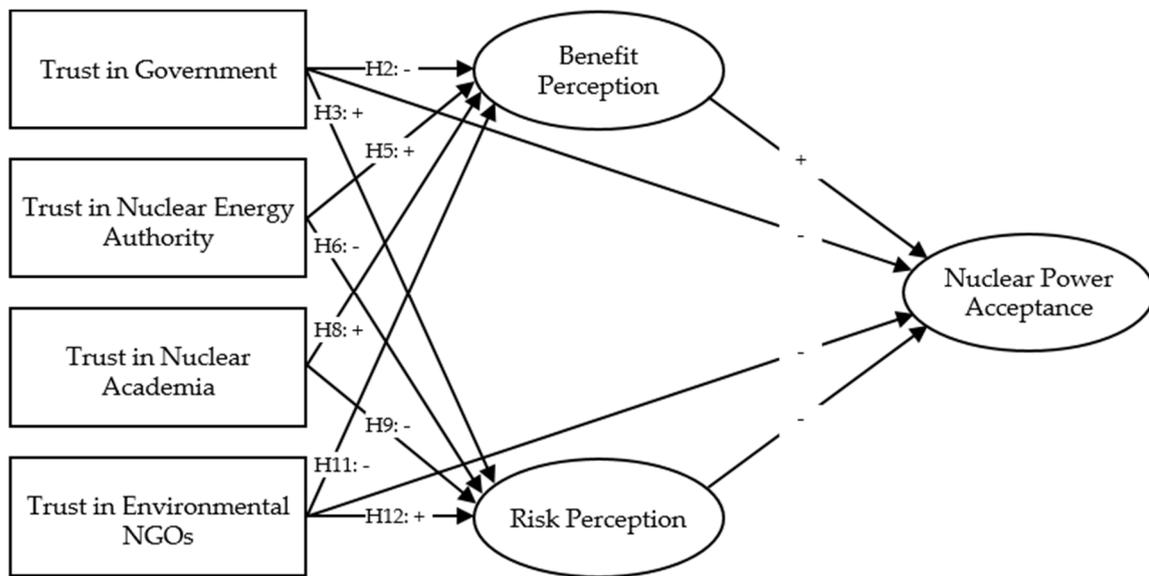


Figure 2. The final model. The variable in a rectangle was measured by a single item; the one in an ellipse is a multiple-item variable. Covariances between the trust variables are not explicitly shown in this figure for readability. +: a positive effect; -: a negative effect.

4.2. Test of Presupposed Effects

In the SEM results, the perception of the benefits of nuclear power had a significant positive effect (standardized $\beta = 0.75, z = 18.05, p < 0.001$) and that of risks from nuclear power had a significant negative effect (standardized $\beta = -0.28, z = -7.01, p < 0.001$) on nuclear power acceptance. These support our presuppositions in Section 2.3.

4.3. Hypothesis Testing

Table 4 presents the total, direct, and indirect effects of the trust variables on nuclear power acceptance as well as their effects on benefit and risk perceptions. The detailed results for the total effects and the indirect effects were obtained through a bootstrapping function of Amos—a software package for SEM [85].

Table 4. Standardized estimates of path coefficients.

Trust Variable	Effect	Standardized Coefficient
Trust in government	Total effect (H1: -)	-0.17 (z = -4.25) ***
	Direct effect	-0.06 (z = -2.05) *
	Effect on benefit perception (H2: -)	-0.09 (z = -2.20) *
	Effect on risk perception (H3: +)	0.20 (z = 4.60) ***
	Indirect effect through benefit perception (H2: -)	-0.06 (z = -2.07) *
	Indirect effect through risk perception (H3: -)	-0.05 (z = -3.40) ***
Trust in nuclear energy authority	Total effect (H4: +)	0.16 (z = 4.03) ***
	Direct effect	Insignificant
	Effect on benefit perception (H5: +)	0.17 (z = 4.10) ***
	Effect on risk perception (H6: -)	-0.09 (z = -2.08) *
	Indirect effect through benefit perception (H5: +)	0.13 (z = 3.97) ***
	Indirect effect through risk perception (H6: +)	0.03 (z = 2.00) *

Table 4. Cont.

Trust Variable	Effect	Standardized Coefficient
Trust in nuclear academia	Total effect (H7: +)	0.41 ($z = 10.00$) ***
	Direct effect	Insignificant
	Effect on benefit perception (H8: +)	0.40 ($z = 9.41$) ***
	Effect on risk perception (H9: −)	−0.38 ($z = −8.77$) ***
	Indirect effect through benefit perception (H8: +)	0.30 ($z = 8.14$) ***
	Indirect effect through risk perception (H9: +)	0.11 ($z = 5.40$) ***
Trust in environmental NGOs	Total effect (H10: −)	−0.30 ($z = −7.27$) ***
	Direct effect	−0.07 ($z = −2.09$) *
	Effect on benefit perception (H11: −)	−0.25 ($z = −6.04$) ***
	Effect on risk perception (H12: +)	0.25 ($z = 6.04$) ***
	Indirect effect through benefit perception (H11: −)	−0.17 ($z = −4.97$) ***
	Indirect effect through risk perception (H12: −)	−0.07 ($z = −4.33$) ***

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

As shown in Table 4, the total effect of trust in government on nuclear power acceptance was significantly negative (standardized $\beta = -0.17$, $z = -4.25$, $p < 0.001$), supporting H1. Such trust had a significant negative effect on the perception of benefits of nuclear power (standardized $\beta = -0.09$, $z = -2.20$, $p < 0.05$), thereby having a significant negative indirect effect on nuclear power acceptance through the decreased perception of benefits (standardized $\beta = -0.06$, $z = -2.07$, $p < 0.05$); these support H2. Trust had a significant positive effect on the perception of risks from nuclear power (standardized $\beta = 0.20$, $z = 4.60$, $p < 0.001$), thereby having a significant negative indirect effect on nuclear power acceptance through the increased perception of risks (standardized $\beta = -0.05$, $z = -3.40$, $p < 0.001$), in support of H3.

Similarly, the other parts of Table 4 show that the other hypotheses (H4–H12) were also supported. That is, the hypothesized signs of effects (i.e., + or −) well-matched their corresponding coefficients, and the hypothesized effects were significant.

4.4. Test of Reverse Causality

Our hypotheses and research model are based on the trust–acceptability model. This model assumes causal relationships from trust to benefit/risk perceptions and acceptance and those from these perceptions to acceptance. However, the possibility that the direction of causality is the other way around cannot be ruled out. For example, individuals who accept or oppose nuclear power may adapt their benefit/risk perceptions and trust in relevant actors according to such acceptance or opposition [86]. To investigate this possibility, we additionally set two SEM models that assume reverse causality, as follows, to compare these models with our final model shown in Figure 2 and Table 4.

- The associationist model [86]: the acceptance variable was set to influence both (1) the benefit and risk perception variables and (2) the trust variables, but neither the perception variables nor the trust variables predict the other;
- The full reverse model (named by us): a complete reversal of our research model. The acceptance variable influences the trust variables both (1) directly and (2) indirectly through the benefit and risk perception variables.

After being revised by deleting insignificant paths, both the associationist model ($\chi^2(42) = 483.09$; normed $\chi^2 = 11.50$, $p < 0.001$; CFI = 0.852; TLI = 0.806; RMSEA = 0.123) and the full reverse model ($\chi^2(35) = 137.70$; normed $\chi^2 = 3.93$, $p < 0.001$; CFI = 0.966; TLI = 0.946; RMSEA = 0.065) demonstrated an inferior fit compared to our final model. In particular, since these three models were nested to each other (i.e., the variables were the same but the paths were different), we conducted χ^2 difference tests. Our final model ($\chi^2(30) = 105.27$) was superior to both the associationist model ($\Delta\chi^2(12) = 377.82$, $p < 0.001$) and the full reverse model ($\Delta\chi^2(5) = 32.43$, $p < 0.001$). In addition, in the full reverse model, several paths had a standardized coefficient outside the range between −1 and 1, which

indicates that the model does not account for the data well. These show that the causality that the trust–acceptability model assumes is better supported than the reverse causality in our dataset.

4.5. Summarization of the Results

As we hypothesized, trust in government, which is our main focus of interest, was found to have a negative total effect on acceptance of nuclear power. This total effect was accounted for by (1) the trust's negative indirect effect through decreased perception of benefits of nuclear power, (2) negative indirect effect through increased perception of risks from nuclear power, and (3) negative direct effect on nuclear power acceptance (standardized $\beta = -0.06$, $z = -2.05$, $p < 0.05$). The same was true of trust in environmental NGOs. In contrast, trust in nuclear energy authority and in nuclear academia both had a positive total effect on nuclear power acceptance. Each of these positive total effects was accounted for by the corresponding trust's positive indirect effects through increased perception of benefits of nuclear power and decreased perception of risks from nuclear power.

Trust in government and environmental NGOs had a significant direct effect, whereas trust in nuclear energy authority and nuclear academia did not. This means that each of the effects of trust in nuclear energy authority and nuclear academia on nuclear power acceptance is fully accounted for by the corresponding trust's indirect effects through benefit perception and risk perception.

5. Conclusions

5.1. Theoretical Implications

The present study has findings regarding the relationship between trust and acceptance of nuclear power. First, an individual's trust in government, which is our main focus of interest, was found to have a negative impact on their acceptance of nuclear power, along with a negative effect on the perceived benefits and a positive effect on the perceived risks. This finding is contrary to what previous studies adopting the trust–acceptability model or its analogous frameworks have found (e.g., [2,6–13]). However, given an understanding of the principle of trust, which underlies the trust–acceptability model, these effects do not infringe on the model's validity. The effect of trust in a certain social actor on an individual's perceptions and evaluations of an object occurs because they rely on that trusted social actor when they perceive and evaluate the object [45–47]. Thus, in a country where the government is pushing the phasing out of a certain generation source, it is a reasonable consequence that individuals with a higher trust in the government synchronize their perceptions and evaluations with the government's claims and thus have a lower level of acceptance for that generation source. In this light, although the present study demonstrates effects that are contrary to what previous studies adopting the trust–acceptability model have shown, it actually reinforces the external validity of the model by extending its coverage to a new situation that is difficult to find among existing studies.

Second, by such extension to the new situation of nuclear phase-out, the present study also found that trust in government and in nuclear energy authority exert differentiated effects on nuclear power acceptance in a nuclear phase-out situation. Although it is typical for nuclear energy authorities to be under the significant control and influence of their country's government, their roles differ regarding that country's nuclear energy policy. A government is the direct agent of nuclear phase-out policy, whereas a nuclear energy authority is not [16]. Thus, trust in the latter actor does not necessarily lead to opposition to nuclear power. Instead, as we described in Section 2.3.2, the role of a nuclear energy authority is focused on the actual practice of nuclear power. Thus, higher trust in nuclear energy authority is related to the belief that nuclear power plants are being operated well for public welfare, which leads to the belief that nuclear power is worthwhile. As such, by adopting a new situation of nuclear phase-out, the present study has highlighted the

difference in the effects of trust in the two actors in their close relationship—government and nuclear energy authority.

Third, all trust variables had a significant total effect but only trust in government and environmental NGOs had a significant direct effect. This means that the relationships between these two trust variables and the acceptance variable are likely to have another mediator [87] other than benefit perception and risk perception. This implies that researchers who wish to find underlying mechanisms other than benefit and risk perceptions in the relationship between trust and nuclear power acceptance may benefit from focusing on trust in government and environmental NGOs.

Fourth, our results show a pattern in the relative impact of trust in different actors. The direct agent of nuclear energy policy-making is the Korean government and the agent involved in the actual ownership and operation of nuclear power plants is KHNP, Korea's main nuclear energy authority. In contrast, the nuclear academia and environmental NGOs do not have direct authority to determine or carry out nuclear policy. Our results show that the size of the total effect of trust in the latter group is between medium (0.30) and large (0.50), whereas that of trust in the former group is below medium (0.30) [88]. In other words, trust in actors outside of direct policy-making and actual implementation seems to have a more substantial impact on the Korean public's nuclear power acceptance than direct policy-makers and implementers of nuclear policy. It is unclear whether such a difference between a direct actor group (i.e., the government and the nuclear energy authority) and an outside actor group (i.e., the nuclear academia and environmental NGOs) in the effect of trust is a phenomenon unique to Korea. However, such a difference suggests the need to compare the effect of trust between direct vs. outsider groups.

5.2. Practical Implications

The findings of the present study provide implications for actors in a nuclear phase-out situation, especially for agencies in charge of such phasing-out. First, the importance of earning the public's trust also holds for the government to gather support for the phasing-out of nuclear power. Thus, the government should exert continuous efforts to earn the public's trust by developing effective communication programs.

Second, government agencies need to note that, in a nuclear phase-out situation, trust in government and in nuclear energy authority exert differentiated effects on nuclear power acceptance, although the former controls the latter directly or indirectly. As of 2019, 31 countries around the globe are operating nuclear power plants; about 30 countries are considering, planning, or initiating nuclear power programs. Among those 31 countries, a few have decided to de-nuclearize: Belgium, Germany, Korea, Spain, Sweden, and Switzerland [89–92]. Government agencies in these countries need be mindful of the danger that allowing a nuclear energy authority to deploy active public communications may give that authority public trust, which can lead to increased public acceptance of nuclear power, thereby impeding the government's nuclear phase-out policy.

Third, as we have seen, the total effect of trust in government is relatively small (i.e., small-to-medium [88]). Thus, when deploying public communication programs for nuclear phase-out, the government needs to link up with actors whose trust effect on nuclear power acceptance is relatively large and negative (e.g., environmental NGOs) so that the associated actor might benefit from joint communication programs and earn more trust from the public.

Fourth, all actors who want to increase or decrease public acceptance of nuclear power need to note that the benefit and risk perceptions are the key underlying variable in the relationship between trust and nuclear power acceptance. Thus, when an actor utilizes its gained public trust through public communication, the actor needs to focus on influencing the public's benefit and risk perceptions.

5.3. Limitations and Future Research Directions

This study has limitations that future studies should address. First, as a proxy for trust in an actor related to nuclear power, the survey in this study adopted trust in information or messages about nuclear power from that actor. As we described, we used a proxy to measure the trust construct in a manner that could be easily understood by the survey target—ordinary Korean citizens. However, a proxy is a proxy, regardless of how well it represents the target construct. In addition, due to the limitation in survey length, the trust variables were measured with only one item for each trust target. Several studies have noted that trust is a multi-dimensional construct [46,93]. Consistent with this, different dimensions of trust may have differentiated effects on the acceptance of a generation source. Future research needs to adopt more precise measures of the trust variables and needs to be further refined to compare the effects of different trust dimensions.

Second, we cannot exclude the possibility that proximity to nuclear facilities is a moderator of the relationships in the trust–acceptability model, especially that between trust and risk perception. Individuals living in the vicinity of a nuclear facility may perceive risks from nuclear power to be more relevant to their daily lives and thus have a greater level of risk perception. For risk perception accumulated in life, the impact of external cues such as trust may be relatively weak. In this light, the proximity of an individual’s residential area to the nearest nuclear facility may moderate the trust–risk relationship. However, the residential area in this study’s survey was distinguished only at the levels of the province or metropolitan city (i.e., which province or metropolitan city the respondent resided in), focusing on considering the proportion of the population by province or metropolitan city in the sampling process. Thus, the area measurement was not detailed enough to precisely indicate such proximity. For example, Hanul Nuclear Power Site, one of the nuclear power plants in Korea, is located in Uljin County, Gyeongsangbuk Province. This county is bordered by Gangwon Province, so it is closer to nearby areas in Gangwon Province than it is to distant areas in its own province. Thus, future studies need to further subdivide the residential area at the city or county level so that the area distinction can indicate the proximity from an area to a nuclear facility in a more precise manner.

Third, the levels of the public’s experience, knowledge, and uncertainty about benefits and risks may differ between different generation sources [2]. Thus, the degree to which the public rely on trustworthy social actors when perceiving and evaluating a generation source may also differ across generation sources, thereby rendering the effect of trust different across generation sources. Therefore, verifying the trust–acceptability model for another generation source being phased out in addition to nuclear power (e.g., fossil fuel, which is being phased out by several governments) seems necessary. The present study has extended the coverage of the trust–acceptability model to a new situation of nuclear phase-out and it will be necessary for further research to extend such extension to another generation source.

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