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Does Trust Matter? Analyzing the Impact of Trust on the Perceived Risk and Acceptance of Nuclear Power Energy

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Abstract: Recently, trust has been in vogue in the social sciences. However, in risk studies, there have been few causal models of trust. This study proposes and tests a causal model of trust in which (1) source credibility influences trust and (2) two kinds of trust—i.e., trust in government and trust in regulation—affect the perceived risk and acceptance of nuclear energy. Based on survey data with a sample of 1014 local residents living near a nuclear power station, we tested a causal model using structural equation modeling. As for the results of the analysis: first, we confirmed the validity of the proposed causal model of trust. Second, on the causal path, credibility directly influenced trust in government and trust in regulation and indirectly affected the perceived risk and acceptance of nuclear power. Third, the two kinds of trust had (in)direct impacts on perceived risk and acceptance. Trust in regulation had more power to explain perceived risks and acceptance than trust in government. Trust is important, but the kind of trust is more important.

Keywords: trust; causal model of trust; source credibility; trust in government; trust in regulation

1. Introduction

Following the Fukushima nuclear accident in Japan in 2011, there was an increase in the perceived risk of nuclear power. This fear was the reason for a drop in support for nuclear power energy. In Japan, Kitada [1] analyzed surveys conducted over the past 30 years and reported that (1) negative opinions toward nuclear power generation, which constituted 20–30% over the past 30 years, increased to 70% from 4 to 6 months after the Fukushima accident; (2) many people opposed future replacements or new construction of nuclear power plants; and (3) when considering power generation options, people now tend to focus on the risk of accidents (p. 1686). In the US, according to Gallup, the American people's support for nuclear power as a means for electricity production has fallen from 62% in 2010 to 57% in 2013 [2].

However, different findings have also been reported; Kristiansen et al. [3] analyzed the evolution of public opinion about nuclear energy in Switzerland from 2012 to 2014. They reported that public attitudes toward nuclear energy became slightly more positive as time passed. Visschers and Siegrist [4] studied change and stability in the states and determinants of acceptance of nuclear power. In terms of changes, both acceptance of and trust in nuclear power decreased after the Fukushima accident. However, in terms of stability, the perceived benefits/risks and trust influenced the acceptance of nuclear power before and after Fukushima. Moreover, trust had a strong impact on the perceived benefits and risks. Moreover, the perceived benefits before the Fukushima accident had a relationship with the perceived benefits after it.

An attitude change following the Fukushima incident induced several advanced countries to move their energy policies away from their focus on nuclear power. After the disaster, the Japanese government temporarily cancelled plans for nuclear development, ordered large-scale inspections of nuclear power stations and set up new safety regulations. Around the same time, Germany stopped the operation of eight older reactors. It announced a new plan for generating electricity that mainly focused on renewable energy, as well as a drastic plan to phase out all of its nuclear power plants by 2022. Also, Switzerland made the decision to build no more nuclear power plants and to phase out nuclear power production by 2034.

Siegrist et al. [5] analyzed why some people changed their attitude toward nuclear power after the accident in Fukushima. They pointed out that a change in benefit perception after the accident strongly influenced the acceptance of nuclear power. Moreover, they reported that people perceived somewhat more risks related to nuclear power after the accident. Of course, the trust in nuclear energy depends not only on safety related issues, but also on security issues, nuclear waste management and resource availability issues; Cipollaro & Lomonaco [6] argued that a methodology aiming at enhancing the synergies between nuclear security and safety will contribute to ensuring the nuclear 3S (Safety, Security and Safeguards). Bomboni et al. [7] critically reviewed the recent improvements in minimizing nuclear waste in terms of quantities, long-term activities and radiotoxicities. Chersola et al. [8] discovered that nuclear waste can be used for energy production in new nuclear plants.

When public opposition and fear toward nuclear power energy increase, trust becomes an important factor in making people feel safe. Thus, recently, much attention has been paid to trust in risk studies. However, very few studies have used a causal model of trust to specify and empirically test the relational structure between kinds of trust, its antecedents and its outcomes. Viklund [9] argued that the research on trust and risk perception has been criticized for taking the issue of empirical evidence too lightly (p. 728).

This study proposes and tests a causal model of trust that covers not only different types of trust but also its antecedents and impacts on perceived risk and acceptance of nuclear energy. The importance of trust can be confirmed through verification of this causal model, which specifies the effect of different types of trust and their relationship with the antecedents and outcomes.

2. Theoretical Background

2.1. Overview

Trust has emerged as an important theoretical concept in social science research over the last three decades and in particular during the last decade [9] (p. 728). Many scholars regard the concept of trust as complicated and multi-dimensional, rather than simple and unidimensional [10]. Rousseau et al. [11] defined trust as “a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another” (p. 395).

Many studies have attempted to define trust at the institutional level, because institutional trust matters in the political and administrative spheres. In previous studies, institutional trust was usually defined in terms of agency and institution. Some studies focused on the actors, whom they regarded as proxies for institutions. For example, Moy and Pfau [12] defined institutional trust as an attitude toward a political system, mainly focusing on the political organization and leader. Moreover, Moy et al. [13] added other actors such as courts, police, public education institutions, religion groups, labor unions, healthcare organizations and the news media as objects of trust.

Second, some scholars defined institutions in terms of themselves or specific situations. Based on a factor analysis of about 13 public organizations in China, Yang and Tang [14] suggested 3 types of trust: trust in administrative institutions, trust in legal institutions and trust in societal institutions. Shapiro [15] described institutional trust as people’s belief in the security of situation which is related with safety procedure and structure. According to Cook et al. [16] and Smith [17], institutional trust is a

specific type of trust that citizens hold toward not only public organizations but also public institutions or systems.

Third, trust in institutions is a kind of attributes. Kasperson et al. [18] suggested four dimensions of trust: commitment, competence, caring and predictability. Poortinga and Pidgeon [19] referred to a wide range of trust-related attributions, such as competence, care, fairness and openness, as components of a general trust. Moreover, Reen and Levine [20] identified five behavioral or emotional attributes of trust: perceived competence, objectivity, fairness, faith and consistency.

Why do people trust in specific institutions? First, a lot of studies have focused on the rational basis for trust [21,22]. They understand that institutional trust is not culturally embedded in society but is primarily an evaluation orientation in terms of rational perspective. Therefore, trust is a kind of byproduct of evaluations of the performances of actors and organizations who operate the institutions. Following this view, Hakhverdian and Mayne [23] distinguished input or procedural performance from output or policy performance. Second, other researchers stressed the expectation of not already realized performance. For example, McKnight et al. [24] regarded institution-based trust as a situational normality and structural assurance. The first is a belief in the expectation of success in normal situations, whereas the latter is a positive result stemming from contextual structure, which is based on contracts, regulations and assurances. Third, some studies saw trust as being an implicit norm and a form of moral legitimacy that is not rational but imperative [25]. Why does trust matter? In theoretical terms, a lot of research confirmed the significant role of risk judgment. Hsieh [26] demonstrated that institutional trust has a negative relationship with perceived risk. Similarly, in online transactions, institutional trust decreases the perceived risk [27]. In the case of nuclear power, trust in environmental organizations such as the Environmental Protection Agency, national environmental groups and university scientists did not impact on trust toward nuclear power, whereas that in nuclear-related actors such as the nuclear industry and the Nuclear Regulatory Commission had a negative effect on it [28].

As a lot of theoretical and empirical research about trust has been conducted, evaluating the related theories is demanding. Poortinga et al. [29] did an extensive literature review of trust and identified three theoretical perspectives on trust: (a) the dimensional approach to trust, which aims to identify the basic components of trust; (b) the salient value similarity approach, which holds that people base their trust judgments on the heuristic of perceived value similarity; and (c) the associationist view of trust, which stresses the importance of prior attitudes (p. 1675).

Related to the above dimensional approaches, since trust is so abstract a concept, it has a lot of dimensions of meaning. Therefore, distinguishing the various types of trust has been necessary. Rousseau and colleagues [11] suggested two types of trust: relational and calculative. The first concerns the relationship between the trusting person and the other. The second refers to the past behavior of the other and/or constraints on future behavior.

It is necessary to specify the roles and functions of the different forms of trust in terms of their relationships with their antecedents and outcomes. This demands two research activities. The first is an examination of how various kinds of trust have different effects. The second is the specification of the different forms of trust's relationships with their antecedents and impacts; this requires setting up a *causal model* and then verifying it via empirical testing. Recently, causal models have been built in risk research. For example, Poortinga and Pidgeon [30] suggested a causal model that includes three components: trust, risk and acceptability (see Figure 1).

Moreover, Siegrist [31] demonstrated the causal links between trust, risk and acceptance. The author showed that trust in institutions has a positive impact on the perceived benefits and a negative one on the perceived risks of biotechnology. Moreover, perceived benefits and risks influence the acceptance of biotechnology.

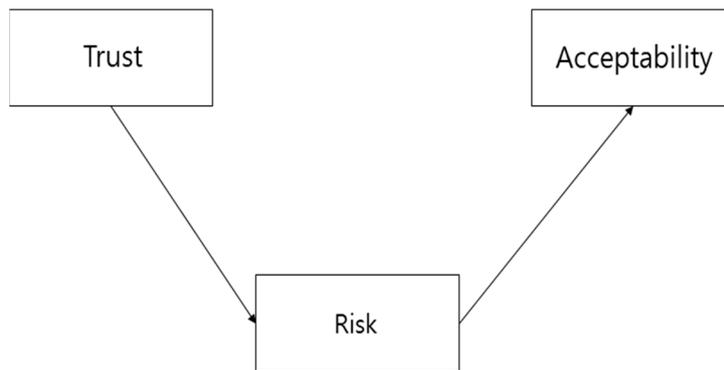


Figure 1. Causal model of trust. Source: Poortinga & Pidgeon [30].

Recently, Poortinga et al. [29] suggested the following causal model of trust: Affect (prior attitude) → evaluation of government → trust in regulation → acceptability. Even though Poortinga et al. [29] proposed the model, it has undergone little empirical testing in risk studies. Therefore, this research focuses on the relationships between (1) source credibility; (2) trust in government and in regulation; and (3) credibility/trust and their impact on the perceived risk and acceptance of nuclear energy. Based on Poortinga and Pidgeon [30] and Poortinga et al. [29], we propose the causal model of trust seen in Figure 2. This model mainly focuses on verifying the relationships that consist of (1) two kinds of trust; (2) an antecedent of trust (e.g., source credibility); and (3) an effect of trust (e.g., perceived risk and acceptance of nuclear power).

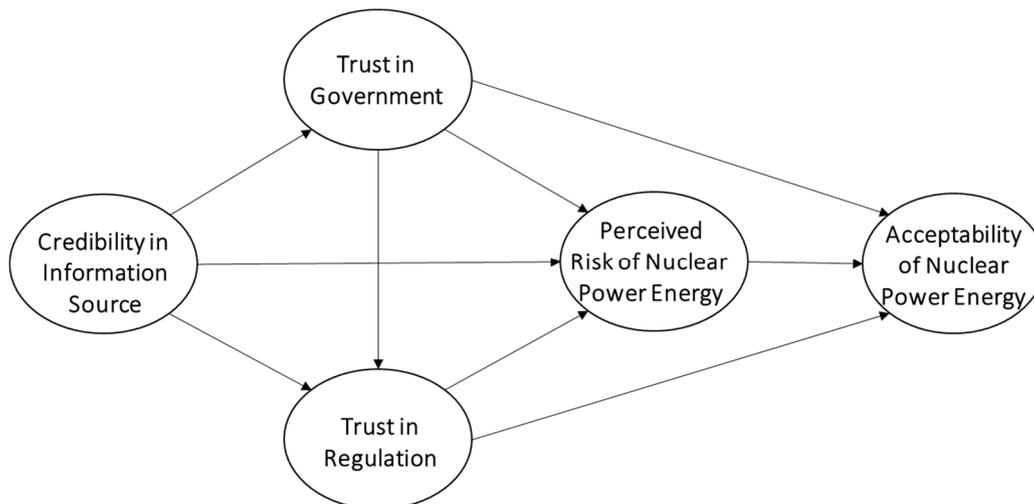


Figure 2. Casual model of trust.

Why does this research focus on credibility and trust in government and regulation in the causal model? Trust is usually oriented to actors or their instruments. We regarded the government as the main actor and the regulations as the main instrument in nuclear power policy. Following the Fukushima accident, opposition to nuclear energy has formed. In this context, there is a need for safer operation of nuclear power plants and materials. The government is responsible for both controlling and regulating nuclear power plants and providing people with safety information related to them. The public thinks that the government is mainly responsible for nuclear power safety [32]. Also, when the government takes an action toward nuclear power, it usually mobilizes regulation as an instrument. Therefore, trust in the government is necessarily linked to trust in regulation of nuclear power.

However, even when there is no government or regulation, the public should make a judgement toward nuclear power. In this case, the public usually depends on information for risk judgment. The effect of source credibility always exists. Even if recipients have no information about the government's capabilities and regulations, they should make a decision. For this, they need information. Information about nuclear power is a basic material for the public's risk judgement. Moreover, in this context, credible information plays a role in improving trust in the government and regulation.

Based on the above, it is reasonable to assume that (1) source credibility increases trust and (2) trust in the government and regulation plays a critical role in judging the perceived risk and acceptance of nuclear power. The following two sections will review the literature on the key components of the causal model, i.e., source credibility and trust in the government/regulation, and their impact on acceptance.

2.2. Source Credibility

Many communication studies have focused on the role of the credibility of an information source. Renn and Levine [20] defined credibility as "the degree of shared and generalized confidence in a person or institution based on their perceived performance record of trustworthiness" (p. 179). Moreover, Hovland et al. [33] defined source credibility as the combination of "the extent to which a communicator is perceived to be a source of valid assertions" and "the degree of confidence in the communicator's intention to communicate the assertions he considers most valid" (p. 21).

The effect of a message's persuasion depends on the credibility of the source [34]. The higher the credibility of an information source, the higher the possibility of changing attitudes [35]. Recipients should determine the reliability of information, even when they do not know it well, by using the cues provided by the information source [36,37].

Credibility can be transmitted from a variety of sources [38]. In other words, source credibility is composed of attributes or components. Source credibility has components that explain why people put trust in a source. Usually, such components are related to the "attributes" of the information source. Many attributes have been analyzed, such as expertise, objectivity, impartiality and fairness [39]. McCroskey and Teven [40] suggested that the factors of credibility include expertise, trustworthiness and goodwill.

Among the attributes of credibility, fairness means the acknowledgement and adequate representation of all relevant points of view [20] (p. 179). According to Renn and Levine [20], perceived fairness is a variable that can compensate for a lack of objectivity. Expertise is one of the main components of source credibility; Farr [41] sees it as consisting of two sub-components: technical competence and practical competence. The former is skillfulness by virtue of possessing special knowledge, whereas the latter is skills that result from direct participation in events or activities. According to Wilson and Sherrell's [42] meta-analysis, among source credibility, source manipulation accounts for 9% of variance among studies. The perceived expertise of information influences attitude and purchase intention [43]. Credible information has a direct effect on behavior related to the information. Objectivity is a lack of biases in information as perceived by others [16]. Trustworthiness is the main aspect of credibility. Trustworthiness is measured by the "degree of dependence, reliability, sincerity and trustworthiness" [41]. Our measurement items for source credibility reflected attributes such as fairness, expertise, objectivity and trustworthiness.

What is the effect of the credibility of an information source? Source credibility's effect has been examined across various domains. The quality of information is a variable that induces people the utilization of information and information system [44–46]. In addition, the quality of the information affects user's satisfaction [47,48], as well as reliability [49,50]. Moreover, according to Zahedi and Song [49] and Zhou, Li and Liu [50], the credibility of information can improve trust in the information provider.

Also, in risk studies on nuclear energy, source credibility was found to influence judgement. Ryu and Kim [51] tested the heuristic/systematic information processing model on the perception of risk

after the Fukushima nuclear accident and reported that source credibility had a positive effect on heuristic judgement. Also, Trumbo and McComas [52] confirmed the effect of source credibility on risk judgment. Our study assumes that credibility will directly influence trust in government and regulation and indirectly influence perceived risk and acceptance.

2.3. Trust in Government and Regulation

Trust studies have tried to specify the various kinds of trust and their impact; but why is it necessary to distinguish the various kinds of trust? Previous findings showed that different types of trust have different impacts. Sjöberg [53] demonstrated that specific trust is more powerful than general trust in explaining risk perception. Viklund [9] found different effects of various trust measures (i.e., general trust explains perceived risk better than specific trust). This evidence suggests the importance of different kinds of trust. Our study focuses on two kinds of trust: trust in government and trust in regulation, because the government is the main actor concerned with nuclear energy and regulation is the main instrument by which the government ensures the safe operation of nuclear power plants. Below, we review the impact of these two kinds of trust on the perceived risk and acceptance of nuclear energy. Also, we review trust as a mediator, which is a key factor in constructing the causal model of trust.

First, in risk studies, trust in government was found to have an impact on decreasing the perceived risk and increasing the acceptance of nuclear power. Pijawka and Mushkatel [54] empirically tested a strong negative relationship between trust in (government) institutions and the perceived risks of a high-level nuclear waste repository; higher trust in government reduced the perceived risk. Using structural modeling, Flynn et al. [55] showed significant negative relationships between trust in risk management and perceived risks. Via a comparative analysis, Viklund [9] demonstrated that trust in those responsible for risk management (politicians, authorities and corporations) could explain the variation in perceived risk (p. 728) and also showed that trust is a significant predictor of perceived risk within countries. However, such effects vary by country. In particular, the perceived capabilities of employees by customers improve not only trust in employees and enterprises but also decrease perceived risk [56].

Moreover, trust increases the acceptance of a risky object. Based on the causal chain account of trust by Eiser et al. [57], Poortinga and Pidgeon [30] verified a causal model that consists of trust, risk perception and acceptability. According to Poortinga et al. [29], three evaluations of governments (value similarity, general trust and skepticism) may impact on trust in regulations, followed by the acceptability of risk objects. They empirically supported the notion that general trust increases trust in regulations, with a strong path. Also, trust in regulations increases the acceptability of risk. Jeong and Kim [58] showed that trust in the government has increased the four dimensions—realistic, local, practical and alternative—of acceptance of nuclear power.

As already mentioned, regulation is the main instrument by which a government achieves specific policy goals. Poortinga and Pidgeon [30] pointed out that although there is a lot of empirical evidence that trust in risk regulation is strongly related to the acceptability of risk, the direction of this relationship is less clear. They showed that there were negative relationships between trust in regulation and perceived risk of GM food. Jeong and Kim [58] showed that trust in regulation among several trust dimensions is the most powerful variable in explaining the acceptance of nuclear power in term of realistic, practical and alternative sides.

Why does regulation have an impact on perceived risk and acceptance? The answer is based on an attribute of regulation called “capability.” Capability has been defined as a trusted subject’s ability to meet needs [59]. Perceived competence is the degree of technical expertise assigned to a message or source [20] (p. 179). The more capability people are perceived to have, the more trustworthiness they have.

The effects of competence or capability on trust can be applied at the institutional level. Regulation’s competence usually induces effectiveness in terms of institutional performance.

For example, according to Renn and Levine [20], the perceived competence of institutions was most likely associated with the perception of successful task performance and the perceived cost-benefit ratio in meeting those tasks. If a regulation has competence, it will reduce the perceived risk of nuclear power by ensuring better performance in safety work. Finally, competent regulation will increase the trust and acceptance of nuclear power. In this vein, we reflected competence in measuring trust in regulation.

Third, trust mediates the relationships between its antecedents and outcomes. Such a mediation is a kind of link connecting cause and result. Flynn et al. [55] showed that trust mediates the effect of trust on opposition to a repository. Biel and Dahlstrand [60] found a very strong negative relationship between trust in experts and risk judgment. Siegrist [11] tested a causal model in which trust mediates the relationships between perceived risk and acceptance of gene technology. Siegrist and Cvetkovich [61] confirmed that when social trust was controlled for, correlations between perceived risks and benefits diminished.

From the above review, we know that trust in government and regulation has an impact on perceived risk and acceptance of nuclear power. Also, trust mediates the relationships between its antecedents and outcomes.

3. Sample and Measurement

To test the model, we analyzed survey data collected from 1014 local residents around four nuclear power station sites in South Korea (Yeongkwang, Uljin, Wulsung and Gori). This survey was conducted from 17 March to 8 April 2015. To ensure the representativeness of the sample, the survey respondents were selected through a proportional quota sampling method. Moreover, we set the quota based on gender, age and region. The surveys were administered by interviewers via person-to-person interviews. A basic description of the respondents can be found below (Table 1).

Table 1. Frequency in demographic variables.

Variable	Categories	Frequency	Percent (%)	Variable	Categories	Frequency	Percent (%)
Gender	Male	509	50.2	Region	Yeongkwang	258	25.4
	Female	505	49.8		Uljin	249	24.6
	19–29	133	13.1		Wulsung	250	24.7
30–39	145	14.3	Gori		257	25.3	
Age	40–49	178	17.6	Social class	Low	449	44.3
	50–59	207	20.4		Middle	463	45.7
	Over 60	351	34.6		High	102	10.1
Education level	Middle School	343	33.8	Household income	199 M.W.	309	30.5
	High School	346	34.1		200–299 M.W.	160	15.8
	University conservative	325	32.1		300–399 M.W.	196	19.3
Ideology	neutral	421	41.5		400–499 M.W.	129	12.7
	progressive	411	40.5		Above 500	220	21.7
		182	17.9				

On 29 April 1978, Korea began operation of a nuclear plant in Gori. By 2016, nuclear power made up 30.0% of electricity production in the country. By 2017, there were 24 nuclear power reactors for electricity generation in 4 areas: Gori, Yeongkwang, Uljin and Wulsung.

Residents near the four nuclear sites showed different attitudes toward nuclear energy. Table 2 lists the mean values of five variables. An ANOVA test showed that four of the five variables showed significant differences. Uljin showed the highest values for source credibility, trust in the government and acceptability but the lowest value for perceived risk. On the other hand, Wulsung showed the highest perceived risk, but lowest source credibility and acceptance of nuclear power. These

findings demonstrate the significant and consistent relationships between credibility, perceived risk and acceptance.

Table 2. Means and differences across the four nuclear power sites (ANOVA test).

Variable	Region	N	Mean	SD	F	Scheffe
Credibility of information source	Yeongkwang (A)	258	2.85	0.67	2.955 *	b > c
	Uljin (B)	249	2.96	0.67		
	Wulsung (C)	250	2.78	0.70		
	Gori (D)	257	2.87	0.67		
	Total	1014	2.87	0.68		
Trust in regulation	Yeongkwang (A)	258	2.86	0.70	1.220	
	Uljin (B)	249	2.91	0.70		
	Wulsung (C)	250	2.79	0.74		
	Gori (D)	257	2.86	0.68		
	Total	1014	2.85	0.71		
Trust in government	Yeongkwang (A)	258	2.89	1.11	3.070 *	b > d
	Uljin (B)	249	3.12	1.35		
	Wulsung (C)	250	2.92	1.03		
	Gori (D)	257	2.86	0.62		
	Total	1014	2.94	1.06		
Perceived risk	Yeongkwang (A)	258	3.41	0.83	7.280 ***	c > a,b
	Uljin (B)	249	3.35	0.89		
	Wulsung (C)	250	3.70	0.85		
	Gori (D)	257	3.50	0.98		
	Total	1014	3.49	0.90		
Acceptability	Yeongkwang (A)	258	2.56	0.89	15.971 ***	a,b,d > c; a,b > d
	Uljin (B)	249	2.53	0.97		
	Wulsung (C)	250	2.05	0.95		
	Gori (D)	257	2.31	0.90		
	Total	1014	2.36	0.95		

* $p < 0.05$; *** $p < 0.001$.

The survey examined whether the credibility of an information source has an impact on trust in the government and regulation and how those variables affect the perceived risk of nuclear power. The credibility of the information source was measured by using a five-point Likert scale that covered the source's accuracy, expertise, validity and trustworthiness. Previous research adopted two methods for measuring the credibility of a source. First, Song et al. [62] defined the source in terms of specific objects; they designated actors and organizations as sources. However, such a method has its limits. Since a source is defined in terms of agency, it is not conceptually differentiated from trust in the actors. In this context, a lot of research conceptualized this in more abstract terms, stressing the attributes of the source, not specific objects. For example, Meyer [63] included accuracy, fairness, bias, trustworthiness and completeness as attributes of a credible source. McCroskey and Teven [40] focused on competence, goodwill and trustworthiness.

Trust in the government was measured by focusing on capability and ability. Trust in regulation was measured by focusing on its sufficiency and appropriateness, using a five-point Likert scale. The measurement of regulation focused on regulation by the government, which takes full responsibility for the safety of nuclear power in Korea. To prevent overlap between the government and regulation in measurement, we stressed the instrumentality of regulation. To this end, we included the attributes of regulation, such as competence, sufficiency and appropriateness in the measures. Perceived risk was measured using a five-point Likert scale. The reliability of the measures is shown in the rightmost column of Table 3. All reliability values (Cronbach's alpha) met the specified minimum (0.60).

Table 3. Concept, measures and reliability.

Latent Variable	Measures	Reliability
Credibility in information source	Information provided by source is reliable information	0.959
	Information provided by source is accurate	
	Information provided by source is based on facts	
	Information provided by source is undistorted	
	Information provided by source is true without falsehood	
	Information provided by source is fair	
	Information provided by source is proven	
	Information provided by source is based on deep knowledge	
	Information provided by source is responsible	
Trust in government	Government	0.754
	Korea Atomic Energy Institute	
	Nuclear Regulation Commission	
Trust in regulation	Regulation competence by government to control nuclear safety is sufficient	0.783
	Current level of regulations toward nuclear power is sufficient to control risks associated with nuclear power plants	
	The level of regulation over nuclear power by government's is appropriate	
Perceived risk	The nuclear power station gives harm to my health	0.909
	The nuclear power station gives loss to my family	
	The nuclear power station is making the health in local resident's health worsen	
Acceptability	I support the construction of another nuclear power station built in our local	0.748
	I agree to build the radioactive waste disposal site in our local	
	I agree to extend the use of nuclear power energy	

4. Analysis & Findings

4.1. Descriptive Statistics

To learn the basic relationships between variables, we calculated the means, standard deviations and simple correlation coefficients, as seen in Table 4. The means of source credibility and trust in government and regulation appeared below 3.0 on the five-point scale. The perceived risk was 3.49, whereas the acceptance of nuclear power was 2.36, a lower score. Those figures may demonstrate present attitudes toward nuclear energy in the local context. Since local residents had directly experienced the risks of nuclear power stations, they tended to have more negative attitudes toward nuclear power stations and energy.

In the simple correlation, the credibility of the information source had a more positive relationship with trust in regulation than trust in the government; it had a higher correlation coefficient with trust in regulation. This implies that the respondents considered not the actors themselves, but the government's competence and the sufficiency of regulations as important factors in their judgments.

Also, there was a positive correlation between trust in government and trust in regulation. However, the coefficient was not larger than that of source credibility and trust in regulation. This means that there exist some distinctions between government and regulation.

Moreover, credibility and trust had negative relationships with the perceived risk of nuclear power. Among the three variables, trust in regulation showed the highest correlation with perceived risk.

Acceptance of nuclear energy had positive relationships with credibility and trust and a negative one with the perceived risk of nuclear energy. Except for the one between acceptance and trust in the government, the three coefficients had similar values, ranging from 0.414 to 0.427. Again, trust in the government showed a lower value. This implies that the government as an actor takes a less

significant role in contributing to trust building at the local level. Table 4 shows the impact of the Fukushima nuclear accident on the five variables in the research model. The accident had a positive relationship with the perceived risk of nuclear power but negative ones with the other four variables.

Table 4. Simple correlation results.

Variable	A	B	C	D	E	F
Credibility of information source (A)	1					
Trust in government (B)	0.356 ***	1				
Trust in regulation (C)	0.611 ***	0.279 ***	1			
Perceived risk of nuclear power energy (D)	−0.321 ***	−0.220 ***	−0.349 ***	1		
Acceptability of nuclear power energy (E)	0.418 ***	0.235 ***	0.414 ***	−0.427 ***	1	
Fukushima nuclear accident risk perception (F)	−0.298 ***	−0.129 ***	−0.271 ***	0.389 ***	−0.312 ***	1
Mean	2.87	2.94	2.85	3.49	2.36	4.11
SD	0.68	1.06	0.71	0.90	0.95	0.73

*** $p < 0.001$.

To learn the causal power of credibility and trust, we regressed the perceived risk and acceptance on them. The results are shown in Table 5. In Model 1, we controlled the sociodemographic variables such as gender, age, education and household income. Then, we added credibility and trust into Model 2.

In Model 2, source credibility ($\beta = -0.148, p < 0.001$), trust in the government ($\beta = -0.114, p < 0.001$) and trust in regulation ($\beta = -0.237, p < 0.001$) all had a negative relationship with perceived risk ($F = 28.819, p < 0.001$). Among those three variables, trust in regulation had the largest standardized coefficient value with energy acceptance.

Model 2 had an explanatory power of 16.1%. It is noticeable that the R^2 change from Model 1 to Model 2 was 15.8%, compared to the lower value of 0.9% for the sociodemographic factors. This shows that more structural factors (e.g., income and education) had less explanatory power than the socially constructed perception factors.

Table 5. Multiple regression analysis of perceived risk.

Variable	Model 1			Model 2		
	<i>b</i>	<i>se</i>	β	<i>b</i>	<i>se</i>	<i>B</i>
(Constant)	3.355 ***	0.136		4.910 ***	0.169	
Gender (male)	−0.146	0.057	−0.082	−0.138 **	0.053	−0.077
Age	0.003	0.002	0.063	0.006 ***	0.002	0.118
Education (above college student)	0.050	0.073	0.026	0.065	0.067	0.034
Household income	0.0001	0.0001	0.019	0.00003	0.00011	0.008
Credibility in information source				−0.195 ***	0.050	−0.148
Trust in government				−0.097 ***	0.026	−0.114
Trust in regulation				−0.301 ***	0.047	−0.237
<i>F</i> -value		2.417 *			28.819 ***	
R^2		0.009			0.161	
ΔR^2					0.158 ***	

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 6 shows the effects of the eight independent variables on the acceptance of nuclear power. The results again showed the powerlessness of the sociodemographic variables, except for household income. Households with higher incomes showed more support for nuclear energy than those with lower ones. Previous research showed that higher income reduced the perceived risks [46]. It seems that this discounting of the risk by income induces higher acceptance.

Table 6. Multiple regression analysis for acceptance of nuclear power.

Variable	Model 1			Model 2		
	1. <i>b</i>	2. <i>se</i>	3. β	4. <i>b</i>	5. <i>Se</i>	6. β
(Constant)	2.254 ***	0.144		1.723 ***	0.222	
Gender (male)	0.112	0.061	0.059	0.062	0.051	0.033
Age	0.000	0.002	−0.003	−0.002	0.002	−0.034
Education (above college student)	−0.074	0.077	−0.037	−0.075	0.065	−0.037
Household income	1.0.0003 *	2.0.0001	0.072	3.0.0003 **	4.0.0001	0.086
Credibility in information source				0.278 ***	0.048	0.199
Trust in government				0.050 †	0.026	0.056
Trust in regulation				0.252 ***	0.046	0.188
Perceived risk				−0.297 ***	0.031	−0.281
<i>F</i> -value		2.051			54.438 ***	
R ²		0.008			0.302	
ΔR^2					0.294 ***	

† <0.01; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source credibility and trust in two objects had significant positive relationships with acceptance, whereas perceived risk had a negative one. Among the four independent variables, perceived risk had the foremost explanatory power in terms of the standardized beta-coefficients, followed by source credibility, trust in the government and trust in regulation. Trust in the government still had little explanatory power.

In short, source credibility plays a crucial role in reducing the perceived risk of nuclear power. Among the two kinds of trust, trust in regulation has a more important role than trust in the government. Trust is important, but the kind of trust is more important.

4.2. Measurement Model

Regression analysis has its limits, as it does not show the causal relationships between independent variables or their impact on dependent variables. This is because it covers just “one step” of the causal chain from an independent variable to a dependent one. As it cannot cover a causal chain with more than two steps, it does not provide the role of antecedents laying before independent variables in a regression. Moreover, it does not remove measurement errors. Therefore, to show more complex causal chains and control the measurement errors, we adopted a structural equation model, by which we verified more sequential causal chains (source credibility → trust in government and regulation → perceived risk → acceptance) while controlling the measurement errors.

In this step, first we tested the proposed measurement model to verify if the measurement variables that reflected the latent variables were suitable, as shown in Figure 3. The model fit index of the measurement model was very good at $\chi^2 = 256.293$ ($p < 0.001$, $df = 80$), CFI = 0.980, NFI = 0.972, TLI = 0.970 and RMSEA = 0.047. The correlations between the latent variables were all significant at the $p < 0.001$ level. The factor loadings on the measurement variables reflecting the latent variables were higher than 0.5 and were significant at the $p < 0.001$ level.

In addition, to test the reliability and validity of the measurement variables, we applied the method suggested by Fornell and Lacker [64] and Fornell et al. [65]. The results are shown in Table 7. The criteria for reliability were above (1) 0.5 for standardized factor loading between the latent and measurement variables, (2) 0.7 for construct reliability, and (3) 0.5 for average variance extracted (AVE).

Validity requires that (1) the standardized factor loading value (λ) is significant and exceeds 0.07 and (2) the latent variables' AVE is more than the square of the correlation coefficient of the latent factors.

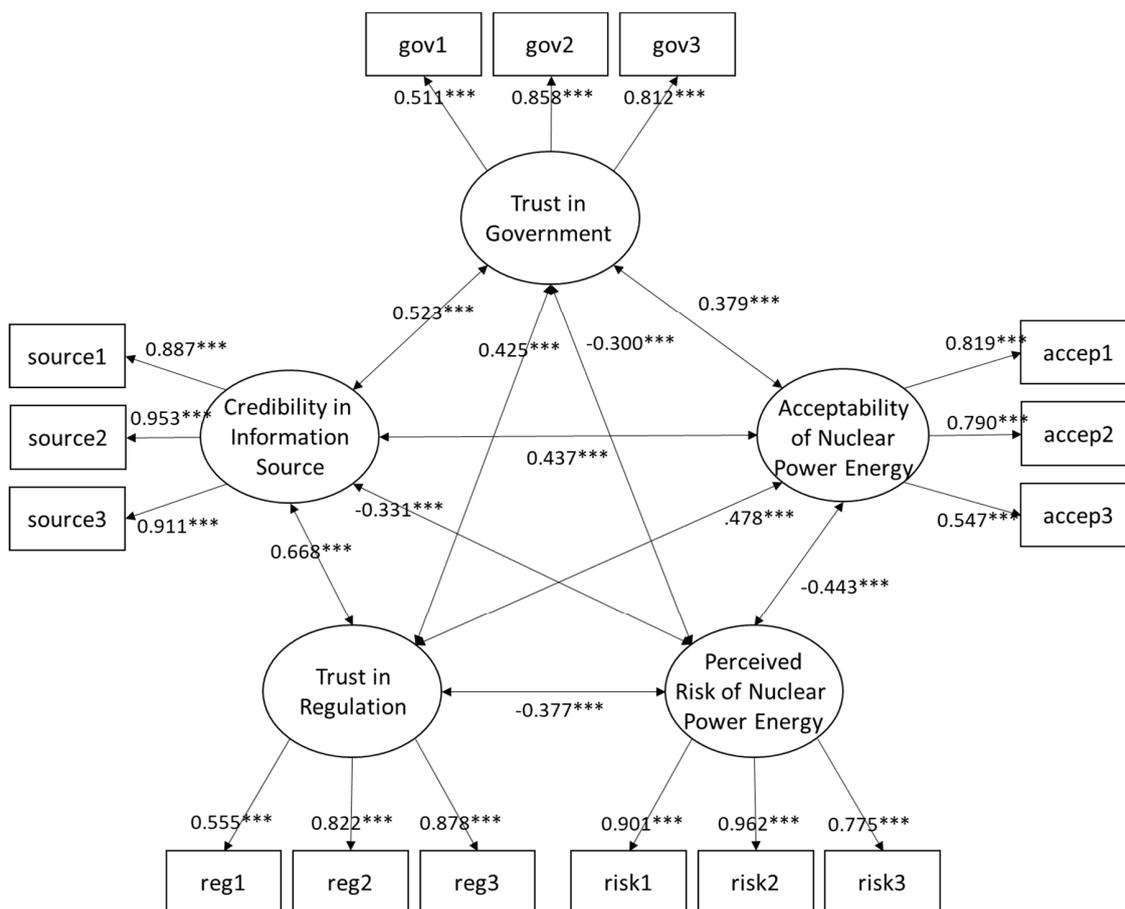


Figure 3. Measurement model. *** $p < 0.001$.

The results showed that except for three items, the measurement variables' standardized factor loadings were significantly higher than 0.7. Moreover, five latent variables' C.R. and AVE exceeded 0.5. The latent variables' AVE values appeared to be more than the square of the correlation coefficients of the related latent factors. All of these results prove the validity and reliability of the measurement in our model.

Table 7. Results on the measurement model.

Latent Variable	Measurement Variable	Standardization Coefficient (Squared)	AVE	CR	Correlation (Squared Correlation)
credibility in information source (A)	variable1	0.887 *** (0.787)	0.842	0.941	A&B = 0.523 *** (0.274); A&C = 0.668 *** (0.446); A&D = -0.331 *** (0.110); A&E = 0.437 *** (0.191)
	variable2	0.953 *** (0.908)			
	variable3	0.911 *** (0.830)			
Trust in government (B)	item1	0.511 *** (0.261)	0.552	0.780	
	item2	0.858 *** (0.736)			
	item3	0.812 *** (0.659)			

Table 7. Cont.

Latent Variable	Measurement Variable	Standardization Coefficient (Squared)	AVE	CR	Correlation (Squared Correlation)
Trust in regulation (C)	item1	0.555 *** (0.308)	0.585	0.803	B&C = 0.425 *** (0.181); B&D = -0.300 *** (0.090); B&E = 0.379 *** (0.144)
	item2	0.822 *** (0.676)			
	item3	0.878 *** (0.771)			
Perceived risk (D)	item1	0.901 *** (0.812)	0.779	0.913	C&D = -0.377 *** (0.142); C&E = 0.478 *** (0.228)
	item2	0.962 *** (0.925)			
	item3	0.775 *** (0.601)			
Acceptability (E)	item1	0.819 *** (0.671)	0.531	0.768	D&E = -0.443 *** (0.196)
	item2	0.790 *** (0.624)			
	item3	0.547 *** (0.299)			

*** $p < 0.001$.

4.3. Research Model

The model fit of the proposed research model (shown in Figure 4) was excellent: $\chi^2 = 39.841$ (df = 22, $p < 0.05$), CFI = 0.997, NFI = 0.993, TLI = 0.995 and RMSEA = 0.023. The credibility of the information source significantly influenced both trust in the government ($\beta = 0.526, p < 0.001$) and in regulation ($\beta = 0.619, p < 0.001$). Both trust in the government and in regulation had a positive impact on risk perception; the latter had a larger coefficient than the former. This means that regulation as an instrument to ensure safe operation is more important than stressing government competence. Moreover, in the course of risk management and communication for building and operating nuclear power stations, this means that the government should pay attention to gaining trust in regulation as a policy instrument from the public. Source credibility does not have a direct impact on perceived risk ($\beta = -0.078, p = 0.110$).

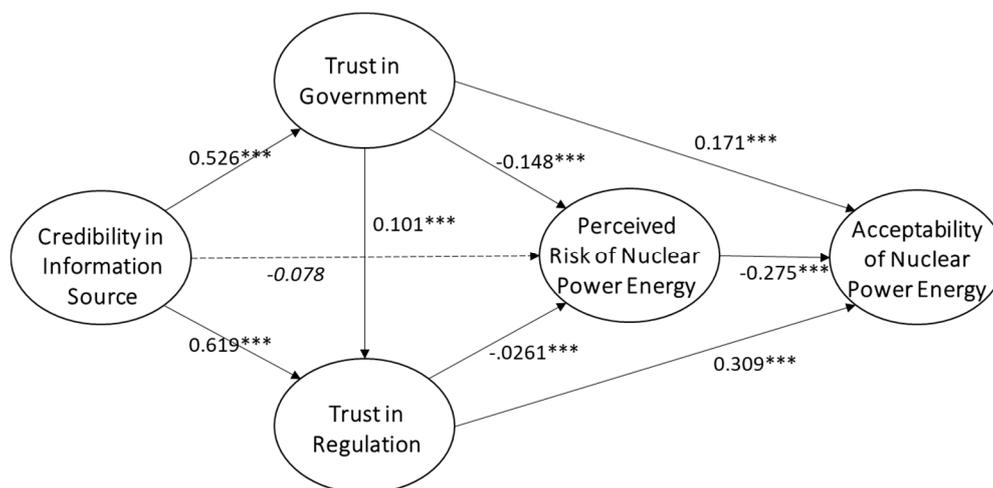


Figure 4. Research model. *** $p < 0.001$.

In terms of indirect effects, source credibility had negative impacts on the perceived risk of nuclear power by way of trust in both the government and regulation. Moreover, trust in the government significantly decreased the perceived risk of nuclear energy through trust in regulation. This revealed a significant indirect impact of the credibility of an information source and trust in the government by way of trust in regulation. Trust in regulation played the role of gatekeeper, facilitating the effect of credibility and trust in the government on perceived risk.

Acceptance was directly influenced by three variables: perceived risk, trust in regulation and trust in the government. Trust in regulation explained the largest variance in nuclear acceptance, followed by perceived risk and trust in the government. Perceived risk increased acceptance ($\beta = -0.275, p < 0.001$), whereas trust in the government and regulation decreased it. It is remarkable that trust was more powerful than perceived risk ($\beta = 0.171, p < 0.001$; $\beta = -0.261, p < 0.001$).

Credibility indirectly influenced acceptance through trust in government and regulation; the path by way of trust in regulation had more explanatory power than that by trust in the government. Perceived risk did not mediate the effect of credibility on acceptance. To decrease the perceived risk and increase acceptance, strategies will be needed that combine information credibility with trust in the government and regulation in the course of utilizing the information.

Moreover, perceived risk mediated the effect of credibility and the two kinds of trust on acceptance. Perceived risk buffered the positive effect of those two variables on acceptance. However, since the two kinds of trust directly increased acceptance, the final direction of acceptance depended on the power relationship between them and perceived risk.

Finally, by far the longest causal path significantly linked credibility to trust in the government to trust in regulation to perceived risk and to the acceptability of nuclear power. Such a long path suggests that the determinants of acceptance have different spatial distances; some are near, whereas others are farther. Understanding the process of acceptance will require a more comprehensive model that includes the various factors in this long causal path.

To test the statistical significance of the indirect effects, we used the bootstrapping technique. As seen in Table 8, all paths except for one (source credibility, perceived risk and acceptance of nuclear energy) were statistically significant.

Table 8. Tests of the indirect paths.

Indirect Path	<i>b</i>	BCI 95% (Lower:Upper)
A→B→E	0.174	0.094:0.260
A→C→E	0.259	0.172:0.351
A→D→E	0.028	−0.010:0.072
A→B→C→E	0.037	0.016:0.071
A→B→D→E	0.039	0.017:0.067
A→C→D→E	0.062	0.036:0.097
A→B→C→D→E	0.009	0.003:0.018

A: credibility in information source; B: Trust in government, C: Trust in regulation; D: Perceived risk of nuclear power energy; E: Acceptability of nuclear power energy.

Figure 5 shows the structural differences across the four local areas. Credibility of the information source showed all significant impacts on trust in the government and trust in regulation across the four areas. However, it did not directly impact perceived risk in the cases of Yeongkwang and Uljin, contrasting with Wulsong and Gori. Moreover, trust in the government showed a variety of impacts on perceived risk across the four regions; trust in the government in Uljin, Wulsong and Yeongkwang did not have a significant impact. Those varied impacts also applied to explaining the acceptability of nuclear power; trust in the government and regulation had positive impacts on acceptability everywhere except Yeongkwang. Perceived risk decreased acceptability in three out of four sites. Of course, the size of the standardized regression coefficients differed between the four regions. This implies that the local context matters when judging nuclear power issues.

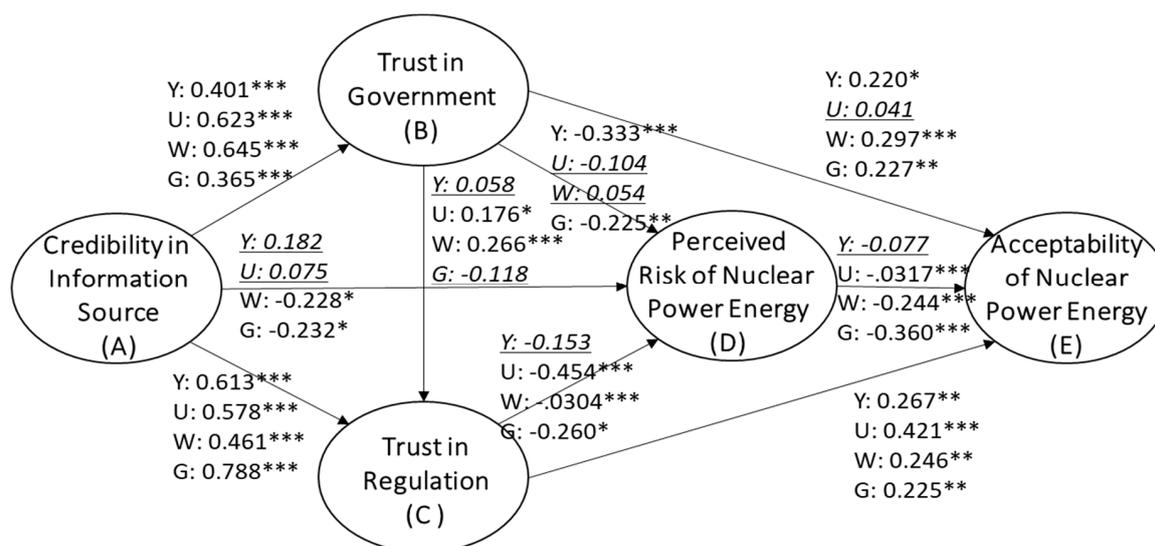


Figure 5. Research model at the regional level. Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Italics and underlining represent non-significance and standardized regression weights, respectively. Y: Yeongkwang; U: Uljin; W: Wulsung; G: Gori.

5. Findings & Discussion

This study aimed to propose and test a causal model of trust in which (1) the credibility of the information source affects trust in the government and regulation; (2) trust in the government and regulation influences the perceived risk of nuclear power and its acceptance; and (3) the effect of the credibility of the information source on the perceived risk is mediated by trust in the government and regulation.

First, the causal model we suggested showed excellent model fit: $\chi^2 = 39.841$ ($df = 22$, $p < 0.05$), CFI = 0.997, NFI = 0.993, TLI = 0.995 and RMSEA = 0.023. In the model, trust was the main factor that directly influenced the perceived risk and acceptance of nuclear power and mediated the effect of credibility on them.

Second, in the causal path, the credibility of the information source had a positive impact on trust in the government and regulation. This means that the credibility of an information source is the first condition for trust in the government as an actor and regulation as an instrument. However, source credibility did not have a significant impact on perceived risk.

Third, trust in the government and regulation had a direct positive effect on the perceived risk of nuclear power. People who were likely to positively evaluate the government and regulation showed negative evaluations of the safety of nuclear power. Source credibility did not impact the perceived risk; its effect came by way of trust in the government and regulation. However, it had indirect negative impacts on perceived risk by mediating the two kinds of trust. Moreover, trust in the government decreased the perceived risk through trust in regulation. Trust in regulation was a strong mediator of the link between credibility and trust in the government and risk perception. These findings mean that the government should have well-designed strategies for regulation as part of its risk management and communication efforts.

Fourth, acceptance was directly influenced by the two kinds of trust and perceived risk, among which trust in regulation explained the largest amount of variance, followed by perceived risk and trust in the government. Moreover, even if credibility was the farthest variable from acceptance, it indirectly influenced acceptance via the mediating variables. Therefore, it is still a variable that should be considered.

Our analysis showed the importance of two kinds of trust in risk communication; they directly or indirectly influenced the perceived risk and acceptability of nuclear power. Therefore, trust

management is needed in the risk communication process. Renn and Levine [20] explained that “trust in communication refers to the generalized expectancy that a message received is true and reliable and that the communicator demonstrates competence and honesty by conveying accurate, objective and complete information” (p. 179). To enhance trust as a means of making people feel safe, the government should build communication strategies to increase source credibility and trust in the government and regulation. In particular, it should try to set up better designs and implementations of regulations related to nuclear power.

Moreover, although trust matters, the kind of trust matters more. Our analysis showed that trust in regulation has more power to affect energy acceptance than trust in the government. In this vein, the government should consider implementing better designs for regulations. Moreover, it needs to set the priority among the various kinds of trust. Finally, even if information credibility does not directly influence perceived risk, it is still important because it influences all of the variables through indirect paths in two to four steps.

Our research shows the potential of a causal model of trust that consists of source credibility, two kinds of trust and their effect on perceived risk and acceptance. Credibility directly increases trust in the government and regulation and indirectly affects trust in regulation. Further, it indirectly reduces the perceived risk and acceptance of nuclear power through a long causal path. Trust in regulation has more power of explanation over perceived risk and acceptance than trust in the government. The effect of trust is mediated by perceived risk.

This research confirmed that (1) there exists a significant causal model of trust, which is useful in terms of theory and practice; (2) credibility and trust play important roles in the risk perception and acceptance of nuclear power; and (3) while trust is important, the kind of trust is more important.

Our researches contribute to theoretical side. First, because trust has been analyzed mainly in terms of actors, there are very few studies over regulation as a trusted object. We highlighted the significant role of trust in regulation in perceived risk and acceptance. Second, our study highlighted the structure of trust underlying overall trusts. Although previous studies have demonstrated the role of trust, the structural relationships between components of trust have not been clarified. We empirically tested the causal model of trust that previous researches conceptually suggested [29,30].

However, this study had its limits. First, we used only two kinds of trust. Second, although conflicts between trust and authority, trust and reputation, trust and power were very important issues, we did not cover those themes. Third, important variables in the psychometric paradigm, such as stigma and knowledge, were not considered in the causal model. More trust and risk perception factors should be entered into the causal model in the future.

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Conflicts of Interest: The authors declare no conflict of interest.

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