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Searching for the Next New Energy in Energy Transition: Comparing the Impacts of Economic Incentives on Local Acceptance of Fossil Fuels, Renewable, and Nuclear Energies

Seoyong Kim [1], Jae Eun Lee [2,*] and Donggeun Kim [3]

[1] Department of Public Administration, Ajou University, Worldcup-ro, Suwon 16499, Korea; seoyongkim@ajou.ac.kr
[2] Department of Public Administration, Chungbuk National University, Chungdae-ro 1, Seowon-Gu, Cheongju, Chungbuk 28644, Korea
[3] Department of Economics, Ajou University, Worldcup-ro, Suwon 16499, Korea; kimdongg@ajou.ac.kr
* Correspondence: jeunlee@chungbuk.ac.kr; Tel.: +82-43-261-2197

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Abstract: This study compares the impacts of economic incentives on attitudes related to the acceptance of fossil fuels, renewable, and nuclear energies. Linear and nonlinear regression models are applied for the robust estimation results. Empirical findings based upon these regression models are summarized as follows: First, when people belong to the upper social class, reside in metropolitan area, and have more trust in the government's energy policy, they tend to accept the construction of specific energy-related facilities in a neighborhood and raise the probability of attitude change and stability. Second, those who have more perceived risk and negative image are less likely to accept any types of energies and tend to lower the probability of attitude change toward positive direction or stability. Third, those who have more knowledge are less likely to accept some energy sources such as fossil fuels and there exists a trade-off relationship between knowledge and trust. Finally, the structural changes between acceptance of all energy sources with and without economic incentives imply that economic incentives play a significant role in determining acceptance of energies.

Keywords: attitude change; economic incentive; acceptance of fossil fuel energy; acceptance of renewable energy; acceptance of nuclear energy

1. Introduction

The purpose of this study is to understand the impact of economic incentives on attitude changes toward the acceptance of different forms of energies and the determinants of this impact. Our studies began with consideration of some practical and theoretical issues.

Viewed from a practical perspective, after the Fukushima disaster in 2011, global concerns were raised regarding the safety of nuclear power generation. This disaster offers an opportunity to initiate a global transition toward a new energy supply. Many governments consider not only economic advantages and eco-friendliness but also safety and social acceptance in setting new energy policies and, thus, announce energy transitions from policies centered on nuclear or fossil fuel energy to those centered on renewable energies, such as solar or wind energy.

However, to determine the new direction of an energy transition, a government must correctly understand whether its citizens currently prefer renewable or other new energies over traditional energies, such as nuclear power or fossil fuels. When government has planned to construct energy-related utilities and increases the acceptance of the residents of the areas where these energy-related utilities or facilities are to be built, it may consider providing economic incentives to the public in the case of unfavorable energy sources, particularly nuclear energy. Whether or not citizens increase their support for the energy source and agree to construct unfavorable energy-related facilities in their neighborhoods is a critical issue. Thus, it is important to analyze people's responses to various conditional requests, such as the provision of economic incentives. In particular, this analysis requires understanding the acceptance of the public's energy choice when economic incentives are provided to mitigate the opposition toward an (un)favorable energy source. Moreover, we must understand not only the public attitude changes under different conditions but also the factors that influence such attitude changes.

In terms of the theoretical side, it is necessary to understand the limits of past and current research and is necessary to make some progresses in the research on this area. Several drawbacks of previous studies are noticed through literature review and briefly described below.

First, even though several studies put the stress on the acceptability of nuclear power, most of them are simply focused on the outcome of attitude change caused by external events and tend to overlook the cause of the attitude change in research design. Some studies merely focused on the impact of disaster on the attitude change. For example, the Chernobyl accident on April 26, 1986 made people change their attitude toward nuclear power. Hohenemser and Renn [1] report that there was a sharp increase in opposition to nuclear power in Europe shortly after the Chernobyl accident. The opposition rate in Finland, Yugoslavia, and Greece increased more than 30%, and in Austria, West Germany, and Italy, this opposition rate increased more than 20%. After analyzing the changing pattern of acceptability of the same subjects with various time periods such as two months before the accident, one month after the accident, five months, and 19 months after the accident, Verplanken [2] shows that the opposition rates keep increasing.

Here is another example. The recent dreadful accident of Fukushima Daiichi nuclear power plant caused by the tsunami has changed people's attitude toward nuclear power dramatically. WIN-Gallup poll held in 47 countries in April 2011, just right after the Fukushima Daiichi disaster, reported that the percentage point expressing favor to nuclear energy drops from 57% before the accident to 49% after it [3]. According to Kessides [4]'s survey over 24 countries, 62% of respondents are against nuclear power. In addition, 26% of respondents say that they have changed their attitudes in favor of Fukushima nuclear plant after the accident.

In the UK, MORI [5] shows that the favorable attitude toward nuclear energy changes from 40% in November 2010 before the Fukushima accident to 28% in June 2011 after Fukushima. In Switzerland, after analyzing the three follow-up surveys which are conducted for Swiss residents in September 2010, March 2011, and October 2011, Siegrist and Visschers [6] show that the Fukushima accident has a negative impact on acceptability. In the case of China, Huang et al. [7] show that since the Fukushima nuclear accident, knowledge and risk about nuclear power have increased but convenience, trust, and acceptance about nuclear power have decreased. In the case of Italy, Prati and Zani [8] show that confidence in nuclear power has declined since the Fukushima nuclear accident.

However, these studies considered natural disasters which could not be controlled by policy makers as exogenous variable. To analyze the nexus between attitude change and characteristics of particular energy source through a variable which can be controlled by government or policy makers, we choose economic incentives. In addition, since previous research systematically compares the determinant structures of attitude before and after attitude change, we apply the comparative approaches in this study which compares the attitude before and after the economic incentive provided.

Second, previous studies usually focus on psychological measurements and neglect the influence of social aspect of energy variables such as energy security and energy affordability. Many studies on energy acceptability have relied on psychometric paradigms. The psychometric paradigm developed by Paul Slovic and his colleagues [9] considers risk not as an objective attribute but as a subjective construct. Visschers and Siegrist [10] (p.63) distinguish between risk research that they ares; "(1) research on the psychometric paradigm, which explains variations between the perception of different risks and (2) research on factors such as perceived benefits, trust, knowledge, affective association, values, and fairness that may determine an individual's perception of a risk. The first focuses on differences between the perceptions of different hazards. Fischhoff et al. [11] identify characteristics of risk as the dread and the unknown. The second tries to find out the perception structure by which individuals judged risks and the perception variations by which differences exist among people. In the case of nuclear power, perceived benefit and risk [12,13], trust [14–16], negative emotion [17], and knowledge [18] have been observed as variables that influence the acceptance of it.

There have been many criticisms about these perceptual studies because they ignored the social aspects of energy. The social or contextual aspects of energy such as energy security and energy affordability, can influence the acceptance of specific energies. Recent studies like Yamamura [19] show that the variables at the scientific and technological level influence nuclear-related attitudes. Demski et al. [20] show that energy security is key drive for major energy transitions. Corner et al. [21] demonstrate that people who express greater worry about energy security do not support nuclear power. Moreover, Spence et al. [22] demonstrate that concerns about energy affordability are positively related to preparedness to think about energy.

Third, there are not enough comparative studies among various energy sources. Few studies have attempted to make comparisons in terms of attitude change. Studies on acceptance of nuclear power have focused on perceived risks and benefits [12,13], negative emotions based on negative images [23], trust [14], and knowledge [18]. In the case of renewable energy, Sütterlin and Siegrist [24] show that people almost unanimously hold a strongly positive image of solar power. Stigka et al. [25] demonstrate that education, interest in environmental issues, and knowledge are associated with willingness to pay for renewable energy sources. Mallett [26] shows that to increase social acceptance of renewable energy innovations, people need not only knowledge, persuasion, implementation, and confirmation but also cooperation in which active participants are from various sectors and interact continuously throughout the process. According to Hosseini et al. [27], wind energy has the better social acceptance level than solar and geothermal energies in selected developing countries.

Fourth, while previous studies have focused on perceived benefit, there is a lack of research on what changes in acceptance may occur when perceived benefit changes. For example, according to Frewer et al. [28], the public acceptance of risky objects is determined by the magnitude of the perceived benefit about them unless the risk about them is too great to be acceptable. In Tanaka's [29]'s study, benefit perception has a greater impact on the acceptance of nuclear energy than risk perception does. According to Tusujikawa et al. [30], the perceived benefits have a positive impact on the acceptance of nuclear power plants. According to Vainio et al. [31], perceived benefits have a negative impact on the willingness to pay for alternatives to nuclear energy. Williams et al. [32] confirm that the economic benefits and reliance on the location of nuclear weapons facilities are functioning of lowering the perceived risks to nuclear energy. However, since these studies focus on the relationship between perceived benefits and acceptance, they cannot appropriately examine changes in acceptability when perceived benefits actually change.

Finally, previous studies do not analyze the various aspects of attitude change; i.e., they are rather post hoc analyses of attitude change. Therefore, it needs various kinds of attitude change such as comparison before and after the attitude change and its structure, the degree of change, the direction of change, and comparison between the change and the non-change groups.

Considering those arguments mentioned above, this study can extract four novel research aspects as follows: First, this study reflects the attitude change factors as endogenous variables, not exogenous ones, and analyzed the determinants of attitude change. Second, explanatory variables affecting the acceptance of various energies include not only perception factor abut also social aspect of energy such as energy security and affordability. Third, in addition to the perceived benefits, we analyze whether economic incentives can bring the attitude change or not. Finally, this study analyzes various aspects of attitude change; degree of change, the direction of change, comparison between groups, the determinant structure before/after providing economic incentives.

The rest of the paper is organized as follows: Section 2 contains the theoretical background, Section 3 provides the information about data and measurement, Section 4 shows the empirical findings, Section 5 includes discussion, Section 6 is about the summary and implication.

2. Theoretical Background and Research Model

2.1. Attitude Changes toward Different Types of Energy Sources

Because all the current energy transitions depend on the public's attitudes and attitude changes toward nuclear power, we need to observe previous studies about attitude changes to identify the factors that affect the public acceptance of specific energies. Studies of attitude changes toward energy have been conducted at both aggregate or country and individual levels.

At the country or aggregate level, many studies have examined changes in attitudes toward nuclear energy after the Fukushima disaster. Ipsos' [33] survey in June 2011, which covered 24 international surveys with 18,787 observations, found that many people expressed negative attitudes toward nuclear energy after the Fukushima disaster. Moreover, according to Black's [34] study of survey data, although the acceptance rating for nuclear power increased the most from 2005 to 2011 in the UK, ten other countries indicate showed decrease in acceptance of nuclear energy. Recently, Kim et al. [35] using data from 43 countries reveals that the Fukushima disaster decreased public acceptance of nuclear power globally. On the contrary, after tracking 790 people before and after the Fukushima disaster, Visschers and Siegrist [6] analyze the structure of a causal model of acceptance. They report that although the magnitudes of some coefficient values change owing to the Fukushima nuclear accident, the basic causal structure centered on trust, perceived benefits, risk, and acceptance do not change. Moreover, Midden and Verplanken [36] compare acceptance before and after the Chernobyl accident and show that attitudes toward nuclear power are not very different before and after the accident. These studies show that there exists attitude stability which does not vary much regardless of nuclear power accidents.

All these studies were executed at the country level, but attitudes and stability must be examined at the individual level as well. Moreover, since previous studies generally focused on natural disasters as stimuli for attitude changes, other situations must be examined as stimuli for attitude changes as well. Therefore, this study focuses not only on the stability of the public's preferences but also on the dynamics of attitude changes by focusing on economic incentives as stimulus at the individual level.

2.2. Economic Incentives

Previous studies have considered the roles of perceived benefits or economic incentives in decision-making regarding the acceptance of energies and have examined the positive effects of perceived benefits on the acceptance. Perceived benefits play an important role, as do perceived risk, trust, emotion, and knowledge, all of which are key variables in risk perception paradigms (the so-called psychometric paradigm) [30,37].

Economic incentives or perceived benefits can take various definitions because they include various elements. Chung and Kim [37] consider that the benefits of nuclear power include perceived regional image; perceived value of regional assets; perceived regional employment change; and perceived changes in local culture, education, and cultural facilities. Vainio et al. [31] describe the benefits of nuclear power to mitigate the negative impact from climate change. They state that "no international climate cooperation can be achieved without building a new nuclear power plant" and "accepting nuclear power will reduce dependence on coal and fossil fuel energy." De Groot and Steg [12] measure a variety of benefits obtained through economic growth, reduced climate change, job creation, affordable energy, reduced carbon dioxide emissions, reduced reliance on energy supplies, and reduced coal fuels.

These studies show that economic benefits or incentives refer not only to physical, but also to perceptual objects. Many studies have explored the influence of perceived benefits on the acceptance of specific energies. Chung and Kim [37] show that perceived benefit has a positive effect on the acceptance of a radioactive waste disposal facility. According to Tsujikawa et al. [30], perceived benefits have a structural impact on the acceptance of nuclear energy, in addition to perceived risk, managerial trust, and environmentalism. According to Tanaka [29], an individual's perceived benefits influence her/his acceptance of nuclear power plants and of high-level radioactive waste disposal sites. Visschers et al. [38] and Siegrist et al. [39] show that economic incentives are the main driver of support for nuclear energy. Visschers and Siegrist [6] demonstrate that the perceived benefits before and after Fukushima positively affect the acceptance of nuclear energy. These benefits include the acceptance of nuclear power plants based on dependence on electricity power generation, the existence of nuclear power plants without problems (reversed), and the acceptance of nuclear power generation owing to the insufficiency of renewable energy. Latent variables representing those benefits positively affect the acceptance of nuclear power.

In the case of renewable energy, according to Bidwell et al. [40], the belief that wind farms can provide economic benefits to one's community positively influences the support of commercial wind energy. Garcia et al. [41] show that the compensation influences the willingness to accept local wind energy development. They show that local resistance to wind development depends on the compensation mechanism, as households favor public compensation more than private one.

In addition to their direct effects, perceived benefits have indirect effects through mediation or moderation. De Groot et al. [13] demonstrate that perceived benefits not only have a positive effect on the acceptance of nuclear energy but also mediate the effect of value on the acceptance. According to Vainio et al. [31], the perceived benefits of nuclear energy negatively influence the willingness to pay for alternative energy. In addition, perceived benefits mediate the impacts of trust in information source on such willingness to pay. Tsujikawa et al. [30] show that perceived risk partly mediates the effect of trust on acceptance. In a study by Visschers and Siegrist [6], the effects of perceived benefits on acceptance are mediated by perceived risk.

Economic incentives motivate human behavior change. Niesten and Gjertsen [42] show that economic incentives drive local resource users to adopt environmentally sustainable behaviors that conserve biodiversity and natural habitats and enhance livelihoods. However, economic incentives do not always lead to their intended consequences. Based on a natural field experiment that introduces monetary and non-monetary rewards for eco-driving, Schall and Mohnen [43] demonstrate the potential superiority of non-monetary rewards to monetary compensation. Sometimes, unwanted accidents lessen or eliminate the effect of the incentive. According to Kato et al. [44], after the Fukushima accident, the benefit recognition of utility bill refunds declined even though that of public facilities was not. Moreover, monetary incentives can create unintended consequences in that they may produce the opposite result from the original intention. For example, economic incentives for siting nuclear energy will reduce its acceptance. Several studies have investigated why providing such benefits results in the lower acceptability of an unfavorable energy source. Kunreuther and Easterling [45] argue that rewards with no corresponding effort to reduce risk are likely to be perceived as bribes to gain public support. Frey et al. [46] explain that extrinsic incentives, such as economic rewards, not only destroy but also negatively impact the public's intrinsic motivation. They refer to this notion as a crowding-out effect. Moreover, Schively [47] points out that direct economic rewards are perceived as bribes to the public, which have unintended side effects. Thus, it is necessary to measure the impact of economic incentives on the acceptance of energy-related facilities in specific areas.

2.3. Perception Factors

Not only perceived benefits but also perceived risk, affective image, trust, and knowledge influence the acceptance of specific energy types. First, perceived risk and benefit are the critical factors to influence the acceptance of an energy source. De Groot et al. [13] argue that the increased use of nuclear energy depends on the trade-off between risks and benefits. The higher the perceived risk and the lower perceived benefits are, the lower the acceptance of nuclear power is [12,48]. Visschers and

Siegrist [38] show that perceived risks, rather than perceived benefits, before and after the Fukushima nuclear accident, have a negative impact on the acceptability of nuclear energy. Ho et al. [49] show that nuclear risk perception is an important determinant in the planning of new nuclear power plants. According to Yamamura [19], perceived risks from nuclear accidents are positively related to experience with technical disasters. In the case of renewable energy, after studying the factors influencing citizens' acceptance of wind energy in Germany, Langer et al. [50] demonstrate that the perceived risk, such as the fear of infrasound, is a crucial factor for acceptance. On the other hand, the higher benefit increases the acceptance of nuclear power [51].

Second, affective image refers to the emotional response, in contrast to the rational response. In a study by Peter and Slovic [23], negative emotions based on negative images have a decisive influence on perceived risk, which is critical for the acceptance of nuclear power. Sjöberg [17] demonstrates that empirical emotions affect perceived risk and benefit, which are key determinants of nuclear acceptance. Additionally, the emotional response to renewable energy matters. Maehr et al. [52] examine the emotional response to image of wind turbines on the landscape and report that turbines are more calming than other industrial constructions are and have an equivalent effect to that of churches.

Third, Cha [53] defines trust as the level of confidence in organizations that provide information about risks and that manage risk directly or indirectly. Higher trust in nuclear energy reduces the perceived risk of nuclear power and, ultimately, promotes the acceptance of nuclear [54]. In Katsuya's [14] study, trust in nuclear operations (e.g., the nuclear power utility company or government promotion of nuclear policy) is statistically significantly correlated with the acceptance of nuclear energy. Visschers and Siegrist [6] show that trust before and after the Fukushima nuclear accident affects perceived risks and benefits. In the case of renewable energy, trust has a positive impact on the general acceptance of wind power plants; trust in technology plays a more important role than trust in stakeholders does [55].

Finally, knowledge about energies generally enhances the acceptance of them. Knowledge has a positive impact on the acceptance of nuclear energy [7]. More knowledge implies greater perceived benefits from nuclear power, greater trust, and lower perceived risk, all of which lead to an increase in the acceptance of nuclear energy. Bang et al. [56] show that in general, consumers with more knowledge are likely to be willing to pay a premium for renewable energy more than those with relatively less knowledge about renewable energy are. Greenberg and Truelove [18] analyze the relationship between knowledge and risk and then show that individuals with a high level of knowledge about a particular object tend to accept it more even if the object is risky. We propose that the perception factors play a critical role in both attitude stability and changes related to the acceptance of energy.

2.4. Social Aspects of Energy

Among social aspect of energy, we focus on energy security and affordability. The International Energy Agency [57] defines energy security as "the uninterrupted availability of energy sources at an affordable price." According to Demski et al. [20], concerns about energy security are the key drivers of proposals for major energy transitions. They show that the UK public has relatively high concerns about energy security but is susceptible to framing. Concerns about energy security have been critical to justifying the recent return of nuclear power as electricity generation option globally [58]. Moreover, based on a British survey with 1822 respondents, Corner et al. [21] show that in general, people who express greater worry about energy security are less likely to favor nuclear power. However, given an explicit "reluctant acceptance" framing that allows respondents to express their dislike for nuclear power alongside their conditional support, concerns about energy security become a positive force for support on nuclear power. When energy security is stressed, the public favors cheaper and more bountiful energy resources.

Energy affordability is an abstract concept with many meanings. At the household level, energy is said to be affordable when a household can maintain a comfortable indoor temperature without undue financial hardship [58,59]. At the country level, according to Demski et al. [60], affordability is part of the energy trilemma that includes climate change and energy security concerns. According to Spence et al. [22], affordability concerns are positively associated with preparedness to think about energy rather than to reduce energy use. If respondents have energy affordability, they can seek energies that are beyond the cheapest ones (e.g., nuclear energy and fossil fuel energy).

When choosing an energy source, both demographic factors, such as age, education, income, and city size, and perception and social aspects of energy influence attitudes and attitude changes. We adopt economic incentives as the conditional factor which influence the respondents' attitude changes. To measure the stability and changes of attitudes, we set up four attitude variables related to the acceptance of energies as dependent variables: (1) positive attitudes with no changes, (2) negative attitudes with no changes, (3) changes from negative to positive attitudes, and (4) changes from positive to negative attitudes. The first and second variables refer to stability, and the third and fourth refer to attitude changes. After setting up these four variables as dependent variables in binary response model analysis, we compare the first with the second and the third with the fourth. Moreover, we use the siting of an energy-power-generation plant as the situation for which economic incentives are provided. We summarize the theoretical discussion with the research models shown in Figure 1.

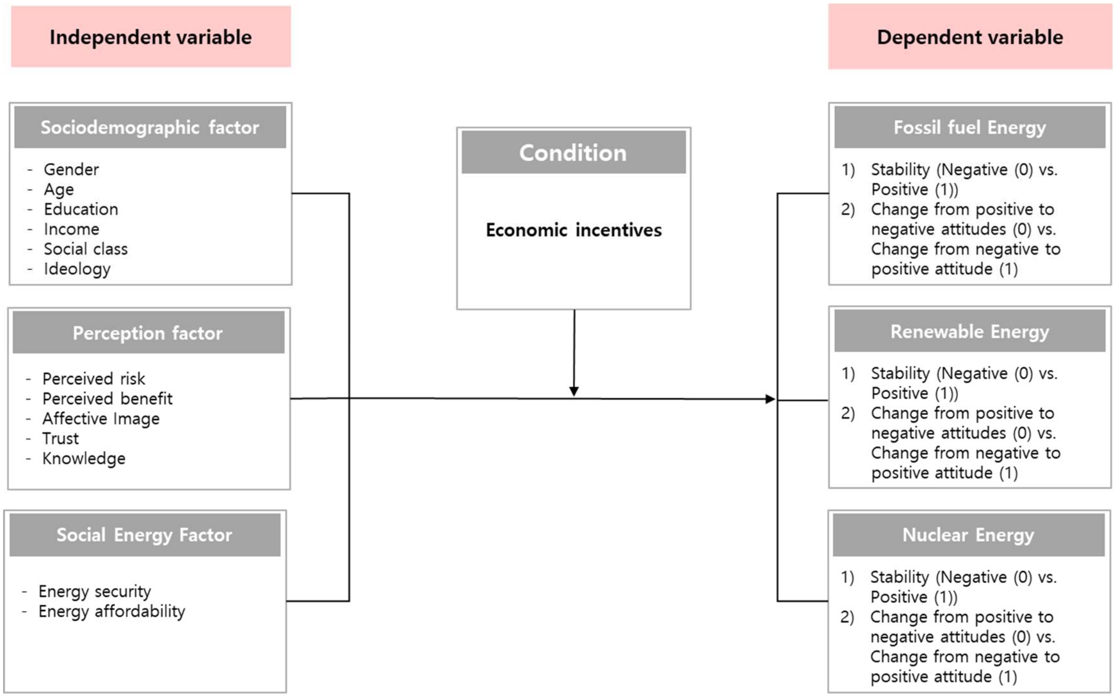

Figure 1. Research framework.

3. Materials and Methods

3.1. Data and Measure

The data used in this study were collected from April 15, 2014 to May 30, 2014 in Korea. We used a probabilistic stratified sampling method based on multilevel quotas. The initial survey design was set to 2300 respondents. Contact to respondents was attempted up to three times, and, if final contact failed, the targeted person was replaced with another similar sample. Finally, the number of people who participated in the survey was 1543, and the response rate was 67.08%. However, since 43 respondents with low reliability were excluded, we used 1500 respondents for analysis (Please see the Supplementary Materials). The average response time is about 36 min. The main demographic characteristics are as follows; 49.5% of the respondents are male and 50.5% female; 17.6% of the respondents are in their 20s, 19.5% in their 30s, 21.9% in their 40s, 19.5% in their 50s, and 21.5% older than 50 years; 10.6% of respondents are primary school graduates, 41.7% high school graduates, and

47.7% college graduates and above. For more detail about the representativeness of sample, please, see Appendix A.

This study analyzes attitude changes regarding energy acceptance and the determinants of these changes when economic incentives are provided. Various benefits are used as policy tools for enhancing the acceptance of various energy sources. However, only a few empirical studies have examined whether providing economic benefits can change attitudes. To explore this issue, we first measure respondents' support for various energy types (i.e., fossil fuels, renewable, and nuclear energies). Then, to identify the public's response to economic incentives, we ask respondents to answer the following question: "Given enough economic incentives to compensate for the construction of energy-related facilities in your neighborhood, to what extent do you agree or disagree with the use of the following energies (fossil fuels, renewable, and nuclear energies)?" Analyzing these conditional questions can demonstrate the structure of individual attitude changes toward specific energy types. We compare the attitudes after providing economic incentives with those before providing incentives. In this study, we consider three energy sources: fossil fuels, renewable, and nuclear energies. Measurement of the acceptance of fossil fuel energy is based on metrics for oil and coal. Acceptance of renewable energy is measured using metrics for solar and wind power. To use two items as one conceptual measure, we average the values of the two measures.

Perceived benefits, perceived risk, and negative image are measured on a ten-point scale, whereas knowledge, trust, energy security, and energy affordability are measured on a five-point scale. The description of these variables is presented in Table 1.

Table 1. Description and Measuring Units of the Variables in the Survey Data.

Category	Variables	Description
Acceptance	Acceptance without Economic Incentives provided (dependent variable)	Level of Acceptance for increasing the use of each energy type (fossil fuels, renewable, and nuclear energy). 5-point scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree
	Acceptance with Economic Incentives provided (dependent variable)	Level of Acceptance for each energy-related facility (fossil fuels, renewable, and nuclear energy) to be built in your local area under sufficient economic compensation by government. 5-point scale: strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5
Socio-demographic factors	Gender	Dummy variable (Male = 0, Female = 1)
	Education	Dummy variable (high school graduate = 0, college graduate = 1)
	Income	Average monthly household income (measuring unit = 10,000 Korean Won)
	Location	Dummy variable (non-metropolitan area = 0, metropolitan area = 1)
	Social status	Self-declared social class. 10-point scale (lowest class = 1, . . . , highest class = 10)
	Ideology	Self-declared political stance. 10-point scale (conservative = 1, . . . , liberal = 10)
Perception factors	Perceived benefit	Degree of benefit perceived from each type of energy (fossil fuels, renewable, and nuclear energy). 10-point scale. the least benefit = 1, . . . , the largest benefit = 10
	Perceived risk	Degree of risk perceived from each type of energy (fossil fuels, renewable, and nuclear energy). 10-point scale. the smallest risk = 1, . . . , the biggest risk = 10
	Negative image	Instant image from each type of energy (fossil fuels, renewable, and nuclear energy). 10-point scale. Extremely positive image = 1, . . . , extremely negative image = 10

Table 1. *Cont.*

Category	Variables	Description
Perception factors	Knowledge	Degree of overall knowledge of each type (fossil fuels, renewable, and nuclear energy) of energy situation and policy. 5-point scale. No knowledge = 1, . . . , strong knowledge = 5
	Trust	Credibility level on government's energy policy. 5-point scale. Never trust = 1, . . . , strongly trust = 5
Social aspects of energy	Energy security	Personal acceptance of investing in oversea energy sources or taking higher tax burden for energy security. 5-point scale. Strongly disagree = 1, . . . , strongly agree = 5
	Energy affordability	Personal affordability level of energy expenses such as electricity bill. 5-point scale. Heavy burden = 1, . . . , no burden = 5

3.2. Methodology

3.2.1. Testing for Structural Change

Let y be the dependent variable and $X = (x_1, x_2, \ldots, x_k)$ be a vector of explanatory variables. We divide the linear regression model by two groups; one is before the economic incentive is provided and the other is after the economic incentive is provided. Then the model can be written as

$$\begin{aligned} & y_{i,g} = \beta_{0,g} + \beta_{1,g}x_{1,i} + \beta_{2,g}x_{2,i} + \ldots + \beta_{k,g}x_{k,i} + u_{i,.g},\ i = 1, 2, \ldots, n_g \\ & where\ \ g = \begin{cases} 1\, if\ the\ economic\ incentive\ s\ are\ not\ provided \\ 2\, if\ the\ economic\ incentives\ are\ provided \end{cases} \\ & and\ n_1 + n_2 = n \end{aligned} \tag{1}$$

To test for equality between sets of coefficients in two linear regressions in Equation (1), Chow [61] suggests a test statistic as follows;

$$\begin{aligned} & H_0:\ \beta_{0,1} = \beta_{0,2},\ \beta_{1,1} = \beta_{1,2}, \ldots, \beta_{k.1} = \beta_{k,2}\quad vs.\quad H_1:\ H_0\ is\ not\ true \\ & Chow\ Test = \frac{[SSR_P - (SSR_1 + SSR_2)]/(k+1)}{(SSR_1 + SSR_2)/[n - 2(k+1)]} \\ & where\ \ SSR_P = the\ sum\ of\ squared\ residuals\ from\ pooling\ the\ two\ groups;\quad n = n_1 + n_2 \\ & \qquad SSR_1 =\ the\ sum\ of\ squared\ residuals\ from\ the\ group\ without\ economic\ incentive;\ n_1 \\ & \quad and\ SSR_2 =\ the\ sum\ of\ squared\ residuals\ from\ the\ group\ with\ economic\ incentive;\ n_2 \end{aligned} \tag{2}$$

Chow test in Equation (2) is a modified version of F-test and used to test for the structural change between groups. If the null hypothesis is true, then it implies that two groups are the same and there is no structural break or change between them. On the contrary, if the null hypothesis is rejected, then it implies that the economic incentives play some role in determining the acceptance decisions.

3.2.2. Binary Response Models

Let y* be a latent variable, $X = (x_1, x_2, \ldots, x_k)$ be a vector of explanatory variables and suppose that $y^* = X\beta + u,\ y = 1[y^*] > 0$, where $1[\bullet]$ is the indicator function, which takes on 1 if the value in the bracket is true and 0, otherwise. It is assumed that u follows either the standard logistic distribution or the standard normal distribution. The response probability for y is derived in Equation (3).

$$\begin{aligned} & P(y = 1|X) = P(y^* > 0|X) = P(u > -X\beta|X) = 1 - G[-X\beta] = G(X\beta) \\ & where\ G(\bullet) = cumulative\ distribution\ function\ (cdf) \end{aligned} \tag{3}$$

The conditional density function of y given X is written as

$$f(y\big|X;\beta) = [G(X\beta)]^y[1 - G(X\beta)]^{1-y},\ y = 0,\ 1 \tag{4}$$

The log-likelihood function for observation i is obtained by taking the log of Equation (4).

$$l_i(\beta) = y_i \log[G(X_i\beta)] + (1 - y_i) \log[1 - G(X_i\beta)] \quad (5)$$

Equation (5) is the log-likelihood function. If G(.) is the standard Logit cdf, then the MLE of β is the Logit estimator, if G(.) is the standard normal cdf, then the MLE of β is the Probit estimator. More detail can be seen in Wooldridge [62] (pp. 560–563).

4. Results

4.1. Basic Data Analysis

The analysis of respondents' attitudes toward fossil fuels, renewable, and nuclear energy is shown in Figure 2. Means value for each energy acceptance is presented before and after the conditional question. The higher scores mean the higher acceptance of energies. Before economic incentives are provided, renewable energy has the highest score, followed by fossil fuels and nuclear energy. We can conjecture the low acceptance rate for nuclear energy as the spreading of negative attitudes toward nuclear power due to the Fukushima disaster in 2011. This preference ranking remains the same even after economic incentives are provided.

Figure 2 shows that preferences before and after economic incentives are provided do not fluctuate much. Surprisingly, even after economic incentives are provided, the acceptability levels of all types of energies declined. This result is opposed to most of previous studies such as Visschers et al. [38], Siegrist et al. [39], Garcia et al. [41], and Niesten and Gjertsen [42] and contradicts the usual expectation that economic incentives boost the acceptability of an energy source. Moreover, the acceptance of nuclear energy decreases more than those of the other two energy sources. Acceptance of nuclear energy drops by 11.51% (2.78→2.46) while acceptances of fossil fuels and renewable energy drop by 6.6% (3.03→2.83) and 3.26% (3.99→3.86), respectively. A relatively larger decline in the acceptance of nuclear energy than those of the other energies suggests that providing economic incentives may reduce the likelihood of using nuclear energy or that the respondents recognize the economic incentives as a signal for the latent danger of nuclear energy in local level.

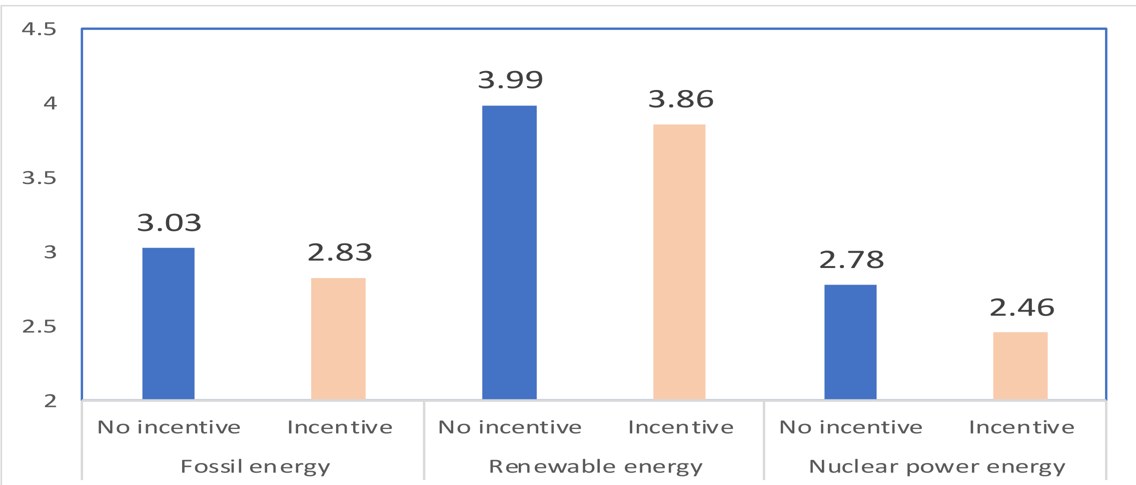

Figure 2. Difference of acceptance of energy source when the economic incentives provided (N = 1500).

Table 2 shows how respondents' attitudes change when the economic incentives are provided. In the case of fossil fuels, 30.7% of respondents are opposed, 33.3% neutral, and 35.9% amenable before economic incentives are provided. After economic incentives are provided, however, 42.3% of respondents are opposed, 31.8% neutral, and 25.9% supportive. The proportion of respondents opposed to fossil fuels is increased by 11.6% (30.7%→42.3%) after economic incentives are provided. This result is paradoxical in the sense that the economic incentives are originally intended to boost acceptance level. We can raise three possible reasons for such responses. First, providing economic incentives may be regarded as a bribe, destroying the public spirit. Second, this result may be driven by respondents' opposition to the establishment of a facility in their local area, that is, the notion of "not in my backyard". Or, based upon the asymmetric information theory, the respondents regard the economic incentives as a bad signal and make a poor decision.

In the case of renewable energy, 4.0% of respondents are opposed, 8.1% neutral, and 87.9% amicable before economic incentives are provided. However, after providing incentives, 5.7% are opposed, 11.7% neutral, and 82.6% favorable. Even in the case of renewable energy, the rate of opposition increases, but the degree of change is lower than in the case of fossil fuel energy. This small change can be interpreted as a result of the very favorable attitude (i.e., 87.9%) toward renewable energy before the provision of economic incentives.

In the case of nuclear energy, 39.0% of respondents are opposed, 36.7% neutral, and 24.3% favorable before economic incentives are provided. After incentives are provided, however, 53.7% are opposed, 28.8% neutral, and 17.5% still supportive. The opposition rate is increased by 14.7% (39.0%→53.7%) but both neutrality and acceptance rates are decreased. Please note that the initial acceptance level of the nuclear energy source is lower than the other types of energy sources.

We find that 9.8% of respondents have changed their attitudes from opposition to acceptance for fossil fuels, 48.3% for new renewable energy, and 3.2% for nuclear energy. Nuclear energy has the smallest change in attitudes from opposition to acceptance. These findings suggest that providing the economic incentives has little impact on the acceptability of building nuclear energy facilities in respondents' local areas. By contrast, the percentages of respondents who change their attitudes from acceptance to opposition are 23.2% for fossil fuels, 3.6% for renewable energy, and 26.6% for nuclear power, respectively.

The analysis based upon the attitude change when the economic incentives are provided in Table 2 allows us to consider two important realities. First, people seem to think that nuclear energy source is initially different from the other types of energies and, as a result, the response toward nuclear energy should be analyzed with a different point of view. Second, people may have inherent reluctance to nuclear energy and tend not to change their preoccupation about it.

Table 2. Attitudes before and after providing economic incentives.

				Economic Incentive													
				Fossil Fuel Energy					**Renewable Energy**					**Nuclear Energy**			
				Oppose	**Neutral**	**Accept**	**Total**		**Oppose**	**Neutral**	**Accept**	**Total**		**Oppose**	**Neutral**	**Accept**	**Total**
No economic incentive	Fossil fuel energy	Oppose	N	324	92	45	461	Renewable energy	19	12	29	60	Nuclear energy	481	85	19	585
			%	70.3%	20.0%	9.8%	100% (30.7%)		31.7%	20.0%	48.3%	100% (4.0%)		82.2%	14.5%	3.2%	100% (39.0%)
		Neutral	N	185	231	84	500		19	52	50	121		228	243	79	550
			%	37.0%	46.2%	16.8%	100% (33.3%)		15.7%	43.0%	41.3%	100% (8.1%)		41.5%	44.2%	14.4%	100% (36.7)
		Accept	N	125	154	260	539		47	112	1160	1319		97	104	164	365
			%	23.2%	28.6%	48.2%	100% (35.9%)		3.6%	8.5%	87.9%	100% (87.9%)		26.6%	28.5%	44.9%	100% (24.3)
		Total	N	634	477	389	1500		85	176	1239	1500		806	432	262	1500
			%	42.3%	31.8%	25.9%	100%		5.7%	11.7%	82.6%	100%		53.7%	28.8%	17.5%	100%

Note: Percentages in parentheses are the rates of respondents before economic incentives were provided.

4.2. Determinants of Acceptance Before and After Providing Economic Incentives

We apply the linear regression analysis to identify the determinants of respondents' attitudes toward each energy source (i.e., fossil fuels, renewable, and nuclear energy) before and after providing economic incentives. Primarily, the acceptance of three types of energies was measured in a 5-point scale discrete indicator ranging from 1 to 5. To fit better for the linear regression analysis, this variable is normalized through standardization process and set as the dependent variable. The linear model is described in Equation (6):

$$\begin{aligned} acceptance_k = {} & \beta_0 + \beta_1 gender + \beta_2 age + \beta_3 education + \beta_4 \log(income) + \beta_5 location + \beta_6 social\ status \\ & + \beta_7 ideology + \beta_8 perceived\ benefit + \beta_9 perceived\ risk + \beta_{10} negative\ image \\ & + \beta_{11} trust + \beta_{12} knowledge + \beta_{13} energy\ security + \beta_{14} energy\ affordability + u,\ k = 1,2,3 \end{aligned} \tag{6}$$

where $acceptance_1$ = acceptance of fossil fuels, $acceptance_2$ = acceptance of renewable energy, $acceptance_3$ = acceptance of nuclear energy

Table 3 shows the linear regression results for fossil fuel energy. Model 1 and 2 represent the acceptance of fossil fuels without and with the economic incentives, respectively. In Model 1 in Table 3, social status in socio-demographic factors, perceived benefit, perceived risk, negative image, and trust in perception factors and energy security are significant while log (income), location, and social status in socio-demographic factors, perceived risk, negative image, trust, and knowledge in perception factors and both energy security and affordability are significant in Model 2 in Table 3.

Compared to Model 1, a few more variables are significant in Model 2: i.e., log (income), location, knowledge, and energy affordability are significant only in Model 2, while perceived benefit is significant only in Model 1.

Regardless of the significance level, overall coefficients of both models are very similar in magnitudes and signs. To test the structural changes, Chow test is applied. The fundamental assumption for Chow test is that under the null hypothesis, the error variances for both groups must be identical. The empirical error variances between these two groups are very similar. However, we apply Gould [63]'s method that enables us to test for the structural break without constraining the residual variances of the groups to be the same. The Chow test results reject the null hypothesis of no structural change between these two groups at the 1 % level of significance, which implies that the economic incentives systematically affect the determinants of the acceptance of power generation from fossil fuels.

It is worth noting that perceived benefit in Model 1 and knowledge in Model 2 have negative marginal effects on the acceptance of fossil fuels, which are opposite to the previous studies such as Chung and Kim [37], Tsujikawa et al. [30], Tanaka [29], Bidwell [40], De Groot et al. [12] for perceived benefit and Bang et al. [56] for knowledge. In Table 3, perceived benefit has a negative effect on the acceptance of fossil fuels without economic incentives but becomes insignificant when economic incentives are provided in Model 2. One reasonable explanation for the result is that economic incentives offset the negative effect of perceived benefit and invalidate it in Model 2. On the other hand, knowledge is insignificant in Model 1 when no economic incentives are provided but has a negative effect on the acceptance of fossil fuels when economic incentives are provided. Besides, the coefficient of knowledge has an opposite sign to that of trust in Model 2. These results indicate that those who have more knowledge are less likely to accept fossil fuels and that there exists a trade-off between knowledge and trust.

Table 3. Linear regression results of the acceptance of fossil fuels before/after providing economic incentives.

			Dependent Variable			
			Model 1: Acceptance of Fossil without Economic Incentives		**Model 2: Acceptance of Fossil with Economic Incentives**	
			Coefficient (S.E.)	**Beta Coefficient**	**Coefficient (S.E.)**	**Beta Coefficient**
Independent variable	Socio-Demographic factors	Gender	0.019 (0.043)	0.010	−0.060 (0.045)	−0.030
		Age	0.001 (0.002)	0.010	0.001 (0.002)	−0.007
		Education	−0.040 (0.054)	−0.021	−0.024 (0.058)	−0.012
		Log(income)	−0.088 (0.054)	−0.039	**−0.162** *** (0.051)	−0.069
		Location	−0.023 (0.043)	−0.012	**0.098** ** (0.045)	0.048
		Social status	**0.085** *** (0.019)	0.116	**0.118** *** (0.019)	0.154
		Ideology	−0.008 (0.015)	−0.013	−0.016 (0.015)	−0.025
	Perception factors	Perceived benefit	**−0.030** * (0.017)	−0.049	−0.009 (0.018)	−0.014
		Perceived risk	**−0.096** *** (0.023)	−0.158	**−0.087** *** (0.025)	−0.137
		Negative image	**−0.220** *** (0.023)	−0.345	**−0.239** *** (0.024)	−0.360
		Trust	**0.161** *** (0.035)	0.123	**0.173** *** (0.038)	0.126
		Knowledge	−0.024 (0.039)	−0.017	**−0.109** *** (0.041)	−0.072
	Social aspects of energy	Energy security	**−0.113** *** (0.033)	−0.086	**−0.070** ** (0.032)	−0.052
		Energy affordability	−0.062 (0.039)	−0.042	**−0.125** *** (0.039)	−0.081
		Constant	**1.979 *** (0.458)**	.	**2.240** *** (0.442)	
	Number of observations		1500		1500	
	R square		0.294		0.301	
	Adjusted R square		0.287		0.295	
	Chow test		**6.57; *p*-value = 0**			

Note: 1. The numbers in parentheses are heteroskedasticity-robust standard errors. 2. *, **, and *** are 10%, 5%, and 1% significance levels, respectively.

Table 4 shows the determinants of the acceptability of renewable energy. Model 3 and 4 in Table 4 represent the acceptance of renewable energy without and with economic incentives, respectively. Age and log(income) in socio-demographic factors, perceived risk, negative image, and knowledge in perception factors, and none in social aspects of energy are statistically significant in both models. On the other hand, ideology in social-demographic factors, perceived benefit and trust in perception factors are statistically significant only in Model 3 and social status in socio-demographic factors and energy affordability in social aspects of energy are statistically significant only in Model 4. After providing introduction of economic incentives, the coefficient of social class changes its sign and even becomes significant at the 10% level of significance. However, acceptance is lower when energy affordability increases. The probability of accepting fossil fuels is 0.041 higher for those who can afford the energy source than for those who do not. Chow test indicates that there exists the structural change in the determinants of the acceptance of renewable energy source.

Unlike perceived benefit in Table 3, it has a positive effect on the acceptance of renewable energy before economic incentives are provided but becomes insignificant when economic incentives are provided in Table 4. This supports that the effect of perceived benefit is replaced by that of economic incentives. The coefficient of knowledge changes its sign from (−) to (+) when economic incentives are provided, which is in accordance with the results in Table 3. It is also interesting that as economic incentives are provided, those who are in the upper social class are more likely to accept renewable energy. In general, it is believed that upper-class people are usually more conservative and less likely to confront social changes. This is the case, then social status has a negative effect on the acceptance of renewable energy. Unlike our expectation, economic incentives would not be distributed to all social classes equally; the upper social class tends to have a larger interests in economic incentives than the lower class does. Energy affordability has a negative effect on the acceptance of renewable energy when economic incentives are provided. This result suggests that when energy is affordable, people do not feel the need to change their attitudes depending upon energies.

Table 4. Linear regression results of the acceptance of renewable energy before/after providing economic incentives.

			Dependent Variable			
			Model 3: Acceptance of Renewable without Economic Incentives		**Model 4: Acceptance of Renewable with Economic Incentives**	
			Coefficient (S.E.)	**Beta Coefficient**	**Coefficient (S.E.)**	**Beta Coefficient**
Independent variable	Socio-demographic factors	Gender	−0.050 (0.046)	−0.026	−0.048 (0.050)	−0.023
		Age	**0.005** ** (0.002)	0.073	**0.005** ** (0.002)	0.066
		Education	0.009 (0.058)	0.005	−0.016 (0.066)	−0.008
		Log (income)	**0.142** ** (0.058)	0.064	**0.172** *** (0.066)	0.072
		Location	0.033 (0.031)	0.017	0.033 (0.051)	0.016
		Social status	−0.029 (0.021)	−0.039	**0.037** * (0.022)	0.047
		Ideology	**0.060** *** (0.015)	0.098	0.020 (0.017)	0.030
	Perception factors	Perceived benefit	**0.030** ** (0.012)	0.066	0.004 (0.014)	0.008
		Perceived risk	**−0.048** ** (0.022)	−0.090	**−0.040** * (0.023)	−0.070
		Negative image	**−0.184** *** (0.028)	−0.300	**−0.192** *** (0.030)	−0.293
		Trust	**−0.161** *** (0.037)	−0.123	−0.050 (0.043)	−0.036
		Knowledge	**0.096** ** (0.039)	0.067	**−0.090** ** (0.043)	−0.059
	Social aspects of energy	Energy security	0.004 (0.033)	0.003	0.031 (0.038)	0.022
		Energy affordability	−0.044 (0.038)	−0.030	**−0.096** ** (0.043)	−0.061
		Constant	−0.310 (0.450)		−0.338 (0.506)	
	Number of observations		1500		1500	
	R square		0.198		0.143	
	Adjusted R square		0.190		0.134	
	Chow test		**3.77; *p*-value = 0.00**			

Note: 1. The numbers in parentheses are heteroskedasticity-robust standard errors. 2. *, **, and *** are 10%, 5%, and 1% significance levels, respectively.

Model 5 and 6 in Table 5 represent the acceptance of nuclear energy without and with the economic incentives. All the variables except knowledge in perception factors are statistically significant in both models. Only location in socio-demographic factors is statistically significant at the 1 % significant level in Model 5. According to He et al. [64], respondents living far from nuclear facilities are more critical toward nuclear power. On the contrary, social status in socio-demographic factors, knowledge in perception factors and energy security are statistically significant only in Model 6. Again, since the economic incentives are provided, the sign of the coefficient of perceived benefit changes from positive to negative direction, which implies that perceived benefits may be replaced by the effect of economic incentives. Both regression results look very similar not only in magnitudes but also in signs. However Chow test statistics is 9.89, which rejects the null hypothesis at the 1 % level of significance and indicates that the economic incentives play some role to determine the acceptance of nuclear energy power generation.

Based upon the linear regression results presented in Tables 3–5, some important implications are described as follows;

1. Social status and knowledge have very similar pattern in all types of energies.
2. Knowledge about energies and trust for government energy policy have a trade-off relationship.
3. Economic incentives may not be distributed to all social classes equally.

Table 5. Linear regression results of the acceptance of nuclear energy before/after providing economic incentive.

			Dependent Variable			
			Model 5: Acceptance of Nuclear without Economic Incentives		**Model 6: Acceptance of Nuclear with Economic Incentives**	
			Coefficient (S.E.)	**Beta Coefficient**	**Coefficient (S.E.)**	**Beta Coefficient**
Independent variable	Socio-demographic factors	Gender	0.011 (0.042)	0.006	−0.041 (0.042)	−0.020
		Age	0.0002 (0.002)	0.002	−0.0001 (0.002)	−0.001
		Education	0.079 (0.052)	0.040	0.004 (0.053)	0.002
		Log(income)	−0.043 (0.051)	−0.019	−0.052 (0.053)	−0.023
		Location	**0.154** *** (0.043)	0.078	0.064 (0.042)	0.032
		Social status	0.026 (0.018)	0.035	**0.048** *** (0.017)	0.064
		Ideology	−0.001 (0.015)	−0.001	0.002 (0.014)	0.003
	Perception factors	Perceived benefit	**0.049** *** (0.011)	0.108	**−0.025** ** (0.011)	−0.055
		Perceived risk	**−0.039** ** (0.016)	−0.087	**−0.079** *** (0.016)	−0.173
		Negative image	**−0.195** *** (0.016)	−0.426	**−0.204** *** (0.017)	−0.440
		Trust	**0.099** *** (0.036)	0.075	**0.101** *** (0.035)	0.075
		Knowledge	−0.052 (0.039)	−0.035	**−0.062** * (0.037)	−0.042
	Social aspects of energy	Energy security	−0.001 (0.031)	−0.001	**−0.056** * (0.031)	−0.041
		Energy affordability	0.004 (0.039)	0.003	−0.029 (0.033)	−0.019
		Constant	**1.145** *** (0.422)		**1.860** *** (0.431)	
	Number of Observations		1500		1500	
	R Square		0.328		0.360	
	Adjusted R Square		0.322		0.354	
	Chow Test		**9.89; *p*-value = 0.00**			

Note: 1. The numbers in parentheses are heteroskedasticity-robust standard errors. 2. *, **, and *** are 10%, 5%, and 1% significance levels, respectively.

4.3. Determinant of Attitude Changes: Degree of Attitude Change

To calculate the degree of attitude change, we subtract the value of acceptance before providing economic incentives from that after providing economic incentives. If this value is positive, then the attitude toward the specific energy has changed positively, and if it is negative, then the attitude has changed to be negative. The linear regression analysis with these values as dependent variables are implemented and reported in Table 6.

In Model 7 in Table 6, location, social class, and knowledge are statistically significant. Respondents living in metropolitan areas and in the upper class positively change their attitude toward fossil fuels, whereas those who have more knowledge negatively change their attitude toward this energy source.

In Model 8 in Table 6, the variables that affect changes in attitude toward renewable energy source are social status, ideology, perceived benefit, trust, and knowledge. The upper social class has a more positive attitude toward renewable energy than the lower class has. However, negative attitude toward renewable energy also emerges from ideologically progressive respondents. The greater trust is, the stronger the positive attitude becomes. However, higher perceived benefit and knowledge lead to stronger negative attitude. In general, as Wang and Kim [51] show, perceived benefit increases positive attitude, which is contrary to our findings. This result might arise because many of the advantages of this energy type are offset by its negative aspects.

In Model 9 in Table 6, the attitude toward nuclear energy of those who reside in metropolitan area becomes more negative. Among the perception factors, perceived benefits and perceived risk contribute to reducing positive attitude toward nuclear power. Remarkably, despite the perceived benefits, positive attitude tends to attenuate. We can interpret this result as the strong opposition based on higher perceived risk overwhelming the positive effects of perceived benefits.

The regression results in Table 6 are based upon the first difference between the values of acceptance before and after the economic incentives as a measure for the degree of attitude changes. However, using this measure as dependent variable has some drawbacks. First, the dependent variable is derived from the first difference of two initial 5-scale indicators and has very limited finite integers, which, as a result, may not fit into linear regression analysis. Second, coefficients from the linear regression models are very hard to interpret. To avoid these problems, the results of the first difference are converted as follows; if the first difference is greater or equal to 0, then 1 is assigned, otherwise 0 is assigned. The value 1 implies that the degree of attitude toward accepting specific energy source grows stronger or at least indifferent. The value 0 implies that the attitude changes from positive to negative manner. Using this binary variable as dependent variable in linear regression analysis is called the linear probability model (LPM) analysis. The LPM is simple not only to apply but also to interpret estimates. The regression results are reported in Table 7. Due to the nature of binary response dependent variable, heteroskedasticity problem is inherited. Thus, heteroskedasticity-robust standard errors are calculated and reported in Table 7.

In Model 7′ in Table 7, ideology in socio-demographic factors, negative image, and trust in perception factors and energy affordability in social aspects of energy are statistically significant. The coefficient of ideology is −0.016 and statistically significant at the 10% significant level, which means the probability of accepting fossil fuels gets lower as people become more progressive. As the same token, the probability of accepting fossil fuels is 0.022 higher as those who have one more unit of negative image. The probability of accepting fossil fuels is 0.039 higher as trust for government's energy policy is incremented by one unit. The probability of accepting fossil fuels is 0.041 higher for those who can afford the energy source than for those who do not. In Model 8′ in Table 7, age in socio-demographic factors, knowledge in perception factors, and energy affordability are statistically significant. The coefficient of age is −0.003 and statistically significant at the 5% significant level, which implies that as people get older by one year, the probability of accepting renewable energy source lowers by 0.003. As people gather more knowledge, the probability of accepting renewable energy source increases by 0.050. The effect of energy affordability is higher in renewable energy than in fossil fuels. In Model 9′ in Table 7, only two coefficients are significant. The coefficient of age is −0.002 and statistically significant at the 10% significant level and the coefficient of perceived benefit is 0.031 and statistically significant at the 1% significant level. These results are very similar to those in renewable energy source.

The LPM regression results in Table 7 show that no single explanatory variable has all-inclusive effect throughout all types of energies. All significant explanatory variables except negative image in Model 7′ are economically significant. The coefficient of negative image in Model 7′ is 0.022, which is against our expectation and hard to interpret. This result may be due to the drawback of LPM and more specifically fulfilled models such as Probit or Logit need to be carried out for more appropriate regression analysis. The coefficient of ideology in Model 7′ is −0.016, which implies that as people become more progressive, they are less likely to change their attitude toward fossil fuels. Ideology is effective only in fossil fuels. One possible explanation for the result is that as people become more progressive, they are aware of human rights, environmental conservation, and anti-pollution issues. These tendencies may be against the use of fossil fuels and lower the probability of attitude change toward fossil fuels. Energy affordability has positive effect not only in fossil fuels but also in renewable energy. This result is consistent with Spence et al. [22]. Age has negative influence on the acceptance of renewable and nuclear energy sources. Considering that people tend to be more conservative as they are older, this result seems plausible. Both knowledge and perceived benefit have positive effects and these results are also consistent with previous studies such as Bang et al. [56], Huang [7], Chung and Kim [37], Tsujikawa et al. [30], Tanaka [29], Bidwell [40], and, De Groot et al. [12].

Table 6. Linear regression results of the degree of attitude change toward fossil fuels, renewable, and nuclear energy.

			Dependent Variable					
			Model 7: Attitude Change on Fossil Fuels		**Model 8: Attitude Change on Renewable Energy**		**Model 9: Attitude Change on Nuclear Energy**	
			Coefficient (S.E.)	**Beta Coefficient**	**Coefficient (S.E.)**	**Beta Coefficient**	**Coefficient (S.E.)**	**Beta Coefficient**
Independent variable	Socio-demographic factors	Gender	−0.057 (0.036)	−0.042	0.001 (0.036)	0.001	−0.053 (0.050)	−0.028
		Age	−0.001 (0.002)	−0.018	−0.0001 (0.002)	−0.001	−0.0002 (0.002)	−0.003
		Education	0.011 (0.046)	0.008	−0.017 (0.046)	−0.012	−0.077 (0.063)	−0.040
		Log(income)	−0.053 (0.046)	−0.033	0.020 (0.044)	0.013	−0.010 (0.062)	−0.004
		Location	**0.087** ** (0.037)	0.063	−0.0002 (0.036)	0.000	**−0.093** * (0.051)	−0.048
		Social status	**0.024** * (0.014)	0.045	**0.045** *** (0.017)	0.084	0.022 (0.021)	0.031
		Ideology	−0.006 (0.013)	−0.013	**−0.027** ** (0.012)	−0.062	0.003 (0.017)	0.004
	Perception factors	Perceived benefit	0.015 (0.014)	0.034	**−0.018** * (0.009)	−0.054	**−0.076** *** (0.013)	−0.171
		Perceived risk	0.007 (0.020)	0.015	0.006 (0.013)	0.014	**−0.041** ** (0.020)	−0.093
		Negative image	−0.014 (0.018)	−0.031	−0.006 (0.016)	−0.013	−0.009 (0.020)	−0.020
		Trust	0.008 (0.031)	0.009	**0.076** ** (0.030)	0.080	0.002 (0.043)	0.001
		Knowledge	**−0.061** * (0.035)	−0.059	**−0.127** *** (0.031)	−0.121	−0.011 (0.047)	−0.007
	Social aspects of energy	Energy security	0.031 (0.026)	0.033	0.018 (0.027)	0.019	−0.056 (0.037)	−0.043
		Energy affordability	−0.046 (0.029)	0.043	−0.036 (0.030)	0.033	−0.034 (0.044)	−0.023
		Constant	0.188 (0.374)		−0.019 (0.337)		0.735 (0.530)	
	F-Value		1.39		2.19 ***		3.99 ***	
	R Square		0.013		0.023		0.035	
	Adjusted R Square		0.004		0.014		0.026	

Note: 1. The numbers in parentheses are heteroskedasticity-robust standard errors. 2. *, **, and *** are 10%, 5%, and 1% significance levels, respectively.

Table 7. Linear probability model estimation results of the attitude change toward fossil fuels, renewable, and nuclear energy.

			Dependent Variable					
			Model 7′: Attitude Change on Fossil Fuels		**Model 8′: Attitude Change on Renewable Energy**		**Model 9′: Attitude Change on Nuclear Energy**	
			Coefficient (Robust S.E.)	**Beta**	**Coefficient (Robust S.E.)**	**Beta**	**Coefficient (Robust S.E.)**	**Beta**
Independent variable	Socio-demographic factors	Gender	0.031 (0.025)	0.032	−0.002 (0.026)	−0.002	0.014 (0.026)	0.014
		Age	−0.001 (0.001)	−0.027	**−0.003** ** (0.001)	−0.077	**−0.002** * (0.001)	−0.056
		Education	0.019 (0.032)	0.020	−0.052 (0.032)	−0.052	−0.009 (0.033)	−0.009
		Log(income)	−0.031 (0.031)	−0.028	−0.041 (0.033)	−0.036	−0.045 (0.032)	−0.039
		Location	0.015 (0.026)	0.063	0.010 (0.026)	0.011	0.037 (0.026)	0.036
		Social status	−0.002 (0.011)	−0.006	−0.010 (0.011)	−0.027	−0.008 (0.011)	−0.021
		Ideology	**−0.016** * (0.009)	−0.013	−0.002 (0.009)	−0.007	0.005 (0.009)	0.016
	Perception factors	Perceived benefit	0.014 (0.009)	0.045	0.009 (0.007)	0.038	**0.031** *** (0.006)	0.132
		Perceived risk	0.022 (0.012)	0.037	0.002 (0.010)	0.005	0.002 (0.009)	0.009
		Negative image	**0.022** * (0.012)	0.069	0.019 (0.012)	0.060	0.002 (0.009)	0.007
		Trust	**0.039** * (0.020)	0.060	0.007 (0.021)	0.011	0.007 (0.021)	0.011
		Knowledge	0.008 (0.022)	0.011	**0.050** ** (0.023)	0.067	−0.027 (0.023)	−0.036
	Social aspects of energy	Energy security	0.025 (0.018)	0.039	−0.007 (0.019)	−0.010	0.020 (0.019)	0.029
		Energy affordability	**0.041** ** (0.020)	0.056	**0.058** *** (0.021)	0.076	0.032 (0.021)	0.041
		Constant	0.372 (0.262)		**0.587** ** (0.259)		**0.602** ** (0.263)	
	F-Value		2.22 ***		1.92 **		3.24 ***	
	R square		0.020		0.023		0.027	

Note: 1. The numbers in parentheses are heteroskedasticity-robust standard errors. 2. *, **, and *** are 10%, 5%, and 1% significance levels, respectively.

4.4. Determinants of Attitude Change: Stability and Direction of Attitude Change

To examine the determinants of the acceptability of different types of energies more closely, we classify the respondents by two categories: stability and directional changes of attitude. For stability, we divide the respondents into two groups. One is the respondents who maintain positive attitude when the economic incentives are introduced and the other is those who show negative attitude even though the economic incentives are introduced. The latter is set as the control group. For attitude change, we divide the respondents into two sub-groups. The one is those who change their attitude from negative to positive directions and the other is those who change their attitude from positive to negative directions. Again, the latter is set as the control group. Both stability and attitude change are binary variables. LPM can be used but it has its limits due to the nature of nonlinearity of the binary response model. To overcome the drawbacks of LPM, Probit, and Logit models for binary dependent variable are applied. To test for functional form of misspecification of LPM, Ramsey's [65] regression specification error test (RESET) is implemented. Then Hausman [66] test is also applied to test for statistically significant differences between Probit and Logit models.

Stability and attitude change of fossil fuels are estimated by these three regression models (i.e., LPM, Probit, and Logit models) and those regression results are reported in Table 8. In Model 10 in Table 8, RESET statistics is 12.04, which rejects the null of no misspecification error of LPM at the 1% significant level. In addition, Hausman test statistics is 37.46 and rejects the null of no statistically significant difference at the 1% significant level, which indicates that Logit model is preferred to Probit model. Based upon these specification test results, log(income), location, social status in socio-demographic factors, perceived risk, negative image, and trust in perception factors, and both energy security and affordability are statistically significant in Logit model. As respondents have higher monthly household income, live in metropolitan area, trust government energy policy more, and are the upper class, the probability of holding positive attitude toward fossil fuels increases. On the contrary, as respondents have negative image and are more alert to perceived risk, energy security, and affordability, the probability of maintaining positive attitude toward fossil fuels decreases. Model 11 in Table 8 represents the regression results of the attitude change of fossil fuel. Based upon the specification test results, both LPM and Probit models seem to be proper and show that only location and perceived benefit are statistically significant. The marginal effects of location and perceived benefit of Probit model when the mean values of explanatory variables are used are 0.117 and 0.026, respectively. These marginal effects are very similar to those from LPM. The marginal effect of 0.117 of location implies that the probability of changing attitude from negative to positive directions is 0.117 higher for those who live in metropolitan area than those who do not live in there. Similarly, the marginal effect of perceived benefit is 0.026, which implies that the probability of changing attitude from negative to positive direction is 0.026 higher when respondents increase their perceived benefit by one more unit.

In Model 10 in Table 8, log(income) and social class have opposite effects on the probability of stability of fossil fuels. Considering that the former is only marginally significant, these results are concurrent with attitude stability suggested by Visschers and Siegrist [38]. All significant explanatory variables are reasonable and consistent with previous studies in Section 2.3. However, energy affordability has negative effect and lowers the probability of stability of fossil fuels, which contradicts Spence et al. [22]. This may be due to the property of fossil fuels, i.e., as people are more affordable, they want to switch from fossil fuels to other types of cleaner energy sources. In Model 10 in Table 8, both location and perceived benefit have positive effects on the probability of directional change of attitude toward fossil fuels, which are exactly concurrent with our expectation and the results from previous studies in Section 2.

Table 8. Binary response model estimation results of attitude change (Fossil fuels).

			Dependent Variable					
			Model 10: Stability, Negative (=0) vs. Positive (=1) Response			Model 11: Change from Positive to Negative Response (=0) vs. from Negative to Positive Response (=1)		
			LPM	Probit	Logit	LPM	Probit	Logit
Independent variable	Socio-demographic factors	Gender	−0.035 (0.031)	−0.089 (0.136)	−0.118 (0.239)	−0.026 (0.036)	−0.037 (0.102)	−0.124 (0.169)
		Age	0.001 (0.001)	0.002 (0.006)	0.004 (0.011)	−0.002 (0.002)	−0.005 (0.005)	−0.007 (0.008)
		Education	−0.027 (0.040)	−0.131 (0.175)	−0.177 (0.313)	0.28 (0.045)	0.082 (0.127)	0.132 (0.210)
		Log(income)	**−0.091 ** (0.037)**	**−0.240 * (0.177)**	**−0.497 * (0.292)**	−0.064 (0.043)	−0.184 (0.122)	−0.300 (0.202)
		Location	**0.138 ** (0.032) ***	**0.464 *** (0.139)**	**0.837 *** (0.248)**	**0.115 *** (0.038)**	**0.325 *** (0.105)**	**0.534 *** (0.175)**
		Social status	**0.054 *** (0.013)**	**0.244 *** (0.062)**	**0.460 *** (0.107)**	0.008 (0.016)	0.025 (0.044)	0.038 (0.073)
		Ideology	−0.003 (0.010)	−0.003 (0.047)	−0.0249 (0.084)	−0.004 (0.012)	−0.014 (0.034)	−0.020 (0.057)
	Perception factors	Perceived benefit	0.008 (0.009)	−0.027 (0.053)	−0.044 (0.097)	**0.026 * (0.015)**	**0.074 * (0.042)**	**0.123 * (0.070)**
		Perceived risk	−0.016 (0.016)	**−0.119 * (0.065)**	**−0.212 * (0.118)**	0.010 (0.017)	0.028 (0.048)	0.047 (0.081)
		Negative image	**−0.125 *** (0.017)**	**−0.532 *** (0.071)**	**−0.939 *** (0.129)**	−0.003 (0.018)	−0.010 (0.052)	−0.015 (0.086)
		Trust	**0.062 *** (0.024)**	**0.312 *** (0.110)**	**0.561 *** (0.207)**	−0.020 (0.032)	−0.059 (0.088)	−0.094 (0.146)
		Knowledge	−0.033 (0.027)	**−0.240 * (0.130)**	−0.353 (0.225)	0.013 (0.032)	0.037 (0.091)	0.060 (0.149)
	Social aspects of energy	Energy security	**−0.076 *** (0.023)**	**−0.292 *** (0.100)**	**−0.491 *** (0.174)**	0.014 (0.026)	0.036 (0.074)	0.066 (0.123)
		Energy affordability	**−0.084 *** (0.024)**	**−0.389 *** (0.112)**	**−0.644 *** (0.199)**	0.022 (0.030)	0.068 (0.084)	0.105 (0.136)
		Constant	**1.629 *** (0.294)**	**4659 *** (1.399)**	**8.090 *** (2.470)**	0.443 (0.379)	−0.103 (1.081)	−0.209 (1.780)
	Log likelihood			−223.868	−222.942		−421.957	−422.038
	N		584	584	584	685	685	685
	R^2		0.467	0.442	0.444	0.025	0.020	0.020
	RESET		**12.04 *** **			0.68		
	Hausman Test			**37.46 *** **			4.00	

Note: 1. The numbers in parentheses are heteroskedasticity-robust standard errors. 2. *, **, and *** are 10%, 5%, and 1% significance levels, respectively.

Table 9 shows the regression results of stability and attitude change from the renewable energy source. In Model 12 in Table 9, both RESET and Hausman test results indicate that the Probit model is preferred to the other two models. Log (income) and social status in socio-demographic factors, perceived risk, negative image, and trust in perception factors, and none in social aspect of energy are statistically significant. The marginal effects of these explanatory variables when the mean values are used are 0.006, 0.002, −0.002, −0.002, and −0.004, respectively. As household income increases 1%, the probability of maintaining positive attitude toward renewable energy source increases about 0.00006. Those who are in the upper class have 0.002 higher probability for maintaining positive attitude than the lower-class respondents. Both perceived risk and negative image lower the probability of maintaining positive attitude by 0.002. However, as respondents have trust in government energy policy more, the probability of maintaining positive attitude rather decreases by 0.004, which is not a usual phenomenon and conflicts with many previous studies such as Whitefield et al. [54], Katsuya [14], and Visschers and Siegrist [6]. Further study needs to be done for this issue.

Model 13 in Table 9 is of attitude change toward renewable energy source. Specification test results show that both LPM and Probit seem adequate, but no explanatory variable is statistically significant in Probit Estimation results. One possible explanation for this result may be related to the number of observations for the model that is only 269 which is much smaller compared to the other models' numbers of observations.

Table 10 shows the regression results from the binary dependent variable models with nuclear energy source. The Logit model turns to be the most suitable one for Model 14 in Table 10. Gender in socio-demographic factors, negative image, trust, and knowledge in perception factors are statistically significant. Females are more cautious and lower the probability of maintaining positive attitude. As respondents have more trust in government energy policy, the probability of maintaining positive attitude increases. It is also reasonable that the probability of maintaining positive attitude decreases as respondents have more knowledge and negative image of nuclear energy. These regression results are reasonable and consistent with previous studies in Section 2. It is worth noting that knowledge has negative effect on the probability of stability of nuclear energy source. This result supports the trade-off between knowledge and trust regardless of the types of energies.

Lastly, Model 15 in Table 10 depicts the attitude change of nuclear energy source. The specification test results indicate that both LPM and Probit models are suitable. Both regression results report that perceived benefit and risk are statistically significant. The marginal effects of those explanatory variables when the mean values are used from the Probit model are −0.042 and −0.024, respectively. The probability of changing to positive attitude decreases by 0.024 as respondents are aware of the perceived risk of nuclear energy source. However, even though the perceived benefit gets higher, the probability of changing to positive attitude decreases by 0.042. This result is not usual and at odds with previous studies such as Chung and Kim [37], Tsujikawa et al. [30], Tanaka [29], Bidwell [40], and, De Groot et al. [12]. However, this unusual result could be partly from the fear of Fukushima disaster. Even though respondents perceive the benefits from nuclear energy, they do not want to accept any risk of nuclear accident, no matter how little the possibility is, and to convert their attitude to positive direction.

Table 9. Binary response model estimation results of attitude change (Renewable energy).

			Dependent Variable					
			Model 14: Stability, Negative (=0) vs. Positive (=1) Response			**Model 15: Change from Positive to Negative Response (=0) vs. from Negative to Positive Response (=1)**		
			LPM	**Probit**	**Logit**	**LPM**	**Probit**	**Logit**
Independent variable	Socio-demographic factors	Gender	−0.006 (0.008)	−0.132 (0.213)	−0.343 (0.559)	−0.077 (0.059)	−0.191 (0.162)	−0.321 (0.269)
		Age	0.0004 (0.0004)	0.018 (0.011)	0.034 (0.028)	−0.001 (0.003)	−0.007 (0.008)	−0.012 (0.013)
		Education	0.001 (0.010)	0.156 (0.308)	0.193 (0.772)	−0.021 (0.072)	−0.123 (0.205)	−0.216 (0.337)
		Log(income)	**0.019 ** (0.010)**	**0.547 ** (0.237)**	**1.106 * (0.568)**	−0.021 (0.076)	−0.088 (0.212)	−0.170 (0.359)
		Location	0.005 (0.008)	0.081 (0.229)	0.043 (0.590)	**−0.114 * (0.059)**	−0.262 (0.171)	−0.436 (0.282)
		Social status	**0.007 ** (0.003)**	**0.200 ** (0.087)**	**0.431 ** (0.215)**	0.011 (0.025)	0.066 (0.069)	0.113 (0.115)
		Ideology	0.003 (0.002)	0.099 (0.072)	0.219 (0.189)	−0.030 (0.020)	−0.093 (0.058)	−0.147 (0.093)
	Perception factors	Perceived benefit	0.0004 (0.001)	0.049 (0.049)	0.074 (0.128)	−0.001 (0.017)	0.050 (0.080)	0.081 (0.100)
		Perceived risk	**−0.006 * (0.003)**	**−0.141 ** (0.057)**	**−0.295 * (0.131)**	0.017 (0.024)	0.053 (0.077)	0.098 (0.127)
		Negative image	**−0.009 ** (0.004)**	**−0.165 ** (0.064)**	**−0.330 ** (0.150)**	0.034 (0.027)	−0.068 (0.062)	−0.120 (0.131)
		Trust	−0.007 (0.005)	**−0.349 ** (0.159)**	**−0.825 ** (0.401)**	0.036 (0.048)	0.097 (0.139)	0.157 (0.234)
		Knowledge	−0.007 (0.005)	−0.179 (0.169)	−0.471 (0.435)	−0.100 (0.063)	−0.271 (0.170)	−0.446 (0.281)
	Social aspects of energy	Energy security	0.001 (0.006)	−0.045 (0.172)	0.137 (0.423)	−0.063 (0.046)	−0.187 (0.125)	−0.314 (0.206)
		Energy affordability	0.000 (0.007)	−0.058 (0.190)	−0.177 (0.465)	−0.019 (0.050)	−0.002 (0.139)	−0.010 (0.233)
		Constant	**0.872 *** (0.064)**	−0.685 (1.874)	−0.424 (4.486)	0.965 (0.628)	1.657 (1.821)	2.883 (3.078)
	Log likelihood			−73.218	−75.287		−165.084	−165.038
	N		1,179	1,179	1,179	269	269	269
	R^2		0.044	0.247	0.226	0.067	0.041	0.041
	RESET		**7.99 *** **			0.89		
	Hausman Test			12.55			4.14	

Note: 1. The numbers in parentheses are heteroskedasticity-robust standard errors. 2. *, **, and *** are 10%, 5%, and 1% significance levels, respectively.

Table 10. Binary response model estimation results of attitude change (Nuclear energy).

			Dependent Variable					
			Model 14: Stability, Negative (=0) vs. Positive (=1) Response			**Model 15: Change from Positive to Negative Response (=0) vs. from Negative to Positive Response (=1)**		
			LPM	**Probit**	**Logit**	**LPM**	**Probit**	**Logit**
Independent variable	Socio-demographic factors	Gender	−0.033 (0.024)	**−0.295 * (0.168)**	**−0.555 * (0.311)**	−0.038 (0.037)	−0.111 (0.110)	−0.188 (0.186)
		Age	−0.0004 (0.001)	−0.004 (0.007)	−0.011 (0.014)	−0.002 (0.002)	−0.005 (0.005)	−0.009 (0.009)
		Education	**0.052 * (0.029)**	0.332 (0.205)	0.541 (0.389)	−0.058 (0.048)	−0.171 (0.141)	−0.289 (0.233)
		Log(income)	−0.022 (0.032)	−0.104 (0.198)	−0.159 (0.377)	−0.036 (0.046)	−0.095 (0.134)	−0.175 (0.226)
		Location	0.0240 (0.025)	0.157 (0.162)	0.291 (0.305)	−0.054 (0.039)	−0.162 (0.118)	−0.274 (0.199)
		Social status	−0.002 (0.010)	0.041 (0.065)	0.044 (0.123)	0.020 (0.016)	−0.062 (0.046)	0.102 (0.076)
		Ideology	0.007 (0.008)	0.002 (0.056)	−0.004 (0.108)	0.003 (0.013)	−0.011 (0.038)	0.018 (0.065)
	Perception factors	Perceived benefit	−0.001 (0.005)	0.020 (0.048)	0.043 (0.091)	**−0.040 *** (0.010)**	**−0.122 *** (0.030)**	**−0.203 *** (0.051)**
		Perceived risk	**−0.021 ** (0.011)**	−0.055 (0.051)	−0.084 (0.092)	**−0.023 ** (0.011)**	**−0.070 ** (0.034)**	**−0.116 ** (0.056)**
		Negative image	**−0.107 *** (0.011)**	**−0.593 *** (0.064)**	**−1.071 *** (0.122)**	−0.019 (0.012)	−0.054 (0.037)	−0.095 (0.062)
		Trust	**0.069 *** (0.019)**	**0.715 *** (0.141)**	**1.319 *** (0.266)**	0.006 (0.029)	0.017 (0.090)	0.035 (0.149)
		Knowledge	**−0.038 * (0.019)**	**−0.389 *** (0.128)**	**−0.679 *** (0.240)**	−0.008 (0.033)	−0.022 (0.100)	−0.044 (0.167)
	Social aspects of energy	Energy security	−0.019 (0.016)	−0.170 (0.121)	0.305 (0.224)	−0.016 (0.028)	−0.053 (0.084)	−0.094 (0.139)
		Energy affordability	**−0.040 ** (0.019)**	−0.169 (0.126)	−0.306 (0.225)	0.034 (0.031)	0.097 (0.092)	0.164 (0.151)
		Constant	**1.266 *** (0.253)**	**3.255 (1.798)***	**5.842 * (3.386)**	**0.973 *** (0.363)**	1.407 (1.088	2.510 (1.807)
	Log likelihood			−155.697	−156.951		−358.132	−358.054
	N		645	645	645	612	612	612
	R^2		0.533	0.5742	0.571	0.048	0.041	0.041
	RESET		**104.42 ***			0.66		
	Hausman Test			**35.64 ***			7.01	

Note: 1. The numbers in parentheses are heteroskedasticity-robust standard errors. 2. *, **, and *** are 10%, 5%, and 1% significance levels, respectively.

5. Discussion

The empirical findings in this study disclose some significant implications. First, since most of the previous studies of attitude change focus on the variables or events that are predetermined and uncontrolled by government or policy makers and, and as a result, they overlook the effect of the third variable which reflects the role of government or policy makers. On the contrary, this study included the economic incentives which was a variable reflecting the role of government and analyzed how this variable affects the attitude change and its determinants. The regression-based analysis in the study shows that the structure of attitude change is greatly affected by the existence of economic incentives. For example, in the case of fossil fuel energy, only two variables (social class and perceived benefits) have marginal effects of the acceptability of fossil fuels without economic incentives provided but nine variables have marginal effects on the acceptance of it when economic incentives provided. This empirical finding is also verified by the Chow test results regardless of energies. It is suggested that government and policy makers should realize the importance of the economic incentives and develop improved incentive systems in future policies.

Second, those studies following psychometric paradigm do not include social or contextual variables and cannot maintain well-balanced view on this subject. As a way to overcome this possible drawback, we include the social aspects of energy such as energy security and affordability which are social or contextual variables in the study and find that energy security lowers the acceptance of fossil fuels and nuclear energy when economic incentives are provided and that energy affordability lowers the acceptance of fossil fuels and renewable energy when economic incentives are provided. Especially in terms of the degree of energy change, the energy affordability enhances the acceptance of fossil fuels and renewable energy.

Third, the attitude changes of different energies are affected by different sets of determinant factors or variables and the types of energies play some role to affect the attitude change. For example, in Table 7, attitude change on fossil fuels is affected by ideology, trust, and energy affordability; attitude change on renewable energy by age, knowledge, and energy affordability; and attitude change on nuclear energy by age, perceived benefit. Perceived benefit and perceived risk, and negative image do not have marginal effects on both the acceptances of fossil fuels and renewable energy, while perceived risk, negative image, and trust do not relate to the acceptances of renewable and nuclear energies and negative image. The acceptances of fossil fuels and nuclear power are not affected by knowledge

Fourth, our study also shows that there is a trade-off between economic incentives and perceived benefit. This finding suggests that applying a quantitative analysis to measure the magnitudes of the trade-off between them can help to understand people's attitude change.

Last, we carry out comprehensive and multifaceted empirical analyses to consider change before and after providing economic incentives, degree of change, direction of change, and difference between control group and treatment group. Based upon these robust regression analyses, it is shown that there are differences in the determinants according to those variant contents of attitude change.

6. Conclusion and Implications

The purpose of this study is to analyze the effect of economic incentives on attitude changes. Using the survey data of 1500 Korean respondents, we compare attitudes related to support for the construction of specific energy-related facilities in a neighborhood before and after economic incentives are provided. This study examines the degree and determinants of the acceptability of different types of energy (fossil fuels, renewable, and nuclear energy) sources with or without conditional questions. The conditional question asked whether or not respondents will support the construction of a facility for each type of energy in their neighborhood if a sufficient amount of economic incentives is provided. It is worth noting that when examining the descriptive statistics of the data, the provision of economic incentives does not necessarily lead to a change in the acceptance of various energies to the expected direction. On the contrary, providing economic incentives results in a significant reduction in the acceptance of nuclear energy.

For the robust empirical results, various types of regression-based analyses such as OLS, LPM, Probit, and Logit models are carried out. First, the linear regression analysis is used to identify the determinants of respondents' attitudes toward each energy source (i.e., fossil fuels, renewable, and nuclear energies) before and after providing economic incentives. Then Chow test is applied to test for the structural change due to the economic incentives. These results are reported in Tables 3–5. Next, to analyze the degree of attitude change, both traditional linear regression model and LPM are carried out and reported in Tables 6 and 7. Lastly, to examine the determinants of the acceptability of different types of energies more closely, we classify the respondents by two categories: stability and directional changes of attitude. These binary response dependent variables are estimated by LPM, Probit, and Logit regression models and specification tests such as RESET and Hausman tests are conducted to check for more suitable models among them. These estimation results are reported in Tables 7–10.

The empirical findings from these regression analyses can be summarized two-fold: One is in terms of dependent variables and the other is in terms of explanatory variables. Three sets of dependent variables (acceptance, attitude change, stability and the directional changes in attitudes) are used in this study. Tables 3–5 are for acceptances of three types of energies due to economic incentives. Tables 6 and 7 are for degree of attitude changes of each energy source. Tables 8–10 are for stability and the directional changes in attitudes of each energy source. The empirical findings based upon the dependent variables are summarized as follows:

1. In the analysis of acceptance of various energies due to economic incentives, most of coefficients maintain the same sign and the magnitudes of the coefficients are not noticeably different throughout all types of energies. Only knowledge in renewable energy and perceived benefit in nuclear energy change the signs of coefficients from positive to negative. However, Chow tests reject the null hypothesis of no structural breaks and indicate that the economic incentives play some role to determine the acceptance of these energies.
2. In the analysis of the degree of attitude change, each type of energy source depends on different sets of explanatory variables and is determined separately. No single explanatory variable affects the degree of attitude change throughout all these three energies. For example, age lowers the probability of the degree of attitude change in renewable and nuclear energies while energy affordability raises the probability of the degree of attitude change only in fossil fuels and renewable energies. On the other hand, education, log(income), location, social status, perceived risk, negative image, and energy security play no role in the degree of attitude change regardless of energy types.
3. In the analysis of stability and the directional changes in attitude, each and every explanatory variable has consistent effect on each dependent variable, but no explanatory variable plays any role for all three energies. Only age, education, and ideology have no effect on any model of stability and the directional changes in attitudes.

The variables in three sets of factors (socio-demographic, perception, and social aspects of energy) are used as explanatory variables in the study. Some explanatory variables have consistent effects regardless of energies, but some have mixed effects. The empirical findings based upon explanatory variables are summarized as follows:

1. Education has no effect on any of these models.
2. All the coefficients of log (income) are positive except Model 2 and Model 10 where the dependent variables are the acceptance of fossil fuels with economic incentives and stability, respectively.
3. All the coefficients of location are positive except Model 9 where the dependent variable is change attitude on nuclear energy source.
4. All the coefficients of social status are positive throughout all the models.
5. Perceived benefit has mixed results. The coefficients are negative in Model 1, 6, 8, 9, and 15 but they are positive in Model 3, 5, 9′, and 11. In fossil fuels, perceived benefit has a negative effect

on the acceptance of that energy source when economic incentives are not. In renewable energy source, benefit has a positive effect on acceptance when economic incentives are not provided but it has a negative effect on the attitude change. In nuclear energy source, perceived benefit has a positive effect on acceptance when economic incentives are not provided but it changes to negative when the economic incentives are provided. The coefficient is positive when the dependent variable is attitude change but it is negative when the dependent variable is directional changes of attitude.

6. All the coefficients of perceived risk are negative throughout all the models.
7. All the coefficients of negative image are negative throughout all the models.
8. All the coefficients of trust are positive except Model 3 and Model 12 where the dependent variables are the acceptance of renewable energy without economic incentives and stability of renewable energy source, respectively.
9. All the coefficients of knowledge are negative except Model 3 and 8′ which are for renewable energy source.
10. All the coefficients of energy security are negative throughout all the models.

These empirical findings are also summarized in Table 11.

Table 11. Summary of empirical findings.

		Fossil Fuel		Renewable		Nuclear		Fossil Fuel	Renewable	Nuclear	Fossil Fuel		Renewable		Nuclear	
Model Number		**1**	**2**	**3**	**4**	**5**	**6**	**7/7′**	**8/8′**	**9/9′**	**10**	**11**	**12**	**13**	**14**	**15**
Socio-demographic factors	Gender														−	
	Age			+	+				/−	/−						
	Education															
	Log(income)		−	+	+						−		+			
	Location		+			+		+/		−/	+	+				
	Social status	+	+		+		+	+/	+/		+		+			
	Ideology			+				/−	−/							
Perception factors	Perceived benefit	−		+		+	−		−/−	−/+		+				−
	Perceived risk	−	−	−	−	−	−			−/	−		−			−
	Negative image	−	−	−	−	−	−	/−			−		−		−	
	Trust	+	+	−		+	+	/+	+/		+		−		+	
	Knowledge		−	+	−		−	−/	−/+						−	
Social aspects of energy	Energy security	−	−				−				−					
	Energy affordability		−		−			/+	/+		−					

Note: The signs in front of '/' are from Model 7, 8, and 9 and the signs after '/' are from 7′, 8′, and 9′, respectively.

In this study, we analyze changes in energy acceptance if economic incentives are provided as well as the factors that affect these attitude changes. Our findings are expected to provide useful information when using economic benefits as a policy instrument for enhancing the acceptability of various energy types in the future. However, this study has the following limitations. First, because it does not take an experimental approach to attitude changes, measuring precise attitude changes is challenging. Second, because the conditional sentence has two stimuli, namely, economic benefits and the installation of a power plant in the local area, it is difficult to clearly distinguish which stimulus influences acceptability. Third, although there were various cultural value, communication, structure, and other perception variables in the acceptance of policy or technology [67–73], we did not consider them.

Supplementary Materials: We provided three supplementary materials: First is the survey questionnaire which included the questions used for analysis; Second is the explanation note for variable coding and analysis; Third is the data set used for analysis. The following are available online at http://www.mdpi.com/2071-1050/11/7/2037/s1.

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Appendix A : Representativeness of Sample

To know the difference between actual demographics and the data used in this survey, we compare the former with the latter in terms of gender and age. The population data are derived from the census survey executed by Commissioner of Statistics Korea (KOSTAT). The difference in percent between the population and the sample appear in the last column in Table 2. There is ±0.8% difference in gender. By age, 1% in the 20s, 0.6% in the 30s, 0.6% in the 40s, 1.6% in the 50s and 1.6% in those over 60s. In the case of education level, 4.4% in middle school, 1.3% in high school, and 3.1% in college. There is small difference between population and sample.

Table A1. Difference between population and sample.

		Population		Sample		Percent gap (A-B)
Variable	Category	Frequency	Percent A (%)	Frequency	Percent B (%)	
Gender *	Female	20,348,268	49.7	757	50.5	−0.8
	Male	20,572,715	50.3	743	49.5	0.8
	Total	40,920,983	100	150	100	0.0
Age *	20–29	6,796,396	16.6	264	17.6	−1.0
	30–39	7,738,472	18.9	293	19.5	−0.6
	40–49	8,726,984	21.3	292	21.9	−0.6
	50–59	8,220,296	20.1	292	19.5	0.6
	Over 60	9,438,835	23.1	322	21.5	1.6
	Total	40,920,983	100	1500	100	0.0
Education Level **	Middle school	NA	15.0	159	10.6	4.4
	Higher school	NA	40.4	626	41.7	−1.3
	College	NA	44.6	715	47.7	−3.1
	Total	NA	100%	1500	100	0

Note: Population Data Source; * KOSIS (Korean Statistical Information System) [74], ** OECD [75].

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