Examining Factors Affecting Attitudes toward Nuclear Power in Taiwan

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Abstract

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Nuclear power has become a major issue in Taiwan for several decades. The objective of the present study is to obtain evidence about the major determinants contributing to attitudes toward nuclear power, by investigating socioeconomic factors, environmental attitudes, knowledge of issues, trust, and risk perception, in shaping nuclear attitudes. A face-to-face survey was conducted using paper-based questionnaires from July 2014 to September 2014. Finally, 364 surveys were collected, of which 356 met validation requirements. The findings showed (1) knowledge of issues, trust in university scientists, trust in environmental groups, and risk perception directly influence attitudes toward nuclear power. (2) Risk perception is directly influenced by trust in nuclear authorities, trust in environmental groups, environmental attitudes, and party preference. (3) Gender, age, and party preference directly influence knowledge, trust in

nuclear authorities, or trust in university scientists. The potential explanations and implications of findings are discussed.

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Chapter 1. INTRODUCTION

1.1 STATUS QUO OF TAIWAN'S NUCLEAR ENERGY INDUSTRY

According to the 2015 Key World Energy Statistics published by the International Energy Agency, nuclear energy produced 4.8% of the total global primary energy supply in 2013 (International Energy Agency, 2015). However, nuclear energy accounts for a larger proportion of energy in East Asia. Many East Asian countries rely on nuclear power for a portion of their electricity. For example, the share of electricity production by nuclear reactors in South Korea was 30.4% in 2014 (World Nuclear Association, 2016). China has 32 nuclear power reactors currently in operation and 22 under construction, with construction about to start on additional nuclear plants (World Nuclear Association, 2016). Until 2011, Japan was one of the Asian countries that relied most heavily on nuclear power. Japan generated 30% of its electrical power from nuclear reactors and [until 2011] planned to increase that share to 40% (World Nuclear Association, 2016). As described below, the catastrophic nuclear power plant failures in Fukushima following the Tōhoku earthquake and tsunami in 2011 altered these plans.

Taiwan currently has six reactors in three nuclear power stations, located in Shimen, Wanli, and Hengchun. These three power plants generate about 40 billion KWH electricity per year. In 2014, nuclear power accounted for 19 % of total electric power generation in Taiwan (Taipower Company, 2015). In addition to these three currently operational plants, construction started on a fourth nuclear power plant in Gongliao in 1999, but due to intense controversy, the Taiwanese government decided to halt the remaining construction in April 2014.

1.2 NUCLEAR POWER - A MAJOR ISSUE IN TAIWAN

1.2.1 *How did nuclear power become a major issue?*

Taiwan started to plan its first nuclear power plant in 1968. At that time, some legislators questioned the construction plan in the Legislative Yuan. There was also some opposition, subsequently, when the government decided to construct a third nuclear power plant. However, this opposition did not become a significant public issue, and failed to reach the political agenda

until Taipower Company (the only company generating electricity before 1995) announced plans to construct the fourth nuclear power plant in Gongliao in 1980 (Chang, 1989).

Between 1980 and 1985, opposition to the construction plan for the fourth plant began to develop. Some legislators questioned the budget for this project, claiming it was too high. In April 1985, 55 legislators asked to defer construction of the fourth plant, and the government agreed. The opposition during the early 80s was mainly concerned with economic issues, with little emphasis on nuclear safety concerns.

In July 1985, a hydrogen leak, accompanied by a major fire, occurred at the third nuclear power plant, and repairs to the generator took more than a year. One year later, the world's worst nuclear accident – the Chernobyl disaster – happened in Ukraine. At that point, the public began to worry about nuclear safety issues and the impacts of nuclear power on the environment, and the critics of nuclear power expanded their critique from the economic and financial aspects of constructing the fourth plant, to questioning nuclear energy as a whole (Chang, 1989). However, because Taiwan was still in a period of martial law, in which citizens' rights were limited, including freedom of speech and freedom to organize in civil society, there were no large anti-nuclear protests during this period.

After the Chinese Nationalist Party (KMT) government abolished martial law in July 1987, more and more environmental groups, such as the Taiwan Environmental Protection Union (TEPO) and the New Environment Foundation, were established. In addition to these national-scale non-governmental organizations (NGOs), local residents at the planned location of the fourth plant established the Yanliao Anti-Nuclear Self Help Association to make their voices heard. Large anti-nuclear protests were organized at this time through cooperation between environmental NGOs and this local group. This was the period in which the anti-nuclear movement organized on a grassroots basis and gained significant influence.

In the 1990s, TEPO and some other environmental groups began to cooperate with the Democratic Progressive Party (DPP), a growing political party established by forces opposing the KMT, in an attempt to put pressure on legislators to change the pro-nuclear policies that were in effect. These forces also tried to depose legislators supporting nuclear power in the Taipei County government. In 2000, the DPP took the presidency for the first time, and the new president Chen Shui-bian announced a stop to construction of the fourth nuclear power plant. However, due to intense political pressure, the DPP government decided to re-commence

construction on February 2001; the anti-nuclear movement was therefore left powerless for several years until the 2010s, since it had lost its legislative ally.

On 11 March 2011, a magnitude 9.0 earthquake, and the tsunami that followed, damaged several nuclear power plants in the Tohoku region of Japan. This combination of natural disasters with the inadequate emergency preparedness resulted in the Fukushima nuclear disaster, which aroused many anti-nuclear protests in Japan. As a result, the Japanese government decided to close most of its nuclear plants until 2015, when the government restarted several reactors in Kyushu. In addition to the domestic influence of the Fukushima disaster, reports from print and television media on this accident dominated headlines around the globe for weeks, and had an impact on energy policies in many different countries (Wittneben, 2012). In fact, some studies have found that the Fukushima disaster influenced public attitudes toward nuclear power, and decreased the acceptance of nuclear energy (Prati & Zani, 2012; Visschers & Siegrist, 2013).

Because of Taiwan's geographic proximity and historical ties to Japan, the effect of the Fukushima disaster may in fact have been greater in Taiwan than in other countries. For example, the Taiwanese public had demanded certain food products from Japan every year until March 2011, but after the disaster many people became suspicious of important products coming from the Tohoku area. After March 2011, the anti-nuclear movement in Taiwan re-ignited. Anti-nuclear groups have subsequently organized large protests every year, with large street demonstrations. With the influences of the Fukushima disaster and of social media, the scale of protests is much larger than in the past. The largest demonstration was in 2013, attracting about 200,000 people to march nationwide. As a result of the widespread opposition and intense controversy about the fourth plant, the current KMT government decided to halt construction again in 2014.

1.2.2 *National Polls*

Nuclear power has been a popular topic for national polls conducted in Taiwan over the last two decades. Civil Service Development Institute, Executive Yuan of Taiwan conducted a comprehensive review of national polls by various organization from 1993 to 2013, showing a pattern that reflected the history of the nuclear power issue in Taiwan.

From 1993 to 2000, most of the public supported the construction of the fourth plant, as well as nuclear power in general, and this support was usually above 50%. Overall, about 50% of those polled supported building the fourth plant, 20% to 30% had no opinion, and about 20% to 40% were opposed. From 2000 to 2008, the levels of support for stopping construction of the fourth plant, and for continuing construction, were closely matched. From 2008 to 2013, most of the Taiwanese public supported the fourth plant (if it were guaranteed to be completely safe), supported the gradual elimination of nuclear energy in the future, and supported a halt to the remaining construction of the fourth plant (Civil Service Development Institute, 2013).

Taiwan Indicators Survey Research (2015) has conducted national polls about attitudes toward nuclear power since 2013, which do not focus solely on the fourth nuclear power plant. The results of the polls are shown below:

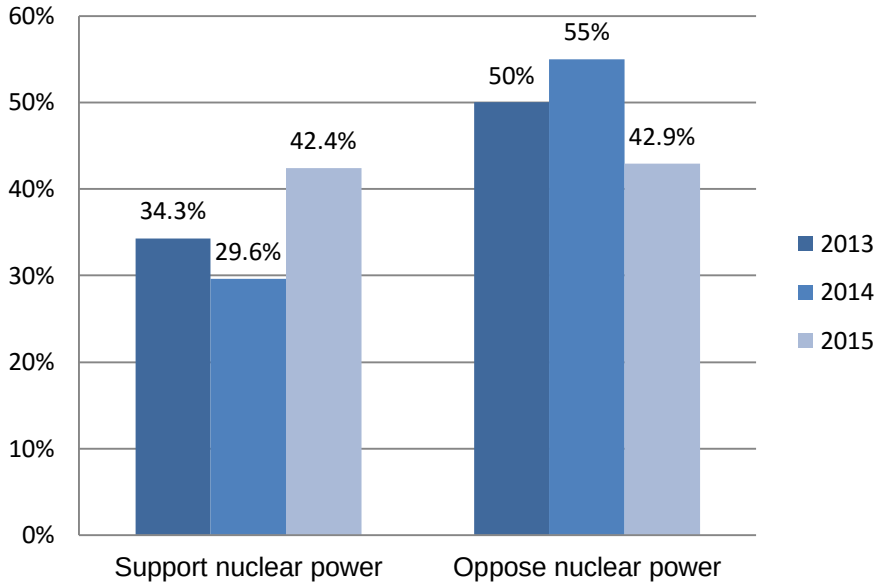

Figure 1.1. National Polls about Attitudes toward Nuclear Power from 2013 to 2015

The most recent poll in 2015 showed 42.4% support for nuclear power with 42.9% opposition to it, which is a very close result, while more people had opposed nuclear power in 2013 and 2014. Taiwan Indicators Survey Research assumed that this change reflected a lower level of concern over the fourth plant, since the government had decided to halt construction.

In summary, according to recent national polling, the majority supported a halt to the construction of the fourth nuclear plant, but this does not imply that the same majority would

oppose the use of nuclear power generation in general. Whether it is appropriate to use nuclear energy is still highly controversial in Taiwan.

1.3 Objectives of the Present Study

The primary objective of this study is to gain an understanding of the factors contributing to attitudes toward nuclear power in Taiwan. In other words, this study tries to answer two research questions: 1) who is more likely to hold positive or negative attitudes toward nuclear power, and 2) what factors may encourage them to change or maintain their attitudes.

Although many national polls have been taken in Taiwan during the past two decades, only a few studies have analyzed the determinants of attitudes toward nuclear power in greater depth. Therefore, the objective of the present study is to obtain evidence about the major determinants contributing to attitudes toward nuclear power, by investigating socioeconomic factors (gender, age, education, income, and party preference), environmental values, knowledge of issues, trust, and risk perception, in shaping nuclear attitudes, and thus provide an improved understanding of how these factors may influence their attitudes towards nuclear power in Taiwan. The results of this study may be useful for the government and environmental NGOs to develop future policy positions, and to communicate more effectively with the public, and could also be used in the field of environmental education.

Chapter 2. LITERATURE REVIEW

For the present study, several potential variables have been selected to build a model of factors associated with and likely determinants of attitudes toward nuclear power. The following sections discuss each potential determinant, and provide the conceptual basis for the hypothetical model.

2.1 Socioeconomic Status and Environmental Beliefs

2.1.1 *Empirical Evidence - Socioeconomic Factors as Predictors*

Recently, numerous studies have shown socioeconomic factors to be a determinant of attitudes toward nuclear power. For example, Whitfield, Rosa, Dan, and Dietz (2009) explored attitudes toward nuclear power in the U.S., and found that nonwhites are more supportive than whites of this form of power generation. Corner et al. (2011) examined public attitudes toward nuclear power in Britain; their results showed that men, older individuals, those of higher social status, and those with a voting preference for the Conservative party, rated nuclear power more favorably than others. Ertor-Akyazı, Adaman, O¨zkaynak, and Zenginobuz (2012) explored citizens' preferences concerning nuclear and renewable energy sources in Turkey. Their analysis showed that men rather than women are more likely to endorse nuclear energy investments. Ho et al. (2013) also examined determinants of public opinion regarding the fourth nuclear power plant in Taiwan. Their results revealed that significantly more women than men opposed the operation of a new nuclear power plant.

2.1.2 *Environmental Beliefs and the New Ecological Paradigm (NEP) Scale*

Environmental attitudes (called "environmental beliefs" in some literature) represent a psychological tendency to evaluate the natural environment with some degree of favor or disfavor, and are a crucial construct in the field of environmental psychology (Milfont, 2007). Dunlap and Van Liere (1978) developed the "New Environmental Paradigm" (NEP) scale, to measure environmental beliefs systematically. Since then, this has been perhaps the most widely used scale to assess various environmental topics. The background for the development of the NEP scale was that its authors believed that new, eco-centric beliefs were emerging. For

example, they noted the increasingly prevalent idea that human beings are part of natural systems and are thus constrained by nature. These emerging beliefs challenged the anthropocentric beliefs typical to modern, Western societies. Western modernism held that human beings were independent from nature, and were of greater significance than other organisms in nature (Dunlap & Van Liere, 1984). Hawcroft and Milfont (2010), reviewing the measurement of environmental beliefs, agreed that only three scales have been widely used, the Ecology Scale, the Environmental Concern Scale, and the NEP scale. Even though all three scales have been widely used, some items in the Environmental Concern Scale and the Ecology Scale emphasize specific environmental issues. These issues are probably outmoded, while many new issues have emerged. The NEP Scale is the only environmental scale that does not emphasize any specific issue, instead measuring general beliefs about the relationship between humans and nature (Dunlap & Jones, 2002). In 2000, Dunlap and Van Liere revised their original NEP scale from 12 items to 15, consisting of 5 basic parts: the reality of limits to growth, anti-anthropocentrism, the fragility of the balance of nature, the rejection of human exceptionalism, and the possibility of an eco-crisis.

Value-Belief-Norm (VBN) theory has been applied to environmental psychology, postulating that general beliefs act as a filter or amplifier when individuals receive information regarding environmental threats. The NEP scale measures beliefs which Stern et al. called "folk" ecological theory (Stern, Dietz, & Guagnano, 1995). Stern et al. (1995) called the NEP scale the best tested of all measures of environmentalism, and embedded it in their original VBN model (Stern, Dietz, Abel, Guagnano, & Kalof,1999; Stern, 2000).

Existing works that have applied VBN theory to nuclear power have all used the NEP to measure environmental beliefs, although some of them do not use the full version of the NEP Scale. The present study uses a 7-item subset of the NEP, which was also used by Whitfield et al. (2009). (All items are listed in the appendix A and B.)

2.1.3 *Relationship Between Socioeconomic Factors, Beliefs, and Behaviors*

Stern et al. (1995), and Dietz, Stern and Guagnano (1998), have examined the associations between social-structural factors, environmental beliefs, and environmental concerns. They proposed a causal model that includes four basic parts: (1) social-structural factors, such as gender, race, age, and education; (2) general life values, such as religious

strength; (3) generalized and specific beliefs concerning the environment, and environmental worldview; and (4) environmental behavior. Their results revealed that generalized environmental beliefs may be influenced by social structure, and stronger relationships were found between environmental behavior and social-psychological variables including beliefs, attitudes, and worldviews.

Based on the findings of the studies by Stern et al. (1995) and Dietz et al. (1998), Johnson, Bowker, and Cordell (2004) applied a simpler version of the model, setting aside general life values or specific environmental beliefs in order to address ethnic and cultural characteristics. They proposed a causal model in which socio-structural variables may influence people's general beliefs about the environment, and such beliefs may directly affect their environmental behavior. Figure 2.1 shows this comparison.

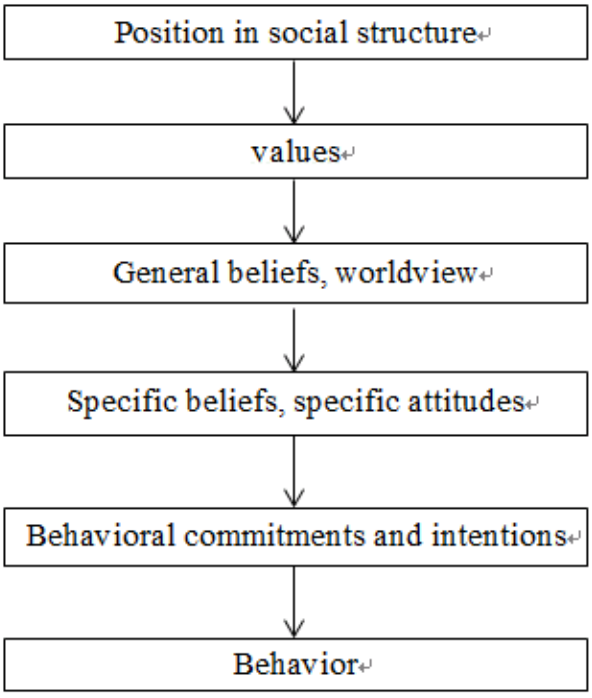

Figure 2.1. Model Comparison between Stern et al. (1995) (top) and Johnson et al. (2004) (bottom). Derived from Johnson et al (2004) figures 1 and 2.

Building on their numerous previous studies, Stern et al. (1999) developed a Value-Belief-Norm (VBN) model of environmental movement support, which contains human values; beliefs, including environmental beliefs measured by New Ecological Paradigm (NEP); awareness of consequences; ascription of responsibility; pro-environmental personal norms; and environmental behavior. The VBN theory links value theory, norm-activation theory, and the NEP perspective, postulating that norms underlying the environmental attitudes are given effect

by beliefs that environmental issues will lead to serious problems, that individuals are able to take actions to moderate these threats, and that these serious problems also threaten personal values. Stern (2000) provided an example to illustrate this concept: "people who value other species highly will be concerned about environmental conditions that threaten those valued objects, just as altruists who care about other people will be concerned about environmental conditions that threaten the other people's health or well-being." (p. 413)

In addition, Whitfield et al. (2009) argued that when individuals are asked to evaluate the perceived risks of environmental threats, the VBN model posits that their decision-making process is more intuitive than calculative. The logic of VBN theory suggests that people are more likely to link a referent consisting of their values and beliefs, rather than to engage in the calculative logic assumed by rational actor theory. People may engage in an elaborated, calculative process when they have an opportunity to discuss an issue with others at length, or have enough information available for personal deliberation. However, it is very difficult to achieve these conditions during paper-based surveys or by asking respondents to evaluate risks (Dietz and Stern, 1995).

Stern et al. (1999) also compared VBN theory with three other prevalent theories (indicators of four cultural biases, postmaterialist values, and belief in the sacredness of nature). They concluded that VBN theory is the best available account of non-activist environmentalism (support for the environmental movement without committed to public actions).

Whitfield et al. (2009), De Groot, Steg and Poortinga (2013) and Prati and Zani (2012) have successfully applied VBN theory to the nuclear power issue, but with revisions. Whitfield et al. (2009) dropped consideration of norms for action and behavioral intentions, but added trust to their scale. Their results showed that attitudes towards nuclear power were influenced both directly and indirectly by environmental beliefs, trust in nuclear organizations, and perceptions of risk, sustaining the predictions of the VBN model. De Groot et al. (2013), examined the relationships between egoistic, altruistic and biospheric values; perceived risks and benefits of nuclear energy; and the acceptance of nuclear energy. These authors dropped environmental beliefs and trust from Whitfield's scale, but added "perceived benefits of nuclear energy" to compare with its perceived risks. Their findings showed that perceived benefits and risks directly affected acceptance of nuclear energy, and that values indirectly affect acceptance through the perception of benefits and risks. Prati and Zani (2012) focused on the effect of the

Fukushima nuclear accident on the VBN cluster of variables. Compared to the revised model of Whitfield et al. (2009), they added two sections: behavioral intentions, and information related to the Fukushima accident. They found that participants reported decreases in trust and pronuclear attitudes, along with significant increases in pro-environmental attitudes as assessed by NEP. Therefore, they presumed that a major nuclear accident like Fukushima might influence environmental beliefs so that people's attitudes are accordingly influenced.

Despite some previous studies that have examined determinants of attitudes toward nuclear power in Taiwan, no known study has applied VBN theory in this context. The present study applies the concepts of VBN theory to nuclear power issues, and uses a revised framework building on the model of Whitfield et al. (2009).

2.2 TRUST

The importance of trust has attracted a great deal of study in the social sciences in recent decades. Trust is thought to moderate social complexity and uncertainty, and is seen as a requirement of a stable democratic society and economy, and a significant component of social capital (Earle & Cvetkovich, 1995; Cook, 2000).

In the field of risk research, many studies have shown that institutional trust — "the level of confidence in those agents responsible for the management of risks" (Whitfield et al., 2009) — is an important factor. Researchers commonly hypothesize that more trust in regulatory authorities will decrease perceived risks and increase acceptance. Earle (2010) comprehensively reviewed empirical research about trust in the field of risk management, noting that even though a considerable body of research has developed, studies differ in whether the final dependent variable should be risk perception or acceptance of a technology, or whether risk perception mediates between trust and technology acceptance. Some of the empirical evidence on this question has focused on the nuclear power industry. Katsuya (2001) collected data from three main cities in Japan, Tokyo, Osaka, and Nagoya, examining public perceptions of nuclear power after the Tokai nuclear accident. The author analyzed two types of trust as predictors of perceived risks and technology acceptance: trust in government and trust in nuclear power operators. Their results revealed that both types of trust related negatively to perceptions of risk, and positively to acceptance of nuclear power. Tanaka (2004) conducted a survey in Japan with randomly selected adult participants, examining the relationship between trust in regulatory

authorities, including government and industry, and acceptance of nuclear power. However, Tanaka's causal model did not regard trust as a potential determinant of risk perception. Instead, risk perception was interpreted as a separate, independent variable predicting acceptance of the technology. The results also showed that trust in authorities was positively related to acceptance of nuclear power.

Since nuclear power has become a hotly debated public issue, regulatory authorities may not be the only stakeholders that influence public attitudes. Other groups, such as environmental NGOs and academic experts also provide their points of view on this issue, which can include support for, or opposition to, the current energy policies made by regulatory authorities. Public trust in regulators and other groups can differ. Laird (1989) argued that there has been a dramatic growth of trust in environmental groups since the 1970s in the U.S., which accompanied a decrease in public trust in institutions. Whitfield et al. (2009) also conducted research in the U.S. and examined two types of trust, one being "nuclear trust," including the nuclear industry and the Nuclear Regulatory Commission, while the other was "environmental trust," including trust in the Environmental Protection Agency, environmental groups, and university scientists. Risk perception was regarded as mediating the relationship between trust and nuclear attitudes in Whitfield's causal model. Their results revealed that individuals who have more nuclear trust were less likely to perceive more risks, and that trust only had indirect effects on nuclear attitudes, through risk perception; individuals who perceive more risks are more likely to oppose nuclear power. Costa-Font, Rudisill, and Mossialos (2008) conducted a survey in UK with a multi-stage random sample of residents aged 15 and over, examining respondents' trust in information from various sources, such as U.K. agencies in charge of radioactive waste, the U.K. government, the European Union, media, nonprofits, international organizations, and independent scientists. They observed that trust in information from the nuclear power industry, international organizations, and the media had a positive influence for shaping support of nuclear energy, while trust in UK agencies, nonprofits, and European Union negatively related to public attitudes toward nuclear power.

Depending on energy policies and circumstances in different places, the relationship between trust in these various groups, and attitudes toward nuclear energy, may differ accordingly. However, researchers often examine trust in various nuclear power stakeholders, not only in regulatory authorities.

The present study separates trust into three types. The first is nuclear trust, including trust in information from the Executive Yuan Atomic Energy Council, a government institution that is in charge of nuclear policies and supervises nuclear power operation, and trust in information provided by Taipower Company, the only company operating nuclear power plants in Taiwan. The second type of trust is scientific trust, which represents trust in information from the Institute of Nuclear Engineering and Science in National Tsing Hua University (NTHU), historically the only department in Taiwan that focuses on nuclear engineering. The last aspect is environmental trust, which represents trust in information from environmental groups.

2.3 KNOWLEDGE

It might seem straightforward to assume that knowledge about a technology is related to perceptions of risk and attitudes toward this technology. Fishbein and Ajzen (1975) assumed that knowledge is an indirect determinant of attitudes through salient beliefs (a small number of relevant beliefs). Johnson (1993) discussed the role of knowledge in risk perception studies, finding that the relationship between knowledge and risk perception, or between knowledge and attitudes, are sometimes contradictory. Sjöberg and Drottz-Sjöberg (1991) conducted a survey among nuclear power plant workers in Sweden, finding that those individuals who had more knowledge about nuclear power plants were more likely to perceive lower risks. Katsuya (2001) also examined the relationship between knowledge about nuclear power and acceptance of nuclear energy, but found no statistically significant connection.

In addition to those studies examining knowledge about nuclear power plant operation, other studies evaluated the impact of knowledge about other types of nuclear technology. Costa-Font et al. (2008) examined the relationship between knowledge about radioactive waste storage and attitudes toward nuclear power, and the results showed that individuals with more knowledge about radioactive waste were more likely to oppose nuclear power. Maharik and Fischhoff (1993) examined the relationship between knowledge about risks of using nuclear energy in space and the acceptance of this nuclear technology. Their findings showed that people who have more knowledge about risks were more likely to accept the technology, in this case.

Two potential reasons could explain these contradictory results. The first factor is the different knowledge scales used by researchers. One type measures self-rated knowledge, which

means participants themselves rate how much they know about a topic. Such items in the scale might include "how much do you know about nuclear power," with numbers 1-5 from very little to very much, or a statement "I have more knowledge about nuclear power than other people," with numbers 1-5 from strongly disagree to strongly agree. However, this type of knowledge scale might not be very reliable and might lack external validity. The answers given by respondents could easily be influenced by extraneous factors or socially desirable answers (Visschers & Wallquist, 2013). The other type of scale measures objective knowledge, where all questions usually have a correct answer, and researchers can evaluate the knowledge score for each sample. This type of scale is more reliable than self-rated knowledge, but specific knowledge domains can still produce contradictory results (Davidson & Freudenburg, 1996). For example, if the items only focus on knowledge about nuclear accidents, the result would probably be a negative relationship between knowledge and acceptance. On the other hand, if the items only focus on knowledge about nuclear plant operations, the relationship would probably be positive. Visschers and Wallquist (2013) suggested a knowledge scale about nuclear power which included three domains: the current context of the Swiss nuclear industry, nuclear power technology, and radioactivity, and attempted to create a comparatively comprehensive nuclear knowledge scale.

In addition, some studies have revealed that gender could be a determinant of nuclear power-related knowledge. In some contexts, men were found to have more knowledge about nuclear power, on average, than women (Drottz-Sjöberg & Sjöberg, 1991; Davidson & Freudenburg, 1996).

No studies to date have attempted to develop a comprehensive nuclear power knowledge scale that could be applied extensively. The present study employs, in essence, a simplified and revised combination of the scale by Visschers and Wallquist (2013) and that of Costa-Font et al. (2008), applied to Taiwanese circumstances, and includes additional items to assess knowledge about the recent Fukushima nuclear accident.

2.4 RISK PERCEPTION

Beck (1992) argued that of the way in which disasters are understood has varied over time, with differing concepts of risk employed in three distinct periods: (1) pre-modernity, (2) industrial society, and (3) risk society. Most of the risks faced by human beings in pre-

modernity were natural hazards, such as earthquakes, floods, and famine. No matter how bad these were, human beings tended to interpret them as "acts of god" or nature, with the assumption that human beings could not affect the course of such events and had to adapt to these hazards. As industrialization progressed, many risks resulting from nature could be controlled effectively by such societal means as risk assessment, early warning, and insurance. Now, according to Beck, developed a "risk society" has developed with many unintended, incalculable, and uncontrollable risks produced by human societies, such as nuclear accidents, hazardous waste pollution, and chemical contamination. Therefore, as the effects of technology have gradually been perceived to drift out of the control of human agency, and the risks derived from technology have become uncertain and unpredictable but still weigh on every individual, people tend to link risks to fear, and want to eliminate risks where they are able to do so (Beck, 1992; Slovic, 1987).

Irwin, Allan, and Welsh (2000) pointed out that, during the Cold War, some economists and politicians attempted to promote nuclear power, regarding it as a safe, environmentally-friendly, and low-cost technology. However, Adam and Loon (2000) argued that, until technological disasters happened, people were unlikely to take risks into account, but having experienced a major incident and determined the possible impact of the technology, the risks would become deeply embedded in popular perception.

Risk is presented in modern society, in two fundamental forms: "Risk as feelings (perceived risks) refers to our instinctive and intuitive reactions to danger," while "risk as analysis brings logic, reason, and scientific deliberation to bear on risk assessment and decision making" (Finucane, Alhakami, Slovic, & Johnson, 2000; Slovic & Peter, 2006. P. 322). United State Nuclear Regulatory Commission defined risk as a concept that "combines the probability of an accident with the consequences of that accident", which is close to Slovic and Peters' concept of risk as analysis, because it takes probability into consideration. However, Slovic and Peters (2006) pointed out that when the potential impact is extremely serious, individuals tend to ignore evidence about the probability of an accident occurring. For example, the potentially catastrophic impact of a nuclear accident causes people to ignore the low probability of nuclear accidents. Slovic (1987) argued that the mechanisms underlying complicated nuclear technology are unfamiliar to most people. Therefore, rather than using a calculative assessment to evaluate

risks, most people just rely on intuitive judgment. Building on these arguments, risk perception is expected to be an important determinant of attitudes toward nuclear power.

In fact, most of the empirical evidence in the field of nuclear research has shown that risk perception is a powerful determinant of nuclear attitudes/acceptance (Whitfield et al., 2009; Ho et al., 2013; Ieong et al., 2014; Visschers & Siegrist, 2013; Liang, 2014). In addition to being a determinant of nuclear attitudes, risk perception is itself determined by various factors discussed above, including trust, knowledge, socioeconomic status, and values (as measured by the NEP) (Sjöberg & Drottz-Sjöberg, 1991; Katsuya, 2002; Whitfield et al., 2009; Hung & Wang, 2011). The present study regards risk perception as the major mediator between these other independent variables and attitudes toward nuclear power.

2.5 Previous Studies in Taiwan

Hung and Wang (2011) conducted a study that focused on the second nuclear power plant in Taiwan. They examined determinants of risk perceptions for nuclear power locally, instead of nuclear attitudes, and attempted to map the spatial heterogeneity of risk perception. In their causal model for examining the determinants of risk perception, the authors proposed 5 potential groups of variables, which are: (1) compensation; (2) social trust, including levels of trust in the information provided by Taipower (the nuclear power operator), academic research, and environmental groups; (3) socioeconomic factors; (4) local context, including distance to SNPP, neighbors (level of trust in neighbors' information about nuclear power risk); and (5) quality of life (the degree to which the power plant would affect the quality of everyday life); plus a hybrid psychometric measure, which included health impacts (the levels of expected harm) and benefits (the perceived probability of potential benefit). Their findings revealed that nuclear power risk perception was mainly influenced by social trust, education, age, and local context, rather than proximity.

Ho et al. (2013) examined determinants of public opinion towards the planned fourth nuclear power plant in Taiwan. Their causal model consisted of (1) socioeconomic factors including gender, age, and education, (2) trust in nuclear safety including safety management, and comparing emergency plans in Japan and Taiwan, (3) location, and (4) risk perception. Unlike the models of Hung and Wang (2011) and the studies applying VBN theory, this model postulated that both trust and risk perception could influence nuclear attitudes directly, and that

there is no relationship between trust and risk perception. Their findings showed that opinions were mainly affected by gender, location, trust, and risk perception. These results differed from the Hung and Wang (2011) study, in which trust in information from various sources could affect risk perception.

Liang (2014) examined determinants of attitudes toward nuclear power including (1) socioeconomic factors and (2) risk perception. They found that gender and party preference had a significant influence on nuclear attitudes. Men and KMT supporters were more likely to support nuclear power, while women and DPP supporters were more likely to oppose it. In addition, they also compared the explanatory power of two different models, the first using socioeconomic status variables as independent variables, and the second employing various types of risk perception about nuclear power, as explanatory factors. The results showed that analysis based on risk perception had higher explanatory power.

These studies have included such variables as socioeconomic factors, geographic proximity (distance to power plants), trust, and risk perception, although the specific items varied in their formulation. However, in the case of Taiwan, no existing literature has taken into consideration either general values, as suggested by VBN theory, or objective measures of respondents' knowledge about nuclear issues.

The present study attempts to place more emphasis on a social-psychological approach, by applying VBN concepts to build a model that includes objective knowledge, in order to better understand determinants of attitudes toward nuclear power in Taiwan.

2.6 Research Hypothesis and Analytical Model

Building on all literatures mentioned in the previous sections, the present study proposes a model that treats socioeconomic factors as the primary independent variables, including gender, age, income, education, and party preference, which may directly or indirectly affect all other mediating variables and the ultimate dependent variable. Environmental values, knowledge, nuclear trust, and environmental trust are second-level, which can be directly predicted by socioeconomic status, and can in turn directly or indirectly predict the intermediate variables at the next level and the dependent variable. Risk perception is the third-level mediator, which can directly predict the dependent variable and be predicted by all other independent and

intermediate variables. Finally, the final dependent variable reflects attitudes toward nuclear power.

The hypothesized model may be depicted as follows:

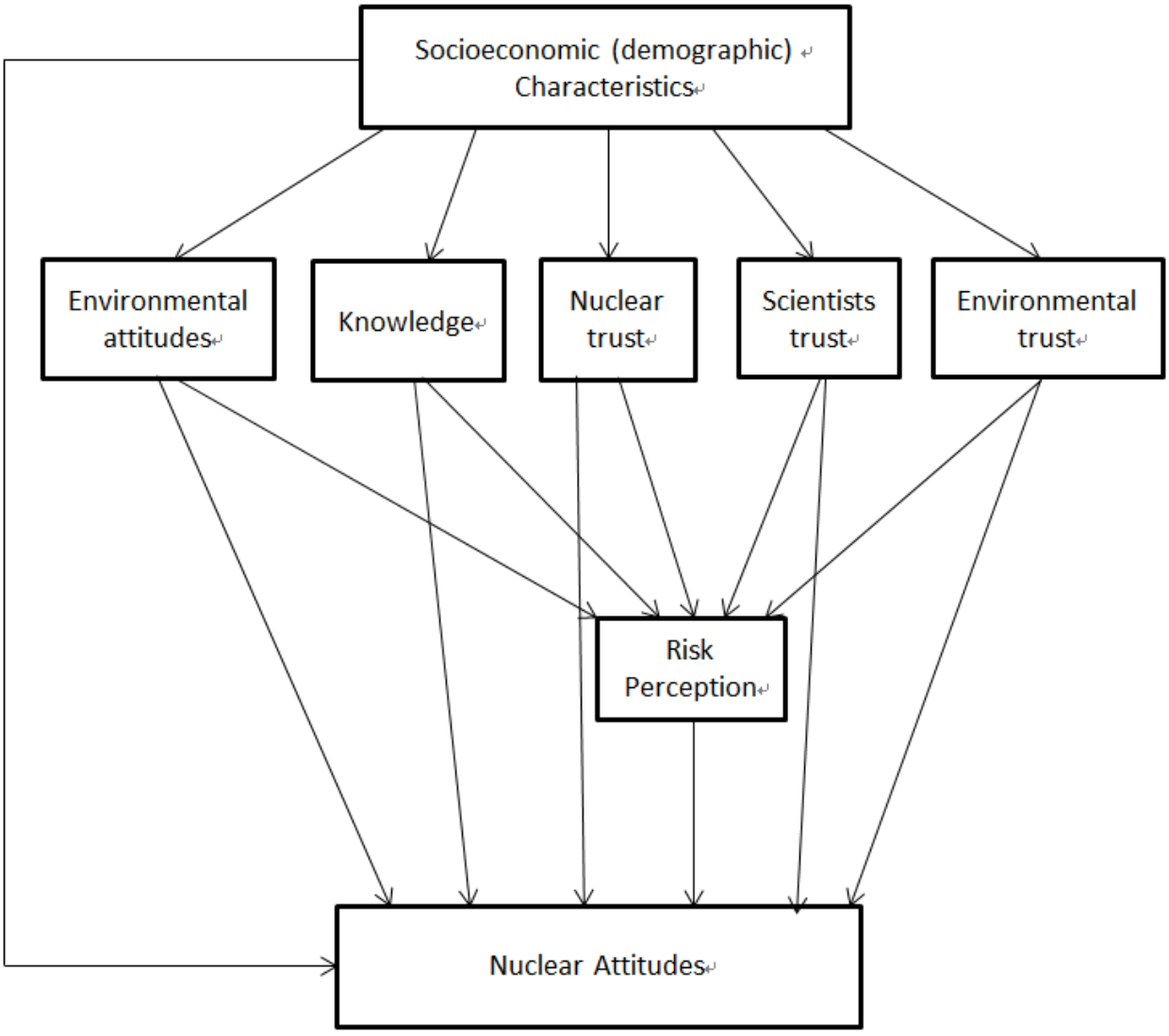

Figure 2.2 Research Hypotheses and Analytical Model

Chapter 3. METHODOLOGY

3.1 SAMPLING METHOD

From July 2014 to September 2014, a face-to-face survey was conducted using paper-based questionnaires in Taipei City, Taichung City, and Tainan City, collecting data from different regions (north, central, and south Taiwan) to enhance reliability. The present study used convenience sampling, which means that subjects were selected because they were easy to access: most data were collected from public open spaces such as parks, squares, and university campuses, while some surveys were administered in class settings at the National Chung Hsing University in Taichung. Surveyors randomly asked people in public open spaces whether they were willing to participate this survey, gave them questionnaires with short introduction of this survey if they were willing to participate, and then collected questionnaires after they finished. In class settings, class instructors announced there will be a survey where the participation is completely voluntary, and then leave class first. Surveyors gave questionnaires with introduction to those who were willing to participate, and collect data after participants finished. The participants were all 18 years of age or older. Finally, 364 surveys were collected, of which 356 met validation requirements. The final valid sample consisted of 147 surveys collected in Taipei, 172 in Taichung, and 37 in Tainan. Seventy-eight of the 356 survey participants were student participants from classes in Taichung. This survey received approval from Human Subject Division, University of Washington.

3.2 MEASUREMENT

The full questionnaires used in this study are provided in Appendix A (translated in English) and in Appendix B (original)

3.2.1 *Socioeconomic Characteristics*

The present study collected demographic information (socioeconomic characteristics) for all respondents. Participants' gender, age, level of education (in 6 categories, from elementary school to Ph.D.), personal annual income (in 6 categories, from less than 200,000 to more than a million New Taiwanese Dollars), and party preference, were ascertained. Party preference was

measured according to three options: Pan-Blue (a political alliance consisting of several parties, where the KMT is the primary partner), Pan-Green (another multi-party alliance, where DPP is primary), and no party preference.

3.2.2 *Environmental Values*

A seven-item subset of the New Ecological Paradigm (NEP) scale (Whitfield et al., 2009) was included in the survey. The NEP scale measures general beliefs about the environment, specifically to determine the extent to which the subject shares a "pro-ecological" worldview. Responses were measured on a 1-5 scale, from "strongly disagree" (1) to "strongly agree" (5).

3.2.3 *Trust*

Three conceptually distinct trust scales were used. The first one, "trust in nuclear authorities," reflected the respondent's trust in information from Executive Yuan Atomic Energy Council and Taipower Company, the public institution and the private operator, respectively, in charge of nuclear energy in Taiwan. The second scale, "trust, in scientists," reflected trust in university-based scientists. The third measure, "trust in environmentalists," reflected trust in information received from environmental groups. Response options ranged from "very little trust" (1) to "a great deal of trust" (5).

3.2.4 *Knowledge*

The present study employed what amounted to a simplified revision and combination of scales from Visschers and Wallquist (2013) and Costa-Font et al. (2008). There were 10 items in this scale, which included the current context of the Taiwanese nuclear industry, nuclear power technology, and radioactivity, as suggested by Visschers and Wallquist. All items were measured using true or false questions, with respondents given three options: true, false, and "don't know". In order to analyze the data, these answers were transformed to a score representing the number of questions that were answered correctly.

3.2.5 *Risk Perception*

Three items that derived from Visschers and Siegrist (2013), which applied to the Taiwanese situation, were used to measure participants' risk perception. The options for response ranged from "strongly disagree" (1) to "strongly agree" (7).

3.2.6 *Nuclear Attitudes*

In this scale, three items measured participants' attitudes toward nuclear power, identifying three different reasons put forward to justify the need for nuclear power plants in Taiwan. Responses were measured on a 1-5 scale, from "strongly disagree" (1) to "strongly agree" (5).

3.3 DESCRIPTION OF THE SAMPLE

Table 3.1 shows a demographic description of the sample. The male participants (52.5%) outnumbered females (47.5%). A large portion of participants (41.2%) were under 25 years old, primarily because participants on campuses and in class settings were generally college students; few participants were over 50 years old (13.8%). Most respondents possessed bachelor's or higher degrees, which is typical of Taiwanese society, especially for younger cohorts. A large proportion of participants (43.8) reported an individual income less than 200,000 New Taiwanese Dollars (NTD), probably because many of them were young adults. 80% of participants had no party preference, with 43 Greens and 27 Blues.

The finding that only 20% of respondents reported a party preference may not reflect the reality of Taiwanese society. It is believed that most Taiwanese have a party preference, roughly equally divided into Pan-Blue and Pan-Green affiliations, but most people would not want to express their preference to others.

This may result from special features of Taiwanese politics. Unlike other democracies, the political spectrum in Taiwan over the past few decades has not been based on competition between conservative and progressive values, but has basically related to national identity issues, namely the competing goals of Chinese unification and Taiwanese independence. Further, the KMT's authoritarian history and issues of ethnicity also caused party preference to become a

sensitive topic. The predominance of subjects reporting no party preference, however, may cause bias in data analysis.

Table 3.1. Description of the Sample

Variable	Total N (%)
Number of subjects	356
1. Gender	
Male	187(52.5)
Female	169(47.5)
2. Age	
Mean(SD)	31.4(12.8)
<25	146(41.2)
25-49	159(45.0)
≧50	49(13.8)
3. Education (current students included)	
Elementary school	1(0.3)
High school	21(5.9)
Junior college	61(17.3)
Bachelor	212(59.6)
Master	53(14.9)
PhD	5(1.4)
4. Personal income (NTD)	
<200,000	156(43.8)
200,000-399,999	28(8.5)
400,000-599,999	42(12.7)
600,000-799,999	51(15.4)
800,000-999,999	20(6.0)
≧1,000,000	34(9.6)
5. Party preference	
Pan-Blue	27(7.7)
Pan-Green	43(12.3)
None	280(80.0)

3.4 DATA ANALYSIS

Since the scales in the present study are derived from existing studies, the present study uses confirmatory factor analysis to the check factor loadings for each item. Additionally, Cronbach's alpha is also provided, to show the reliability of each scale.

Descriptive statistics (mean and standard deviation) were calculated for all scales and for three items in the nuclear attitudes scale. The response distribution for the 10 items in the knowledge scale were also provided. Next, t-tests and analysis of variance (ANOVA) were performed to investigate how socioeconomic status affects the other scales. T-tests were used when the independent variable is nominal and carries only two options (such as gender, and party preference). Where a nominal variable allows more than two options, ANOVA must be used. Age and education (continuous and ordinal) variables were regrouped to employ ANOVA.

Baron and Kenny (1986) proposed a three-step approach in which several conditions must be met to confirm mediation effects:

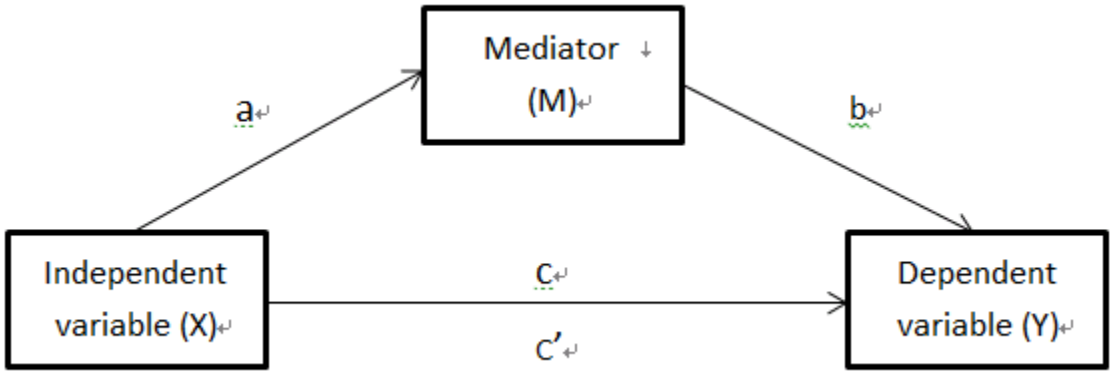

Figure 3.1. Conceptual Diagram of Mediation

Step 1. Conduct a regression analysis with an independent variable predicting the dependent variable, to confirm coefficient c is significant. $Y = \beta 0 + \beta 1 X + e$

Step 2. Conduct a regression analysis with an independent variable predicting a mediator, to confirm coefficient a is significant. $M = \beta 0 + \beta 1 X + e$

Step 3. Conduct a regression analysis with both the independent variable and the mediator predicting the dependent variable, to confirm coefficient b is significant. $Y = \beta 0 + \beta 1 X + \beta 2 M + e$

If coefficient a, b, and c are all significant, then there is a mediation effect.

Baron and Kenny (1986) also mentioned that if c' is zero, the effect is a complete mediation; if not, multiple mediating factors are suggested (partial mediation). Also, Shrout and Bolger (2002) reviewed Baron and Kenny's work, and recommended that their first step is not

required to show mediation. Building on these studies, the present study performs multiple regression analyses, to test the hypothetical relationships and mediations in the analytical model.

Chapter 4. RESULTS

4.1 TESTS OF VALIDITY AND RELIABILITY

Confirmative factor analysis verified all scales, with Chronbach's alpha as an estimate of the reliability of the scales.

Table 4.1. Confirmatory Factor Loadings and Reliability of Scales

Factor/Variable	Factor Loading	Alpha
New ecological paradigm		**0.73**
Human ingenuity will insure that we do NOT make the earth unlivable.	0.42	
Humans are severely abusing the environment.	0.68	
The balance of nature is strong enough to cope with the impacts of modern industrial nations.	0.61	
The so-called ''ecological crisis'' facing humankind has been greatly exaggerated.	0.62	
The earth is like a spaceship with very limited room and resources.	0.64	
The balance of nature is very delicate and easily upset.	0.62	
If things continue on their present course, we will soon experience a major ecological catastrophe.	0.74	
Nuclear trust		**0.85**
Atomic Energy Council, Executive Yuan	0.93	
Taiwan Power Company	0.91	
Risk perception		**0.80**
I am very concerned about the dangers of nuclear power plants in Taiwan.	0.85	
A nuclear power plant that is built now or in the future is safe.	0.89	
The risks of catastrophe with nuclear power plants are very small.	0.82	
Nuclear attitudes		**0.90**
Taiwan needs nuclear power plants because alternative energy sources do not produce sufficient electricity.	0.92	
In light of health concerns about acid rain, damage to the ozone layer, and climate change associated with the burning of coal and oil, Taiwan should rely on nuclear power to meet its future electricity needs.	0.90	
Nuclear power is an acceptable approach for meeting the nation's energy needs.	0.90	

Nunnally (1978) suggested factor loadings should be greater than 0.4. As presented in Table 4.1, confirmative factor analysis results revealed that factor loadings were adequate (all above 0.4), suggesting high scale validity. The Chronbach's alphas were strong as well (greater than 0.7), suggesting high reliability.

4.2 DESCRIPTIVE STATISTICS

4.2.1 *Mean and SD for Scales*

The present study calculated descriptive statistics to show an overview of all scales:

Table 4.1 Mean and SD for all scales

Scale	Mean	SD
Environmental attitudes (NEP) (1=strongly disagree, 5=strongly agree)	4.13	0.58
Knowledge (none correct=0, all correct=10)	3.24	1.96
Nuclear trust (1=very little trust, 5=a great deal of trust)	2.62	0.90
Environmental trust (1=very little trust, 5=a great deal of trust)	3.21	0.70
Risk perception (1=strongly disagree, 7=strongly agree)	5.17	1.30
Nuclear attitudes (1=strongly disagree, 5=strongly agree)	2.89	1.03

As shown in Table 4.1, participants typically endorse a "pro-ecological" worldview, and tend to distrust nuclear regulatory authorities compared with environmental groups and university-based scientists. Nuclear power seems not to be a very safe technology, according to the perceptions of respondents.

Table 4.2. Mean and SD for items reflecting nuclear attitudes

Item (1-strongly disagree to 5-strongly agree)	Mean	SD
Taiwan needs nuclear power plants because alternative energy sources do not produce sufficient electricity	2.72	1.11
Taiwan should rely on nuclear power to mitigate the potential impact derived from the use of fossil fuel	3.00	1.09
Nuclear power is an acceptable approach to meet the nation's energy needs.	2.97	1.20

There are no significant differences among the three items in the nuclear attitudes scale. Subjects tend to disagree that alternative energy is insufficient to meet national energy requirements; in other words, they tend to see alternative energy as a possible alternative to nuclear power.

4.2.2 *Answers in the Knowledge Scale*

There were a total of 10 questions in the knowledge scale, where each question had a correct answer and three responses were available: true, false, and "don't know". Figure 4.1 shows the distribution of answers to questions 1-5, about radioactive technology and the current context of the nuclear power industry in Taiwan.

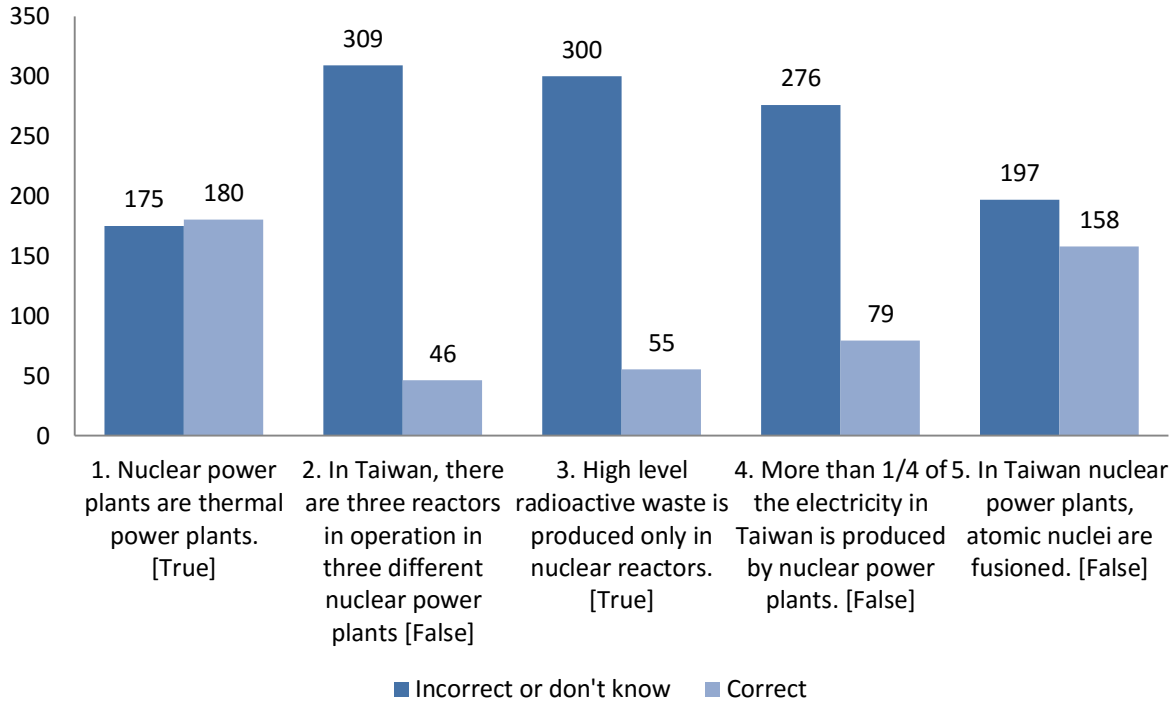

Figure 4.1 Responses to knowledge questions 1-5. See Appendix C for the answer key.

As presented in Figure 4.1, question 1 and 3 were about radioactive technology, questions 2 and 4 were about the current context of the nuclear power industry in Taiwan, and question 5 engaged both aspects. Compared to the radioactive technology questions, participants showed less knowledge about the current context of Taiwan's nuclear power industry.

Figure 4.2 shows the answer distribution for questions 6-10, about major nuclear accidents in human history.

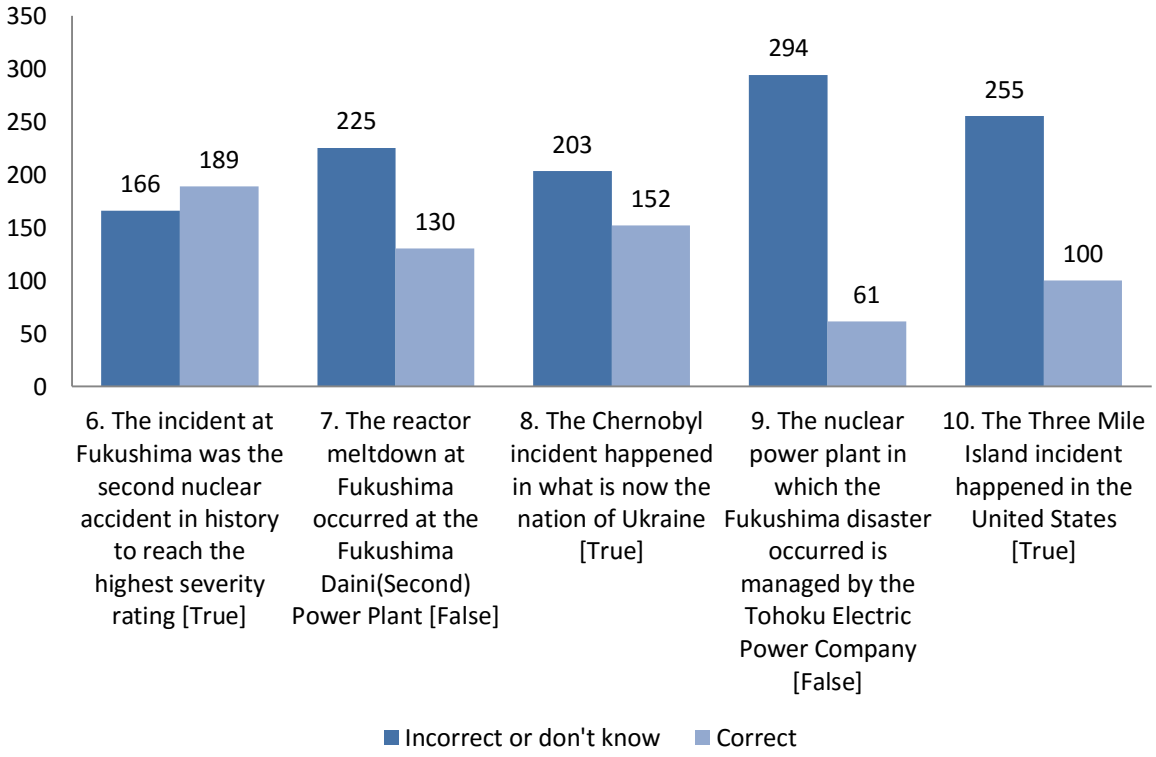

Figure 4.2 Responses to knowledge questions 6-10. See Appendix C for the answer key.

As presented in Figure 4.2, compared with question 1-5, respondents seemed to possess more knowledge about international nuclear accidents.

4.3 T-TESTS AND ANOVA FOR SOCIOECONOMIC FACTORS

In order to perform ANOVA, the level of education of respondents was regrouped into 3 groups: junior college or under, bachelor's degree, and Master's or Ph.D. Age was also re-grouped into three categories: less than 25 years old, from 26 to 49, and 50 or over. In addition, Scheffe post hoc analysis was also conducted to identify specific group differences.

The results of t-test and ANOVA indicated that female respondents had lower knowledge scores, had more trust in information from regulative authorities, and perceived significantly higher risks, compared to males. When age was taken as a factor, the F-value was significant, but Scheffe's post-hoc test showed that no specific group differed significantly from the others.

That was probably because the samples were unevenly divided by age, with a large proportion of respondents belonging to the youngest generation.

Table 4.3. T-test and ANOVA for Socioeconomic Characteristics

	Environmental Values	Knowledge	Nuclear Trust	Scientists Trust	Environmental Trust	Risk Perception	Nuclear Attitudes
	mean	mean	mean	mean	mean	mean	mean
Gender							
Male (1)	4.12	3.75	2.52	3.28	3.01	5.13	2.97
Female (2)	4.15	2.67	2.73	3.36	3.19	5.21	2.81
T value	-0.47	**5.37*** **	**-2.23*** **	-0.98	-1.81	-0.53	1.43
Age							
<25(1)	4.09	3.26	2.76	3.47	3.05	5.08	3.08
26-49(2)	4.12	3.30	2.56	3.20	3.12	5.29	2.79
>49(3)	4.32	2.96	2.49	3.23	3.04	4.96	2.67
F value	2.85	0.58	2.75	**4.23** **	0.23	1.67	4.38**
Differences				**(1)>(2)**			
Education							
Jr. college & under (1)	4.21	2.7	2.43	3.13	3.17	5.29	2.58
Bachelor (2)	4.13	3.35	2.67	3.33	3.16	5.16	2.95
Master & PhD (3)	4.05	3.71	2.69	3.55	2.78	5.03	3.11
F value	1.22	**5.31*** **	2.43	**4.44** **	**4.20** **	0.67	**6.10*** **
Differences		**(3)>(1)**		**(3)>(1)**	**(1)>(3), (2)>(3)**		**(3)>(1)**
Income							
<200,000(1)	4.06	3.31	2.72	3.47	3.03	5.06	3.03
200,000-399,999(2)	4.30	2.57	2.38	2.96	3.18	5.64	2.88
400,000-599,999(3)	4.04	2.83	2.60	3.12	3.40	5.19	2.81
600,000-799,999(4)	4.20	3.20	2.56	3.45	3.31	5.17	2.85
800,000-999,999(5)	4.19	4.40	2.20	2.90	2.80	5.62	2.20

≧1,000,000(6)	4.31	3.74	2.56	3.24	2.94	4.99	2.72
F value	2.00	3.00**	1.78	4.04**	2.32**	1.59	**2.70****
Differences							**(1)>(5)**
Party preference							
Blue (1)	4.34	2.96	2.54	3.15	2.89	4.86	3.11
Green (2)	4.05	3.88	2.58	3.49	3.21	5.46	2.64
No preference (3)	4.13	3.23	2.62	3.31	3.10	5.17	2.91
F value	2.11	2.58	0.14	1.52	0.99	1.83	1.91
Differences							

(**) Significant at 5% (***) Significant at 1%

Those who possess Master's or Ph.D. degrees had significantly higher scores on the knowledge scale, more trust in university scientists, and more support for nuclear power, than those with junior college, high school, or elementary school education. On the other hand, those with advanced degrees had less trust in information from environmental groups than those possessing only a Bachelor's degree or lower.

There was a significant difference in nuclear attitudes between those with an annual income between 800,000 and 999,999 NTD and those making less than 200,000. Those who have more income showed less support for nuclear power.

4.4 MULTIPLE REGRESSIONS FOR ANALYSIS MODEL

In order to add nominal variables into the regression model, gender and party preference variables were transformed into dummy variables. For gender, 0 was used to represent male respondents while 1 represented females. Party preference was transformed into two dummy variables: 1) a "Pan-Blue" variable where 0 represented Pan-Green or no preference, and 1 represented Pan Blue, and 2) a "No preference" variable, where 0 represented Pan-Blue or Pan-Green, and 1 represented no preference.

Table 4.4. Standardized Regression Coefficients

Independent variables	Dependent variables(Endogenous)						
	NEP	Knowledge	Nuclear trust	Scientists trust	Environmental trust	Risk perception	Nuclear attitude
Gender	0.02	-0.23***	0.18***	0.10	0,07	0.04	-0.09
Age	0.03	-0.11	-0.21**	-0.22**	-0.05	-0.06	-0.15
Education	-0.04	0.07	0.02	0.02	-0.11	0.002	0.01
Income	0.08	016	0.08	0.07	0.04	0.06	-0.03
Pan-Blue	0.11	-0.14**	0.01	-0.09	-0.13	-0.15**	0.09
No preference	0.04	-0.14**	0.03	-0.07	-0.08	-0.08	0.05
NEP						0.31***	-0.05
Knowledge						-0.02	-0.10**
Nuclear trust						-0.34***	0.07
Scientists trust						-0.05	0.11**
Environmental trust						0.16***	-0.21***
Risk perception							-0.40***

(**) Significant at 5% (***) Significant at 1%

Three levels of regression were conducted. At the first stage, gender, age, education, income, Pan-Blue, and No preference [i.e., no political preference] were used as independent variables, while environmental values, knowledge, trust in nuclear authorities, and trust in environmentalists as dependent variables. At the second stage, gender, age, education, income, Pan-Blue, Pan-Green, environmental values, knowledge, trust in nuclear authorities, and trust in environmentalists are all used as independent variables with risk perception as a dependent variable. For the third stage, nuclear attitudes were used as the final dependent variable, with all other scales and socioeconomic characteristics as independent variables.

Table 4.4 shows all standardized coefficients in the regression models. As mentioned above, female respondents are more likely to have lower knowledge scores and more trust in regulatory authorities. Older respondents tend to distrust information from institutions in charge of nuclear power, and also to distrust information from university scientists. Pan-Blue supporters tend to have lower knowledge scores and perceive lower nuclear power risks than

Pan-Green supporters. People who have no party preference are likely to have less knowledge about nuclear issues than Pan-Green supporters. People who endorse pro-environmental values more strongly tend to perceive higher risks. People who possess more knowledge about nuclear power are more likely to oppose nuclear power. People who possess more trust in regulatory authorities tend to perceive lower risks, and people who have more trust in university scientists are more likely to support nuclear power, while people who have more trust in environmental groups tend to perceive higher risks and oppose nuclear power. Finally, and consistent with results from prior studies, those who perceive higher risks are more likely to oppose nuclear power.

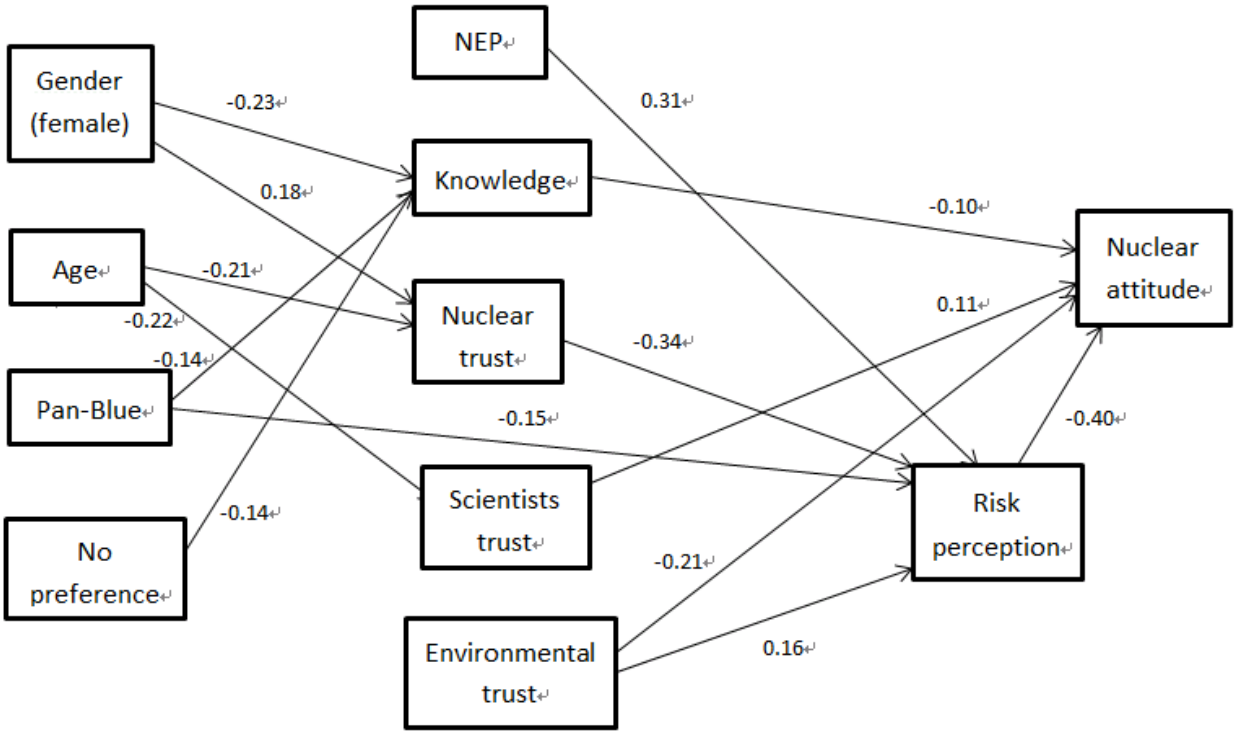

Figure 4.4. Reduced model

Figure 4.4 depicts all significant paths in the model hypothesized. Building on studies by Baron and Kenny (1986) and Shrout and Bolger (2002), at a conceptual level there are several mediators at work in this model: knowledge, trust in nuclear authorities, trust in scientists, and risk perception. As presented in Figure 4.4, trust in environmentalists influences nuclear attitudes both directly and indirectly, while other conceptual mediators influence nuclear

attitudes either directly or indirectly, but not both. Trust in environmentalists might be a "weaker mediator" by comparison with other intermediate variables, because both direct effects of trust in environmentalists, and indirect effects through risk perception, are expected to influence nuclear attitudes.

Chapter 5. DISCUSSION

In summary, the results of t-tests and ANOVA revealed:

(1) female respondents are more likely to trust nuclear power authorities and have, on average, lower knowledge scores;

(2) respondents under the age of 25 are more likely to trust university scientists;

(3) respondents who possess Master's or Ph.D. degrees have significantly higher scores on the knowledge scale, are more likely to trust university scientists, and tend to support nuclear power more frequently than those who possess junior college, high school, or elementary school education. On the other hand, they are less likely to trust environmental groups than those who possess lower levels of education;

(4) respondents who have an annual income between 800,000 and 999,999 NTD are less likely to support nuclear power than those who have income under 200,000 NTD;

Meanwhile, the results of regressions showed:

(1) female subjects are more likely to trust nuclear power authorities and tend to have lower knowledge scores;

(2) older respondents are slightly but significantly less likely to trust nuclear authorities and university scientists;

(3) Pan-Blue supporters and those with no party preference are likely to have lower knowledge scores than Pan-Green supporters. Pan Blue tends to perceive lower risks than Pan-Green;

(4) respondents who rate pro-environmental values more highly tend to perceive higher risks to nuclear power;

(5) people who have more knowledge about the industry are more likely to oppose nuclear power;

(6) respondents who have more trust in nuclear power authorities tend to perceive lower risks;

(7) people who have more trust in university scientists are more likely to support nuclear power;

(8) Respondents who have more trust in environmental groups are more likely to perceive higher risks and tend to oppose nuclear power;

(9) Respondents who perceive higher risks are more likely to oppose nuclear power.

The results of t-tests and ANOVA showed that education and income are significantly associated with other variables, as described above. However, when all socioeconomic variables were included with the other independent variables in the regression, the influence of education and of income disappeared in the presence of the other variables, while the influence of gender and age remained, with women more likely to trust nuclear power authorities and have lower knowledge scores, and older respondents slightly, but significantly, less likely to trust university scientists.

The findings of regressions showed some demographic characteristics in analytical model, such as education and income, don't have significant influences neither on attitudes toward nuclear power nor on other factors. Gender, age, and party preference have significant influences on knowledge, nuclear trust, or scientists trust, but they don't have direct significant relations with attitudes toward nuclear power. Building on Baron and Kenny (1986), it can be conceptually observed that knowledge, nuclear trust, scientists trust, and risk perception as mediators in analytical model. However, these mediations are not very valid.

5.1 Compared to National Polls and Existing Studies

Consistent with recent national polls, the average score on nuclear attitudes in this study is in the lower mid-range (mean: 2.89; range: 1-5), indicating a continuing ambivalence toward nuclear power, perhaps leaning slightly toward opposition.

Gender has been an important factor shaping risk perception and attitudes toward nuclear power in some of the existing studies, where women more often connect nuclear power with negative feelings and negative environmental effects or tend to oppose nuclear power more often than men, as reported by Keller, Visschers, and Siegrist (2012) and Seidl, Moser, Stauffacher, and Krütli (2012) in Switzerland; and Corner et al. (2011) in the UK. Previous studies in Taiwan revealed various results, with women more likely to oppose the fourth nuclear power plant than men in the study by Ho et al. (2013), while gender was not a significant determinant of risk perception in the findings of Hung and Wang (2011). Liang (2014) also performed both t-tests and regression analysis, finding that women tended significantly to perceive higher risks than males in t-tests, but this influence disappeared in the presence of the other variables in his regression model. The present study revealed that women are more likely to trust nuclear power

authorities and have less knowledge scores than men, but there were no significant relations between gender, risk perception, and nuclear attitudes.

Although both male and female respondents tend to distrust nuclear institutions (mean: 2.52 for males, 2.73 for females; range 1-5), t-tests showed that females trust nuclear institutions comparatively more than males, contrary to Whitfield (2009)'s finding in the U.S. where males were found to trust nuclear institutions more than females. Liang (2015) indicated that the Fukushima disaster affected men more than women, and compared to American men, Taiwanese men might perceive a greater impact to Fukushima, since they are closer to the accident's location. Therefore, the impact of Fukushima might be a potential explanation of the gender differences observed regarding trust in nuclear institutions. Additionally, gender is related to nuclear knowledge in Taiwan, as was true in some studies in other countries.

Few previous studies have shown education and income to be significant determinants of risk perception and of nuclear attitudes. Although results of ANOVA revealed significant differences in knowledge or nuclear attitudes based on education and income, no significant relationships emerged in regression modeling. Whitfield (2009) found that level of education can predict risk perception in the U.S., and Hung and Wang (2011) argued that both income and education levels can predict risk perception. However, no such relationship emerged in the present study.

Holmberg and Hedberg (2012) argued that party preference might be the most important explanatory variable for public attitudes toward nuclear power, but this effect is usually lost when researchers attempt to build a model to examine potential determinants. Consistent with Liang (2014)'s study, the present study also shows that Pan-Blue supporters tend to perceive lower risks. However, the present study found no significant direct effect on nuclear attitudes.

The results of regression modeling, therefore, sustain previous findings (Katsuya, 2001; Tanaka, 2004; Whitfield, 2009), revealing the importance of institutional trust in shaping risk perception and the importance of risk perception in shaping attitudes toward nuclear power. Age has a moderate influence on trust in nuclear institutions and on trust in university scientists: older people are less likely to trust both regulatory authorities and university scientists. This differs from the results of Whitfield et al. (2009) in the US, in which older respondents tended to trust nuclear power authorities accounted for by lower scores on the NEP scale, and there was no significant relationship between age and trust in university scientists.

Since environmental groups in Taiwan almost always oppose nuclear power, and spread information that shows nuclear power to be dangerous and not "clean", it is reasonable that respondents who have more trust in information from environmental groups would perceive higher risks and tend to oppose nuclear power. This result is similar to the findings of Hung and Wang (2011), in which trust in environmental groups had a significant, positive relationship with perceived risks of the second nuclear plant in Taiwan. On the other hand, the present study only investigates scientists trust in scientists in reference to information from the Institute of Nuclear Engineering and Science in NTHU. As the only institution addressing nuclear engineering in Taiwan, their scientists' attitude toward nuclear power conveyed in the available information is ambivalent. Most of the Institute's faculty release information which attempts to convince the public that nuclear energy is safe (Shih, 2016), but other faculty report that nuclear energy is dangerous (Apple Daily, 2013). It is therefore understandable that respondents who have more trust in this institute are slightly, but significantly, more likely to support nuclear power, but is also consistent with Hung and Wang's (2011) observation that respondents who have more trust in college research reports are more likely to perceive higher risks for the second nuclear power plant.

5.2 Extended Discussion

As Holmberg and Hedberg (2012) have suggested, party preference could be an important explanatory variable to include in studies about nuclear attitudes, and Liang (2014) promoted party preference as a required explanatory variable in the field of nuclear risk research in Taiwan. The present study has shown that Pan-Green supporters are likely to be more knowledgeable than Pan-Blue supporters and those who have no party preference, while Pan-Blue supporters tend to perceive lower risks than Pan-Green supporters and those with no party preference.

Nuclear power is a politically sensitive issue in many national contexts. It can be politicized at a specific point in time – in 1980s in the Taiwanese case – and can then experience phases of overt conflict and of latency, which was not only influenced by plans a for new nuclear plant and by nuclear accidents in other countries, but was also affected by such other domestic factors as the abolition of martial law and changes in government.

All nuclear power plants in Taiwan were planned while the KMT ruled as a dictatorship. Some people believe that constructing nuclear power plants represented collusion with the U.S., since all reactors were supplied by Westinghouse Electric and General Electric, at a time when many planned nuclear projects in the U.S. were cancelled. Taipower, a state-run electric company, had a monopoly on electricity generation until 1995, and even now private power plants can only sell electricity to Taipower, which owns all of the distribution lines. Also, the government established the Institute of Nuclear Engineering and Science in NTHU in 1956, as the only institute for training nuclear power specialists. The lack of transparency in the Taipower company and the Institute of Nuclear Engineering and Science, the lack public accountability during the martial law period, as well as several accidents occurring in nuclear power plants in other countries, may explain public distrust in nuclear energy.

"Anti-nuclear is anti-dictatorship" was a popular slogan of anti-nuclear groups in Taiwan in the 1980s. They tried to connect nuclear power to the KMT dictatorship and cooperated with DPP at that time. After the DPP took presidency in 2000, the anti-nuclear movement confronted a difficult situation, seeming to lose an important target of mobilization. Jun-yi Lin who developed the slogan "anti-nuclear is anti-dictatorship" redefined this slogan in 2013: "anti-dictatorship not only opposes the political dictatorship of a specific party, it also opposes the dictatorship of those experts, plutocrats, and bureaucrats who deny public participation in the decision-making process" (Lin, 2013), attempting to rehabilitate this slogan in response to a different political situation.

After the KMT government abolished martial law in 1987, Taipower ended their monopoly on electricity in 1995, and the Institute of Nuclear Engineering and Science changed its name to the "Department of Engineering and System Science" in 1995 to expands its focus beyond nuclear power, it has been easier for the public to hold the nuclear power industry accountable, which may explain why older respondents are less likely to trust nuclear power authorities and university scientists, since the younger generation may have limited awareness of political events before 1995.

Compared to other types of energy, nuclear power has a special political situation and history, with potential dangers widely perceived by the public. Pan-Green respondents might prefer to learn about nuclear accidents, or may tend to retain this kind of information when presented in the media. These may explain how party preference can influence knowledge and

risk perception in the present study, and probably influences attitudes toward nuclear power, albeit indirectly.

Limits of This Study

The present study chooses to use convenience sampling due to financial limitations and a shortage of interviewers, which causes some bias in the analysis:

(1) The sample size is not enough to estimate for the overall population of Taiwan. The target population of this study is Taiwanese citizens who are 18 years of age or older, which consists of approximately nineteen million people as of 2014.

(2) Since a large portion of the sample was collected from university classes or on university campuses, younger people (41.2%, under 25 of age) and low income respondents (43.8%, less than 200,000 NTD) are overrepresented in the sample, so unweighted results do not represent overall population attitudes. This also causes bias in ANOVA and regression analyses.

(3) The sampling locations cannot represent the national population in its entirety. The present study collected data in three cities, Taipei, Taichung, and Tainan located in north, central, and south Taiwan, in an attempt to enhance reliability by collecting data from different regions. However, there is still no representation of other cities, the countryside, and east Taiwan, including those living near Gongliao, New Taipei City – the planned location of the fourth nuclear power plant – and Daren, Taitung County – the planned nuclear waste storage site.

There might also be some non-sampling errors in this study, such as response error and self-selection error. For example, few participants expressed their political party preference on the survey, which may not reflect the reality in Taiwanese society. Only 70 participants (20%) expressed an identification with the Pan-Green or Pan-Blue factions, which is too few to estimate the influence of political affiliation on the other factors for the target population. In Taiwan, politics is a private, sensitive topic in daily conversation. It may be difficult to collect party preference data in a face-to-face survey. A survey undertaken by email or by online questionnaire might be a better method to get party preference data. Also, those who were willing to participate survey might be interested in nuclear power issue, while those who were not interested in nuclear power issue might reject to participate, but it doesn't mean they didn't have points of view on this topic, which might cause a self-selection error to estimate population.

In addition, the present study is a cross-sectional study, using three times regressions to observe relations between selected factors. All significant relations showed in the results cannot

conclusively represent any causality, but only provide correlations (suggestive of causal findings).

Chapter 6. CONCLUSION

The results of this study reaffirm that risk perception influences attitudes towards technologies, and that trust in regulatory authorities influences risk perception. No matter which party is in power and what type of energy will be selected in the future, the present study suggests that government should attempt to enhance—or rather, earn—public trust in the Taipower Company. Such actions could include improving transparency, communicating with the public without abstruse terms or data (especially for older people), and involving the public in the decision-making process. Otherwise, any proposed energy policy may encounter resistance and opposition.

Previous studies that have explored determinants of attitudes toward nuclear power in Taiwan have mainly focused on risk perception, trust, and socioeconomic variables. None of these have included knowledge and values, which have been examined in foreign studies. Unfortunately, the sample of the present study is not sufficiently robust to generalize to the population of Taiwan. Future research could consider values and knowledge as independent variables with a better sample design, and could also compare different analytical models to find the most appropriate one for the Taiwanese situation.

In addition, the method proposed by Baron and Kenny (1986) and used in the present study can only observe mediation between variables conceptually, which is not very robust. Future studies could consider using a structural equation model to test whether mediation effects are significant.

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APENDIX A: SURVEY INSTRUMENT (TRANSLATED)

Environmental attitude (New Environmental Paradigm)
(measured by 5-points scale, 1strongly disagree to 5strongly agree)

1. Human ingenuity will insure that we do NOT make the earth unlivable.
2. Humans are severely abusing the environment.
3. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
4. The so–called ‘‘ecological crisis’’ facing humankind has been greatly exaggerated.
5. The earth is like a spaceship with very limited room and resources.
6. The balance of nature is very delicate and easily upset..
7. If things continue on their present course, we will soon experience a major ecological catastrophe.

Knowledge
(measured by true or false question, true/false/don’tknow)

1. Nuclear power plants are thermal power plants.
2. In Taiwan, there are three reactors in operation in three different nuclear power plants
3. High level radioactive waste is produced only in nuclear reactors.
4. More than 1/4 of the electricity in Taiwan is produced by nuclear power plants.
5. In Taiwan nuclear power plants, atomic nuclei are fusioned.
6. The incident at Fukushima was the second nuclear accident in history to reach the highest severity rating
7. The reactor meltdown at Fukushima occurred at the Fukushima Second Power Plant
8. The Chernobyl incident happened in what is now the nation of Ukraine
9. The nuclear power plant in which the Fukushima disaster occurred is managed by the Tohoku Electric Power Company
10. The Three Mile Island incident happened in the United States

Trust
(measured by 5-points scale, 1 very little trust to 5 a great deal of trust)

1. Information released by Atomic Energy Council, Executive Yuan
2. Information released by Taiwan Power Company
3. Information released by Institute of Nuclear Engineering and Science, National Tsing Hua University
4. Information released by environmental groups

Risk perception
(measured by 7-points scale, 1strongly disagree to 7strongly agree)

1. I am very concerned about the dangers of nuclear power plants in Taiwan.
2. The nuclear power plant that is built now or in the future is safe.
3. The catastrophe risks in nuclear power plants are very small.

Nuclear attitudes
(measured by 5-points scale, 1strongly disagree to 5strongly agree)

1. Taiwan needs nuclear power plants because alternative energy sources do not produce sufficient electricity.
2. In light of health concerns about acid rain, damage to the ozone layer, and climate change associated with the burning of coal and oil, Taiwan should rely on nuclear power to meet its future electricity needs.
3. Nuclear power is an acceptable approach for meeting the nation's energy needs.

Socioeconomic

1. Gender: male_____ female_____
2. Year of birth: _____
3. Education (including current students): elementary school___ high school___ junior college___ bachelor___ master ___ PhD___
4. Personal annual income (in NTD): <200,000___ 200,000-399,999___ 400,000-599,999___ 600,000-799,999___ 800,000-999,999___above 1,000,000___
5. Party preference: Blue___ Green___ None___

APENDIX B: SURVEY INSTRUMENT (ORIGINAL)

地點_____日期_____時間_____編號_____

第一部分：此部份是關於您的環境態度。請依您的個人想法圈選適當的項目。

	非常不同意				非常同意
1. 人類的智慧可以保證不會使地球無法居住	1	2	3	4	5
2. 人類目前正嚴重地濫用自然環境	1	2	3	4	5
3. 自然界的自我平衡能力足以應付現在工業發展國家帶來的衝擊	1	2	3	4	5
4. 所謂人類正面臨「生態危機」只是一種誇大的說法	1	2	3	4	5
5. 地球就像一艘太空船，資源和空間都非常有限	1	2	3	4	5
6. 自然界的平衡是很脆弱的，且容易被破壞	1	2	3	4	5
7. 人類如果繼續照現在的方式破壞自然，很快就會經歷一場重大的生態災難	1	2	3	4	5

第二部分：此部份是關於您對於核電的了解。若您認為該項敘述是正確的請圈選「是」，錯誤的請圈選「否」，若不清楚請圈選「不清楚」。

1. 核能發電是一種運用熱能產生電力的發電技術	是	否	不清楚
2. 目前在台灣，共有三個反應爐在三個不同的核電廠運轉	是	否	不清楚
3.「高階核廢料」僅由核子反應爐產生	是	否	不清楚
4. 在台灣，超過四分之一的電力由核能產生	是	否	不清楚
5. 台灣的核電廠是運用核融合來產生能量	是	否	不清楚
6. 福島核能事故是史上第二個被列為最高核災等級的核能事故	是	否	不清楚
7. 在福島事故中，發生爐心熔毀的是福島第一核電廠	是	否	不清楚
8. 車諾比(Chernobyl)核能事故發生在現今的烏克蘭	是	否	不清楚
9. 發生福島核能事故的核電廠隸屬於東北電力公司	是	否	不清楚
10. 三哩島(Three-Miles Island)核能事故發生在美國	是	否	不清楚

第三部分：此部分是關於您對於核能訊息來源的信任感，請根據您的感受圈選適當的項目。

	非常不信任				非常信任
1. 來自行政院原子能委員會(原能會)的訊息	1	2	3	4	5
2. 來自台灣電力公司(台電)的訊息	1	2	3	4	5
3. 來自清華大學核子工程學系(清大核工系)的訊息	1	2	3	4	5
4. 來自環保團體的訊息	1	2	3	4	5

第四部分：此部份是關於您的風險知覺。請依您的看法，針對以下的描述圈選最符合您的項目。

	非常不同意						非常同意
1. 對於台灣核電廠的危險性我非常地不放心	1	2	3	4	5	6	7
2. 台灣正建造或未來建造的核電廠是安全的	1	2	3	4	5	6	7
3. 核電廠的重大災害風險是非常小的	1	2	3	4	5	6	7

第五部分：此部份是關於您對於核電的態度。請依您的想法圈選適當的項目。

	非常不同意				非常同意
1. 由於替代能源無法產生足夠的電力，因此台灣需要核電廠	1	2	3	4	5
2. 基於與燃燒化石能源關聯的氣候變遷、臭氧層破壞以及酸雨等問題，台灣 應倚賴核能以符合未來的電力需求。	1	2	3	4	5
3. 為了滿足國家未來的能源需求，核能是一種可接受的方案	1	2	3	4	5

第六部分：此部份是關於您的基本資料。

1. 性別：□男 □女
2. 年齡：_____歲
3. 教育程度(含在學)：
   □國小 □中學 □專科及二技 □大學 □碩士 □博士
4. 個人 2013 年的稅前年收入(新台幣為單位)：
   □少於 200,000NT □200,000-399,999NT □400,000-599,999NT
   □600,000-799,999NT □800,000-999,999NT □1,000,000NT 以上
5. 政治傾向：□偏藍 □偏綠 □無

APPENDIX C: ANSWERS FOR THE KNOWLEDGE SCALE

1. Nuclear power plants are thermal power plants.
   True
2. In Taiwan, there are three reactors in operation in three different nuclear power plants
   False, there are total six reactors in operation
3. High level radioactive waste is produced only in nuclear reactors.
   True
4. More than 1/4 of the electricity in Taiwan is produced by nuclear power plants.
   False, always less than 1/5
5. In Taiwan nuclear power plants, atomic nuclei are fusioned.
   False, atomic nuclei are fissioned
6. The incident at Fukushima was the second nuclear accident in history to reach the highest severity rating
   True
7. The reactor meltdown at Fukushima occurred at the Fukushima Daini(Second) Power Plant
   False, occurred at the Fukushima Daiichi(first) power plant
8. The Chernobyl incident happened in what is now the nation of Ukraine
   True
9. The nuclear power plant in which the Fukushima disaster occurred is managed by the Tohoku Electric Power Company
   False, managed by the Tokyo Electric Power Company
10. The Three Mile Island incident happened in the United States
    True