

An Evaluation of Public Attitude toward Nuclear Power after Fukushima Accident: Evidence from Taiwan

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ABSTRACT—*After Japan Fukushima accident, several countries are discussing whether they will maintain their nuclear power plants in the next few decades. Therefore, the purpose of this paper is to analyze what information and psychometric factor has an effect on the propensity to the decision of terminating the 4th nuclear power plants in Taiwan. Multi-regression method is used to analysis the role of information factors and psychometric factors in attitude changing toward nuclear power; and using model comparison to analysis the explanation power between two information and psychometric models. The results showed that only amount of information cannot changes the attitude of Taiwan's public toward nuclear power. But psychological factors, such as perceived risk/benefit and trust, could influence the direction and degree of attitude changing.*

Keywords—Attitude, Nuclear Power, Multi-regression Analysis

1. INTRODUCTION

After Japan Fukushima accident, several countries are discussing whether they will maintain their nuclear power plants in the next few decades. The economic development of a nation largely depends on how its energy requirements being satisfied; hence, the decision about energy will influence their citizens' quality of life and the level of industrialized, urbanized, and mobile societies [1].

Taiwan currently has three nuclear power plants in operation and one, the fourth plant, under construction with 97% completion and 41% completion for pre-op testing as of 30 April 2012 [2]. The fourth plant has encountered significant delays over the past decade and is facing numerous difficulties during pre-op testing over the past year. New target dates have not been set for commercial operation. The fourth nuclear power plant has been plagued by delays since construction began in 1999. Last year, the Taiwan Cabinet proposed putting the plant's fate to a referendum amid nuclear safety concerns that have grown since the Fukushima nuclear disaster. A major challenge now is whether to proceed, or suspend until a thorough safety evaluation is completed.

As a result, policy makers are interested in the public's perception of nuclear power and the opinions regarding nuclear power. People often associate a given object with a number of different attributes, holding many beliefs about that object. Attitude is determined by the entire set of beliefs that a person holds, an attitude only serves to predispose the person to engage in a set of behaviors that are consistent with the attitude [3]. According an opinion poll in 2012, a little more than 89 percent of residents in Taipei, New Taipei City and Keelung are favor a nuclear energy-free Taiwan and 83 percent lack confidence in the government's ability to deal with a possible nuclear disaster. As for the opinion on the power plant being built in Gongliao, 54.4 percent of respondents said they support the plant if safety is not a concern, while 38.8 percent said the plant should not operate, regardless of its safety [4].

The use of Fourth Nuclear power is a major issue linked to national energy safety, the stability of power supply and public held value. To help resolving a longstanding dispute over nuclear electricity in Taiwan, authorities decide put the fate of the power plant to a national referendum. In line with the previous findings [5]-[8], we found Psychometric paradigm and information paradigm are the most important determinants for explaining the risk judgment and attitude change. Therefore, the purpose of this paper is to analyze what information and psychometric factor has an effect on the propensity to the decision of terminating the 4th nuclear power plants.

2. LITERATURE REVIEW AND DISCUSSION

There are two competing paradigms for explaining the risk judgment and attitude change; Psychometric paradigm and information paradigm. Psychometric paradigm has focused on role of psychometric variables, such as perceived risk/benefit, trust and knowledge [6]. Psychometric research identified two important issues concerning public acceptance of technology is affected by perceptions of risks and benefits that are functionally related to each other [9]. However, Sjöberg [7] found that the psychometric model's explanatory power is not enough, insisting to consider the other factors to explain the attitude change.

Anderson & Norman [8] confirmed the influence of information integration on attitude change. According to information paradigm, information itself is an instrument for affecting attitudes and building image. Transparency, inclusive and interactive information can clarify misconception of nuclear and increase the public's confidence in government's ability to manage risks and commitment to provide correct risk information [10]. In this way, public are better informed about nuclear technology and more aware of its benefits [11].

Hence, this study proposes an integrated model to connecting the psychometric model with the information model. In this integrated model, we will set up two information variables and three psychometric variables as independent variables and the propensity to the decision of terminating the 4th nuclear power plants as dependent variables.

2.1 Risk/benefit perceptions

Nuclear power has many advantages over non-nuclear power, including extremely low carbon dioxide emissions during its life cycle, supplement to solar and wind energy to produce sufficient energy to meet the world's current needs, and currently still quite cheap source of power generation [12], [13]. However, most of the public is worried about reprocessing, waste management, and the costs of fuel cycle, including decommissioning of facilities. Those concerns cause perception of high level risk towards nuclear safety among the public. Risk perception came to be seen as an obstacle to technology, most notably to nuclear technology.

Nuclear energy has already brought many economic benefits. However, the advance of technology produces high levels of uncertainty related to health, environmental, ethical, and societal aspects of human life. Individual often has both positive and negative attitudes towards nuclear energy at the same time. In general, individual will do the cost-benefit analysis when choosing between alternatives.

2.2 Trust

Desvousges et al. [14] and Mushkatel et al. [15] have found that no matter what people's stance on nuclear energy, the degree of trust in the government appears to be a key determinant affecting attitudes toward nuclear technology. Fischer [16] and Cohn [17] also indicated that trust and credibility of information are elements of successful communication to public policy, which can mitigate public risk perception and increase benefit perception. In line with the previous findings [5] [16], we found distrust is the most important factor contributing to the anti-nuclear, and the antecedents of perceived risk.

2.3 Energy policy in Taiwan

In light of Japan's Fukushima Nuclear disaster on March 11, 2011, the government reviewed Taiwan's energy situation, and formulate the New Energy Policy to "ensure nuclear energy security, steadily reduce nuclear energy dependence, create a friendly low-carbon green energy environment, and gradually move towards a nuclear-free homeland " [18]. Taiwan is insufficient in natural resources, and constrained by limited environment carrying capacity; how to efficient use of limited resources to support sustainable green energy to create a win-win-win solution in energy, environment, and economy is still unclear and vague.

Berg & Damveld [19] recognized that the lack of a clear policy on the future of nuclear energy made it difficult for the public to develop trust. Clear policies are crucial to let public knowing future energy development and knowing the role of nuclear in the energy structure. Most people in Taiwan unaware of the future energy policy and suspicious about the security of energy supply. The public ought to be aware of impact of long-term economic, environmental and energy-security interests along the path of energy policy. There is a strongly support that clear policy, in general, has an effect on perceptions of risk and benefit [5] [19] [20]. From above discussion, this study is strongly support that with clear policy on nuclear energy can mitigate the risks perception and enhance the benefits perception.

2.4 Nuclear knowledge

The capability to process information has been a main factor to influence potential attitudes toward nuclear power and it is presumed to be related to level of education. However, Hursti & Magnusson [21] found that the direction of

knowledge effect is somewhat ambiguous, because level of education could result in a better capacity to identify risks as well as benefits. Knowledge itself is an instrument for affecting attitudes and building image. Therefore, authority should fully disclose the information on nature of benefits and risks about nuclear power. In this way, public can construct their knowledge about nuclear and are better informed about nuclear issues and more aware of its benefits [11].

3. RESEARCH METHOD

This study is to examine whether people's attitude toward nuclear facility can be explained by psychometric and information factors. From literature review, we found benefit perception, risk perception, trust, Clear energy policy and nuclear knowledge are the most important factors which can influence the public's intention to support or terminate the fourth nuclear power station in Taiwan. Multi-regression analysis adopted to understand the role of information factors and psychometric factors in attitude changing, and using model comparison to compare relative explanation power between two factors.

3.1 Samples and Data Collection

The research is based on a nationally representative sample of adults aged 22+, and used quota sampling to obtain a representative sample of the Taiwan population. Data is collected from online questionnaire across Taiwan. The data collection period spanned from April 1, 2013, to May 31, 2013. The total number of responses was 356. The total response rate was 36%. After removing participants who provided incomplete data, 269 questionnaires were used in the final data analysis.

3.2 Questionnaire and Variables Measurement

According to Lee and Wang [5] study of Taiwan nuclear policy, we designed questions to measure trust, risk perception, benefit perception, clear policy and nuclear knowledge. Three statements were adapted from previous research regarding attitude [3], [10] to measure public attitude toward the issues of terminating the 4th nuclear power plant. Each item was rated on a 7-point scale (1="strongly disagree", 7="strongly agree").

4. DATA ANALYSIS

Exploratory Factor Analysis (EFA) and multi-regression analysis were used to test the proposed theoretical model.

4.1 Scale analysis

This study uses factor analysis to identify structure within a group of variables. From factor matrix (see Table 1), each variable has a single high loading on only one factor; there is no problem of cross-loading.

The means, standard deviations, item-to-total correlations and factor loadings, and reliabilities of the variables are together provided in Table 2. Internal consistency for these dimensions was above 0.85 (except the dimension of Nuclear Knowledge), with item-to-total correlations ranging from 0.420 to 0.869. All indicator factor loadings were range from 0.547 to 0.918 on their respective dimensions. These high correlations indicate that the scale is measuring its intended concept. This scale shows a good level of convergent validity. Table 1 shows all constructs have sufficient discriminant validity since each variable has a single high loading on only one factor and low loadings on other factors.

Factor analysis identifies 6 factors and accounts for 75.62% of variance. This study uses Harman single-factor test to address the issue of common method variance. The result shows the single factor of exploratory factor analysis is 37.27%, not accounting for the majority of the variance in our measures. Thus, there is no considerable amount of evidence that common method variance can have a substantial effect on observed relationships between measures of different constructs.

The simple correlation among all the research constructs is shown in Table 3. Although "Risk Perception" and "Nuclear Knowledge" show no correlation, several variables showed significant correlations, their values ranged from -0.32 to -0.53.

4.2 Model analysis

4.2.1 Model 1: Psychometric paradigm

Model 1 was linearized by psychometric paradigm model estimated with ordinary least squares (OLS). Results of the regression analysis are presented in Table 4. Coefficients of variables are reported on the second column in Table 4, which capture the impact of the psychometrics' variables on the attitude toward ceasing the operation of the fourth nuclear power plant. A summary consideration of the results indicates that all the parameters estimated are significant at $p < 0.01$ and in the predicted direction. The adjusted R² of the model is 0.41. We calculated the variance inflation factor to check for multicollinearity. Their tolerance values ranged from 1.14 to 1.40, indicating that multicollinearity is not a likely threat to the parameter estimates [22].

Table 1: Factor Matrix

	Component					
	Trust	Benefit Perception	Clear policy	Risk Perception	Stop Plant	Nuclear Knowledge
CP1			.721			
CP2			.602			
CP3			.918			
CP4			.902			
NK1						.672
NK2						.547
NK3						.807
NK4						.709
BP1		.604				
BP2		.795				
BP3		.779				
BP4		.749				
RP1				.864		
RP2				.910		
RP3				.808		
TA1	.776					
TA2	.869					
TA3	.874					
TA4	.817					
stop1					.874	
stop2					.868	
stop3					.734	

4.2.2 Model 2: Information paradigm

Model 2 was linearized by information paradigm model estimated with OLS, considering the variables of Clear Policy and Nuclear Knowledge. Results of the regression analysis are presented in Table 4. Coefficients of variables are reported on the third column in Table 4. The two parameters estimated are significant at $p < 0.05$ and have negative relation with the dependent variable (the attitude toward ceasing the operation of the fourth nuclear power plant). The results indicate the Information can enhance public attitude toward nuclear power. However, the adjusted R^2 of the model is 0.13. The VIF is also in the range of tolerance, posing no multicollinearity threat.

4.2.2 Model 3: Integration Model

Model 3 was linearized by integration of psychometric and information paradigm, and also estimated with OLS. Results of the regression analysis are presented in Table 4. Coefficients of variables are reported on the fourth column in TABLE IV, which capture the influence of the psychometrics and informations variables on the attitude toward ceasing the operation of the fourth nuclear power plant. The results indicate that all the parameters estimated (except for Clear Policy) are significant at $p < 0.05$ and in the predicted direction. However, the impact of information variables in integration model is lower than the Model 2. The adjusted R^2 of the model is 0.42. The variance inflation factor to check for multicollinearity is range from 1.15 to 1.76, indicating that multicollinearity is not a likely threat to the parameter estimates.

Table 2: The Result of the EFA Analysis

Constructs	Item	loading	Item reliability	C.R	Mean (std)	VE% (C%)*
Trust	1	.776	.778	.93	3.13 (1.47)	15.55 (15.55)
	2	.869	.844			
	3	.874	.869			
	4	.817	.813			
Benefit Perception	1	.604	.544	.85	4.85 (1.30)	13.81 (29.37)
	2	.795	.670			
	3	.779	.809			
	4	.749	.744			
Clear Policy	1	.721	.747	.89	3.73 (1.41)	13.05 (42.41)
	2	.602	.640			
	3	.918	.820			
	4	.902	.801			
Risk Perception	1	.864	.742	.88	5.71 (1.91)	11.75 (54.16)
	2	.910	.861			
	3	.808	.718			
Stop 4th Nuclear Power	1	.874	.884	.92	4.95 (1.49)	11.30 (65.46)
	2	.868	.880			
	3	.734	.726			
Nuclear Knowledge	1	.672	.420	.73	4.91 (0.99)	10.16 (75.62)
	2	.547	.443			
	3	.807	.693			
	4	.709	.564			

*VE(C): Variance Explained (Cumulative proportion of total)

Table 3: Construct Correlations

Construct	A	B	C	D	E	F
Trust (A)	1					
Benefit Perception (B)	.50*	1				
Clear Policy(C)	.48*	.48*	1			
Risk Perception (D)	-.32*	-.29*	-.16*	1		
Stop Nuclear Plant (E)	-.46*	-.53*	-.28*	0.48*	1	
Nuclear Knowledge (F)	.33*	.52*	.47*	-.08	-.34*	1

*: P < 0.05

4.3 Model comparison

The Model 1 with higher R-squared or Adjusted R-squared is better. However, we should check the residuals of model to check the adequacy of the fitted model. This study tests whether the regression coefficients of information variables are equal to zero; we set Model 3 as full model (F) and Model 1 as reduced model $SSE(R) = 348.81$, $SSE(F) = 341.68$, the $F^* = (SSE(R) - SSE(F)) / (df_R - df_F) \div SSE(F) / df_F = 2.76$. The result show non-significant for coefficients of information variables, which mean the Model 1 is better than Model 3. We can conclude that Taiwan public's attitude toward whether to stop the fourth nuclear power station is totally affected by psychometric variables, not influenced by the information variables.

5. CONCLUSIONS

Generally, people receive the information about specific issues which influence the risk judgment. However, for nuclear power, only amount of information cannot changes the attitude of Taiwan's public toward nuclear power. But psychological factors, such as perceived risk/benefit and trust, could influence the direction and degree of attitude

change. From the integration model, we can know that the information cannot beyond the psychometric variables, it also have

Table 4: The results of multi-regression

Variables	Model 1		Model 2		Model 3	
	β	VIF	β	VIF	β	VIF
Constant	5.13***	--	--	--	5.54***	--
Trust	-.20**	1.40	-	-	-.20**	1.56
Benefit perception	-.39***	1.37	-	-	-.34***	1.76
Risk Perception	.40***	1.14	-	-	.42***	1.15
Clear policy	-	-	-.17*	1.28	.07	1.56
Nuclear knowledge	-	-	-.41***	1.28	-.20*	1.52
R^2	0.42		0.14		0.43	
Adj. R^2	0.41		0.13		0.42	
F statistic	63.50***		20.94***		39.7***	
Durbin-Watson	1.95		2.06		2.00	

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

little effect in the model for attitude change. For Taiwan, government always emphasizes the information paradigm, neglecting more fundamental psychological variables which people usually have in mind. We suggest that Taiwan's authority should put more efforts on understanding public's psychometrical factors.

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