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Analysis on the Perception of Nuclear Power Plant and the Preference of its Policy Alternatives for Public Acceptance

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원자력발전소에 대한 인식과 국민수용성 향상을 위한 정책대안들의 선호 분석

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Abstract

Public acceptance has become an important factor in nuclear power program particularly after Chernobyl accident and recent rapid democratization in Korea. Methods reflecting public opinions in order to improve public acceptance are firstly to understand what the public think about nuclear power plant and secondly to find out the public preference values for its policies. For this purpose, simplified multi-attribute utility (MAU) model was applied to analyze the public perception pattern for five power production systems. And the conjoint analysis was applied to find out the quantitative values of public preferences for twelve policy alternatives to improve the safety and to support communities surrounding nuclear power plants in Korea. To implement these perception and preference analyses, mail survey was conducted to the qualified sample who had the experience of visiting nuclear power plant. Diagnosis of their perception pattern for five power production systems was made by the simplified MAU model. Estimation of the quantitative preference values for potential policy alternatives was made by the conjoint measurement technique, which made it possible to forecast the effectiveness of each option. The results from the qualified sample and the methods used in this study would be helpful to set up new policy of nuclear power plant.

요 약

원자력 발전에 대한 국민수용성은 체르노빌 사고와 급격한 민주화 이후 한국의 원자력발전 프로그램에 큰 영향을 주게 되었다. 국민수용성 향상을 위한 여론 반영 방법은 첫째, 국민들의 원자력발전에 대한 인식을 이해하고 둘째, 그에 따른 정책 대안들에 대한 국민들의 선호도를 알아내는 것이라고 할 수 있다. 이를 위해 이 연구에서는 다섯 가지 발전방식에 대한 국민들의 인식패턴을 분석하기 위해 단순화된 다요소효용모델을 적용하고, 12개의 안전성 향상 및 발전소 주변지역 지원 정책 등에 대한 선호도를 측정하기 위해 컨조인트 분석 방법을 적용하여 보았다. 원자력발전소 방문 경험이 있는 특정인들을 대상으로

실제 우편 설문조사를 통하여 그들의 인식을 진단하고, 가능성 있는 정책대안들에 대한 선호도를 알아본 후 이로부터 각 정책의 효과를 예측하여 보았다. 이 결과와 이러한 분석 방법은 새로운 원자력발전소 정책대안들에 대한 국민수용성을 알아보는데 유용할 것이다.

1. Introduction

The advance of science and technology was considered as a prerequisite for economic development and associated with a highly positive value and progressive image. However, the risks created by new technologies have initiated the public concerns, controversies, and social oppositions. Sometimes these public responses were short episodes, but the reconsideration of ambivalence of technologies made the future development of technologies much dependent on the agreement of society [1]. Thus, it is quite natural that the public opinions should be reflected and respected in such an influential decision as nuclear power program [2]. Through the public involvement in the decision making process, a policy can be formulated responsive and consonant with the preferences and beliefs of the affected public.

In Korea, nuclear power has been an essential backbone to maintain rapid economic development. Because of the lack of energy resources, the contribution of nuclear energy to today's economic development have been substantial. Especially taking into consideration the fact that more than 40% of electrical power production relies on nuclear power, public acceptance of nuclear power for national electric power expansion planning is essential. But recent movement of environmentalism and democratization have made it grow the critical public opinion toward nuclear power plant. In this situation, Korea selected "Development of Next Generation Reactor Technology" as a national R&D project with the objective to develop more safe and economic nuclear power plant. And in 1989, "Act for Supporting the Communities Surrounding Power Plants" was promulgated in order to help the regional development and public information activities surrounding power plants. In accordance with the law, Korea Electric Power Corporation (KEPCO) assisted the communities surrounding nuclear power plant with 3.7 billion won in 1990, 3.8 billion won in 1991, 4.8 billion won in 1992 (each community with about 1 billion won), and 7.7 billion won in 1993 (each community with about 1.5 billion won).

But it is uncertain that the public accept the current nuclear power program and that they perceive the nuclear power plant as being safe and economic. That is, their perceptions may be different from the policy maker and their priorities to new policies may be something different. In these situations, it is necessary to understand why the public would not accept the nuclear power plant and to find out the policy that can improve effectively the public acceptance at minimum cost. In order to start this process, it is firstly needed to improve our understanding of how society judges the acceptability of existing or new technologies [3, 4]. This procedure is related to detecting public perceptions about the technology, which requires understanding the dimensions used by the public to judge the specific technology and how this technology is placed on those dimensions [5, 6, 7, 8]. The potential advantage of this kind of multi-attribute models over the unidimensional approach (e.g., the degree of "overall like-dislike") is to gain understanding of attitudinal structure. That is, perception analysis lets the policy maker know on what dimensions public judge the specific object and its position along with the dimensions. This will give him vital information about the direction of policy action.

But he doesn't yet know which remedial action is more preferred by the public. Thus, an appropriate method should be utilized to evaluate the policy alternatives with improvements on the dimensions of perceived drawbacks. In this study, the trade-off method of conjoint analysis was chosen to measure public preference values for policy alternatives deliberately designed to get the positive effect on public acceptance of nuclear power plant. Conjoint analysis was developed in applied psychology and has been widely used in marketing area [9, 10]. It estimates the structure of a consumer's preferences, when given his or her overall evaluations of a set of alternatives that are specified in terms of levels of different attributes [11, 12]. Trade-off method is based on subject's trading off two attributes which helps us get the result of more realistic situation than direct survey method, because the latter may reveal only that people like more good and less bad things.

On the basis of multi-attribute utility model, perception analysis was conducted to compare public attitudes toward the five energy systems and to find out the negatively perceived dimension for nuclear power plant. And on the basis of conjoint analysis, preference analysis was conducted to measure the preference values for imaginary policies designed to improve the negatively perceived dimensions of nuclear power plant and to help the communities' development.

2. Overview of Theories

2.1. Multi-attribute Utility Model

Utility models are mathematical models that can be used to transform a numerical description of an item or alternative into a single number, the utility of that item of alternative. Multi-attribute utility (MAU) models are designed to obtain the utility of items or alternatives that have more than one valued properties and therefore must be evaluated on more than one criterion [13].

Several researchers have studied the following form of two-stage rating approach of MAU model

$$U_q = \sum_{n=1}^{N} b_n u(x_{nq}) \quad \cdots\cdots \qquad (1)$$

where $u(x_{nq})$ are *ratings* (by the subjects) of the utility obtained from the q-th alternative on the n-th attribute and b_n are the relative importance (rated also by the subjects) of the n-th attribute [13].

Huber indicated that the use of subjective values as parameters in MAU functions were validated by behavioral science research and that these simple models usually predicted actual decisions and evaluations as well as more complex models in the choice criterion problem [13].

2.2. Trade-off Method of Conjoint Analysis

The basic assumption of trade-off analysis is that what is needed in real world is information about people's "trade-off". For example, since nobody can make an infinitely safe and high performing power plant for a price of zero, it becomes relevant to determine how they value various levels of each attribute and the extent to which they would forego a high level of one attribute to achieve a high level of another. Thus, as was indicated by Johnson [14], this analysis is based on the premise that each subject's choice behavior is governed by such trade-off values and that, although he or she may be unable to articulate them, they may be revealed by choices among object concepts having characteristics which are varied in systematic ways.

Let us suppose that there are four alternative policies (X, Y, Z, W), each with three available levels ((x_1, x_2, x_3), (y_1, y_2, y_3), (z_1, z_2, z_3), (w_1, w_2, w_3)). Then, rating data of preference for an respondent constructs six trade-off matrices like Figure 1.

In first trade-off matrix, this person's relative liking for a combination having x_i level of policy X and y_j level of policy Y is represented by responded rating data R^{ij}_{n}(where index of attribute level i, j = 1, 2, 3 ; index of combination n = 1, 2, ⋯, 9 and R^{ij}_{n} is restricted by $0 \leq R^{ij}_{n} \leq 100$. See Figure 1.). Consider a simple model of preference formation which assumes that each respondent has a utility value for each level of each policy, and that the degree of his 'overall preference', R^{m}_{n} is obtained by adding together his utilities for the attribute levels describing that combination

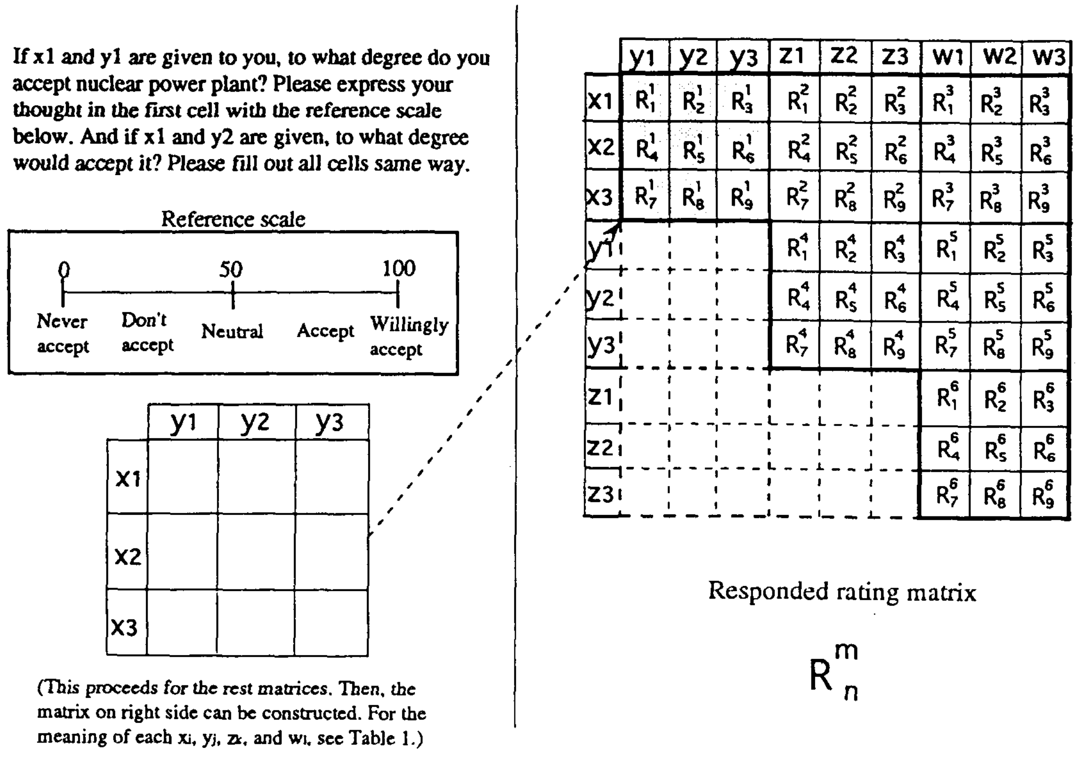
$$\begin{array}{l|l|c|l}
R^1_1 \cong u_x(x_1)+u_y(y_1) & R^2_1 \cong u_x(x_1)+u_z(z_1) & & R^6_1 \cong u_z(z_1)+u_w(w_1) \\
R^1_2 \cong u_x(x_1)+u_y(y_2) & R^2_2 \cong u_x(x_1)+u_z(z_2) & & R^6_2 \cong u_z(z_1)+u_w(w_2) \\
\cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots \\
R^1_9 \cong u_x(x_3)+u_y(y_3) & R^2_9 \cong u_x(x_3)+u_z(z_3) & & R^6_9 \cong u_z(z_3)+u_w(w_3)
\end{array} \qquad (2)$$

or, by multiplying together them

$$\begin{array}{l|l|c|l}
R^1_1 \cong u_x(x_1)u_y(y_1) & R^2_1 \cong u_x(x_1)u_z(z_1) & & R^6_1 \cong u_z(z_1)u_w(w_1) \\
R^1_2 \cong u_x(x_1)u_y(y_2) & R^2_2 \cong u_x(x_1)u_z(z_2) & & R^6_2 \cong u_z(z_1)u_w(w_2) \\
\cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots \\
R^1_9 \cong u_x(x_3)u_y(y_3) & R^2_9 \cong u_x(x_3)u_z(z_3) & & R^6_9 \cong u_z(z_3)u_w(w_3)
\end{array} \qquad (3)$$

where each attribute x_i, y_j, z_k, w_l, (i, j, k, l=1, 2, 3) can be viewed as nominal-scaled and each u_x, u_y, u_z, u_w is a real-valued utility function for x_i, y_j, z_k, w_l attributes.

The additive form is less sensitive to unsatisfactory attribute levels than is the multiplicative form. For example, in a multiplicative model if any u(x) reaches zero, the effect is for R^m_n to go to zero, thus taking the associated alternative out of consideration. In an additive model, the effect on R^m_n would be damped



If x1 and y1 are given to you, to what degree do you accept nuclear power plant? Please express your thought in the first cell with the reference scale below. And if x1 and y2 are given, to what degree would accept it? Please fill out all cells same way.

	y1	y2	y3
x1			
x2			
x3			

(This proceeds for the rest matrices. Then, the matrix on right side can be constructed. For the meaning of each x_i, y_j, z_k, and w_l, see Table 1.)

	y1	y2	y3	z1	z2	z3	w1	w2	w3
x1	R^1_1	R^1_2	R^1_3	R^2_1	R^2_2	R^2_3	R^3_1	R^3_2	R^3_3
x2	R^1_4	R^1_5	R^1_6	R^2_4	R^2_5	R^2_6	R^3_4	R^3_5	R^3_6
x3	R^1_7	R^1_8	R^1_9	R^2_7	R^2_8	R^2_9	R^3_7	R^3_8	R^3_9
y1				R^4_1	R^4_2	R^4_3	R^5_1	R^5_2	R^5_3
y2				R^4_4	R^4_5	R^4_6	R^5_4	R^5_5	R^5_6
y3				R^4_7	R^4_8	R^4_9	R^5_7	R^5_8	R^5_9
z1							R^6_1	R^6_2	R^6_3
z2							R^6_4	R^6_5	R^6_6
z3							R^6_7	R^6_8	R^6_9

Responded rating matrix

R^m_n

Fig. 1. Questionaire Form of Preference Analysis and 6 Trade-off Matrices

by the other terms in the model. Both model form and utility magnitudes are only approximations to those actually contained in the minds of respondents. They should not be viewed as totally descriptive of their thought processes. None portrays the totality of a choice situation, but additive model and multiplicative model are very useful approximations and allow us to analyze the minds of respondents. In this study, these two models are applied to each person and better model for her or him is found out.

3. Approaches of the Study

3.1. Sample

Mail survey was conducted to science teachers of middle or high school throughout the country who had visited the nuclear power plant by the program of the Organization for Korea Atomic Energy Awareness (OKAEA). It was expected that the same background of science teacher would make the sample homogeneous and that the experience of visiting the plant would give them the motive to understand the energy problems in right perspective. 157 mails were sent and 56 subjects responded (response rate = 35.7%). The questionnaire consisted of two part : perception part to analyze the public attitudes toward five power production systems and preference part to compare the policy alternatives. One or two respondents did not completely fill in the questionnaire : one in perception part and two in preference part. Therefore usable answers are 55 in perception analysis and 54 in preference analysis.

3.2. Questionnaire for Perception Analysis

In order to analyze the public attitudes comparatively toward the electricity production systems, the modified MAU model was applied, where the q was qualitative object that is, the five systems to be compared. The attributes must be selected to cover all relevant variables and to describe the perception process. Five attributes were extracted from the literature survey [4, 5, 6, 7, 8] and from the pilot test for 80 students of Chung-Nam university in which seven attributes had been used. The attributes were (1) economy, (2) security of supply, (3) health and environment impact, (4) safety, and (5) spin-off effect. And the five systems for comparison were selected to be (1) nuclear, (2) coal-fired, (3) oil-fired, (4) hydro, and (5) solar power plant. Formally, the perceived utility of a system is determined by the attribute weighting and rating of the system on that attribute :

$$U_q = \sum_{n=1}^{5} W_n R_{nq} \cdots\cdots \qquad (4)$$

where U_q : perceived total utility of q system

q : 5 alternative energy systems (Nuke, Coal, Oil, Hydro, Solar)

n : 5 attributes

(1 = economy, 2 = security of supply, 3 = health & environment impact, 4 = safety, 5 = spin-off effect)

W_n : importance weighting of n-th attribute ($\sum_{n=1}^{5} W_n = 100$)

R_{nq} : performance rating of q-th system on n-th attribute($0 \leq R_{nq} \leq 100$).

To implement this model, the subjects were required to rate the R_{nq}'s ranging from 0 to 100 and to allocate 100 to the W_n's. And to verify the model, the subjects were required to intuitively rank the five systems from best (1st rank) to least (5th rank) one for power production (Intuitive Rank Judgment).

3.3. Questionnaire for Preference Analysis

To compare the effectiveness of the alternative policies to improve public acceptance, the trade-off approach of conjoint analysis was conducted after the perception questionnaire part was done. Roughly two alternative policies may be feasible and will be necessary : the safety improvement and/or benefit increase from siting nuclear power plant. The safety improvement can be achieved by technological development

Table 1. Four Policy Alternatives With Three Levels to be Compared

Safety Improvement	Benefit increase from siting nuclear power plant
• Technological development (X)	• Regional promotion program (Z)
current reactor (x1)	current state (z1)
improvement of reactor safety 10 times (x2)	more employment opportunity (z2)
improvement of reactor safety 100 times (x3)	reduction of electric power rates for surrounding area (z3)
• Regulation and monitoring (Y)	• Subsidy for regional development (W)
current state (y1)	1 billion won per year (w1)
2 times stricter regulation (y2)	1.5 billion won per year (w2)
establishment of civilian monitoring system (y3)	2 billion won per year (w3)

and/or stricter regulation by government or civilian monitoring system which can lead to openness of information to the public. The benefit increases are resulted from employment, reduction of electric power rates, and/or subsidy. Hence, four policy alternatives with three levels were compared (See Table 1).

The subjects were required to fill out the 6 trade-off matrices in terms of the extent to which they would accept to site the nuclear power plant near their town in case that the pair of policies would be carried out. The questionnaire form is shown on left side of Figure 1.

3.4. Computing Method for Trade-off Analysis

The respondent's utility values ($u_x(x_1)$, $u_x(x_2)$, $u_x(x_3)$, $u_y(y_1)$, $u_y(y_2)$, $u_y(y_3)$, $u_z(z_1)$, $u_z(z_2)$, $u_z(z_3)$, $u_2(w_1)$, $u_w(w_2)$, $u_w(w_3)$) should be estimated so as to account simultaneously for all responded rating data R_n^m in six trade-off matrices of Figure 1. The numerical techniques available to convert the observed rating values into estimates of utilities are equivalent to regression analysis. The computing method used in this study is an iterative procedure which attempts to maximize a measure of "goodness of fit" of the estimated overall preference to the real response R_n^m.

The sample correlation coefficient is used as "goodness of fit" measure. The coefficient of calculated overall preference and responded rating data is given by

$$\gamma = \frac{\sum_{m=1}^{6}\sum_{n=1}^{9}(R_n^m - \bar{R})(R'^m_n - \bar{R'})}{\sqrt{\sum_{m=1}^{6}\sum_{n=1}^{9}(R_n^m - \bar{R})^2 \sum_{m=1}^{6}\sum_{n=1}^{9}(R'^m_n - \bar{R'})^2}} \quad \cdots\cdots \quad (5)$$

where R_n^m : real response value in n-th data of m-th matrix,

$\bar{R}$: average of R_n^m over m and n,

R'^m_n : calculated value from equations in (2) for additive model or (3) for multiplicative model,

$\bar{R'}$: average of R'^m_n over m and n.

The problem is to find out 12 utility values ($u_x(x_1)$, $u_x(x_2)$, $u_x(x_3)$, $u_y(y_1)$, $u_y(y_2)$, $u_y(y_3)$, $u_z(z_1)$, $u_z(z_2)$, $u_z(z_3)$, $u_w(w_2)$, $u_w(w_3)$) maximizing r. The value of r is bounded by -1 and 1, with higher values indicating better correlation to the actual response data.

The computer program was developed on the basis of the steepest ascent algorithm [15] with the dichotomous search method [15] in subroutine. And to obtain the unique solution regardless of starting point and to compare subjects' value in same unit, the utility values were transformed to normalize in (0, 1) for additive form and to make maximum value 1 for multiplicative form because these linear transformations would not change the r value maximized. For the r function may not be convex, r values and utility values were calculated 5 times with random starting point. If the r function has local maximum points, different starting points will lead to different maximum solutions. Though this method can't resolve local maxima problem exactly, 5 computed r values and utility values were all the same with different iteration. This shows that the numerical method used here is appropriate for this problem.

4. Results and Discussions

4.1. Results of Perception Analysis

For the importance weighting, W_n, health and environment impact was considered as the most important criterion. Economy and safety were the next ones. From the standard deviation and the person's distribution of W_n, it seems that perceptual judgments about the importance weighting of criteria is nearly homogeneous over the respondents.

It was revealed that the judgments for one of the five systems were much more determined by the perceived performance of the systems (R_{nq}). This is illustrated in Table 2.

This table lists mean performance ratings of the Nuke and Solar systems according to the intuitive judgment. For instance, the perceived performance of Nuke on safety criterion is 68.4 by those who considered Nuke as first rank in intuitive judgment, and 37.0 by the others (t-value = 4.06 ; 99.5% significant). The two groups' W_n assignments were not different significantly but the R_{nq} assignments reveals the gap between the different groups quite clearly. Thus, there is much more agreement on the weights to be assigned to five criteria than on the perceived properties of each evaluated option with respect to this criterion. This conclusion is similar to the study in Germany [16].

In order to investigate the predictive power of the MAU model, the confusion matrix was calculated, which is the conditional probability of actual judgment rank given predicted judgment rank by the model (For the confusion matrix, see [17]). Two basic models are considered, one based on the sum of

Table 2. The Performance Ratings for Nuke and Solar System According to the Difference in Intuitive Judgment ($t_{0.9}=1.298$ and $t_{0.995}=2.677$)

group / criteria & system	Pro-Nuke(N = 45)		Others(N = 10)		|t-Value|
	mean	sd	mean	sd	
economy					
Nuke	83.84	13.38	69	18.53	2.95
Solar	50.36	31.47	84	17.76	3.25
security of supply					
Nuke	78.68	19.39	63.5	27.49	2.06
Solar	62.07	30.11	66	38.93	0.35
health and environment impact					
Nuke	71.73	15.66	47	27.91	3.86
Solar	82.42	27.25	76	34.38	0.64
safety					
Nuke	68.4	21.4	37	25.41	4.06
Solar	82.47	27.88	82.5	29.56	0.003
spin-off effect					
Nuke	86.16	13.50	76.5	21.35	1.83
Solar	77	25.57	69	32.81	0.85

the unweighted ratings for each system and the other one based on the MAU model. The predictive power of the two basic models is shown in Table 3.

Both the models are especially effective in predicting first and last rank judgments, and the diagonals are dominant for every rank ; this analysis yields 39.2% and 36.4% correct predictions, which are poor ones.

This analysis was performed without the Solar option and without other option. The results were decreased correct prediction in case without Nuke option and a little increased correct predictions in cases without Coal, Oil and Hydro (Table 4).

This table shows that the solar option was the major error source which resulted in the obscure judgment of the respondents and that the simple sum model had more predictive power than the MAU model. Interesting result to be noticed is that the more inputs to model did not improve the prediction of respondents' judgments. The reason is probably that the public answered the ratings with the weights included.

The last job of perception analysis was to compare each option in terms of five criteria perceived by the respondents. Attribute scores of each systems calculated from simple sum model are shown in Figure 2. This shows that Nuke is perceived being superior in economy, security of supply and spin-off effect.

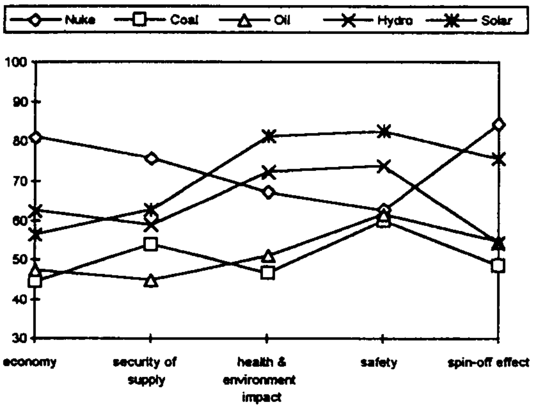


Fig. 2. Mean Performance Rating for Each System

Table 3. Predictive Power of Simple Sum Model and MAU Model in Parenthesis

[% of correct prediction]

Predicted / Actual	1	2	3	4	5
1	54.1(54.5)	27.8(24.6)	7.1(12.7)	3.6(1.8)	2.0(5.7)
2	9.8(7.3)	29.6(29.8)	21.4(23.6)	23.6(27.3)	16.3(11.3)
3	9.8(9.1)	13.0(17.5)	37.5(34.5)	25.5(21.8)	14.3(17.0)
4	6.6(9.1)	20.4(19.3)	12.5(14.5)	34.5(27.3)	28.6(30.2)
5	19.7(20.0)	9.3(8.8)	21.4(14.5)	12.7(21.8)	40.4(35.8)

Mean = 39.2% (36.4%)

Table 4. Correct Predictions of two Basic Models Without One Option

Model / Cases	Mean % of correct prediction	
	simple sum	MAU
without Nuke	38.2% (− 1%)	35.5% (− 0.9%)
without Coal	41.2% (+ 2%)	39.5% (+ 3.15%)
without Oil	43.7% (+ 4.5%)	43.8% (+ 7.4%)
without Hydro	44.6% (+ 5.4%)	40.5% (+ 4.1%)
without Solar	57.4% (+ 18.2%)	53.7% (+ 17.3%)

4.2. Results of Preference Analysis

Preference values for 12 alternatives were estimated by two composition rule, one was additive form of equation (2) and the other was multiplicative form of equation (3). Of 54 respondents, some (N=23) have higher r values in additive form and others (N=31) have higher r values in multiplicative form. The former respondents will be denoted by Addition group and the latter respondents by Multiplication group in terms of the preference model. The obtained values of r indicated generally good fits for the majority of the 54 respondents. The mean r was 0.867 with a standard deviation of 0.105 for Addition group and 0.859 with a standard deviation of 0.098 for Multiplication group.

Since each respondent has one's own preference feature different from one another, cluster analysis [18] was performed with the two groups' preference values in order to investigate overall feature of preference value. Two clusters (N=12, 11 in each cluster) in Addition group and three clusters (N=10, 8, 13 in each cluster) in Multiplication group were clustered. Mean preference values as well as rank order of 12 policies for each cluster are shown in Table 5. The values were also graphed in Figure 3 and Figure 4 (refer to Table 1 and Table 5 for variable notation).

Cluster 2 of Addition group assigned highest approval to establishment of civilian monitoring system and other groups did it to improvement of reactor safety 100 times.

The effectiveness of policy is calculated from the preference difference between the current state and the new policy. The value differences of eight new policies for each group are shown in Table 6.

This table shows quantitatively the degree of effectiveness of each policy. For example, the establishment of civilian monitoring system is about 3 times more effective than the subsidy of 2 billion won per year for Cluster 1 of Addition group, 1.2 times for Cluster 2 of Addition group, and so on. As another example, reduction of electric power rates has 1.8~2.7 times more effectiveness than more employment opportunity.

Interesting result to be noticed is that 80% of respondents assigned highest preference value to 100 times safer plant (Table 5) and 37% of them regard the option as most effective policy (Table 6), while

Table 5. Mean Preference Values and Their Rank Order of Five Clusters

	group	Addition group				Multiplication group					
	(% of total)	cluster 1 (22%)		cluster 2 (20%)		cluster 1 (19%)		cluster 2 (15%)		cluster 3 (24%)	
alternatives	mean r	0.875		0.841		0.920		0.786		0.857	
variable	notation	mean	rank	mean	rank	mean	rank	mean	rank	mean	rank
x_1	CrRx	0.08	12	0.17	11	0.81	9	0.17	3	0.38	8
x_2	10Rx	0.48	3	0.64	6	0.89	5	0.37	2	0.55	4
x_3	100Rx	0.84	1	0.85	2	0.97	1	0.49	1	0.82	1
y_1	CrReg	0.11	9	0.15	12	0.76	12	−0.03	11	0.19	11
y_2	2Reg	0.40	4	0.62	7	0.84	7	−0.01	10	0.38	9
y_3	moni	0.83	2	0.89	1	0.95	2	0.04	9	0.74	2
z_1	noNew	0.09	10	0.40	8	0.77	10	0.12	5	0.40	7
z_2	empl	0.22	7	0.65	5	0.85	6	0.04	8	0.49	6
z_3	redEle	0.33	5	0.71	4	0.90	4	0.06	7	0.65	3
w_1	1billion	0.08	11	0.23	10	0.77	11	−0.08	12	0.18	12
w_2	1.5billion	0.19	8	0.54	8	0.84	8	0.07	6	0.26	10
w_3	2billion	0.32	6	0.82	3	0.94	3	0.16	4	0.53	5

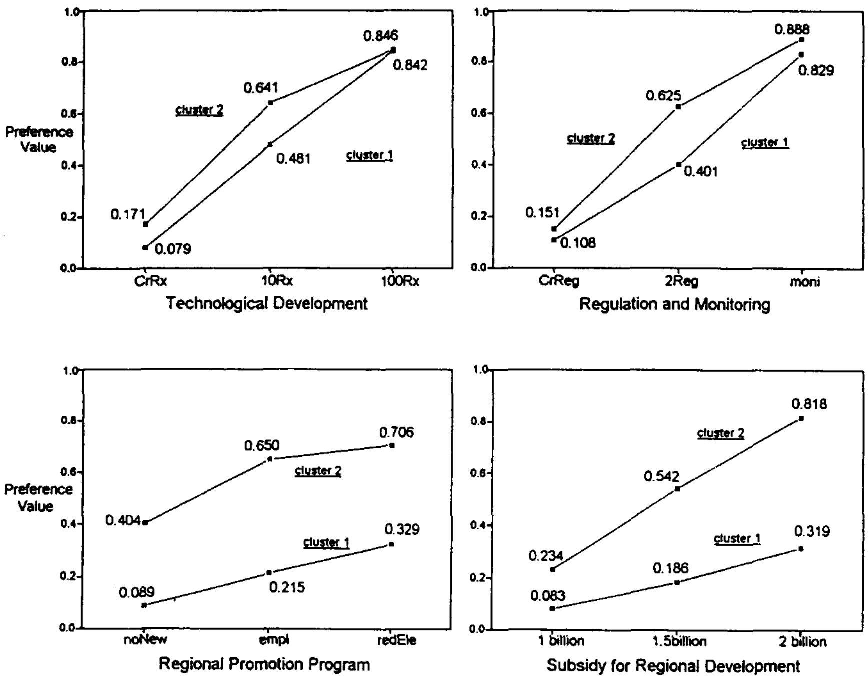


Fig. 3. Preference values for each cluster of Addition Group From Cluster Analysis

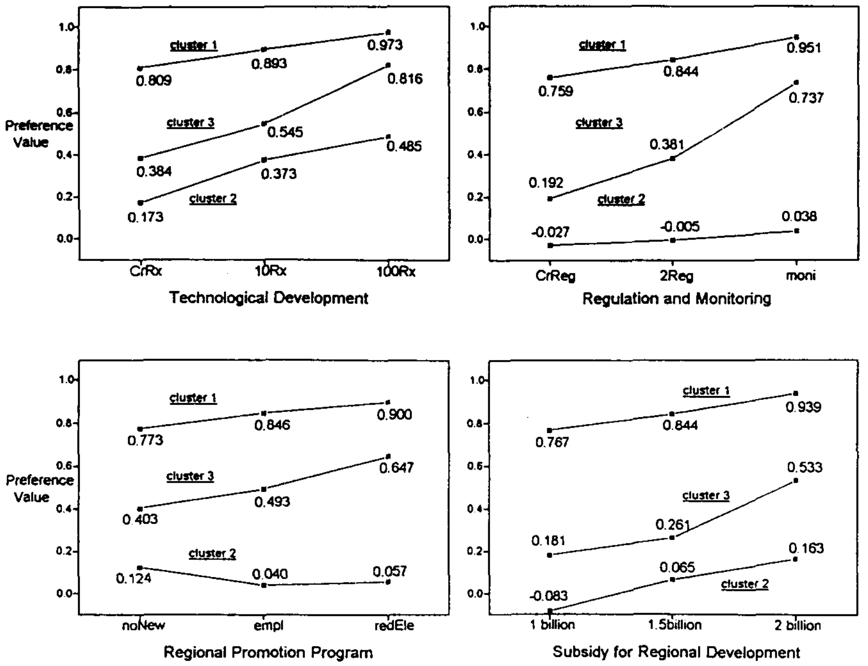


Fig. 4. Preference Values for Each Cluster of Multiplication Group From Cluster Analysis

Table 6. Increased Preference Value for Each Policy and the Normalized Value in Parenthesis by Dividing the Maximum Value of Each Cluster

policy group(% of total)	10Rx	100Rx	2Reg	moni	empl	redEle	1.5billion	2billion
Cluster 1 of Addition group(22%)	0.40 (0.53)	0.76 (1)	0.29 (0.38)	0.72 (0.95)	0.13 (0.17)	0.24 (0.32)	0.10 (0.13)	0.24 (0.32)
Cluster 2 of Addition group(20%)	0.47 (0.64)	0.68 (0.92)	0.47 (0.64)	0.74 (1)	0.25 (0.34)	0.30 (0.41)	0.31 (0.42)	0.58 (0.78)
Cluster 1 of Multiplication group(19%)	0.08 (0.42)	0.16 (0.84)	0.09 (0.47)	0.19 (1)	0.07 (0.37)	0.13 (0.64)	0.08 (0.42)	0.17 (0.89)
Cluster 2 of Multiplication group(15%)	0.20 (0.65)	0.31 (1)	0.02 (0.06)	0.07 (0.23)	−0.08 (−0.26)	−0.07 (−0.23)	0.15 (0.48)	0.25 (0.81)
Cluster 3 of Multiplication group(24%)	0.16 (0.29)	0.43 (0.78)	0.19 (0.35)	0.55 (1)	0.09 (0.16)	0.24 (0.44)	0.08 (0.15)	0.35 (0.64)

Table 7. The Integrated Results of the Degree of Effectiveness by Summing up the Normalized Values of Table 6 With the Proportion of Respondents Weighted.

policy	10Rx	100Rx	2Reg	moni	empl	redEle	1.5billion	2billion
effectiveness	0.49	0.90	0.39	0.87	0.18	0.35	0.30	0.67

20% of respondents assigned highest preference value to civilian monitoring system and 63% of them regard the option as most effective one. The reason may be that the experience of visiting nuclear power plant leads the respondents to regard nuclear power plant as technologically safe and that they, however, distrust the operation and the public information system. Thus, technologically safer power plant is regarded as ultimate goal to be achieved, but at present time, the civilian monitoring system is regarded as urgent.

5. Conclusions

Since the respondents had the experience of visiting nuclear power plant which was expected to give them the motives of understanding the energy problems in right perspective, the results from them seem reliable to aid new strategy of nuclear energy policy. By the perception analysis, it was revealed that they had the consistent judgment for nuclear power plant and ambiguous judgment about solar power system and that they regarded nuclear power plant as having superior attributes in economy, security of supply and spin-off effect but less superior in safety and impact on health and environment. Quantitative values of the public preferences for new nuclear policies and the degree of effectiveness of them could be obtained. The integrated results of the degree of effectiveness by summing up the normalized values of Table 6 with the proportion of respondents weighted are shown in Table 7.

From this table, the establishment of civilian monitoring system was revealed to be as effective as the improvement of reactor safety 100 times. Moreover, the former can be implemented easier than the latter. Therefore, this option seems to be best to improve public acceptance of nuclear power in Korea. In benefit increase part, the subsidy of 2 billion won is about 2~3.5 times more effective than others.

The acceptability and the effectiveness of policy alternatives found in this study would give helpful information to the policy maker.

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