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MEASURING THE ECONOMIC BENEFITS FROM THE CONTAMINATED SOIL REMEDIATION POLICY IN KOREA: A CONTINGENT VALUATION STUDY

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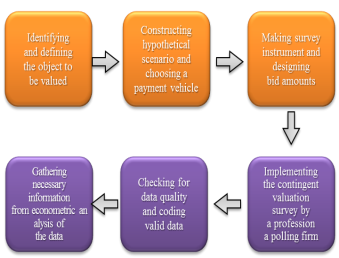
Graphical abstract



Abstract

Soil contamination caused by economic growth through industrialization and urbanization has been progressed in Korea. Soil polluted with heavy metals and chemicals makes significantly negative effects on human and wildlife health. This paper attempts to measure the economic benefits from the contaminated soil remediation policy using a specific case study of Korea. To this end, the contingent valuation (CV) method is employed. A CV national survey of randomly selected 500 households was implemented using person-to-person interviewing in May 2105. To elicit the willingness to pay (WTP), we apply one-and-one-half bound dichotomous choice question format to reduce the potential for response bias and spike model to deal with zero willingness to pay (WTP). The mean WTP for the policy is estimated to be KRW 1,357 (USD 1.2) for next ten years per household per year and statistically significant at the 1% level. Expanding the value to the national population gives us KRW 25.4 billion (USD 22.9 million) per year. We can judge that the Korean public places a significant value and be utilized in assessing the total benefits from the policy.

Keywords: Contaminated soil, contingent valuation, economic benefit, willingness to pay

1.0 INTRODUCTION

In the course of last twenty five yeas, Korea has undergone relatively high economic development. Real gross domestic product has grown at an average annual rate of 5.1%. This economic growth was fuelled by processes of industrialization, urbanization, and population growth and was not achieved without sacrifices. It was not until the early 2000s that people in Korea realized a soil pollution problem must be counted among those sacrifices. When the amounts of soil contaminants exceed natural levels pollution is generated. According to Korea Ministry of Environment (KMOE), the soil pollution level has been getting more serious.

The main causes of soil pollution are industrial activity, agricultural activities, waste disposal, accidental oil spills, and acid rain. Soil pollution occurs when there are the following main mechanisms: a) Accidental leaks and spills of gasoline and diesel; b) Foundry activities and manufacturing processes; c) Mining activities of raw materials; d) Construction activities; e) Agricultural activities involving the spread of herbicides; f) Vehicle emissions; e) Illegal dumping); g) Storage of wastes in landfills.

Soil contamination causes severe impacts on human health and wildlife. Of them, two effects are quite important. First, soil pollution can have a number of harmful effects on human health. The harmful effects of soil pollution may come from direct contact with polluted soil or from contact with other resources, such as water, that have come in direct contact with the polluted soil. Crops and plants grown on polluted soil absorb much of the pollution and then pass these on to us. This could explain the sudden surge in small and terminal illnesses. Long term exposure to such soil can affect the genetic make-up of the body, causing congenital illnesses and chronic health problems that cannot be cured easily.

Second, it makes impacts on the growth of plants. The ecological balance of any system gets affected due to the widespread contamination of the soil. Most plants are unable to adapt when the chemistry of the soil changes so radically in a short period of time. Fungi and bacteria found in the soil that bind it together begin to decline, which creates an additional problem of soil erosion.

Thus, policymakers are currently considering the contaminated soil remediation policy that reduces the soil pollution level by 20% relative to the situation with no policy. If adopted, costs of the policy will be incurred, with the expectation that inhabitants in Korea will reap the ensuing benefits. Employing economic efficiency as the sole criterion, the policy should be evaluated in a conventional cost-benefit analysis context. In other words, policy implications of whether to implement the contaminated soil remediation policy could, in principle, be deduced from an examination of costs and benefits associated with such policy.

Comparing with expenditures, programs' goals should be evaluated and managed. Since R&D policy has been operated from national budget, assessment of the policy is necessary [1-3]. Moreover, some information on the economic benefits would be useful to make an informed public decision. This study addresses a component of the benefits that such an analysis would consider: the benefits of the contaminated soil remediation policy. There are some studies in which the soil pollution damage costs or the benefits of the contaminated soil remediation is measured (for example, see Pimentel *et al*., 1995; van Wezel *et al*., 2007) [4]. However, far less information is available for Korea. The results of this study will be an important first step in fostering a productive debate over the policy is a better understanding of its benefits and costs

The study attempts to apply a contingent valuation (CV) method to measuring economic values of the contaminated soil remediation policy. The rest of this paper is divided into some sections. Section 2 is devoted to explaining the measurement method employed in this study. Section 3 reviews the study design issues. Section 4 deals with the willingness-to-pay model. Section 5 presents and discusses the results. The final section contains some concluding remarks.

2.0 METHODOLOGY

2.1 Object to be Valued

As discussed in the introduction, the contaminated soil remediation policy that reduces the soil pollution level by 20% relative to the situation with no policy is considered. Because soil pollution in Korea has became the widespread problem. To deal with this problem, KMOE initiated R&D program for soil remediation and management. The improvement goal for the proposed policy to be evaluated is to have 20% decreases in pollution, using a variety of policy instruments. The main instruments include: a) investigating soil pollution, b) find pollutant, c) development of prevention and remediation technologies. If policy implements, soil should be improved and reduce negative effects.

2.2 CV Method

The cornerstone principle in measuring the economic benefits from proposed projects is the concept of the consumer's WTP for the policy [5]. This concept represents the amount people would be willing to pay to avoid a specified environmental damage, achieve a stated improvement in environmental quality, or receive a specified supply of a public good. This objective is pursued through a survey approach called the CV method, which is presented in Figure 1.

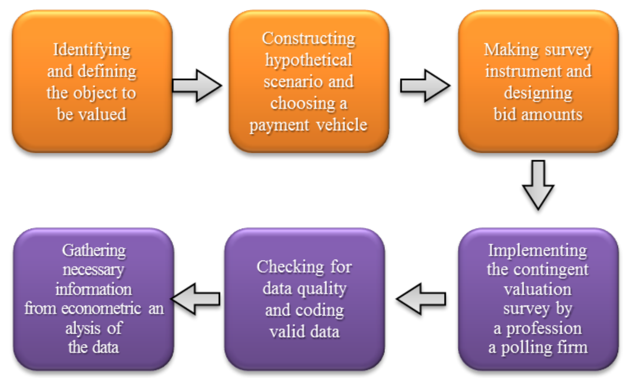


Figure 1 The processes of the CV method

The CV method is a standardized and widely used survey method for estimating WTP (Mitchell and Carson, 1989). The distinguished National Oceanic and Atmospheric Administration's (NOAA) Panel concluded that the CV method can produce estimates that are reliable enough to be the starting point for administrative and judicial determinations and presented several recommendations (Arrow *et al*). Furthermore, the validity and accuracy of a CV study can be enhanced if people are familiar with the good to be valued, professional interviewers are used, and other conventions suggested by the NOAA Panel are followed. The CV survey was conducted with the heads of household or housewives whose ages ranged from 20 to 65. The survey yielded 500 reliable interviews. Such a survey can be conducted either by face-to-face interviewing, telephone interviewing, or by mail. Of these methods, we chose to use face-to-face interviews for the CV survey for cultural and practical reasons.

First, we felt that randomly chosen Korean households would be even less likely than Americans or

Europeans to be familiar with the idea of supplying unprompted values for proposed public goods if they were confronted with a telephone interview or mail survey questions. However, face-to-face interviews with well-trained interviewers can offer the most scope for detailed questions and answers. In this regard, we selected the most experienced and best-educated of the polling firm's interview experts to conduct the interviews and gave them a thorough briefing.

Second, a telephone interview was the least preferred method because conveying information about the product or service being considered may be difficult over the telephone. Finally, mail surveys are rarely used because they suffer from non-response bias and extremely low response rates; thus it seemed especially risky to use this method in the context of Korea.

2.3 Survey Instrument

The survey instrument (questionnaire) was pre-tested with 50 persons. In designing a CV survey, the scenario should offer the respondents information on the characteristics of a specific product or service and the context that will meet the requirements of understandability, plausibility, and meaningfulness to enhance the credibility of the survey and the likelihood of producing reliable results. The survey questionnaire consisted of i) introductory questions, such as the respondents' perception after providing general background information on soil pollution; ii) the WTP question about the contaminated soil remediation policy; and iii) household information.

2.4 Elicitation Method

The elicitation format employed in this study is a referendum or dichotomous choice (DC) question according to the 'blue-ribbon CV panel' of Arrow *et al*. (1993), which strongly endorses a referendum question rather than an open-ended question. The DC model has been favored since it was popularized by Hanemann (1984) [6] and it is generally considered to be a superior elicitation method. Typically, a random sample of the population is asked a question with a 'yes' or 'no' possible response regarding their willingness to contribute a specific amount toward purification and conservation of contaminated soil which is environmental resource for the public.

The results of the pre-test for a focus group were used to refine the range of bid amounts for the DC WTP questions. The respondents were randomly assigned to ten subgroups, with each sub-sample being asked to respond to a different bid in Korean won (KRW). The bids used in this study were: KRW 1,000, 2,000, 3,000, 4,000, 5,000, 6,000, 7,000, 8,000, 9,000 and 10,000 (at the time of the survey, USD 1.0 was approximately equal to KRW 1,109.2).

2.5 The Payment Vehicle

The WTP question was "Would your household be willing to pay a certain amount more in higher income tax each year for the contaminated soil remediation policy, provided that the success of this policy is guaranteed?" A provision point mechanism was used to define the costs that the households themselves were likely to bear. The respondents were told that "The amount you indicate will tell us what it is really worth to your household. If the policy actually costs less than people are willing to pay, you would only have to pay what it would cost. If the policy finally costs more than people are willing to pay, it would not be implemented."

The information given to respondents about all aspects of the hypothetical market, together with such information as is provided on the good being valued, constitute the framing of the good.

3.0 MODEL

We use the spike model when dealing with our double-bounded (DB) dichotomous choice (DC) contingent valuation (CV) survey data with zero observations to obtain an appropriate welfare measure such as the mean willingness to pay (WTP). The spike model takes into account a spike at zero that is the truncation, at zero, of the negative part of the WTP distribution. Originally, the spike model was suggested by Kriström (1997) for single-bounded (SB) DC CV data.

Hanemann (1984) developed a utility difference approach to analyze SB DC CV data and Hanemann *et al*. (1991) [7] adjusted the approach to investigating DB DC CV data. Thus, it is necessary to combine Hanemann *et al*.'s (1991) DB DC CV model and Kriström's (1997) [8] spike model in order to model the DB DC CV data with zero observations (Yoo and Kwak, 2002) [9]. Let $i = 1,\ldots,N$ be the index for each respondent in the sample. Let A be the bid amount presented to a respondent. Given the assumption of a utility-maximizing respondent where A_i is the first bid, A_i^u ($A_i < A_i^u$) is the higher second bid when the individual responds 'yes' to the first bid, and A_i^d ($A_i > A_i^d$) is the lower second bid when the individual responds 'no' to the first bid.

When each respondent is presented with two bids, there are four possible outcomes: (a) both answers are 'yes' (yes-yes); (b) both answers are 'no' (no-no); (c) a 'yes' followed by a 'no' (yes-no); and (d) a 'no' followed by a 'yes' (no-yes) whose binary-valued indicator variables are I_i^{YY} , I_i^{YN} , I_i^{NY} , and I_i^{NN} , respectively, such that:

$$\begin{aligned} I_i^{YY} &= \mathbf{1}(i\text{th respondent's response is 'yes - yes'}) \\ I_i^{YN} &= \mathbf{1}(i\text{th respondent's response is 'yes - no'}) \\ I_i^{NY} &= \mathbf{1}(i\text{th respondent's response is 'no - yes'}) \\ I_i^{NN} &= \mathbf{1}(i\text{th respondent's response is 'no - no'}) \end{aligned} \quad (1)$$

where $\mathbf{1}(\cdot)$ is an indicator function, whose value is one if the argument is true and zero otherwise.

It should be noted that the 'no-no' respondents are made up of two groups: those who really have a zero WTP, and those who have a positive WTP that is less than A_i^d. For people who gave a 'no-no' response, a third follow-up question was asked: "Are you willing to pay anything at all?" Those providing a 'no' answer to this question represent a valid representation of their zero WTP. Thus, the answer to the question allows us to estimate the spike model. That is, 'no-no-no' answers are taken as zero responses. For each respondent i, I_i^{NN} in equation (1) is classified into I_i^{NNY} and I_i^{NNN} such that:

$$I_i^{NNY} = \mathbf{1}(i\text{th respondent's response is 'no-no-yes'})$$
$$I_i^{NNN} = \mathbf{1}(i\text{th respondent's response is 'no-no-no'}) . \quad (2)$$

We recognize WTP (hereafter denoted as C) is a random variable with a cumulative distribution function (cdf) defined here as $G_C(\cdot;\theta)$, where θ is a vector of parameters. Following the practice of former studies, formulating $1-G_C(\cdot)$ as logistic cdf and combining this with $\theta=(a,b)$ yields:

$$G_C(A;\theta) = [1+\exp(a-bA)]^{-1} . \quad (3)$$

To estimate the distribution of WTP, we assume that WTP is distributed as a logistic on the positive axis. The log-likelihood function for the spike model is given by:

$$\begin{aligned}\ln L = \sum_{i=1}^{N} \{ & I_i^{YY} \ln[1-G_C(A_i^u;\theta)] \\ & + I_i^{YN} \ln[G_C(A_i^u;\theta) - G_C(A_i;\theta)] \\ & + I_i^{NY} \ln[G_C(A_i;\theta) - G_C(A_i^d;\theta)] \\ & + I_i^{NNY} \ln[G_C(A_i^d;\theta) - G_C(0;\theta)] + I_i^{NNN} \ln[G_C(0;\theta)]\} , \end{aligned} \quad (4)$$

where:

$$G_C(A;\theta) = \begin{cases} [1+\exp(a-bA)]^{-1} & \text{if } A>0 \\ [1+\exp(a)]^{-1} & \text{if } A=0 \\ 0 & \text{if } A<0 \end{cases} . \quad (5)$$

Thus, the spike is defined by $[1+\exp(a)]^{-1}$. Using (5), the mean WTP (C^+) in the spike model can be calculated as:

$$C^+ = (1/b)\ln[1+\exp(a)] . \quad (6)$$

4.0 RESULTS AND DISCUSSION

4.1 WTP Estimation Results

Table 1 shows the results of estimation for spike model. According to the results, all the parameters in the model are statistically significant at the 1% level. Based on the Wald statistic, the null hypothesis that all the coefficients of the equation are zero can be rejected at the 1% level. The coefficient for the bid amount is negative, as expected. That is, a higher bid makes a 'yes' response less likely. One can use these regression results and $1-G_C(\cdot)$ to generate an estimate of the mean WTP. The yearly mean WTP per household is calculated as KRW 1,357 (USD 1.2). Its *t*-value is computed as 12.43; thus, we can reject the hypothesis that the mean is zero at the 1% level and conclude that the mean WTP is not different from zero.

Table 1 Estimation results of spike model

Variables	Estimates
Constant	-0.3183 (-3.54) *
Bid amount [a]	-0.4027 (-16.86) *
Spike	0.5789 (26.42) *
Number of observations	500
Log-likelihood	-600.82
Wald statistic [b] (*p*-value)	340.66 (0.000)
Yearly mean WTP	KRW 1,357 (USD 1.2)
t-value [c]	12.43 *
95% confidence interval [d]	1,195-1,552

[a]The unit is KRW 1,000 (USD 0.90).
[b]The hypothesis suggests that all the parameters are jointly zero and the corresponding *p*-value is reported in the parentheses.
[c]The *t*-value was calculated using the delta method.
[d]The confidence interval was calculated using the Monte Carlo simulation technique of Krinsky and Robb with 5,000 replications. The numbers in parentheses below the coefficient estimates are *t*-values, which were calculated from the analytic second derivatives of the log-likelihood.
* indicates statistical significance at the 1% level.

Further, instead of reporting only the point estimate, we constructed confidence interval for the point estimate of the mean WTP to take uncertainty into account. For this, we used the Monte Carlo simulation technique proposed by Krinsky and Robb (1986) with 10,000 replications is used. This method quantifies and models the uncertainty, shows the likely range of the WTP given the uncertainties involved in doing this type of estimation, and coincides with one objective of modern policy-makers, who prefer to be presented with a range of values rather than one best value.

4.2 Expanding from Sample to Population Estimates of WTP

Once individual estimates of mean WTP are obtained, the next step is to estimate aggregate values, which Arrow *et al*. (1993) has identified as one of the important issues in the use of CV results. When expanding the sample to the population, one critical concern is the external generalization of the sample values to the population. This is dependent on the representativeness of the sample frame and the survey response rate. As described earlier, the sample frame was a random sample of households selected by a professional polling firm. The sample response rate for the face-to-face interview was almost 100 % and thus, our data are likely to provide accurate figures for the economic value of the contaminated soil remediation policy.

Using the mean WTP in Table 1, the estimate of yearly WTP for the typical household in the survey was about KRW 1,357 (USD 1.2). We can generate an estimate of the total WTP for the entire population of the nation by multiplying the estimate per household by the number of households of nation. According to the Korea statistical information service, there were 18,705,004 households in 2015. Multiplying these by WTP and annualizing it yields a total of about KRW 25.4 billion (USD 22.9 million), as shown in Table 2.

Table 2 The economic benefit from contaminated soil remediation policy in Korea [a]

Annual WTP per household	Number of household	Annual values
KRW 1,357 (USD 1.2)	18,705,004	KRW 25.4 billion (USD 22.9 million)

5.0 CONCLUSIONS

Soil contamination caused by economic growth through industrialization and urbanization has been progressed in Korea. Soil polluted with heavy metals and chemicals has made significantly negative effects on human and wildlife health. To deal with the problem, the Korean government is considering the contaminated soil remediation policy of reducing the soil pollution level by 20%. This study attempted to value the economic benefits that ensue from the policy implementation in order to help policy-makers take appropriate evaluations related to policy. In particular, we applied the CV method using a national survey of randomly selected 500 households. In addition, we employed the spike model to deal with zero WTP observations.

The mean WTP was estimated to be KRW 1,357 (USD 1.22) per household per year. It is statistically significant at the 1% level. Expanding the value to the national population gives us a value of KRW 25.4 billion (USD 22.9 million). This study provided a preliminary indication of the benefits of the policy, which can be used in conventional cost-benefit analysis. The main preliminary results indicate that concern about soil pollution is on the rise, and that people are willing to shoulder the burden to reduce contaminated soil. There may be evidence that the public is ready to accept significant increases in income tax to which the implementation of the contaminated soil remediation policy will lead.

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