부산시 수돗물 수질개선 편익의 추정

Valuing the Economic Benefits of the Water Quality Improvement in Busan

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Abstract

Water is an indispensable input to human's existence and industrial production. In these days, people are getting more concerned about their health and the interest in the safety of drinking water has increased. In this situation, this paper attempts to measure the economic benefits of the tap water quality improvement. The study area was restricted to Busan, the second largest city in Korea, where local government is planning to implement a tap water quality improvement program. We apply a one-and-one-half bounded dichotomous choice contingent valuation (CV) method to obtain at least a preliminary evaluation of the benefits. CV is developed for valuing goods or services that cannot be valued either directly or indirectly from market observations and has been applied to several environmental goods. The CV survey was rigorously designed to comply with the guidelines for best-practiced CV studies. We surveyed a randomly selected sample of 400 households in Busan and asked respondents questions in person-to-person interviews about how they would be willing to pay for the water quality improvement. Respondents overall accepted the contingent market and were willing to contribute a significant amount (US$1.66), on average, per household per month. We can also calculate the aggregate value of the program which improves the water quality in Busan. This study is expected to provide policy-makers with useful information for evaluating and planning environmental policies relating specifically to water.

Key words: Water quality improvement, Contingent valuation method, Willingness to pay, Economic benefits

1. Introduction

Water is an indispensable input to human's existence and industrial production. In these days, people are getting more concerned about their health and the interest in the safety of drinking water has increased. Some people prefer purchasing bottled water and using a water-treatment equipment to drinking tap water. These action can be interpreted as an averting behavior against the decline in the quality of water. As the averting behavior causes defensive expenses and deteriorates the level of welfare by declining real incomes, the government tries to provide a policy to improve the quality of water. The policy about

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improving water quality costs much and it is necessary to assess the benefits and costs of the policy. The cornerstone principle that is used for measuring the benefits from a proposed policy is the concept of the consumer's willingness to pay(WTP) for the policy(Brent, 1995). This concept represents how much people would be willing to pay for the water quality improvements.

To achieve this objective, we adopted a survey approach namely, Contingent Valuation(CV) method. This method involves constructing a hypothetical market or referendum scenario and uses questionnaires in a survey to elicit respondents' preferences for the policy of water quality improvements by finding out how much they would be willing to pay (Mitchell and Carson, 1989). Respondents utilize the established hypothetical market to state their WTP or vote for or against the new policy at a particular tax price. CV method has been applied to many environmental goods and several studies dealt with the issue of water quality. Brox et al.(2003) estimated WTP for residential water quality improvements in the Grand river watershed in the province of Ontario, Canada and Barton(2002) conducted identical CV method for coastal water quality of Costa Rica. In addition, Atkins et al.(2007) applied CV and decision tree analysis to investigate public preferences for water quality improvements. Even though there are many studies for the improved water quality, few studies analyze consumers' preferences on water quality in Korea, especially Busan. In particular, this paper employs one and one-half bound dichotomous choice(OOHBDC) CV model for realizing the statistical efficiency. Furthermore, in CV, respondents who say 'no' to the given bids can be divided into two groups: those who really have a zero WTP and those who have a positive WTP that is less than the second lower bid. To address this problem, this paper applies a spike model.

2. Methodology

2.1 Some Survey design issues

In this study, 400 surveys were conducted to study the household WTP for the improvements of the water quality and characteristics. The study area of this research was restricted to the residents of Busan. In order to draw a random sample of the population, sampling was conducted by a professional polling firm. The survey was conducted for heads of household or housewives whose ages range from 20 to 65.

The elicitation format employed in this study is a dichotomous choice(DC) question according to the 'blue-ribbon CV panel' of Arrow et al.(1993). Generally, the DC question format is divided into the single-bounded DC(SBDC) question and the double-bounded DC(DBDC) question. SBDC asks the respondent only one closed-ended question and DBDC presents each respondent with a sequence of two bids and asks the question twice. Although each format has both merits and demerits, SBDC has low statistical efficiency and DBDC may have correlation between the response to two bids. To solve this problem, we adopted OOHBDC, that is presented by Cooper and Hanemann (1995) and Cooper et al. (2002).

The payment vehicle should be familiar to respondents and obviously connected with the good being considered. Therefore, this study employed monthly water rate as a payment vehicle, which is likely to be familiar to most respondents. The WTP question format asked each household to pay a particular Korean won amount each month.

2.2 Model

In the OOHBDC question, the process of elicitation can result in six sets of answers. If the lower bid is randomly drawn as the starting price, then the possible response paths are: 'yes-yes', 'yes-no' and 'no'. If the upper bid is randomly drawn as the starting bid, the possible response paths are: 'yes', 'no-yes' and 'no-no'. The associated binary-valued indicator variables are I_i^{YY}, I_i^{YN}, I_i^{N}, I_i^{Y}, I_i^{NY} and I_i^{NN}, respectively. To consider a spike model which is suggested by Kriström (1997) and allows for the zero WTP responses, the process of elicitation should be divided. When the lower bid is presented as the starting price, the answer of 'no' is partitioned into 'no-yes' and 'no-no'. When the upper bid is presented as the starting price, the answer of 'no-no' is partitioned into 'no-no-yes' and 'no-no-no'. Thus, the binary-valued indicator variables I_i^{N} and I_i^{NN} are separated into I_i^{NY}, I_i^{NN} and I_i^{NNY}, I_i^{NNN} respectively. By using those notations, the log-likelihood function takes the explicit form:

$$
\begin{aligned}
\ln L(\Theta) = \sum_{i=1}^{N} (& I_i^{YY} \ln[1 - G_i(A_i^u)] + I_i^{YN} \ln[G_i(A_i^u) - G_i(A_i^l)] + I_i^{NY} \ln[G_i(A_i^l) - G_i(0)] \\
& + I_i^{NN} \ln G_i(0) + I_i^{Y} \ln[1 - G_i(A_i^u)] + I_i^{NY} \ln[G_i(A_i^u) - G_i(A_i^l)] + I_i^{NNY} \ln[G_i(A_i^l) - G_i(0)] \\
& + I_i^{NNN} \ln G_i(0)
\end{aligned}
$$

where i represents individuals; $Gc(A_i^u)$ is the probability of a 'no' response to A_i^u and $Gc(A_i^l)$ is the probability of a 'no' response to A_i^l. To estimate the distribution of WTP following the practice of former studies, it is assumed that WTP is distributed as a logistic on the positive axis. The spike and the mean WTP in the spike model can be calculated.

3. Estimation Results

Table 1 shows the results of this estimation. The model was estimated by the maximum likelihood estimation method. The second column of Table 1 shows the estimation results of the model without covariates. The coefficient for the bid is negative and statistically significant at the 1% level, as expected. That is, upper bid makes a 'yes' response less likely.

Table 1. Estimation results

Variables	Estimation results
Constant (t-value)	-0.9328 (-8.41)**
Bid (t-value)	-0.1562 (-8.87)**
Spike	0.7176 (31.90)**
Wald statistic (p-value)[a]	1,017.87 (0.00)**
Log-likelihood	-363.1896
Number of observation	400

주: ** indicate statistical significance at the 5% and 1% level
a:The hypothesis is that all the parameters are jointly zero

The estimate of mean WTP is shown in Table 2. The monthly mean WTP estimate is calculated as 2,124 Korean won (USD 1.66) per household. The t-value is estimated to be 7.49. Based on this, one can reject the hypothesis that the mean WTP is not different from zero and conclude that the mean WTP is statistically significantly different from zero. Moreover, the study adopted the strategy of constructing 95% and 99% confidence interval for the point estimate of the mean WTP in order to allow for any uncertainty, rather than only reporting the point estimate. To this end, the Monte Carlo simulation technique of Krinsky and Robb (1986) was used.

Table 2. WTP

Variables	Estimation results
Mean WTP (unit: KRW)	2,124
95% confidence interval	1,719-2,689
99% confidence interval	1,652-2,807
t-value	7.49**

주: ** indicate statistical significance at the 5% and 1% level

The confidence intervals were calculated by the use of the non-parametric bootstrap method with 5,000 replications.

4. Concluding Remarks

The main objective of this study was to obtain estimates of WTP values for improving the quality of water in Busan, Korea. Overall, the survey was relatively successful in eliciting WTP values for water quality improvement. The WTP elicitation was within respondents' ability and the WTP amounts from DC question were statistically different from zero. The mean WTP from OOHBDC spike model CVM was 2,124 Korean won (USD 1.66) per household. The estimates of the benefits to relevant residents was 34.2 billion won (USD 26.7 million) annually.

For policy purposes, the results are useful starting points in understanding the possible implications of water quality improvement. This study illustrates that there is a substantial non-market WTP to improve the quality of water. The analysis provides a preliminary indication of the benefits of the water quality improvement, which can be used in conventional CBA.

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