ECONOMIC VALUE OF DOMESTIC WATER SUPPLY IN REPUBLIC OF KOREA

By

HWANG, Jong In

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

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Committee in charge:

Professor Jongyearn LEE, Supervisor ____________________

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1. Acknowledgements

First of all, I would like to show appreciation to the financial support of K-water which is my company. I would like to express my deep gratitude to my supervisor, Prof. Jongyearn Lee who encouraged and supported me to do independent study. His advices and valuable comments were the milestone in every step of developing my capstone. His advice about related papers made my research more detailed and reliable. And I owe my sincere appreciation to Prof. Seunghoon Yoo. This paper would have been impossible without the data of the previous study which was conducted by him. He was willing to provide his valuable data to me. I have greatly benefited from the WTP of domestic water. And I am deeply grateful to Dr. Moonhyun Ryu who taught me how to use statistical analysis. Without his help, I could not get significant statistical results. In addition, I wish to express special thanks to the KDI school staff for their kind assistance and support during the whole study period of the undertaking. Last but not least, I would like to thank my wife and children for putting up with me.

2. Executive summary

The purpose of this study is to examine the economic valuation methods of domestic water for each region of Republic of Korea and to examine the factors affecting Willingness to Pay, hereafter WTP, of domestic water. KDI guidelines (2008) stipulate that the benefit of domestic water supply and that of industrial water supply should be calculated separately during the pre-feasibility study. For industrial water, the reference value specified in the KDI guidelines (2012) may be applied as WTP, but in the case of domestic water, Contingent Valuation Method, hereafter CVM, should be implemented every time.

The Ministry of Land, Transport and Maritime Affairs (MLTMA, 2012) proposed WTP of domestic water for each region using the results of CVM. I investigate the effect of limited or stopped water supply experience on WTP by using MLTMA (2012) survey results. Multiple regression analysis shows that limited or stopped water supply experience had a positive effect on WTP. But since it is confirmed that there are other variables such as preschool children that have a greater effect on the WTP, it is not meaningful to collectively increase the WTP in a drought area.

Therefore, in this study, the economic value of the domestic water for each region is suggested by applying the consumer price index to the result of MLTMA (2012). If the economic value of domestic water through this research could be included in the KDI guideline like industrial water, and the economic value of domestic water supply can be calculated without conducting CVM, this research will contribute to saving time and money.

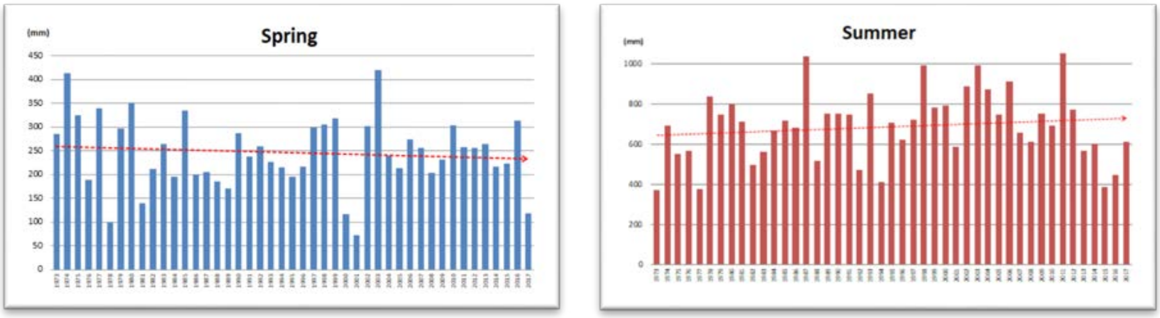
[Table 1] The suggested additional WTP of domestic water

WTP(₩/㎥)	Metropolitan	Chungcheong	Honam	Daekyung	Dongnam	Gangwon
LTMA(2012)	133.4	55.6	96.9	72.6	64.8	130.3
This study(2017)	**141.9**	**59.1**	**103.0**	**77.2**	**68.9**	**138.6**

3. Introduction

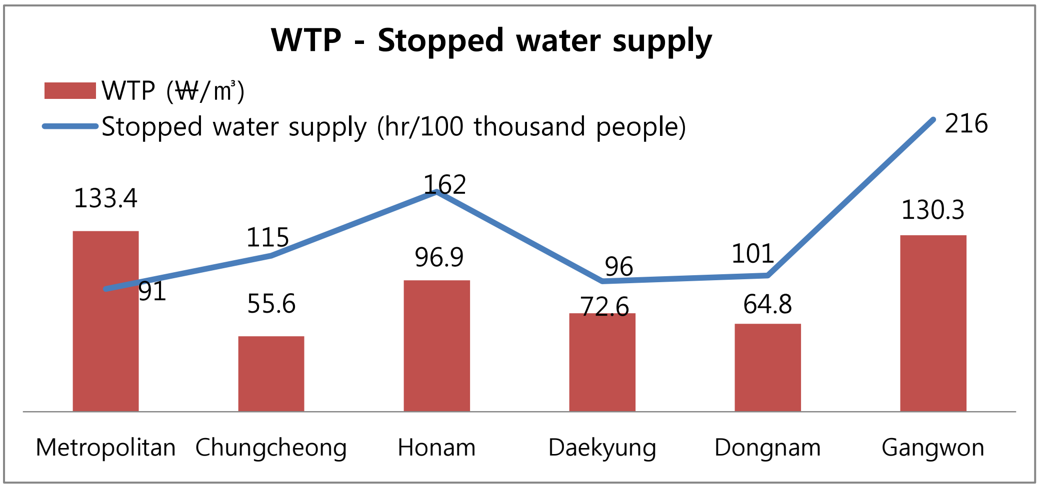
Benefits and cost ratio, hereafter B/C, is calculated in the economic feasibility analysis during the pre-feasibility study, which means that the benefit of the water resources project investment is not just the water rate, but the economic value of the water. KDI guidelines (2008) stipulate that the benefit of domestic water supply and that of industrial water supply should be calculated separately during the pre-feasibility study. CVM is used to measure the benefit of the domestic water supply. However, KDI guidelines (2012) suggested that the method of calculating the benefits of industrial water is different. A reference value is given to the economic value of industrial water and this value is applied as WTP without CVM. Because the feasibility analysis results depend on the economic outputs of water, how to measure the value of water is a matter of significant interest. Therefore it is important to consider whether it is possible to carry out preliminary feasibility study efficiently by estimating reference value of domestic water like that of industrial water to avoid unnecessary time and waste of money due to CVM.

There have been many studies in other countries to estimate the economic value of water, but there are few cases of detailed study of the local domestic water supply by region. Although little research has been carried out on this area in South Korea, estimation on the economic value of domestic water is a significant area of interest. Significant previous research (2012) conducted by the Ministry of Land, Transport and Maritime Affairs, hereafter MLTMA, of South Korea proposed WTP of domestic water for each region based on the results of CVM. But there was lack of detailed examination of what variables affect WTP. In Korea, the amount of water that can be used is not so high because of the phenomenon of rainfall concentration in summer. In addition, due to the effects of climate change, the amount of water available has been further reduced as summer precipitation increases and spring precipitation decreases as shown in [Figure 1]. In the summer, floods will cause more damage, and in spring, the drought will cause more damage.



[Figure 1] Trend of precipitation in Republic of Korea (1973~2017)
* Source : Weather data open portal (Korea Meteorological Administration)

Therefore it is necessary to examine how the economic value of water will be affected by such weather disasters because there may be a limited or stopped water supply in drought. This paper will examine whether the limited or stopped water supply experiences affect the economic value of domestic water and also review the impactful factors on WTP. However, due to resource constraints, this paper will not conduct new CV survey and will analyze based on data of existing research conducted by MLTMA (2012).



[Figure 2] Relationship between stopped water supply experience and WTP
* Source : Waterworks statistics 2007~2016 (Ministry of Environment)

The line graph in [Figure 2] is the annual mean stopped water supply hours per year per 100,000 people. The bar graph indicates the additional WTP of domestic water calculated by MLTMA (2012). Interesting discovery shows that in the rest of the metropolitan area, WTP is high in areas with high numbers of stopped water supply hours. The reason for the high WTP value in the metropolitan area is probably due to high income. Any fact cannot be confirmed through this graph, but this paper will review whether this relationship is simply coincidental or statistically significant.

This paper will be of use to the policymakers, government officers, and public organization officers who wish to plan a new domestic water project or conduct preliminary feasibility studies. If the economic value of domestic water through this research could be estimated and included in the KDI guidelines like industrial water, and the economic value of domestic water supply can be calculated without CVM, this research will contribute to saving time and money. In addition, it is necessary to examine how the limited water supply experience affects WTP of domestic water. This research paper will attempt to answer the following questions: 1) What advantages do we get when we estimate the value of water without CVM? and 2) How does the limited or stopped water supply experience affect WTP?

This paper is divided into four sections. First, I offer a literature review on economic value of domestic water. Second, I explain the research method of measuring the economic value of the domestic water. Third, I analyze and present the economic value of domestic water for each region in Republic of Korea. Then, I analyze how the impact of the limited or stopped water supply experience affects the WTP and propose reference value of domestic water which can be applied to new pre-feasibility guidelines. Finally, the last section of this paper presents limitations and recommendations.

4. Literature Review

In this section I will map out the history of the studies on the economic value of domestic water. Estimating the economic value of water has been an area of important interest in many countries (Frederick & Vandenberg & Hanson, 1996; ADI Nolan Davis and Gardner Pinfold Consulting Economists Limited, 1996). In particular, governmental ministries and public research institutes that manage large-scale national projects or design public policies have been conducting various studies and analyzes on water and water resources. However, in these papers, the value of water was estimated using consumer surplus analysis of demand curve approach, and the concept of CVM was not applied.

Apart from this, guidelines for the application of CVM have developed dramatically from the guideline presented in the NOAA panel report (1992). Since then, CVM has received much attention by scholars in various areas (Kwon, 2007). As a result, many scholars in the water works field began to address research using CVM to investigate WTP of actual consumers in estimating the value of domestic water (Whittington et al., 1992; Altaf et al., 1998; Yeo& Lees & Sim, 2009).

However, some researchers began to cast doubt over existing surveys and claim that they do not reflect individual regional characteristics when economic value of domestic water was estimated, Therefore MLTMA began to call attention to conduct CVM by region in order to estimate WTP of domestic water reflecting regional characteristics (MLTMA, 2010, 2012). Next, I will consider the contemporary context and debate in the field of estimating the economic value of water.

Before proceeding further, it is necessary to clarify the key concept referred to in this paper. At the outset, it is imperative to clarify what we mean when we talk about CVM. CVM is the most widely used method to estimate WTP for non-market goods by face-to-face questioning the value of people's non-market assets. WTP refers to the highest amount that a consumer wants to pay for the purchase of a product. The consumer would like to buy the goods at a lower price for payment but would not try to pay for the excess. The use of CVM allows consumers to see their WTP for new domestic water supplies. Thus, it is possible to estimate the supply benefit of domestic water directly without estimating the demand curve itself.

This paper tends to agree with the claim that the economic value of domestic water should be estimated for each region. MLTMA (2010, 2012) conducted studies to investigate WTP of domestic water using CVM in each region. MLTMA (2010) analyzed 1,000 samples nationwide for CVM application, and these samples were divided into 15 regions, with 20 ~ 236 samples being used for each region. However, there is not sufficient evidence to support the claim that economic value of domestic water varies by region, because the study did not obtain the appropriate number of samples for each region.

Significant previous research (MLTMA, 2012) of South Korea proposed WTP of domestic water for each region based on the results of CVM. This research is highly relevant to this paper. In MLTMA research(2012), CVM was conducted on face-to-face survey method for 5,000 households divided into six (5+1) regions. As result of CVM, the additional WTP for new domestic water supply was about 55.6~133.4₩/㎥(different by region) as of August 2012. In this study, the size of the sample is 900 samples per region - 500 in

Gangwon Province, and it is close to 1,000 ~ 1,500, which is the nationwide sample survey level for ordinary people or general households. So, it is considered to be a reliable level. Therefore, MLTMA (2012) provides a useful framework estimation of the WTP of domestic water by region.

But, it is also necessary to compensate for the difficulty in supplying water such as limited water supply in some areas, for example, the western part of Chungnam because the above values are results obtained before the recent drought. This research paper adopts the view that estimating the WTP of domestic water in advance through CVM nationwide by each reason and using it for economic analysis of the preliminary feasibility study is rational. This paper is mainly based on existing data of previous research conducted by MLTMA (2012); however, this research will further investigate the impact of drought on economic value of domestic water.

So far this paper has focused on the WTP estimation of domestic water through CVM. Let us now turn to discuss how to apply weights to areas where water restriction is frequent due to drought. It is not my intention to determine the frequency of drought since investing the frequency of drought is beyond the scope of this study. My point is to determine the effect of the frequency of limited water supply due to drought on the WTP. Park & Park (2007) estimated additional WTP to prevent limited water supply for household use assuming actual drought. In this study, a survey of 794 residents in seven major cities and 32 drought-raising areas showed that if the water supply limit of 25% was more than usual, respondents were willing to pay an additional fee of 550 won/㎥ in order to avoid the limited water supply caused by the drought. However this research does not address the idea that the drought-affected areas have a higher WTP for the limited water supply than the general area.

In this paper, unlike the expectation, even if someone actually experienced a limited water supply, WTP to avoid the limited water supply was lower than in 7 major cities. This is because the influence of social variables such as income and education level is higher. This paper accepts the view that the experience of limited water supply due to drought affects WTP in the Park & Park (2017). However, how the impact of the limited or stopped water supply experience affects the WTP will be analyzed in detail through the data of MLTMA (2012).

5. Method

Related literature has been described so far. Hereinafter, the method of calculating the water benefit will be described in more detail. Several methods have been developed to measure value using indirect market data. There is a CVM which directly measures the WTP or the Willingness to Accept (WTA) of the payment by virtually or actually creating a constructed market that can buy and sell non-marketable goods. CVM is a way to directly derive the value people place on certain public goods and non-market goods. The use of CVM allows consumers to see their WTP for new water supplies. Thus, it is possible to directly estimate the lower area without estimating the demand function itself. This is the supply convenience of the domestic water supply. The method of calculating the benefit of domestic water is shown in Equation (1). We can calculate the additional WTP through CVM and add the water fee to the area to get the benefit of the domestic water in the area.

* The additional WTP of domestic water supply : Using CVM

The unit benefit of domestic water supply(₩/㎥) =

The regional water rate + The additional WTP of domestic water supply (1)

CVM uses a method of questioning the value of people's non-market assets through person-to-person, mail or telephone interviews. A specially designed questionnaire establishes a hypothetical situation for non-market changes and puts people into virtual situations by setting various conditions. Under these conditions, respondents are likely to have WTP for a virtual change in environmental quality. CVM has a strong rationale, and it has the advantage that it can be used not only for the object to which the indirect method can be applied but also for the object to which the indirect method cannot be applied.

However, CVM has a disadvantage that it relies heavily on the will and ability of respondents. From this point of view, in order for CVM to be successfully used for the benefit estimation, it is necessary to fully comprehend the strategic behavior, virtuality, intentions and behavioral relationships that were controversial in the context of CVM in the application process such as questionnaire preparation and questionnaire process. In addition, the use of survey method as a means of measuring benefits is an important part of the CVM as well as methods of inducing payment and questionnaire methods.

The application of CVM goes through five steps. In the first step, non-market materials are set up. In the second step, we prepare scenarios that can be easily understood by respondents while conveying precisely what they want to communicate about the non-market goods. In the third step, the questionnaire is supplemented so as to avoid the various conveniences that may be expected in the operation of the conditional valuation method. The fourth step is the stage where the questionnaire is carried out directly on the spot and the role of the surveyor who is well educated is emphasized. The fifth step is the stage of collecting and analyzing the data obtained from the questionnaire and drawing the necessary information.

To use CVM to accurately measure values, we need to think of the respondents in virtual markets as if they were actually buying something. However, non-market materials such as air quality, water quality, and toxic chemicals are intangible, which is not easy to work with. Therefore, it is necessary to present water quality ladders that indicate possible activities according to water pollution, or to provide photographs showing visibility depending on the quality of the water so that respondents can easily understand the valuables. This is not the end of a successful description of the situation in which non-market materials are sold.

Next, it is necessary to successfully describe the market structure in which non-market goods are sold. In the case of non-traders, consideration should be given to the fact that the vote is logical but not neutral. In other words, the market structure should be portrayed in order to eliminate the problem of free-riders. It is very important to create a scenario so that respondents can think of themselves as consumers of non-market goods and that the question items do not affect the benefit estimation results. When designing a virtual market, it is necessary to provide meaningful and understandable questions to respondents while satisfying the conditions required by economic theory.

So far, the theoretical principles and application methods of CVM have been explained. Next, I will describe the data collection method in more detail. At present, the benefit calculation for domestic water supply business is estimated through CVM according to KDI Guideline. In order to conduct CVM, about 1,000 samples should be taken and surveyed. However, a questionnaire survey will not be conducted in this study. The results of the survey research by MLTMA (2012) will be used as basic WTP data and the effect on limited water supply will be estimated, then the economic value of the domestic water of the current standard(December 2017) will be finally calculated.

In the study of MLTMA (2012), as shown in [Table 2], the survey was conducted on 5,000 households nationwide. A sample of 5,000 households was reconstructed nationwide into 5 + 1 regions and then randomly extracted. The areas are divided into five regions such as metropolitan region (including Seoul, Incheon, Gyeonggi), Chungcheong region (including Daejeon, Chungbuk, Chungnam), Honam region (including Gwangju, Jeonbuk, Jeonnam), Daekyung region (including Daegu, Kyeongbuk), Dongnam region (including Busan, Ulsan, Gyeongnam) and the last region of Gangwon. The questionnaire was conducted in 900 households for each five regions and 500 households in the Gangwon region by direct face-to-face method.

[Table 2] Surveyed areas

Area	Total	Metropolitan	Chungcheong	Honam	Daekyung	Dongnam	Gangwon
		Seoul Incheon Gyeonggi	Daejeon Chungbuk Chungnam	Gwangju Jeonbuk Jeonnam	Daegu, Kyeongbuk	Busan Ulsan Gyeongnam	Gangwon
Households	5,000	900	900	900	900	900	500

* Source : A Study on the Economic Value of Water by Region (MLTMA,2012)

The survey team used the water rate as a means to deriving the amount of payment for the supply of domestic water. Actually, the tap water is accepted as a household unit. Therefore, survey subjects are households with income rather than individuals. In order to accurately investigate the willingness to pay, respondents included only the spouses of the head of household or heads of household who is considered to have a substantial economic decision with income between 20 and 65 years of age. Since this survey is a household survey, there is no gender or age-specific allocation as in an individual survey. In this study, the size of the sample is 900 samples per region - 500 in Gangwon Province, and it is close to 1,000 ~ 1,500, which is the nationwide sample survey level for ordinary people or general households. In the case of the nationwide survey, a total of 5,000 people were surveyed. This ensures precision in the sample characteristics and the main characteristics of the variables.

Next, I want to describe the CVM model used in MLTMA (2012). The most widely used utility gap model in empirical studies is Hanemann (1984) for Single-Bounded

Dichotomous Model (SBDCM) and Hanemann (1991) for Double-Bounded Dichotomous Choice Model (DBDCM). In SBDCM for N respondents, the log-likelihood function is expressed as:

$$\ln L = \sum_{i=1}^{N} \left\{ I_i^Y \ln[1 - G_C(A_i)] + I_i^N \ln G_C(A_i) \right\} \tag{2}$$

$I_i^Y=1$ (When the answer of the i-th responder is ″Yes″)

$I_i^N=1$ (When the answer of the i-th responder is ″No″)

Where I_i^Y and I_i^N are defined as follows, where 1(・) is an indicator function that has a value of 1 if the contents in parentheses are true, and a value of 0 if it is false. When using DBDCM, the i-th respondent responds with "Yes" or "No" as to whether or not to pay the first bid amount (A_i). The second amount presented to the respondent who answered "Yes" and the second amount presented to the respondent who answered "No" are denoted by A_i^H and A_i^L, respectively. In addition, several variables are further defined to simplify the response to the WTP question as follows.

$I_i^{YY}=1$ (When the answer of the i-th responder is ″Yes-Yes″) (3)

$I_i^{YN}=1$ (When the answer of the i-th responder is ″Yes-No″)

$I_i^{NY}=1$ (When the answer of the i-th responder is ″No-Yes″)

$I_i^{NN}=1$ (When the answer of the i-th responder is ″No-No″)

As mentioned earlier, 1(・) is an indicator function with a value of 1 if the conditions in parentheses are met, and has a value of 0 if it is not satisfied. For example, I_i^{YY} takes a value of 1 if the response of the i-th responder is "Yes-Yes", or 0 otherwise. Now, assuming the sample of N respondents who are seeking utility maximization, the log-likelihood function can be constructed by dividing the response result of the i-th responder as follows.

$$\ln L = \sum_{i=1}^{N} \left\{ \begin{aligned} & I_i^{YY} \ln[1 - G_C(A_i^H)] + I_i^{YN} \ln[G_C(A_i^H) - G_C(A_i)] \\ & + I_i^{NY} \ln[G_C(A_i) - G_C(A_i^L)] + I_i^{NN} \ln G_C(A_i^L) \end{aligned} \right\} \tag{4}$$

According to conventional practice, when $F_\eta(\cdot)$ is formulated as a logistic cumulative distribution function and this is combined with Δ=a-bA, the cumulative distribution function of WTP takes the following form.

$$G_C(A) = [1 + \exp(a - bA)]^{-1} \tag{5}$$

The mean and median values of WTP can be calculated using Eq. (1) and based on Eq. (3), (4), and (5). The Eq. (6) is the mean value in the general sense and Eq. (7) is the truncated mean in terms of the fact that the negative part is truncated.

$$C^{+} = C^{*} = a/b \tag{6}$$

$$C^{++} = (1/b)\ln[1 + \exp(a)] \tag{7}$$

The model described so far is the normal model. It is reasonable to exclude the protest bids from the data set to be analyzed because the irrational payments may disappear. In other words, the payment rejection response must be identified, and the identified chargeback response should be subtracted and analyzed. There is no difference in the analytical model, although it differs from the conventional model in that the number of data is reduced. However, there may be some controversy about the fact that the researcher arbitrarily removes the payment rejection response when there are many payment rejection responses. In other words, if the payment rejection is eliminated, the average WTP will be larger than when the normal model is used. Therefore, it is necessary to be careful when removing the payment rejection response. For example, if a normal model is used without eliminating the payment rejection response, a business model that is difficult to pass the economic analysis after eliminating the payment rejection response may pass the economic analysis.

In MLTMA(2012), these unreasonable responses(protest bids) were analyzed by excluding them from the sample because they were selected from the non-economic point of view such as distrust of the supply of new domestic water without choosing the payment intention from an economic point of view. The irrational response corresponds to the result of ⑦ (The facilities to replace this project are already sufficient.) or ⑧ (Additional taxes will not be used for the specified business.) responses to the question B8.

[Table 3] Available observations

Classification	Total	Metropolitan	Chungcheong	Honam	Daekyung	Dongnam	Gangwon
Total	5,000	900	900	900	900	900	500
Protest Bids	260	20	50	43	72	60	15
Error	7		4	1			2
Available Observations	4,733	880	846	856	828	840.	483

* Source : A Study on the Economic Value of Water by Region (MLTMA,2012

The final observations, excluding irrational responses protest bids and errors, are shown in [Table 3], and the total available observations are reduced from 5,000 to 4,733.

Here, error means the case where no response is given for the second bid amount (2 Q1 or 1 / 2 Q1) in question B5 or B6

So far, this paper has explored the important discussions surrounding the general WTP model. Now, it is necessary to examine the nature of WTP, which is confined to specific public works projects. In fact, certain public works are unfamiliar goods for the general public, and there are few people who are willing to pay for this amount by deliberately reducing his or her consumption for the implementation of certain public works projects. Therefore, it is necessary to utilize the applicable model in this case.

The respondents who indicated that they were not willing to pay the proposed amount when using the SBDCM were asked if they had received a response to the question of whether they have WTP of zero or not. The data that are not willing to pay are divided into zero WTP and data with a WTP that is larger than zero and less than the bid amount. Similarly, in DBDCM, if you answer "No" to both questioning questions, you will be asked if you are willing to pay at all, likewise, this data is composed of the WTP of zero and the amount of WTP that is larger than zero and less than the bid amount. Because the zero-WTP can be identified through the Ask Question, the analytical model should explicitly reflect zero's WTP to ensure consistency with the data. The model suggested and applied in the CVM literature to reflect zero WTP is largely based on the spike model (Kriström, 1997; Yoo and Kwak, 2002) and the mixture model (Werner, 1999; Yoo et al., 2001; Yoo, 2004) combining a probability distribution with zero WTP and a probability distribution with positive WTP in convex combination form. In this paper, the spike model is applied.

A situation that reveals that there is no willingness to pay for a particular project is often observed in the WTP surveys (Yoo et al., 2001a, 2001b). For the analysis of zero-value WTP data, it must be taken into account that many households are unwilling to pay for public works. In other words, the distribution of WTP is divided into a group of respondents with a value of zero and a group of respondents with a positive WTP. In order to obtain the average value of WTP that can be used for economic analysis, the distribution of WTP should be obtained and this point must be considered in order to obtain the distribution of WTP. If the zero WTP response is neglected and analyzed, it will cause a small number of errors.

Economic variables that have only positive values can be analyzed using a distribution defined only in positive areas. However, in the case of economic variables that have both positive and negative values like WTP data, it is difficult to specify. Now, we can formalize the spike model as follows. The response of "No-No" at the end of Eq. (3) is divided into WTP of zero and WTP of less than second presentation amount (A^L), so I_i^{NN} is subdivided into I_i^{NNY} and I_i^{NNN} again.

$I_i^{NNY}=1$ (When the answer of the i-th responder is ″No-No-Yes″)

(8)

$I_i^{NNN}=1$ (When the answer of the i-th responder is ″No-No-No″)

As in the previous case, the mean value WTP can be estimated by constructing a spike model assuming the cumulative distribution function of WTP as $G_C(\cdot \, ; \theta)$ and assuming it as a logistic function. In the spike model, the cumulative distribution function of

WTP at $\theta=(a,b)$ is defined as Eq. (9).

$$G_C(A;\theta) = \begin{cases} [1+\exp(a-bA)]^{-1} & \text{if } A > 0 \\ [1+\exp(a)]^{-1} & \text{if } A = 0 \\ 0 & \text{if } A < 0 \end{cases} \tag{9}$$

Therefore, the log likelihood functions for SBDCM and DBDCM of spike model are as (10) and (11), respectively.

$$\ln L = \sum_{i=1}^{N} \ln \left\{ \begin{array}{l} I_i^{Y}[1-G_C(A_i)] \\ +(I_i^{NY}+I_i^{NNY})[G_C(A_i^L))-G_C(0)]+I_i^{NNN}G_C(0) \end{array} \right\} \tag{10}$$

$$\ln L = \sum_{i=1}^{N} \left\{ \begin{array}{l} I_i^{YY}\ln[1-G_C(A_i^H)]+I_i^{YN}\ln[G_C(A_i^H)-G_C(A_i)] \\ +I_i^{NY}\ln[G_C(A_i)-G_C(A_i^L)] \\ +(I_i^{NN}+I_i^{NNY})[\ln G_C(A_i^L)-G_C(0)]+I_i^{NNN}\ln[G_C(0)] \end{array} \right\} \tag{11}$$

In this case, the spike is defined as $1/[1+\exp(a)]$ and the proportion of samples with zero WTP in the sample. The mean value WTP is estimated as follows.

$$\overline{WTP} = (1/b)\ln[1+\exp(a)] \tag{12}$$

[Table 4] shows the results of the regional responses to the questionnaire [Appedix] of the MLTMA (2012) report. The results show that the rate of responding No-No is very low, 41.7% for Metropolitan and 42.0% for Gangwon, and it can be easily assumed that these regions will have a large WTP. [Table 5] shows the outputs of the regional WTP derived from the results of [Table 4] using the CVM theory. The additional WTP for new domestic water supply was about 55.6~ 133.4₩/㎥(different by region) as of August 2012. As described above, regions with low No-No response rates have high WTP values

(Metropolitan : 133.4₩/㎥, Gangwon : 130.3₩/㎥).

[Table 4] Distribution of responses by region

Answer	Total	Metropolitan	Chungcheong	Honam	Daekyung	Dongnam	Gangwon
Total	4,733 (100)	880 (100)	846 (100)	856 (100)	828 (100)	840 (100)	483 (100)
Yes-Yes	602 (12.7)	153 (17.4)	36 (4.3)	99 (11.6)	154 (18.6)	51 (6.1)	109 (22.6)
Yes-No	664 (14.0)	240 (27.3)	85 (10.0)	51 (6.0)	138 (16.7)	53 (6.3)	97 (20.1)
No-Yes	516 (10.9)	120 (13.6)	125 (14.8)	51 (6.0)	110 (13.3)	36 (4.3)	74 (15.3)
No-No	2,951 (62.3)	367 (41.7)	600 (70.9)	655 (76.5)	426 (51.4)	700 (83.3)	203 (42.0)

* Source : A Study on the Economic Value of Water by Region (MLTMA,2012)

[Table 5] The additional WTP of domestic water

Classification	Metropolitan	Chungcheong	Honam	Daekyung	Dongnam	Gangwon
WTP(₩/㎥)	133.4	55.6	96.9	72.6	64.8	130.3

* Source : A Study on the Economic Value of Water by Region (MLTMA,2012)

So far this paper has focused on the WTP estimation of domestic water through CVM. Let us now turn on to discuss how to apply weights to areas where water restriction is frequent due to drought, it is difficult to find influential factors by examining the effect of drought on WTP of domestic water through other papers. Therefore this paper will analyze the results of the questionnaire survey of MLTMA (2012), which calculated WTP of domestic water by region. We utilize method of analyzing the correlation between the questions and the answers in the questionnaire. Among the questions of the questionnaire survey in [Appendix], there is a question that inquires whether there is a limited or stopped water supply experience ; "A2. Have you ever experienced a limited or stopped tap water supply caused by a pipeline accident in the last 5 years?" Only 7.2% of respondents answered that they have limited water supply experience nationwide. In particular, the survey showed that the rate of limited water experience in Chungcheong province was only 8.1% in [Table 6]. The frequency of droughts due to abnormal weather has become more frequent since this study, especially in Chungcheong Province, which experienced limited water supply for four months due to extreme drought from November 2015 to February 2016. As a result, if we repeat the same questionnaire, the answer to the question of whether there is a limited water supply experience may increase rapidly, which is likely to increase WTP.

[Table 6] Limited or stopped water supply experience, education level, monthly income comparison by region

Classification	Total	Metropolitan	Chungcheong	Honam	Daekyung	Dongnam	Gangwon
Available sample	4,733	880	846	856	828	840.	483
Stopped water supply experience	343(7.2%)	95(10.8%) [3]	69(8.2%) [4]	15(1.8%) [5]	92(11.1%) [2]	14(1.7%) [6]	58(12.0%) **[1]**
Education level (year)		13.6 **[1]**	12.9 [4]	12.1 [6]	13.0 [3]	12.8 [5]	13.3 [2]
Monthly income (ten thousand ₩)		409 **[1]**	333 [2]	297 [4]	250 [6]	325 [3]	285 [5]
WTP (₩/m³)		133.4 **[1]**	55.6 [6]	96.9 [3]	72.6 [4]	64.8 [5]	130.3 [2]

* [ ] : Rank by region
** Source : A Study on the Economic Value of Water by Region (MLTMA,2012)

However, it cannot be concluded that a person who simply replied that he or she has experience of a limited or stopped water supply has shown a high degree of WTP. By region, the rankings of a limited or stopped water supply experience and WTP rankings do not match. In addition to a limited or stopped water supply experience, other variables such as income and education levels can affect each other in WTP. It is observed that the WTP of the metropolitan area with the highest level of education and monthly income is the highest. So, this paper examine whether the influence of the limited or stopped water supply experience affects the magnitude of WTP, or whether the other variables such as education level and monthly average income have a larger effect.

In order to investigate the effect of these factors more objectively, the bid price, which is another influential factor, was also examined including the regression equation. Bid value (Q1 in B4 question ofAeans the amount used when asking whether you are willing to pay for the costs incurred due to the construction of the project in CV research. Bid value is presented in six sections (50, 100, 150, 200, 300, 400₩/㎥) and 5,000 samples are presented in the same ratio (16.6%), and 4,733 available responses except for 260 protest bids and seven error data were also applied to almost the same distribution in six sections in [Table 7]. As shown in [Table 7], the larger the bid value, the smaller the "Yes-Yes" response rate and the greater the "No-No" response rate. In other words, it can be easily deduced that the bid value affects WTP.

[Table 7] Distribution of responses by Bid value

Bid Value (₩/㎥)	Total	50	100	150	200	300	400
Total	4,733 (100)	798 (100)	792 (100)	767 (100)	784 (100)	783 (100)	789 (100)
Yes-Yes	602 (12.7)	185 (23.2)	149 (18.8)	93 (11.8)	82 (10.5)	49 (6.3)	44 (5.6)
Yes-No	664 (14.0)	130 (16.3)	124 (15.7)	103 (13.1)	104 (13.3)	102 (13.0)	101 (12.8)
No-Yes	516 (10.9)	89 (11.2)	103 (13.0)	73 (9.3)	92 (11.7)	75 (9.6)	84 (10.6)
o-No	2,951 (62.3)	394 (49.4)	416 (52.5)	518 (65.8)	506 (64.5)	557 (71.1)	560 (71.0)

* Source : A Study on the Economic Value of Water by Region (MLTMA,2012)

6. Analysis and Findings

Multiple regression analysis was performed to determine whether the experience of a limited or stopped water supply affected the WTP results or the other variables affected WTP. The multiple regression model equation between the dependent variable (WTP) and the independent variables (bid value, limited or stopped water supply experience, age, education level, monthly income, preschool children) is as follows.

$$\text{WTP}(₩/m^3) = \beta 0 + \beta 1 \cdot \text{Bid value} + \beta 2 \cdot \text{Stopped water experience} + \beta 3 \cdot \text{Age} + \beta 4 \cdot \text{Education level} + \beta 5 \cdot \text{Monthly income} + \beta 6 \cdot \text{Preschool children} \quad (13)$$

The null hypothesis (Ho) and alternate hypothesis (H1) in the above regression model are as follows.

$$\text{Ho} : \beta 1 = \beta 2 = \beta 3 = \beta 4 = \beta 5 = \beta 6 = 0 \quad (14)$$

H1 : at least one $\beta i \neq 0$ (i=1~6) : at least one independent variable affects WTP

The results of the statistical analysis using TSP are shown in [Table 8]. The F value of the regression equation (P value of the wald test) is 0.000, which is statistically significant at a confidence level (significance 0.01) of 99%. That is, null hypothesis can be rejected and at least one of the independent variables affecting WTP is derived. It has been confirmed that at least one of the above independent variables affects WTP of domestic water. Then we aim to interpret what variables are more influential.

[Table 8] Multiple Regression Analysis

Parameter	Estimate	Std. Error	t-statistics	P-value
β0 (Intercept)	-0.014	0.296	-3.43	0.001 ***
β1 (Bid value)	-0.431	0.014	-31.31	0.000 ***
β2 (limited or stopped water supply experience ; 1=yes, 0=no)	0.246	0.106	2.32	0.021 **
β3 (Age)	-0.005	-0.004	-1.27	0.206
β4 (Education level)	0.065	0.013	4.81	0.000 ***
β5 (Monthly income ; 1=above 5.0m₩, 0=less than 5.0m)	0.527	0.078	7.52	0.000 ***
β6 (Preschool children) (1=yes, 0=No)	0.267	0.089	2.99	0.003 ***

*, ** and *** indicate significance at the 10percent,` 5 percent and 1 percent levels, respectively

From now on, we will confirm the authenticity of the six hypotheses.

Hypothesis 1 : The bid value will affect the WTP of domestic water.

The coefficient for the bid value is -0.431 and the p-value is 0.000, meaning statistical significance at the significance level 0.01 (99% confidence level), but with negative influences. [Table 8] also shows that the No-No response rate rapidly increases as the bid value increases. This is because the larger the bid value is presented, the more difficult it is to accept the amount, and the greater the probability of responding No.

Hypothesis 2 : The limited or stopped water supply experience will affect the WTP of domestic water.

Now let's look at the analysis of the effects of limited or stopped water supply experience, which is the most curious independent variables. The coefficient for the experience of the limited or stopped water supply experience was 0.246 and the p-value was 0.021, which was statistically significant at the significance level of 0.05 (95% confidence level). The coefficient 0.246 means that respondents with the limited or stopped water supply experience had a higher WTP than respondents without experience. However, when the significance level is 0.01 (99% confidence level), it is not statistically significant.

Hypothesis 3 : The Age will affect the WTP of domestic water.

The p-value of age is 0.206, which is not statistically significant and cannot be attributed to WTP. In other words, there is no statistical correlation between age and the WTP of the domestic water, meaning that age do not affect WTP of water.

Hypothesis 4 : The education level will affect the WTP of domestic water.

The coefficient of education level of respondents was 0.065 and the p-value was 0.000, which is statistically significant at the significance level of 0.01. This means that people with higher education levels are more likely to have higher WTP. However, it is difficult to distinguish whether people with higher education levels are more aware of the importance of water, or whether people with higher education levels are more likely to have higher incomes.

Hypothesis 5 : The monthly income will affect the WTP of domestic water.

The monthly income was examined in more than five million won per month and less than five million won. The coefficient was 0.527 and the p-value was 0.000, which is statistically significant at the significance level of 0.01. That is, the higher the income, the higher the WTP value, which is consistent with what was expected through many papers.

Hypothesis 6 : Presence or absence of preschool children will affect the WTP of domestic water.

Finally, an analysis of the presence or absence of preschool children showed a statistical significance at a significance level of 0.01, with a coefficient of 0.267 and a p-value of 0.003. The coefficient 0.267 means that respondents with preschool children have a WTP of a higher than those without children. This is a very interesting result. Respondents in households with preschool children have a higher appreciation for the importance of water. Even the presence of preschoolers has a greater impact on WTP than the presence of the limited or stopped water supply experiences.

[Table 9] Adoption of Hypothesis

Hypothesis	Estimate	P-value	Significance	Adoption
H1 : Bid value → WTP	-0.431	0.000	1%	O
H2 : The limited or stopped water supply experience → WTP	0.246	0.021	5%	O
H3 : Age → WTP	-0.005	0.206		×
H4 : Education level → WTP	0.065	0.000	1%	O
H5 : Monthly income → WTP	0.527	0.000	1%	O
H6 : Presence of preschool children → WTP	0.267	0.003	1%	O

The results of the adoption of the six hypotheses described so far are shown in [Table

9]. The effect of WTP on the experience of the limited or stopped water supply is statistically significant at the significance level of 0.05 (95% confidence level). However, since the coefficient of the preschool children is larger and the p-value is smaller, this variable is more influential. It is estimated that the WTP will rise if CVM is re-established in the Chungcheong area where a limited or stopped water supply experience has occurred due to recent drought. But, since it is confirmed that there are other variables that have a greater effect on the WTP, it is not meaningful to collectively increase the WTP in a drought area. Therefore, in this study, the economic value of the domestic water for each region is suggested by applying the consumer price index to the result of MLTMA (2012). The economic value of the domestic water given in the MLTMA (2012) is the economic value of 2012, so i derive the economic value at the end of 2017. To this end, the Bank of Korea 's consumer price index [Table 10] was applied and adjusted. [Table 11] shows the economic value of the domestic water supply as of 2017 based on the price index adjustment.

[Table 10] The consumer price index

Year	2012	2013	2014	215	2016	2017
Total Index (2015=100)	96.789	98.048	99.298	100.000	100.970	102.930

* Source : Economic Statistics System (The Bank of Korea)

[Table 11] The suggested additional WTP of domestic water

WTP(₩/㎥)	Metropolitan	Chungcheong	Honam	Daekyung	Dongnam	Gangwon
MLTMA(2012)	133.4	55.6	96.9	72.6	64.8	130.3
This study(2017)	**141.9**	**59.1**	**103.0**	**77.2**	**68.9**	**138.6**

7. Limitations and Recommendations

The purpose of this study is to evaluate the economic value of water in the water service sector, especially in the area of new domestic water supply project. This paper uses CVM widely used to provide important policy data to determine whether the government should implement a large budget project or not.

Also, how the experience of limited or stooped water affects the WTP was also analyzed and statistically significant results were obtained. In addition, the effects of household income level, education level, and presence of preschool children on WTP were analyzed and it can be considered in future studies related to economic benefits not only in the waterworks sector but also in similar fields such as other public goods. The limited or stopped water supply experience was found to have a positive effect on WTP, but it was also found that other variables such as income, education, and preschool children were affected. In particular, the most interesting finding is that the coefficients of preschool children applied as dummy variables were higher than the limited or stopped water supply coefficients. However, given the gradual declining birth rate, the impact of the presence of preschoolers is expected to gradually diminish.

Since the government finances are limited, preliminary feasibility studies are conducted for projects that require large budget inputs, and CVM is applied as a method of economic analysis of public works projects. In this study, the economic value of domestic water for each region is presented as in [Table 11] as of 2017 and it can be used as a reference material in the future preliminary feasibility study. However, since this value has been investigated only for household water, additional correction is necessary for nonhousehold water. In addition, although WTP is expected to increase further in the drought region, it is considered that there is a limit to apply statistically correct parameters. [Table 11] suggest WTP of domestic water without consideration of drought effect. In the future, more research is needed in the related fields about the effect of climate change such as drought on WTP, while the reference value of the economic value of domestic water is presented in the preliminary feasibility study standard. If it is helpful in estimating the benefits of domestic water, it will save a lot of time and money nationwide.

8. References

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9. Appendix

The major questions used in the CV questionnaire (based on the metropolitan area) to estimate additional WTP for the supply of domestic water

A2. Have you ever experienced a limited or stopped tap water supply caused by a pipeline accident in the last 5 years?

① Yes ② No

B4. The water rate of your area is [View card 1] per 1㎥(1000ℓ).

Given the importance of tap water in your household, is your household willing to pay [Q1] (₩) per 1㎥(1000 ℓ) in addition to the current water rate?

① Yes ☞ B5 ② No ☞ B6

B5. So, given the importance of tap water in your household, is your household willing to pay [2 × Q1] (₩) per 1㎥(1000 ℓ) in addition to the current water rate?

① Yes ☞ B9 ② No ☞ B9

B6. So, given the importance of tap water in your household, is your household willing to pay [1/2 × Q1] (₩) per 1㎥(1000 ℓ) in addition to the current water rate?

① Yes ☞ B9 ② No ☞ B7

B7. So, given the importance of tap water in your household, is not your household willing to pay extra money in addition to the current water rate?

① I am not willing to pay ☞ B8 ② I am willing to pay ☞ B9

B8. (If you are not willing to pay.) What is the most important reason why you say there is no willingness to pay in addition to the current water rate?

① My family has no ability to pay.

② It should be covered by the water rate already paid

③ This issue is not as important as it is given priority.

④ The government is already using too much money in this field.

⑤ This project is not of interest to our household

⑥ Not enough information to judge was given.

⑦ The facilities to replace this project are already sufficient.

⑧ Additional taxes will not be used for the specified business.

⑨ Others ( )

B9. So, given the importance of tap water in your household, what is the maximum amount your household can pay per 1㎥(1000 ℓ) in additional to the current water fee?

* Source : A Study on the Economic Value of Water by Region (MLTMA,2012)