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Public Willingness to Pay for Interstate Cooperation to Preserve the Ecological Integrity of the Han River Estuary in Korea

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Abstract: The Han River Estuary (HRE), Yellow Sea, forms part of the border between South Korea and North Korea, and these two countries are militarily hostile. Since the HRE has quite excellent ecological integrity, the task of preserving it well is emerging as important. Thus, the South Korean Government is attempting to preserve the ecological integrity of the HRE through interstate cooperation. By employing contingent valuation, this study delves into South Korean households' willingness to pay (WTP) for this preservation. One thousand households nationwide were sampled and surveyed through face-to-face individual interviews. Annual household income tax was selected as the payment vehicle. Dichotomous choice questioning was chosen as the WTP induction method. A spike model was selected as a method for modelling a WTP of zero. The main results showed statistical significance. Annual WTP per household and national WTP were obtained as KRW 4487 (USD 3.92) and KRW 125.75 billion (USD 109.83 million), respectively. When a 10-year payment period and a 4.5% discount rate were adopted, the value was KRW 766.14 billion (USD 669.12 million). South Korean households placed considerable value on the preservation of the ecological integrity of the HRE through interstate cooperation.

Keywords: Han River Estuary; ecological integrity; interstate cooperation; contingent valuation; willingness to pay



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1. Introduction

The Korean Peninsula is now two countries: South Korea and North Korea. They were originally one country but were divided in 1945 at the end of World War II. Since then, military tensions—in particular, the Korean War, which lasted from 1950 to 1953—have continued. For this reason, among all regions of the world, the Korean Peninsula has one of the highest risks of war breaking out [1]. Both countries have legally prohibited the exchange of goods, as well as people, between each other. South Korea and North Korea face each other across the Han River Estuary (HRE), which flows from east to west to enter the Yellow Sea [2]. These military tensions have made it difficult to develop the HRE, which, ironically, has preserved the ecological integrity of the HRE well.

The HRE refers to the area enclosed by the river embankment, or the area inside the railroad line between Songhae-myeon and Sungnoeri in Ganghwa-gun, and it covers a total area of 60.668 km². Pursuant to the Wetlands Conservation Act, it was designated as a wetland protected area on 17 April 2006. Wetland protected areas are designated by national or provincial governors and are regions in which natural ecosystems are preserved, providing habitats for various organisms, including endangered species. These areas also hold significant landscape, topographical, and geological value.

Moreover, most of South Korea's large river estuaries have banks, but there are no banks on the HRE. Thus, the HRE is the only estuary in the country that has a natural appearance, and it provides numerous ecosystem services and functions. It serves as an ecosystem channel, supplying bio-growth and spawning sites, controlling pollutants from the land, and producing marine products [3,4]. In particular, the HRE provides habitats, wintering sites, and mobile stops for globally endangered species, such as the white-naped crane, the black-faced spoonbill, and the swan goose. For this reason, the HRE is registered as a base habitat on the East Asian–Australian Flyway and is designated as an Important Bird and Biodiversity Area by the International Council for Bird Preservation. In short, the HRE is known to have excellent ecological integrity.

Several studies have been conducted regarding the ecological functions of the HRE, including seven that were recently performed. Yoon and Woo [4] analyzed the effects of changes in river discharge and tides on the salinity of the HRE. Baek et al. [5] applied ichonocoenosis analysis to investigate how the distribution of HRE sediments changes with seasonal changes. Koo et al. [6] examined the effect of the feeding behavior of crabs living in the HRE on the oxygen penetration depth and organic matter removal. Yang et al. [7] studied the trophic relationship between *Sesarma dehaani* and its prey in the HRE. Mok et al. [8] explored the biogeochemical impacts of typhoon-induced freshwater discharge from the HRE on its sediments. An et al. [9] found that the invasive species *Spartina anglica* and the native species *Suaeda japonica* could change the microbial community of the HRE and have a multifaceted impact on the ecosystem there. Park et al. [10] revealed that the invasive species *Spartina anglica* can promote the carbon–sulfur–mercury (C-S-Hg) cycle in the HRE.

However, the HRE is currently facing two threats. First, since the HRE is adjacent to Seoul, the capital of South Korea, and its satellite cities, there are concerns that the ecological integrity of the HRE will be damaged as nearby areas are developed on a large scale [11]. A quarter of the South Korean population lives in Seoul, and half of the South Korean population lives in the Seoul Metropolitan area. Therefore, the environmental load on the HRE is increasing. Second, because there has been no basic investigation into the HRE near North Korea, as a result of military tensions, little is known about the region's ecosystem. Consequently, it is impossible to preserve the ecological integrity in the HRE without North Korea's cooperation. Joint investigation of the neutral zone of the HRE is required as a first step towards preserving the ecological integrity of the HRE.

The HRE neutral zone is a demilitarized zone (DMZ) that was established in the river to prevent armed conflicts between North and South Korea when the Armistice Agreement was signed in 1953. The HRE neutral zone is a sensitive area with a high potential for disputes, as it separates North and South Korea along the Han River. It is managed and controlled by the United Nations Command Military Armistice Commission, based on the provisions of the Armistice Agreement. At the time of the Armistice Agreement in 1953, the military demarcation line, which started in Gangwon Province (currently Gangwon-do), was only set up as far as Manwuri in Paju-si, Gyeonggi-do. Therefore, a separate buffer zone was needed in the HRE.

As a result, a section of approximately 67 km from Manwuri to Boreumdo in Seodomyeon, Ganghwa-gun, was designated as the neutral zone. The subsequent armistice agreements state that neither North nor South Korea can enter the neutral zone within 100 meters of each other without permission from the United Nations Command Military Armistice Commission. It is also prohibited for any civilian vessels carrying weapons, ammunition, or military personnel, or military vessels or neutral country vessels, to enter the neutral zone without permission. Furthermore, no vessel can navigate or engage in activities during the night, and they must be at anchor from 30 min after sunset to 30 min before sunrise.

A joint utilization zone in the HRE between the two Koreas was established in September 2018. From November to December 2018, a joint hydrographic investigation was conducted to measure the waterway and observe the tide at the HRE. The purpose of

the investigation was to secure basic information for safe navigation when the HRE was opened. Since then, relations between the two Koreas, and between North Korea and the United States, have been strained. However, the need for an interstate cooperation project in the neutral waters of the HRE is still present. The purpose of the project is to preserve the ecological integrity of the HRE while easing the military tensions between South Korea and North Korea.

The project broadly has three parts [12]. First, the sea area and tidal flats around the HRE will be designated as marine protection areas. The second part is to expand the transportation network in the area adjacent to the HRE to improve accessibility and to establish a new interstate connection road. The third part is to promote ecotourism programs by restoring the waterway in the HRE, implementing waterway tourism, and building ecological trails and pedestrian bridges to symbolize peace. Three results are expected from the project: first, biodiversity will be protected through the preservation of the ecosystem of the HRE [13,14]; secondly, the military tension between the two Koreas will be alleviated through the promotion of the interstate joint tourism program [15,16]; and, thirdly, the local economy will be revitalized by improving the transportation network in the area near the HRE and enabling the fishing industry to thrive in common waters [17].

Considerable public finances, accumulated from taxes paid by the people, are required to preserve ecological integrity in a neutral zone of the HRE through interstate cooperation. Therefore, the government needs information about households' willingness to pay (WTP) for this preservation. This study aims to derive this information quantitatively and to provide it to the government. This will be achieved by applying the contingent valuation (CV) technique to evaluate the WTP. Of course, there are techniques besides CV that could be used to analyze economic impacts. For example, Moshen [18] and Sherin et al. [19] analyzed the economic impacts of the governance of natural resources, mining, and energy on Tunisia and the economic impacts of salinity-tolerant plants on Egypt's agricultural productivity in terms of value added. However, since the outcome of interstate cooperation to preserve the ecological integrity of the HRE is a non-market value rather than a general economic impact, the authors believe that the CV technique is more suitable for the evaluation target of this study. More specifically, a CV survey was conducted on 1000 randomly sampled households nationwide to collect data on the WTP.

2. Methodology

2.1. Brief Review of Previous Studies That Have Applied CV to Estuaries

Johnston et al. [20] applied CV to obtain the amenity value of the Peconic Estuary in the United States. Stone et al. [21] adopted CV to calculate households' WTP for mangrove restoration in an estuary in India. Sale et al. [22] analyzed the WTP of recreational users for increasing freshwater inflows into two South African estuaries. Guimarães et al. [23] used CV to investigate the preferences of Portuguese and Spanish citizens regarding the implementation of a policy to improve water quality in the Guadiana estuary. Laroutis and Taibi [24] utilized CV to estimate local residents' WTP for conserving the Seine Estuary Wetlands in France. Boxall et al. [25] explored people's WTP for restoring endangered marine mammal species in a Canadian estuary. Zagonari [26] explored Dutch and Belgian citizens' WTP for the implementation of the EU's flood risk management plan in the Scheldt estuary. Dikgang and Hosking [27] used CV to measure the recreational values that local residents attached to seven estuaries in South Africa. Pinto et al. [28] adopted CV to evaluate the non-market value of estuarine ecosystem services in Portugal. Needham and Hanley [29] looked into local residents' WTP for a managed realignment scheme in the Tay Estuary, Scotland, through an application of CV.

2.2. Method

The interstate cooperation for the conservation of the ecological integrity of the HRE, which is evaluated in this study, is not traded in the market. It is, therefore, not possible to determine the WTP for this good using market data. In such cases, specially designed

techniques need to be applied to discover the WTP. The methods that can be applied to non-market goods are broadly categorized into revealed preference techniques and stated preference techniques [30–32]. The former are techniques that analyze data that reflect people's preferences based on their behavior [33], while the latter are techniques that analyze data obtained by asking people directly about their preferences [34,35]. It is only possible to apply revealed preference techniques when the behavior of people in relation to the goods being evaluated can be observed [36]. On the other hand, there are no specific constraints for the application of stated preference techniques [37].

For the application of a stated preference technique, surveys to understand people's preferences are essential. Thus, whether the survey is properly conducted becomes a crucial factor in determining the success of the application of the stated preference technique. Important stated preference techniques include CV and choice experiment (CE). The choice between CV and CE depends on the characteristics of the good being evaluated. If the good being evaluated has multiple attributes and it is meaningful to obtain attribute-specific WTPs, then CE may be appropriate. However, if it is difficult to define multiple attributes for the good being evaluated, the application of CV may be considered as a priority.

CV is a representative technique used to supply reliable and reasonable estimates of a consumer's WTP to consume a particular good or service [38–40]. It is known that CV can reliably and reasonably derive people's WTP through a survey [41–44]. Of course, other techniques may be used to evaluate a consumer's WTP, but CV is the most prevalent in terms of the number and diversity of applications [45]. In addition, there are quite a few case studies in which CV has been applied to issues related to marine policy [46–48]. Most of these found that CV is useful in dealing with public perspectives related to marine policy [49,50]. Therefore, the decision to use CV as a research method in this study is clearly consistent with the literature.

CV inherently requires surveys to be conducted that target potential consumers. Therefore, the application of CV involves three main stages. In the first stage, a survey questionnaire is carefully developed, and appropriate revisions are made to the initial draft. In the second stage, on-site surveys are conducted to collect data. It is necessary to ensure that data collection is carried out by experienced supervisors or by researchers with extensive CV survey experience. In the third stage, statistical analysis is performed on the collected data to derive the necessary information. It is important to apply a model that is generally accepted in the literature.

The procedure for applying CV is, to a large extent, standardized [51]. Moreover, even application guidelines are presented in the literature [37,52]. The procedure and guidelines reported in the literature were followed in this study; these will be described later. What is evaluated using CV is the WTP to achieve the target state instead of the current state. The current state, in this research, is that of not pursuing interstate cooperation to preserve the ecological integrity of the HRE. The target state is preserving the ecological integrity of the HRE through promoting interstate cooperation while realizing the three expected effects suggested in the Section 1.

2.3. Preparation of the CV Questionnaire

As is usual, the CV questionnaire for this study had three major components. The first, after explaining the objective of the survey, asked people about their general perception of interstate cooperation. People's WTP for the interstate cooperation in the HRE was obtained in the second component. The third component sought information about the respondents' socioeconomic status. Following an intensive interview with a small sample of ten people and a supervisor from a professional survey agency, an initial version of the questionnaire was modified to make the meaning clearer and to express the difficult parts in an easier way.

Regarding the WTP question, several factors must be determined. Firstly, income tax, which is a representative national tax in South Korea and the main source of the finance required for interstate cooperation in the HRE, was selected as the payment vehicle.

Secondly, when choosing whether households or individuals were considered, households were adopted as the subject of payment. Household income tax should be used for projects in which central government funds are invested [53]. Thirdly, among the options of only once, once a month, or once a year, the frequency of payment was adopted as once a year [54]. Finally, the payment period was presented to respondents as the next ten years.

2.4. Implementation of the CV Survey

The method used for conducting the survey in this study was to outsource the entire process to a professional survey agency. In other words, the survey interviewers were experienced people working for the survey agency, not the authors. This is because the authors have no experience in conducting on-site surveys and also because it was difficult to hire interviewers, given the COVID-19 situation at the time. The objectivity and professionalism of a survey can be ensured by applying this method. The key consideration was the cost, and, fortunately, a survey budget was secured, allowing the survey to be entrusted to a professional survey agency.

Consequently, the professional survey agency conducted the survey, including interviewer training, sampling, the on-site survey, and verification of the collected data. The agency had extensive experience of CV surveys. The sample size, the survey method, and the method of deriving the WTP response needed to be determined. First, considering the following three aspects comprehensively, a sample size of 1000 was chosen. Arrow et al. [51] suggest, as a guiding rule, using 1000 observations in applications of CV. Most nationwide opinion surveys conducted in South Korea use a sample size of approximately 1000. The survey budget available was at a level that could cover around 1000 observations. Furthermore, the majority of CV studies conducted in South Korea utilized a sample size of 1000.

Second, it was decided to conduct individual face-to-face interviews as the survey method. This method is the most expensive among the various survey methods. For example, Internet surveys, telephone surveys, and mail surveys are much cheaper than individual face-to-face interviews. However, the reason for utilizing individual face-to-face interviews in this study was to secure reliable data while avoiding sample selection bias. Other survey methods are not free from the issue of sample selection bias as the sample itself is not random and can be selected.

The method of deriving the WTP response was chosen to be dichotomous choice (DC) questioning, following the recommendations of Arrow et al. [51]. The WTP is not directly requested in the DC questioning method. Instead, a respondent is asked whether or not they would pay a presented bid amount, T . The DC format is known to be highly incentive-compatible. In other words, when respondents are directly asked about their WTP in an open-ended manner, there is a high possibility that they will respond strategically. However, when they are asked whether or not they would be willing to pay a specific amount, the likelihood of strategic behavior decreases. This is because respondents can simply respond "yes" if the benefits derived from the proposed good or service exceed the stated amount, and "no" otherwise. Therefore, in CV studies, using the DC format instead of open-ended questions can be considered as a kind of rule of thumb.

The CV survey was implemented across the country through household visits during November 2022. Heads of households or their spouses between the ages of 20 and 65 were chosen as respondents. If there was no head in the house, the spouse of the head was interviewed. The interviewers commented that the respondents generally answered the questions in the survey without any difficulty. The survey agency's supervisor verified whether the respondents had answered the questions in the survey accurately by calling the respondents. At the end of the questionnaire, the respondent's mobile phone number was requested. Some questionnaires were judged to be lacking in accuracy. For example, some interviewees were unable to focus during the survey, provided inconsistent responses, or failed to comprehend the project. After these surveys were discarded, a subsequent small-scale survey was conducted to replace the discarded questionnaires.

2.5. Modeling of the CV Data

This research addresses two points when modeling the CV data. First, the one-and-one-half-bound (OB) DC questioning format given by Cooper et al. [55] was chosen from among the various DC questioning methods. When this questioning method is applied, respondents are asked one or two DC questions.

Two amounts, T_1 and T_2 , were determined in advance through a small group survey of 30 persons. More specifically, the following three steps were taken. In the first step, the small group of respondents was asked open-ended questions about their WTP. In the second step, responses with a value of zero were excluded, and the remaining responses were listed in order. In the third step, the top and bottom 15% were trimmed, and the remaining distribution was used to derive a set of bid amounts. All of these procedures were carried out by the professional survey company, which helped to establish a reliable prior distribution of bid amounts.

When T_1 is presented first, and the answer is “yes”, T_2 is additionally presented; if the answer is “no”, there is no additional question. When T_2 is presented first and the response is “no”, T_1 is additionally provided; if the answer is “yes”, there is no additional question. Therefore, if the respondent’s WTP is C , one of three outcomes, $C < T_1$, $T_1 \leq C < T_2$, or $T_2 \leq C$, is observed.

Firstly, the probability of each of the three outcomes occurring should be modeled. The maximum likelihood (ML) estimation method can be applied to find parameter values that maximize the joint probability of the three outcomes. If a person responds “yes” to the offered bid amount T , that person’s WTP will be greater than or equal to T . Therefore, the probability of responding “yes” to the offered amount is 1 minus the cumulative distribution function of WTP. Let $F_C(\cdot)$ be the cumulative distribution function of C . The probability that a person will answer “yes” to T is formulated as:

$$\Pr(\text{“yes” to } T) = \Pr(C \geq T) = 1 - F_C(T) \quad (1)$$

Secondly, a spike model in which a WTP of zero can be explicitly reflected was applied. This model was first suggested by Kriström [56]. A question of whether the WTP was zero or greater than zero was additionally given to those respondents who responded “no” to T_1 . This was to identify a WTP of zero. Thus, a respondent’s response ultimately corresponds to one of four outcomes: $C = 0$, $0 < C < T_1$, $T_1 \leq C < T_2$, and $T_2 \leq C$. The function $F_C(T)$ used in the spike model is often specified as [57]:

$$F_C(T) = \begin{cases} 0 & \text{if } T < 0 \\ [1 + \exp(s_0)]^{-1} & \text{if } T = 0 \\ [1 + \exp(s_0 - s_1 T)]^{-1} & \text{if } T > 0 \end{cases} \quad (2)$$

where s_0 and s_1 are parameters. The spike indicates the probability of $C = 0$. It can be computed as $[1 + \exp(s_0)]^{-1}$. Moreover, the average of C is $(1/s_1)[1 + \exp(s_0)]^{-1}$.

2.6. ML Function for Statistical Analysis

Let T_1^i and T_2^i be, respectively, a lower bid and a higher bid presented to the i th respondent. When T_1^i is presented first, the respondent reports one of four possible answers. If the respondent says “yes” to T_1^i and then “yes” to T_2^i , the answer is “yes-yes”. If the respondent says “yes” to T_1^i and then “no” to T_2^i , the answer is “yes-no”. If the respondent says “no” to T_1^i and then reveals a WTP greater than 0 but less than T_1^i , the answer is “no-yes”. If the respondent says “no” to T_1^i and then reveals a zero WTP, the answer is “no-no”. C_i indicates the i th respondent’s WTP. Using Equations (1) and (2), the probabilities corresponding to these four answers can be defined as follows.

$$\begin{aligned} \Pr(\text{The answer is “yes – yes”}) &= \Pr(C_i \geq T_2^i) = 1 - F_C(T_2^i) \\ &= 1 - [1 + \exp(s_0 - s_1 T_2^i)]^{-1} \end{aligned}$$

$$\begin{aligned}\Pr(\text{The answer is "yes - no"}) &= \Pr(T_1^i \leq C_i < T_2^i) = F_C(T_2^i) - F_C(T_1^i) \\ &= [1 + \exp(s_0 - s_1 T_2^i)]^{-1} - [1 + \exp(s_0 - s_1 T_1^i)]^{-1}\end{aligned}$$

$$\begin{aligned}\Pr(\text{The answer is "no - yes"}) &= \Pr(0 < C_i < T_1^i) = F_C(T_1^i) - F_C(0) \\ &= [1 + \exp(s_0 - s_1 T_1^i)]^{-1} - [1 + \exp(s_0)]^{-1}\end{aligned}$$

$$\Pr(\text{The answer is "no - no"}) = \Pr(C_i = 0) = F_C(0) = [1 + \exp(s_0)]^{-1}$$

Let $I(\cdot)$ be an indicator function, which returns 1 if the proposition in parentheses is true and 0 if it is false. In order to define the likelihood function, a total of four dummy variables with binary values is defined. They are as follows.

$$L_i^{YY} = I(\text{The answer is "yes - yes" when } T_1^i \text{ is offered first})$$

$$L_i^{YN} = I(\text{The answer is "yes - no" when } T_1^i \text{ is offered first})$$

$$L_i^{NY} = I(\text{The answer is "no - yes" when } T_1^i \text{ is offered first})$$

$$L_i^{NN} = I(\text{The answer is "no - no" when } T_1^i \text{ is offered first})$$

when T_2^i , a higher bid, is given first to the i th respondent, similarly, the respondent provides one of four possible answers. The probability of each answer can be defined as follows.

$$\begin{aligned}\Pr(\text{The answer is "yes"}) &= \Pr(C_i \geq T_2^i) = 1 - F_C(T_2^i) \\ &= 1 - [1 + \exp(s_0 - s_1 T_2^i)]^{-1}\end{aligned}$$

$$\begin{aligned}\Pr(\text{The answer is "no - yes"}) &= \Pr(T_1^i \leq C_i < T_2^i) = F_C(T_2^i) - F_C(T_1^i) \\ &= [1 + \exp(s_0 - s_1 T_2^i)]^{-1} - [1 + \exp(s_0 - s_1 T_1^i)]^{-1}\end{aligned}$$

$$\begin{aligned}\Pr(\text{The answer is "no - no - yes"}) &= \Pr(0 < C_i < T_1^i) = F_C(T_1^i) - F_C(0) \\ &= [1 + \exp(s_0 - s_1 T_1^i)]^{-1} - [1 + \exp(s_0)]^{-1}\end{aligned}$$

$$\Pr(\text{The answer is "no - no - no"}) = \Pr(C_i = 0) = F_C(0) = [1 + \exp(s_0)]^{-1}$$

A total of four dummy variables with discrete values may be further defined as follows.

$$H_i^Y = I(\text{The answer is "yes" when } T_2^i \text{ is offered first})$$

$$H_i^{YN} = I(\text{The answer is "yes - no" when } T_2^i \text{ is offered first})$$

$$H_i^{NNY} = I(\text{The answer is "no - no - yes" when } T_2^i \text{ is offered first})$$

$$H_i^{NNN} = I(\text{The answer is "no - no - no" when } T_2^i \text{ is offered first})$$

Consequently, the log likelihood function, LLF , in this study is derived as follows:

$$\begin{aligned}LLF &= \sum_{i=1}^P \ln \{ L_i^{YY} (1 - [1 + \exp(s_0 - s_1 T_2^i)]^{-1}) \\ &\quad + L_i^{YN} ([1 + \exp(s_0 - s_1 T_2^i)]^{-1} - [1 + \exp(s_0 - s_1 T_1^i)]^{-1}) \\ &\quad + L_i^{NY} ([1 + \exp(s_0 - s_1 T_1^i)]^{-1} - [1 + \exp(s_0)]^{-1}) \\ &\quad + L_i^{NN} ([1 + \exp(s_0)]^{-1}) \\ &\quad + H_i^Y (1 - [1 + \exp(s_0 - s_1 T_2^i)]^{-1}) \\ &\quad + H_i^{YN} ([1 + \exp(s_0 - s_1 T_2^i)]^{-1} - [1 + \exp(s_0 - s_1 T_1^i)]^{-1}) \\ &\quad + H_i^{NNY} ([1 + \exp(s_0 - s_1 T_1^i)]^{-1} - [1 + \exp(s_0)]^{-1}) \\ &\quad + H_i^{NNN} ([1 + \exp(s_0)]^{-1}) \end{aligned} \quad (3)$$

The parameters of the cumulative distribution function of the WTP, s_0 and s_1 , are obtained by maximizing Equation (3). Furthermore, the spike was also estimated using these parameter estimates. The technique of obtaining parameter estimates using this method is called maximum likelihood estimation [58–61].

3. Results

3.1. Data

Table 1 summarizes the responses to two suggested bid amounts, T_1 , which was presented first to 500 people, and T_2 , which was presented first to the remaining 500 people. The number of observations for the four possible outcomes is reported when T_1 or T_2 is presented first. A “no-no” response when T_1 was presented first and a “no-no-no” response when T_2 was presented first mean $C = 0$. A total of 588 out of 1000 respondents reported a WTP of zero, accounting for 58.8%. The application of the spike model in this research was justified by the finding that a large number of respondents had a WTP of zero.

Table 1. Number of answers for each set of bids in the sample.

Bids ^a		Number of Answers				
First	Second	“yes-yes”	“yes-no”	“no-yes”	“no-no”	Totals
1000	3000	24	15	2	30	71
2000	4000	17	12	5	37	71
3000	6000	17	17	2	35	71
4000	8000	13	10	7	42	72
6000	10,000	11	4	5	52	72
8000	12,000	6	11	9	46	72
10,000	15,000	12	3	9	47	71
	Totals	100	72	39	289	500
First	Second	“yes”	“no-yes”	“no-no-yes”	“no-no-no”	Totals
3000	1000	21	15	3	33	72
4000	2000	20	13	2	36	71
6000	3000	23	4	1	43	71
8000	4000	20	7	4	40	71
10,000	6000	13	3	4	52	72
12,000	8000	12	4	7	48	71
15,000	10,000	8	4	13	47	72
	Totals	117	50	34	299	500

^a The unit is Korean won (USD 1.0 = KRW 1145 at the time of the survey).

3.2. Estimation Results

There are a total of three hypotheses explored in the following estimation results. The first hypothesis is that all estimated coefficients in the estimated model are zero at the same time. In other words, this hypothesis is that the model itself has no significance. The second hypothesis is that the estimated average WTP is zero. This suggests that the derived average WTP is difficult to use for welfare analysis or expansion to the population. The third hypothesis is that the estimated coefficient for each covariate is zero. This indicates that the effect of any particular covariate on the probability of agreeing to pay the suggested bid amount is not significant. Each hypothesis proposes that the estimated model or estimate is not significant. The Wald test is applied to the first hypothesis. For the second and third hypotheses, individual t -tests are used. The testing procedures and results for the hypotheses will be presented in detail below.

The results from estimating the OB model are presented in Table 2. All estimates possess statistical significance at the 1% level. As the proposed bid amount increases, the probability of answering “yes” to the bid amount should decrease. Thus, it is appropriate that s_1 is estimated to be negative. The statistical significance of the model is also guaranteed. The estimate of household WTP was KRW 4487 (USD 3.92) per annum. The table also

reports the 95% confidence interval calculated through the technique reported by Krinsky and Robb [62].

Table 2. Results from estimating the models.

Variables	One-and-One-Half-Bound Model ^d	Single-Bound Model ^d
Constant	−0.3576 (−5.58) [#]	−0.3610 (−5.63) [#]
Bid amount ^a	−0.1182 (−15.15) [#]	−0.0946 (−11.83) [#]
Spike	0.5885 (37.94) [#]	0.5893 (37.99) [#]
Average of yearly household willingness to pay	KRW 4487 (USD 3.92)	KRW 5589 (USD 4.88)
<i>t</i> -values	13.89 [#]	11.31 [#]
95% CI ^b	KRW 3912 to 5211 (USD 3.42 to 4.55)	KRW 4780 to 6737 (USD 4.17 to 5.88)
Log-likelihood	−1110.78	−915.49
Wald statistics (<i>p</i> -values) ^c	193.03 (0.000)	127.91 (0.000)
Sample size	1000	1000

Source: To estimate the model, a program was coded using an econometric package of TSP5.1. ^a The unit is KRW 1000 (USD 0.87). ^b It means confidence interval computed using the method given in Krinsky and Robb [62]. ^c The null hypothesis is that the model is mis-specified. ^d The values shown in parentheses next to the coefficient estimates are *t*-values. [#] implies that the estimate holds statistical significance at the 5% level ($p < 0.05$).

As Bateman et al. [63] indicated, a response effect can occur in the OB model. If the effect arises, the response to the second question may be distorted. In such a case, a single-bound (SB) model should be used. This model does not use the response to the second question and uses only the response to the first question. If there is no distinction between the mean WTP estimates from the two models, the response effect can be regarded as absent. However, if they are significantly different, the response effect may have occurred.

For comparison, Table 2 also shows the results for the SB model. It appears that the mean WTP for the OB model is 24.6% smaller than that for the SB model. There seems to be a difference between the two values. However, their 95% confidence intervals overlap. This suggests that it is difficult to say that the estimation results are different. Consequently, there seems to be no response effect in the OB model. The OB model and its estimation results are further investigated in the following subsection.

3.3. Discussion of the Results

The findings presented above can be discussed by focusing on five aspects. First, the implications of the test results of the three hypotheses mentioned above are discussed. The first null hypothesis, that the WTP model used in this study was itself not significant, was rejected. This suggests that the model is significant and can, therefore, be appropriately used in further analysis. The second null hypothesis, that the estimated average WTP is equal to zero, was also rejected. This means that it is not unreasonable to use the average WTP value to perform a welfare analysis that estimates the total WTP of the population or to perform a cost–benefit analysis with the cost information. The third null hypothesis, that the estimated coefficient for each variable was not significant, was rejected. This indicates that the effects of key covariates on the likelihood of agreeing to pay the offered bid amount are significant. In other words, it is meaningful to derive implications by interpreting the direction and magnitude of the influence of covariates.

Secondly, the sample version of the household WTP needs to be re-calculated for a population version. In order for the re-calculation to be justifiable, the sample must be sufficiently representative of the population. In this study, for the purpose of securing the representativeness of the sample, a professional survey agency was commissioned to perform the entire process of sampling. The agency attempted to bring the sample closer to the population by securing and utilizing some census data purchased from Statistics Korea.

There were 21,579,415 South Korean households in 2022. Using this information, KRW 125.75 billion (USD 109.83 million) is obtained for the yearly WTP value for the population.

As mentioned above, the payment period was ten years. The government has officially suggested 4.5% as a social discount rate. Using this information, the present value, at the end of 2022, can be calculated as KRW 766.14 billion (USD 669.12 million). Unfortunately, there is no relevant prior research in the literature that allows this value to be compared horizontally. Therefore, the authors refrain from comparing the findings from this study with those from previous studies. Nevertheless, this value is quite large compared to values derived from other CV studies [64–68] conducted in South Korea. Interestingly, the South Korean people give considerable value to interstate cooperation in the HRE. In this regard, if the cost incurred by the cooperation is less than this value, the cooperation will be economically beneficial [61,69,70].

Thirdly, the direction of the influence of the respondents' characteristics on the probability of agreeing to pay T can be discussed. For this purpose, a covariate model is estimated. In Equation (2), covariates may be added after s_0 . Table 3 summarizes the information on the five covariates adopted in this study. The estimation results are given in Table 4. Education level has a positive relationship with the probability of saying "yes" to T . The richer the respondent household, the greater the probability. Those whose residence was the Seoul Metropolitan area had a greater probability of answering "yes" to T than others. The older the respondent, the greater the probability. People with a conservative political orientation were less likely to say "yes" than others. Therefore, it can be seen that a high education level, a high income level, a high age, residence in the Seoul Metropolitan area, and a progressive political orientation increase the probability of agreeing to pay T .

Table 3. Description of variables used in the model.

Variables	Definitions	Mean	Standard Deviation
Education	Education level of the respondent in years	14.24	2.15
Income	Monthly household income of the respondent (unit: million Korean won)	5.321	2.32
Metro	Where the respondent resides (0 = non-Seoul Metropolitan area; 1 = Seoul Metropolitan area)	0.53	0.50
Age	Age of the respondent	49.19	10.00
Politics	Political inclination of the respondent (0 = progressive; 1 = conservative)	0.25	0.43

Table 4. Results from estimating the model with covariates.

Variables ^a	Estimates ^e
Constant	−3.1488 (−4.29) #
Bid amount ^b	−0.1251 (−15.24) #
Education	0.0919 (2.59) #
Income	0.1038 (3.46) #
Metro	0.5442 (4.11) #
Age	0.0154 (2.03) #
Politics	−0.4875 (−3.05) #
Spike	0.5889 (36.77) #
Average of yearly household willingness to pay	KRW 4232 (USD 3.70)
t -value	13.93 #
95% CI ^c	KRW 3686 to 4897 (USD 3.22 to 4.28)
Log-likelihood	193.97 (0.000)
Wald statistic (p -value) ^d	−1075.06
Sample size	1000

Source: To estimate the model, a program was coded using an econometric package of TSP5.1. ^a They are described in Table 3. ^b The unit is KRW 1000 (USD 0.87). ^c It means confidence interval computed using the method given in Krinsky and Robb [62]. ^d The null hypothesis is that the model is mis-specified. ^e The values shown in parentheses next to the coefficient estimates are t -values. # implies that the estimate holds statistical significance at the 5% level ($p < 0.05$).

The findings from this study can be compared with those from previous CV studies targeting South Korea. Regarding the coefficient of the education variable, Jin et al. [48], Kim et al. [65], Park et al. [68], and Nam [71] also observed a positive sign. On the other hand, Lee et al. [64] and Woo et al. [72] detected a negative sign. In short, the education variable generally has a positive effect on the probability of agreeing to pay the suggested amount, but for some evaluation targets, it may instead have a negative effect. The coefficient of the income variable was estimated to be positive by Jin et al. [48], Lee et al. [64], Kim et al. [65], Park et al. [68], Nam [71], Woo et al. [72], and Jeon and Yang [73]. Therefore, the sign for the influence of the income variable shows a consistent trend in the literature. Park et al. [68] used the metro variable and found the same positive coefficient as in this study. Different signs have been found for the coefficient of the age variable. Jin et al. [48], Kim et al. [67], Jeon and Yang [73], and Oh et al. [74] estimated the coefficient to be negative. On the other hand, Lee et al. [64], Kim et al. [65], Nam [71], and Woo et al. [72] discovered a positive sign for the coefficient for the age variable. Consequently, the influence of the age variable does not show a consistent trend in the literature. It was difficult to find a study in which the politics variable was adopted.

The reason for analyzing a model that includes covariates is to determine whether there is internal consistency or theoretical validity in the model. If the estimated coefficients for the key variables are statistically significant and have reasonable signs, there is internal consistency or theoretical validity. If not, this is not established. In particular, the sign and statistical significance of the coefficient for the income variable are crucial. If its value is negative, it indicates that the evaluated goods are inferior, suggesting that they may have been incorrectly specified or that the internal consistency or theoretical validity of the model is difficult to establish. In this regard, the data collected and the model analyzed in this study show internal consistency and theoretical validity.

Fourthly, it is necessary to explore the reasons why some respondents revealed a WTP of zero. In fact, a WTP of zero can be considered natural from an economic theoretical perspective. Typically, WTP can be derived as the solution that maximizes consumer utility under income constraints. If the WTP for a particular good is zero, this means that the consumer is not willing to consume that good at all. This can be derived as a corner solution among many possible solutions. In this regard, this study had 588 respondents with a WTP of zero; when they reported they were unwilling to pay, they were asked a probing question about their reasons.

Nine basic reasons for a WTP of zero were found: (i) taxes that have already been paid should be invested in the cooperation (39.6%); (ii) the cooperation is not important enough for the government to invest in it in the first place (17.0%); (iii) the interstate cooperation project in neutral waters at the HRE is of little value to me (13.6%); (iv) this issue is not of interest to our household (8.2%); (v) not enough information is given to make a judgment (8.0%); (vi) the government already spends too much money in this area (6.6%); (vii) additional tax should not be spent on interstate cooperation in the HRE (5.3%); (viii) my household cannot afford to pay (1.4%); and (ix) other reasons (0.3%).

Among these, responses (iii) and (viii) represent 15.0% of the total and mean a true zero WTP, while the remaining 85.0% represent a protest bid. Therefore, looking at the previous application of the spike model, including the protest bid responses as a WTP of zero would have played a role in lowering the average WTP. Of course, this consideration does not pose a problem for policy analysis, in that the authors take a conservative approach. However, the fact that a large number of people did not place any value on interstate cooperation in the HRE is of significant concern to the government, because public acceptance of the interstate cooperation in the HRE promoted by the government is not high. Currently, interstate relations are strained to a considerable extent. Thus, 63.2% of respondents viewed the prospect of interstate cooperation as bleak. If the government is to promote interstate cooperation in the HRE, it must make special efforts to increase public acceptance.

Lastly, it is necessary to examine the connection between the current situation and the findings of this study. During the data collection period for this research, cooperation

between South Korea and North Korea in the HRE context was under consideration. However, unfortunately, South Korea and North Korea have largely suspended most exchanges and cooperation and are militarily engaged in a serious standoff. Therefore, it cannot be denied that the findings of this study may seem incongruous in the current situation. Currently, interstate cooperation in the HRE is almost impossible. However, despite this, if such cooperation is reconsidered in the future, the findings of this study could be utilized as reference material.

3.4. Limitations of the Research

This study has four limitations. First, it only focuses on citizens of South Korea, one of the two parties involved in the interstate cooperation. North Korea, as a socialist country, has very limited exchanges with foreign countries. Conducting a survey targeting North Korean residents is almost impossible. Furthermore, South Korea has enacted national security laws that fundamentally criminalize contact with North Korean residents. Therefore, from the outset of this study, the authors could not even consider conducting a survey targeting North Korean residents. In this regard, this study clearly falls short because it is missing half of the data, North Korean people's perspective.

Second, this study adopted a total sample size of 1000, but this should be larger. Thanks to the development of sampling and survey-conducting techniques, there is no difficulty in collecting representative opinions of South Korean people, even with a sample of this size. However, 1000 observations are not enough to perform region-specific analysis. In particular, this study used interval data collected through the application of a closed-ended question method, instead of point data collected through the application of an open-ended question method. Thus, the sample size needs to be expanded in order to divide and analyze the sample.

Third, although this study successfully estimates the WTP for interstate cooperation to preserve the ecological integrity of the HRE, it does not perform a cost–benefit analysis of that cooperation. For the government to make informed and responsible decisions, a cost–benefit analysis must be performed. However, it was difficult to calculate the cost required for the cooperation. Moreover, the quantitative figures derived from this study represent only a portion of the benefits. Thus, cost–benefit analysis cannot be conducted in this study.

Fourth, South Korea and North Korea are, in fact, in a state of armistice that has ended the war, but they remain in a state of truce where the war is cold. Actions in the HRE area are not entirely within the hands of the two Koreas. The South Korean side is under the surveillance or protection of the United Nations Command. Therefore, cooperation between the countries in the HRE is not something that they can do at will but must be based on agreements with the United Nations Command and the Republic of Korea–United States Combined Forces Command.

4. Conclusions

The HRE is an important habitat for natural landscapes and aquatic life. The estuary is quite an important ecosystem in South Korea and an area that must be protected for its value. However, the HRE is located in the West Sea border area, where military tensions are high. Currently, as part of measures that will benefit both South and North Korea while easing military tensions, a plan to establish a neutral zone in the HRE and for the two countries to cooperate with each other is being promoted. Most areas of the HRE are tidal flats or the sea and have excellent ecological and tourism resources. The Korea Ministry of Maritime Affairs and Fisheries is leading the cooperation as part of marine policy, and various related ministries should collaborate. In addition, a significant amount of government funding is required. Therefore, this study used CV to estimate South Korean households' WTP for interstate cooperation in the HRE. The main results are significant not only in terms of policy but also in terms of research and contribution to the literature.

First, in terms of policy, quantitative information required by the government was derived and provided. Since the financial resources required for interstate cooperation in the HRE will come from people's taxes, the WTP of households that are taxpayers is an important piece of information. The yearly household and national WTP values were KRW 4487 (USD 3.92) and KRW 125.75 billion (USD 109.83 million), respectively. The present value, obtained by applying the 10-year payment period and a discount rate of 4.5%, was estimated to be KRW 766.14 billion (USD 669.12 million). Ultimately, it was found that some South Korean households put considerable value on interstate cooperation in the HRE; however, it should be noted that 58.8% of the respondents did not put any value on the cooperation. In fact, it was surprising to discover that more than half of the respondents said they would refuse to pay even a penny. Acceptance is not necessarily evaluated only through WTP. Nonetheless, refusal to pay suggests a lack or absence of acceptance of interstate cooperation. This is causing great trouble for the government. The government needs to take steps to increase public acceptance of interstate cooperation in the HRE.

Next, from a research perspective, this study extends CV to the measurement of WTP for interstate cooperation in the HRE. CV is a useful method for assessing WTP for a non-market good such as interstate cooperation in the HRE. Looking at the estimation results, all the estimates were statistically significant. These results were obtained through a combination of well-designed questionnaires, field surveys conducted by experienced supervisors and interviewers, modern sampling and survey techniques, the researchers' extensive experience, a well-established WTP model, and well-developed statistical modelling of the DC CV data. In this regard, CV was applied reasonably in this study. This study clearly demonstrates that CV can be meaningfully applied to address this type of issue. Moreover, the framework of this study can be extended to other research cases considering public WTP for cooperation in the sea between countries bordering the sea. Various related follow-up studies are expected.

This study quantitatively finds a significant and rather large WTP among South Koreans for interstate cooperation to preserve the ecological integrity of the HRE. Although the two Koreas are currently in a tense relationship, this discovery can be useful in the future pursuit of cooperation to promote each other's survival and prosperity. The impact of each covariate on the intention to pay the suggested amount is statistically significant, and the analysis shows that it has an interpretable sign. These results can serve as basic information to increase public acceptance of the cooperation. For example, the higher the level of education, the higher the acceptance. Public acceptance can be further improved if people with low levels of education are informed of the need for cooperation. The fact that more than half (58.8%) of people revealed a WTP of zero for the cooperation implies that it will not be easy to raise financial resources for the cooperation. Above all, if the current tension between South Korea and North Korea does not improve, it will be difficult for cooperation to ever begin. Of course, if the tension improves, cooperation will be meaningful, and the results of this study can play a certain role.

In response to the limitations of this research, outlined in Section 3.4, four follow-up studies can be suggested. First, it will be necessary in the future to compare the results for South Korean residents with the perceptions and judgments of North Korean residents regarding interstate cooperation for preserving the ecological integrity of the HRE. Second, the sample size needs to be expanded to perform region-specific analysis. If additional funding for future surveys is secured and more households are sampled, it will be possible to conduct analysis differentiated by region and to derive differentiated implications by region from this.

Third, the cost-benefit analysis for the cooperation can be performed in a follow-up study. Cooperation can only be socially justified if the benefits exceed the costs. Although this study focuses on preserving the ecological integrity of the HRE, cooperation could also generate other types of benefits. Therefore, these benefits should also be estimated. Moreover, the costs arising from the cooperation should be appropriately calculated. Fourth, in

order for interstate cooperation to be effective, coordination between multiple stakeholders in various countries is necessary. This needs to be examined in depth in future research.

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