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The willingness to pay for removing the microplastics in the ocean – The case of Seoul metropolitan area, South Korea

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ABSTRACT

Microplastics - small plastic particles with less than 5 mm in diameter – in the ocean have become major social concerns among people since it has been found not only harmful to the marine eco-system but also human health. Then, there is an increase in the social demand for appropriate policy by the government. To prepare appropriate countermeasures, it is essential to estimate the environmental damage cost of microplastics in the ocean in advance. Therefore, this study estimates willingness to pay of residents in Seoul metropolitan area in South Korea for removing the microplastics to provide the quantitative information of the environmental damage cost of microplastics in the ocean. This study employed one-and-one-half-bound dichotomous choice with spike model to collect the WTP responses data. To deal with the outliers, we assumed that the distribution of WTP is the contaminated normal distribution, which is heavy-tailed in comparison to normal distribution used in previous studies. In addition, to deal with the numerous zero WTP responses, this study employs the Bayesian censoring regression with data augmentation method. The estimate of the average yearly WTP is KRW 2845.6 (USD 2.59). Additionally, total WTP of households in Seoul metropolitan area was KRW 10.8 billion (USD 9.80 million) annually.

1. Introduction

Microplastics are small plastic particles with less than 5 mm in diameter. There are two types of microplastics: primary microplastics (or microbeads), which are raw materials of plastic products or scrubs added to cosmetics or toothpaste; and secondary microplastics, which are the result of plastic waste breaking down. Reportedly, microplastics have been continuously accumulating in the ocean because they cannot be separated as they are too difficult to be recognized with naked eyes and be filtered even by the water treatment facilities.

According to the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), microplastics in the ocean are steadily accumulating in the body of marine creatures and exerting adverse effects on their health. Furthermore, the effect is found to reach humans through the food chain, which increases the social concern. As a matter of fact, according to the survey conducted in Europe, 75% of the respondents said that microbeads added to cosmetics should be banned [1]. As for South Korea, 94% of the participants in the 2016 national survey by Greenpeace expressed their concern about the risks from microplastics, and 96% of the them indicated that the South Korean government needs to pass a legislative bill [2].

As the social concern about microplastics increases, there is an increase in the demand for more progressive countermeasure by the government. To prepare appropriate countermeasures, it is crucial to estimate the environmental damage cost of microplastics in the ocean, which can be employed the starting points for evaluating the policies and regulations. Without any justified method for estimating the cost, policies and regulations for controlling microplastics will be subject to public discussion. For example, proponents of policies or regulation of microplastics such as environmental groups and numerous residents tend to overestimate the environmental damage cost of microplastics in the ocean. On the other hand, cosmetics industry that uses microplastics in the production process tends to underestimate them. However, related research is still rare because the issue of microplastics is relatively new, and most of the related studies focus on investigating the current status and assessing the risks.

Meanwhile, there are many studies that estimated the environmental damage cost by using a non-market good valuation method such as Contingent Valuation Method (CVM). CVM was employed in a survey designed to directly elicit the respondent's willingness to pay (WTP) toward a certain asset; based on general public's preference, the method has been used for estimating the damage cost of environmental

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pollution. While many studies have been conducted in the areas of air pollution and water pollution, not many studies have calculated damage cost by using CVM in regard to the pollution of the marine environment [3].

The studies that utilized CVM related to marine pollution are as follows. Smith et al. [4] utilized CVM in calculating WTP for removing marine debris from the coasts of New Jersey and North Carolina in the United States. Loomis and Santiago [5] calculated WTP for removing the marine debris in Puerto Rico. Brouwer et al. [6] estimated WTP for removing marine debris and cigarette butts along the coasts of Europe. Aside from them, several previous studies surveyed general public's WTP for improving overall ocean environment including removing marine debris [7,8].

Microplastics greatly differ from other marine debris in terms of how they are created or how much they damage the eco-system. First, depending on how they are formed, microplastics are divided into primary microplastics and secondary microplastics. Therefore, the results of WTP estimated based on ordinary marine debris do not reflect the possible damage from secondary microplastics created by the weathering of plastic waste in the ocean. Second, as the ocean creatures ingest microplastics, the damage exerts an adverse effect on human health through the food chain. In other words, unlike other marine debris, microplastics do not cease at destroying the coastal landscape or marine eco-system; it brings havoc to the entire eco-system including humans. In this vein, it is essential to conduct research to estimate WTP for removing the microplastics in the ocean, instead of utilizing the previous results of WTP about marine debris. Moreover, no study has been conducted in South Korea to estimate the environmental cost of marine debris including microplastics based on general public's perception.

To this end, this study aims to employ CVM in estimating WTP of households in Seoul metropolitan area, where the half of South Korean households live. To elicit WTP from respondents, this study implemented the one and one half bound dichotomous choice (OOHBDC) model. In this model, interviewers randomly were chosen between lower and upper bid as an initial value at which to elicit the respondent's WTP. This model has an advantage of rectifying the limitations of other models such as single-bound dichotomous choice (SBDC), which requires only one answer in response to the suggested value, and double-bound dichotomous choice (DBDC), which has a follow-up question based on the given answer to the suggested bid amount.

Meanwhile, this study focuses on the distribution of WTP. Previous CVM studies have assumed that the distribution of WTP is either logistic distribution or normal distribution. Under these assumptions, the estimate of mean WTP was not robust if there were outliers in a response data; outlier is defined as an observation that deviates too much from other observations. In previous studies, the estimate of mean WTP was derived after outliers had been eliminated from the response data; however, this study aims to resolve this problem by assuming the distribution of WTP as a contaminated normal distribution with a heavy-tail in comparison to previous distributions. In addition, the respondents with zero WTP (i.e., WTP responses are censored at zero) were 47.5% of total respondents. To resolve these problems, this study intends to apply Bayesian censoring regression suggested by Garay et al. [9] and obtained the robust WTP estimation. Meanwhile, the response data of this study was given the interval data. It was necessary to convert these interval data to continuous data to apply the Bayesian censoring regression method. For this, we applied the data augmentation method proposed by Tanner and Wong [10]. In particular, the Bayesian approach in CVM has an advantage that samples by estimated the Bayesian estimation method could be used to aggregate individual welfare measures into an aggregate welfare measure in the perspective of welfare estimation.

The remainder of this study is organized as follows. The second section provides relevant information on the risks of microplastics. The third section reviews the survey design, and the fourth section presents the econometric model. The fifth section presents the results. The final section offers the concluding remarks.

2. Risks of microplastics and policies

Microplastics refer to small plastic particles less than 5 mm in diameter. They are classified into primary microplastics, which are made small in the manufacturing process; and secondary microplastics, which are created as a result of plastic waste breaking down. With regard to primary microplastics, particularly microbeads added to cosmetics, 4000 t are consumed annually in Europe. It was discovered that more than half of these microplastics were released to the ocean without being filtered by water treatment facilities. With regard to secondary microplastics caused by regular plastic waste, the issue is even more serious. According to Jambeck et al. [11], 4.8–12.7 million tons of plastic waste from around the world was released to the ocean in 2010, and the scale was expected to grow continually in the future. Kershaw [1] predicted that microplastics in the ocean would continue to increase due to the current secondary microplastics from broken-down plastic waste even if primary microplastics are no longer released.

Microplastics are absorbed into the primary producer group in the food chain such as plankton or algae; ultimately are ingested by humans through food chain. Therefore, microplastics exert a harmful effect on ocean creatures as well as human health [1]. Accordingly, social concern about microplastics is escalating. In response to this, cosmetics companies began to replace microplastics added to cosmetics with environment-friendly materials. Nevertheless, such autonomous regulation by the private sector was proved to be insufficient. Greenpeace [12] evaluated the microplastic-related policies implemented by the top 30 cosmetic companies around the globe. Based on the result, they pointed out the following problems with autonomous regulation by the private sector. First of all, each company had a very limited definition of microplastics. For example, even the company that scored the highest was still using other types of plastics, by limiting the definition of microplastics to only one type of plastic (polyether) instead of including all plastics. Second, each company had a limited scope of products that use microplastics. In other words, it was found that they stopped using microplastics for some products, but not all products. Greenpeace [12] argued that autonomous regulation of microplastics by the business world was insufficient and a legislative regulatory system by the government should be established. Starting with Europe and advanced countries including the U.S., regulation policies to reduce microplastics have been being established. Canada added microplastics to the list of toxic materials under the Environment Protection Act in 2015 and announced "Microbead Elimination and Monitoring Act" [13]. According to the new law, microplastics added to personal hygiene products, face-cleansing health products, and over-the-counter items would be completely banned. As for Europe, policies were implemented to control not only primary microplastics but also secondary microplastics from plastic waste. Particularly in France, a legislative bill was passed to increasingly ban cosmetics with microplastics starting in 2018 and expanded to disposable plastic products and cotton swabs starting in 2020 to prevent the creation of secondary microplastics [14]. In 2015, the United States also passed a bill to restrict microplastics in callus removers and cleansers, and each State has been establishing the policy to control microplastics. For example, the State of California announced a ban on selling all personal hygiene products containing microplastics (except for products containing microplastics with 1 ppm or under) starting in 2020 [15].

The South Korean government's priority about constructing the microplastic-related policies is to control the ocean-based marine debris. In 2014, the South Korean government announced "A Plan for Managing Marine Debris." This plan is the comprehensive plan for managing all kinds of marine debris, including microplastics; one of the goals of this plan is to increase the recycling rates of ocean-based plastic waste up to 80% by 2018 as they are identified as main culprits of