



Economic benefits of preventing bird collisions in South Korea: findings from a choice experiment survey

Chang-Min Kim¹ · Ju-Hee Kim² · Seung-Hoon Yoo²

Received: 10 January 2022 / Accepted: 28 July 2022 / Published online: 8 August 2022
© The Author(s), under exclusive licence to Springer-Verlag GmbH Germany, part of Springer Nature 2022

Abstract

Bird deaths due to collisions with artificial structures, such as glass windows of buildings and transparent noise barriers, are continuing to occur in South Korea. The government is trying to prevent bird collisions by increasing the attachment of specially designed tapes to help birds avoid windows. This article estimates the economic benefits arising from the prevention of collisions by applying a choice experiment (CE). For this purpose, a CE survey of 1000 South Korean interviewees was conducted. The four attributes to be attached with the tapes for the CE application were a transparent soundproof wall window on an expressway, a transparent soundproof wall window on a general road, a glass window in a public building, and a glass window in a private building. The unit was the percentage of each structure with the tapes attached to the window. The marginal values of a one-unit (1%p) increase in each attribute were computed to be KRW 534 (USD 0.46), KRW 233 (USD 0.20), KRW 1,318 (USD 1.13), and KRW 12,930 (USD 11.05), respectively. This quantitative information will be an important reference for implementing the prevention policy. For example, based on the collision prevention of 1000 birds per structure, the priority for attaching tapes can be placed in the order of expressways, public buildings, private buildings, and general roads.

Keywords Bird collision · Transparent window · Economic benefit · Choice experiment

Introduction

Various human-made structures have a serious negative impact on birds' survival. For example, artificial structures interfere with the smooth movement of birds, exhaust birds, or cause injuries or deaths of birds through collisions

(Drewitt and Langston 2008). Artificial structures that cause bird collisions include dynamic ones, such as automobiles and airplanes, and static ones, such as buildings, power lines, wind turbines, and communication towers. Among them, in particular, bird collisions with transparent or reflective structures such as windows in buildings occur frequently, and these can be fatal to birds (e.g., Klem 1990, 2008; Loss et al. 2015; Riding et al. 2021).

For example, in Canada and the USA, it has been estimated that 16.1 ~ 42.2 and 365.0 ~ 955.0 million birds, respectively, die annually due to collisions with building windows (Machtans et al. 2013; Loss et al. 2014a, b; Loss et al. 2015). According to Loss et al.'s (2015) study, the most important reason for bird deaths in North America is cat attacks, followed by collisions with building windows. A citizen memory recall survey conducted in Argentina found that an annual average of 3.7 ± 10.2 birds per building collide with a building window, of which 0.47 ± 1.22 birds, or 12.7%, die (Rebolo-Ifrán et al. 2019). Despite the fact that a considerable number of birds die due to collisions, studies that have estimated the damage status of bird collisions at the national level are rare. Recently, there have been two

Responsible Editor: Philippe Garrigues

✉ Seung-Hoon Yoo
shyoo@seoultech.ac.kr

Chang-Min Kim
cmkim@seoultech.ac.kr

Ju-Hee Kim
jhkim0508@seoultech.ac.kr

¹ Department of Energy Policy, Graduate School of Convergence Science, Seoul National University of Science & Technology, 232 Gongreung-Ro, Nowon-Gu, Seoul 01811, Republic of Korea

² Department of Future Energy Convergence, College of Creativity and Convergence Studies, Seoul National University of Science & Technology, 232 Gongreung-Ro, Nowon-Gu, Seoul 01811, Republic of Korea

citizen science studies related to bird collisions (Rebolofran et al. 2019; Uribe-Morfin et al. 2021).

Some studies have analyzed the causes and status of bird deaths in South Korea. Bing et al. (2012) reported that the biggest cause of bird deaths is collision with artificial structures in Hongdo, Jeollanam-do, South Korea, a middle stopover for migrating birds in East Asia. More specifically, the main cause of bird deaths (34.8%) is collisions with artificial structures, followed by cat attacks with 21.9%. The Korea National Institute of Ecology (2018) investigated the damage to birds that collided with artificial structures and estimated that a total of 7.88 million birds die every year due to collisions, 7.65 million and 0.23 million birds colliding with building windows and transparent noise barriers, respectively. Every year, 1.07 birds per building and 164 birds per kilometer of transparent noise barriers located along the road die. These birds include protected species, such as endangered species and natural monuments.

Citizens are voluntarily monitoring bird collisions caused by building windows or transparent noise barriers. For example, according to Naturing, an online platform for observing the nature of South Korea, 2723 citizens were participating in investigating wild bird collisions with windows as of November 2021 (Naturing, 2022). Five out of a total of 17 metropolitan governments and 14 out of a total of 228 local governments have also enacted and promulgated ordinances to prevent and reduce wild bird collisions. The US House of Representatives passed H.R. 2, which includes H.R. 919-Bird Safe Buildings Act in July 2020. The Bird-Safe Buildings Act will soon be in the Senate (American Bird Conservancy, 2020).

In particular, the Korea Ministry of Environment is implementing three measures to prevent bird collisions. First, by producing and distributing guidelines for reducing bird collisions, the adoption of measures to reduce bird collisions is encouraged when designing buildings and noise barriers. Second, the notification of the performance and installation standards of soundproofing facilities has been revised to reflect measures to prevent bird collisions when installing transparent noise barriers. Third, it is promoting a pilot project to attach bird collision prevention tapes to glass windows of buildings and transparent noise barriers that have already been installed. In addition, a plan to introduce measures to reduce bird collisions to the evaluation item list during environmental impact assessment is being considered.

Among these, the most important measure is to prevent bird collisions by targeting existing building windows and transparent noise barriers. According to the National Institute of Ecology, South Korea has a total of 7,126,526 buildings with the potential for bird collisions and 1421 km of transparent noise barriers. The

Korea Ministry of Environment supports a pilot project to attach adhesive tapes for preventing bird collisions to a total of 10 buildings and transparent noise barriers annually, with a budget of only KRW 150 million. However, significant additional costs are required to reduce bird collisions drastically. Since this cost will be covered by taxes, it is necessary to investigate whether it is socially desirable to inject a budget for implementing a project preventing bird collisions. First of all, it is necessary to estimate the economic benefits arising from the implementation of the project.

This study aimed to evaluate the economic benefits quantitatively. For this purpose, the choice experiment (CE) method was employed, and CE data were collected through a person-to-person survey of 1000 interviewees nationwide. To the best of the authors' knowledge, this article is the first to deal with the economic benefits of preventing bird collisions in the literature except an unpublished master's thesis which deals with these issues. In addition, the main results of this study, which will be described later, were statistically significant. Therefore, this paper can make a significant contribution to the relevant literature dealing with bird collisions. The subsequent contents of the paper are composed as follows. Section 2 presents the materials and methods. Section 3 covers the main results and discussions. The conclusions are presented in the last section.

Materials and methods

Method: choice experiment

To estimate economic benefits, the estimation method must be determined first. In this regard, a CE was adopted in this study. A CE is one of several techniques that can be used to estimate the economic benefits of consuming a non-market good, such as an environmental protection policy. The method of collecting data on preferences by observing people's behavior is called the revealed preference technique, and the method of collecting data by asking people about their preferences is called the stated preference (SP) technique (Johnston et al. 2017). Concerning the bird collision prevention policy, which is the subject of the evaluation in this study, it is difficult to observe the behavior of the people involved. Therefore, it is hard to estimate the economic benefits of implementing the policy by applying the revealed preference technique. Instead, the SP technique should be applied.

The SP technique largely consists of CE and contingent valuation (CV). Usually, CV asks about consumers' preferences directly, while a CE asks about them indirectly (Ahmed et al. 2015; Jin et al. 2017; Huh and Shin 2018;

Khan et al. 2019). In addition, CV and CE are adopted for goods with a single attribute and multiple attributes, respectively (Lim et al. 2018; Lee et al. 2020; Kim et al. 2021). Therefore, CV estimates the average willingness to pay (WTP) by analyzing data obtained by asking consumers about their WTP for the consumption of a specific single attribute of a good. On the other hand, a CE estimates the utility function from the data obtained by allowing consumers to select their most preferred alternative among several alternatives related to a multi-attribute good composed of various levels of several attributes and then derives the marginal WTP by attribute (Aanesen et al. 2015; Hanley and Czajkowski 2019). There is no absolute superiority and inferiority between the CV and the CE approach, and one is selected from the perspective of the researcher's preference and the suitability for the good to be evaluated (Bersisa et al. 2021).

This research chose to apply the CE method by comprehensively considering the following three points. First, the bird collision prevention policy consisted of several attributes rather than one attribute. There are various targets to which tapes for preventing bird collisions are attached, and the economic benefits need to be estimated for each target. If these targets can be defined as attributes, the bird collision prevention policy becomes a multi-attribute good. Consequently, for the purpose of obtaining economic benefits for each target, a CE, which is applicable to multi-attribute goods, must be applied. As will be described below in more detail, a good with four attributes was adopted in this study.

Second, a CE may avoid or reduce the part-whole bias that CV may cause. An example is a situation in which the WTP for the consumption of two goods is estimated. The values obtained by assuming the simultaneous consumption of two goods in one CV survey and the sum of the values obtained in two CV surveys for each good should be the same according to the theory. However, in actual CV application studies, there may be a difference between the two, which is called part-whole bias (e.g., Mitchell and Carson 1989; Boyle et al. 1994). Part-whole bias can also occur in CE, but the likelihood of such an occurrence is greatly reduced (Hanley et al. 1998).

Third, compared with CV, a CE is unlikely to encounter the problem of response bias (Adamowicz 1995). Response bias means that interviewees respond positively or negatively to WTP questions regardless of their true WTP under the influence of the interviewer. A CV survey asks respondents whether they are willing to pay the proposed amount, while a CE survey allows respondents to choose the best among several alternatives that include price attributes. Therefore, in the former, the interviewer may influence the interviewee's response regardless of the intention, but, in the latter, the

probability of the interviewer's influence is significantly lower (Hanley et al. 1998).

CE is essentially based on two economic theories. The first one is Lancaster's (1966) multi-attribute utility theory. The theory assumes that a good or service consists of a group of attributes and that the utility generated by consuming it is the sum of the values of all the attributes. When an object to be valued is internalized as an attribute of a specific multi-attribute good, it is impossible to consume only that attribute, but, following this assumption, the marginal value of consuming the attribute alone can be evaluated. The second one is McFadden's (1974) random utility maximization (RUM) theory. This assumes that consumers choose the alternative that maximizes their utility when faced with several alternatives. Moreover, it is assumed that the utility consists of two parts: an observable and an unobservable part (Alcon et al. 2020).

Determination of attributes

The first task in applying a CE is to determine the attributes (Kwak et al. 2010; Kim and Yoo 2020; Kim et al. 2021), which means defining each attribute and setting its levels. The authors made an initial version of the attribute list while examining the literature related to bird collisions. In the initial version, the transparent noise barriers and glass windows of the building were considered as key attributes, and conflicting birds were classified into endangered species and other birds. The list of attributes was refined by obtaining advice from experts in bird collisions. In addition, through discussions with policymakers of the Korea Ministry of Environment, meaningful attributes were identified in relation to the implementation of the policy to prevent bird collisions. Through these processes, the type of artificial structure to which tapes are to be attached to prevent bird collisions was identified and specified. However, it was judged that the endangered species did not produce significant results due to the lack of population. By considering the main contents of the policy, the unit of attributes could be determined as the ratio of the artificial structure to which the tapes were attached to the total amount of the artificial structure. Specifically, according to the Korea Ministry of Environment (2021), there are a total of 7,243,472 buildings in South Korea where bird collisions occur as of 2019, and the extension of transparent noise barriers was 1421.94 km as of 2018. In addition, the number of bird deaths caused by bird collisions averaged 1.07 per year per building and 164 per year per km of transparent noise barriers.

Table 1 contains information on the finally confirmed attributes. Apart from the price attribute, the adopted attributes for the CE application were the glass windows of the

Table 1 Attributes selected in this research

| Attributes | Descriptions | Levels |
|------------|--|---|
| Expressway | The percentage of transparent noise barriers on expressways with bird collision prevention tapes | Level 1: 0% [#] Level 2: 3% (protecting 1052 birds) Level 3: 5% (protecting 1753 birds) Level 4: 7% (protecting 2454 birds) |
| Road | The percentage of transparent noise barriers on general roads with bird collision prevention tapes | Level 1: 0% [#] Level 2: 1% (protecting 1977 birds) Level 3: 2% (protecting 3954 birds) Level 4: 4% (protecting 7908 birds) |
| Public | The percentage of public buildings with glass windows with bird collision prevention tapes | Level 1: 0% [#] Level 2: 1% (protecting 2034 birds) Level 3: 2.5% (protecting 5084 birds) Level 4: 5% (protecting 10,169 birds) |
| Private | The percentage of private buildings with glass windows with bird collision prevention tapes | Level 1: 0% [#] Level 2: 0.1% (protecting 7422 birds) Level 3: 0.2% (protecting 14,844 birds) Level 4: 0.3% (protecting 22,266 birds) |
| Price | Additional increase in yearly household income tax for 5 years | Level 1: KRW 0 [#] Level 2: KRW 1000 Level 3: KRW 2000 Level 4: KRW 5000 Level 5: KRW 10,000 |

[#]The business-as-usual or current status of each attribute. USD 1.0 was approximately equal to KRW 1170 at the time of the survey

four types of structures which the tapes would be attached: a transparent soundproof wall window on an expressway, a transparent soundproof wall window on a general road, a glass window in a public building, and a glass window in a private building. The attributes have three main characteristics. First, building windows and transparent noise barriers were considered because most bird collisions are caused by these two structures. For this reason, the Korea Ministry of Environment is currently carrying out a pilot project to attach bird collision prevention tapes to these structures, and expanding this project is the core of the policy to prevent bird collision.

Second, the types of building ownership were divided into the public and private sectors. The reason for this is that in public buildings, the tape attachment and management are relatively easy, while in private buildings, they are relatively difficult because the owner's consent is required. The Korea Ministry of Environment estimates that only 3% of all buildings are publicly owned and the rest are privately owned. Third, transparent noise barriers were divided into those on expressways and those on general roads. The tape attachment and management are easier for the former than for the latter. This is because in the case of South Korea, there are far more owners and managers of general roads than highways. According to the Korea National Institute of Ecology (2018), as of 2017, the transparent noise barriers installed on highways and general roads were about 15% and 85%, respectively.

Designing the choice set

Combining the levels of each attribute presented in Table 1 while excluding the level of 0 from the price attribute yielded a total of 1024 ($= 4 \times 4 \times 4 \times 4 \times 4$) alternatives. It would be impossible for the respondents to evaluate all these alternatives. Even if the respondents were forced to make 1024 value judgments, they would be likely to make inaccurate judgments because there are too many alternatives. In this case, the number of alternatives that respondents should evaluate needed to be reduced through the orthogonal design method. This reduction is a conventional process that is almost always adopted in applied CE studies (Mariel et al. 2021).

Applying the main effect orthogonal design produced a total of 16 alternatives. Of these, two were randomly extracted eight times without replacement, resulting in a total of eight choice sets. A business-as-usual (BAU) alternative means that the current state was added to each choice, which consisted of a total of three alternatives. The choice sets were randomly distributed into two bundles. In other words, each bundle contained four choice sets. All the interviewees were then randomly divided into two groups. The first bundle and the second bundle were presented to the first group and the second group in the questionnaire, respectively. In the CE survey, the interviewees facing each choice set chose their most preferred alternative. Therefore, all the interviewees

| | Alternative A | Alternative B | Alternative C |
|--------------------------|-----------------------------------|----------------------------------|---------------|
| Expressways | 3% (Protecting 1,052 birds) | 7% (Protecting 2,454 birds) | 0% |
| General roads | 4% (Protecting 7,908 birds) | 4% (Protecting 7,908 birds) | 0% |
| Public buildings | 2.5% (Protecting 5,084 birds) | 5% (Protecting 10,169 birds) | 0% |
| Private buildings | 0.2% (Protecting 14,844 birds) | 0.1% (Protecting 7,422 birds) | 0% |
| Price | KRW 1000 | KRW 10000 | KRW 0 |

Please check the most preferred one with V among Alternatives A, B, and C.

Fig. 1 A sample choice set used in this research

performed a total of four choice tasks. Figures 1 and 2 illustrate a choice set.

Implementation of the CE survey

To obtain data objectively and neutrally, a professional survey agency (Research Prime), which is located in Seoul, conducted the CE survey. Prior to conducting the survey, the initial version of the questionnaire was sufficiently modified by a supervisor belonging to the agency. For example, the sentences presented in the questionnaire and explanatory materials were modified to easier expressions and sufficient photographic materials were added. In addition, specific expected effects for each attribute were additionally described in the CE choice card presented to respondents. The subsequent survey was implemented in two stages: a preliminary survey and a main survey. Through a preliminary survey of about 30 people, the clarity and understanding of the draft questionnaire were intensively checked. In addition, open-ended questions about WTP were asked to determine the levels of the price attribute. The final version of the questionnaire was confirmed, with the level of the price attributes reflecting the main results of the preliminary survey.



The survey was conducted during June 2021. Data on 1000 households nationwide was obtained. Interviewees

were selected by the survey agency by applying the method of extraction in proportion to the population by gender, age, and region. At this time, the 2015 census data, the most recent data collected by the National Statistical Office, were used. The unit of the survey was the household, and the interviewees were extracted as the household head or spouse of the head aged 20 to 65. In the CE survey, they were asked to make value judgments on behalf of their household rather than expressing their personal views. Therefore, the information on the economic benefits discussed later was derived from the perspective of individual households.

The survey method was face-to-face individual interviews in which interviewers belonging to the agency visited the interviewees’ house and implemented the questionnaire. Compared with telephone and Internet interviews, individual interviews may have the disadvantage of high costs. However, the authors judged individual interviews to be an appropriate method to induce CE value judgment responses effectively while helping the respondents to understand the good to be valued. Since the survey took place during the COVID-19 pandemic, the survey was conducted with both interviewers and interviewees making every effort to prevent infection. In the process of conducting the survey, visual aids such as pictures, photos, and diagrams were also presented as shown in the “Appendix” section.

Fig. 2 A sample choice set used in this research



| Artificial Structures | | | Number of bird collision accidents |
|----------------------------|---|-----------|------------------------------------|
| Buildings |  | 7,126,526 | 7,649,030 |
| Transparent noise barriers |  | 1,421km | 232,779 |

| Attributes | Current status | Number of bird collision accidents |
|---|----------------|------------------------------------|
| Transparent noise barriers on expressways | 214km | 35,047 |
| Transparent noise barriers on general roads | 1,207km | 197,732 |
| Public building | 190,075 | 206,524 |
| Private building | 936,451 | 7,442,506 |

RUM theory

RUM theory was developed by McFadden (1974) and is largely composed of two parts. First, the core of RUM theory is that the utility arising from the consumption of the chosen alternative is greater than or equal to the utility arising from the consumption of any other alternative when a consumer

selects one among several alternatives. As such, RUM theory is quite intuitive. By generalizing this decision-making process, the situation in which interviewee *p* chooses alternative *q* among *K* alternatives can be expressed as follows:

$$U_{pq} \geq U_{pk} \text{ for all } k \neq q (k = 1, \dots, K) \tag{1}$$

where U_{pq} is the utility that interviewee p enjoys from consuming alternative q , and U_{pk} is the utility that interviewee p enjoys from consuming any other alternative k .

In this way, individuals are often placed in a multinomial choice situation in which they choose one of several alternatives. For example, an individual must choose one of the available transportation modes, such as bus, taxi, subway, or walking, when traveling to a destination. As another example, people have to choose one of the various foods for lunch every day. RUM theory is quite useful in modeling these decisions.

The second part of RUM theory involves a consumer’s utility generated from consuming a good or service, which consists of observable and unobservable components. The former and the latter are also referred to as the deterministic and the stochastic component, respectively. Thus, the utility arising from interviewee p consuming alternative q can be expressed as follows:

$$U_{pq} = V_{pq} + \mu_{pq} \tag{2}$$

where V_{pq} is an observable or deterministic component and is a function of the attributes of alternative q chosen by interviewee p and their characteristics, and μ_{pq} is an unobservable or stochastic component.

Assuming that V_{pq} is a linear function of attributes, following conventional practice in the literature, U_{pq} can be rewritten as follows:

$$U_{pq} = \alpha_1 A_{q1} + \alpha_2 A_{q2} + \alpha_3 A_{q3} + \alpha_4 A_{q4} + \alpha_5 A_{q5} + \mu_{pq} \tag{3}$$

where alternative q is composed of five attributes: expressway, road, public, private, and price, as presented in Table 1, and $\alpha_1, \alpha_2, \alpha_3, \alpha_4,$ and α_5 are the parameters corresponding to the level of the five attributes, $A_1, A_2, A_3, A_4,$ and $A_5,$ respectively.

Applying Roy’s identity from microeconomics to Eq. (3) and omitting subscript q for simplicity, the marginal WTP for each attribute can be derived as follows:

$$MWTP_j = -\frac{\partial A_5}{\partial A_j} = -\frac{\alpha_j}{\alpha_5} \text{ for } j = 1, \dots, 4 \tag{4}$$

Estimation of the utility function

McFadden (1974) proposed a multinomial logit model (MNL) that can be used to estimate Eq. (3). In the MNL model, the stochastic component, μ_{pq} , is assumed to follow independent and identical type I extreme value distribution. The MNL model is widely applied in the literature because Eq. (3) can easily be estimated by applying the maximum likelihood estimation method if this assumption is met. However, the MNL model makes two restrictive assumptions.

First, as indicated by Hausman and McFadden (1984), independence of irrelevant alternatives (IIA) is assumed. This assumption is often violated and not satisfied. Therefore, it may be desirable to apply a model that does not adopt the IIA assumption.

Second, preference homogeneity is assumed. In other words, the parameters of the utility function are assumed to be the same for each respondent (Hess et al., 2005; Hynes et al. 2008, 2021). If the preference homogeneity assumption is satisfied, the parameters of the utility function are fixed values, and thus, there is no need to define the distribution of each parameter. However, this assumption can be too restrictive. If preference heterogeneity is allowed, the parameter of the utility function becomes a random variable. That is, the coefficients for the attribute presented in Eq. (3) become random coefficients.

Therefore, it is necessary to consider a model that allows preference heterogeneity or random coefficients without making IIA assumptions. The mixed logit (MXL) model suggested by Train (2009) is one of the representative models that meet this requirement. The respondents’ preference heterogeneity is explicitly reflected in the MXL model, which considers the coefficient for each attribute as a random variable (Hensher and Greene, 2003). In this regard, this study estimates the utility function by applying the MXL model. The probability of an interviewee choosing alternative q is modeled as follows:

$$\Pr(q) = \int \frac{\exp(V_q)}{\sum_{j=1}^K \exp(V_j)} f(\alpha|\delta) d\alpha \tag{5}$$

where $f(\alpha|\delta)$ is a possibility density function (pdf), δ being a vector of parameters corresponding to a vector of variables, α . Normal pdf is most commonly used, and other types of pdf, such as log normal pdf, are sometimes used (Revelt and Train 1998).

Results and discussion

Data and utility function estimated in this study

As explained above, five attributes, as presented in Table 1, were used. Expressway, road, public, private, and price indicate the percentage of transparent noise barriers with bird collision prevention tapes on expressways, the percentage of transparent noise barriers with bird collision prevention tapes on general roads, the percentage of public buildings with glass windows with bird collision prevention tapes, the percentage of private buildings with glass windows with bird collision prevention tapes, and the additional increase in yearly income tax per household, respectively.

The utility function shown in Eq. (3) has the disadvantage of not reflecting respondent heterogeneity. Therefore, in this study, to reflect respondent heterogeneity explicitly in the utility function, an alternative-specific constant (ASC) was added. The ASC has a value of 1 and a value of 0 when the BAU alternative is selected and when it is not selected, respectively. Adding the ASC, α_p , to Eq. (3) produces the following equation:

$$U_{pq} = \alpha_p + \alpha_1 A_{q1} + \alpha_2 A_{q2} + \alpha_3 A_{q3} + \alpha_4 A_{q4} + \alpha_5 A_{q5} + \mu_{pq} \tag{6}$$

To reflect respondent heterogeneity further, several covariates associated with respondents’ socioeconomic characteristics can additionally be considered (Yoo et al. 2008). Five covariates were considered in this study: gender, age, education, income, and knowledge: definitions and explanations of these covariates are reported in Table 2. The gender variable has a value of 0 when the interviewee is male and 1 when the interviewee is female. The proportion of women and men was exactly the same. The age, education, and income variables refer to the interviewee’s age, with an average value of 48.1 years, the education level of the interviewee in years, and the average monthly income of the interviewee’s household, with a sample average of KRW 5.22 million (USD 4.46 thousand), respectively. The knowledge variable refers to whether the interviewee had heard of bird collisions with artificial structures before the survey, with 71% of all interviewees responding “yes.”

A total of four observations were obtained per interviewee because each interviewee made a total of four value judgments. In the four observations for the same interviewee, the values of the covariates were the same, resulting in a problem of identification. That is, the coefficients of the covariates were not estimated. A common way to solve this problem is to add the cross-product term of the covariate and the ASC to the utility function. This approach was also applied in this study. Thus, Eq. (6) is a utility function without covariates, and the following equation is a utility function including covariates:

$$U_{pq} = \alpha_p + \alpha_1 A_{q1} + \alpha_2 A_{q2} + \alpha_3 A_{q3} + \alpha_4 A_{q4} + \alpha_5 A_{q5} + \alpha_{p1} \alpha_p \cdot Gender_p + \alpha_{p2} \alpha_p \cdot Age_p + \alpha_{p3} \alpha_p \cdot Education_p + \alpha_{p4} \alpha_p \cdot Income_p + \alpha_{p5} \alpha_p \cdot Knowledge_p + \mu_{pq} \tag{7}$$

Results

The second and third columns of Table 3 contain the estimation results of Eqs. (6) and (7), respectively. The total number of observations is 4000 (= 4 × 1000). In Table 3, information on the distribution function of each coefficient used in this study is also presented. The types of distribution functions were determined through the following process. First, when estimating the model without covariates, it was assumed that all the coefficients follow a normal distribution. However, this was not reasonable because the coefficient for the public variable was estimated to be negative. In addition, the coefficients for the private variable were not statistically significant.

Thus, the distribution of coefficients for these two variables was changed from a normal distribution to a log-normal distribution. This produced reasonable signs and statistical significance at the 1% level for all the estimated coefficients in the model without covariates. The coefficients for all four attributes, excluding the price attribute, have positive signs, which is reasonable because it means that people’s utility increases as the number of artificial structures with bird collision prevention tapes increases. In addition, the estimated coefficient for the price attribute is negative, which is also reasonable because it implies that people’s utility decreases as income tax increases.

Second, in the model with covariates, it was assumed that all of the estimated coefficients for the five added terms follow a normal distribution while maintaining the same distribution function of the five attribute variables and the estimation coefficient for the ASC term in the model without covariates. Looking at the estimation results, not only are all the estimated coefficients statistically meaningful at the 1% level but also the sign itself is reasonable. The coefficients of both the ASC·gender term and the ASC·age term were estimated to be positive. This means that

Table 2 Variables adopted in this research

| Variables | Definitions | Mean | Standard deviation |
|-----------|---|-------|--------------------|
| Gender | The interviewee’s gender (0 = male; 1 = female) | 0.50 | 0.50 |
| Age | The interviewee’s age | 48.14 | 9.64 |
| Education | The interviewee’s education level in years | 14.36 | 2.12 |
| Income | The interviewee’s household’s monthly income before tax deduction (unit: million Korean won) | 5.22 | 209.69 |
| Knowledge | Dummy for the interviewee’s recognizing the bird collisions before the survey (0 = no; 1 = yes) | 0.71 | 0.45 |

Table 3 Estimation results of the models

| Variables ^a | Model without covariates | | | Model with covariates | | |
|------------------------|--------------------------|----------------------------------|--------------------------------------|-----------------------|----------------------------------|--------------------------------------|
| | Assumed distribution | Mean of the coefficient estimate | Variance of the coefficient estimate | Assumed distribution | Mean of the coefficient estimate | Variance of the coefficient estimate |
| ASC ^b | Normal | − 26.1290** | 3165.26** | Normal | 12.1300** | 2308.85** |
| Expressway | Normal | 0.9480** | 09.53** | Normal | 2.2260** | 82.36** |
| Road | Normal | 0.4140** | 10.60** | Normal | 0.7760 | 59.07** |
| Public | Log-normal | 2.3410** | 759.45** | Log-normal | 3.9450** | 2022.74** |
| Private | Log-normal | 22.9580** | 19,340.55** | Log-normal | 63.7870** | 307,411.99** |
| Price | Normal | − 17.7560** | 508.16** | Normal | − 49.3720** | 4680.91** |
| ASC•gender | | | | Normal | 16.0310* | 7894.15** |
| ASC•age | | | | Normal | 3.3220* | 661.66** |
| ASC•education | | | | Normal | − 14.3380* | 11,207.20** |
| ASC•income | | | | Normal | − 34.0880* | 72,814.62** |
| ASC•knowledge | | | | Normal | 3.2240 | 2433.66** |
| Log-likelihood | − 3021.38 | | | − 2929.45 | | |
| Number of observations | 4000 | | | | | |

^aThe variables are defined in Tables 1 and 2

^bASC refers to an alternative-specific constant that represents a dummy for the interviewee’s choosing business-as-usual alternative. * and ** indicate statistical significance at the 5% and 1% levels, respectively

Table 4 Yearly household marginal willingness to pay (MWTP) estimates for each attribute from the model without covariates

| Attributes ^a | MWTP estimates |
|-------------------------|-------------------------------|
| Expressway | KRW 534 (USD 0.46) per %p |
| Road | KRW 233 (USD 0.20) per %p |
| Public | KRW 1318 (USD 1.13) per %p |
| Private | KRW 12,930 (USD 11.05) per %p |

^aThe attributes are explained in Table 1. At the time of the survey, USD 1.0 was approximately equal to 1170 Korean won

a female or older interviewee choosing the BAU alternative has greater utility than a male or younger interviewee. On the other hand, the coefficients of the ASC-education and ASC-income terms were estimated to be negative. In other words, for those who chose the BAU alternative, the higher the education level or the higher the income level, the lower the utility.

By combining the results presented in Table 3 with Eq. (4), the MWTP for a unit improvement in each attribute could be estimated. It was important in making this estimation to determine which one of the estimation results of Eqs. (6) and (7) to use. In the case of the model with covariates, the estimation result varies depending on how the set of covariates was selected; thus, the MWTP value for each attribute also varies. Therefore, this study used the estimation results of Eq. (6), free from the influence of the covariates, and estimated the MWTP for each attribute. Table 4 summarizes the MWTP estimation results for each attribute.

The MWTP for transparent noise barriers on expressways, which means the WTP for an increase (1%p) in the percentage of transparent noise barriers with bird collision prevention tapes on expressways, was computed to be KRW 534 (USD 0.46) per household per annum. The MWTP for transparent noise barriers on general roads was KRW 233 (USD 0.20). The MWTP for glass windows of public buildings was KRW 1318 (USD 1.13), and the MWTP for glass windows of private buildings was KRW 12,930 (USD 11.05). These MWTP estimation results are listed in order of size: glass windows in private buildings, glass windows in public buildings, transparent noise barriers on expressways, and transparent noise barriers on general roads.

Discussion of the results

In this section, the results are discussed in two ways. First, some implications derived from the results reported in Table 4 are considered. If the government’s financial resources are infinite, all projects that generate benefits can be implemented. However, since the government always faces budget constraints, it has to prioritize various projects. As can be seen from the information on the attributes presented in Table 1, in this study, four structures were set to be managed where bird collisions occur. By combining Table 1 and Table 4, the annual WTP per household to save 1000 birds by implementing the bird collision prevention policy could be calculated for each structure. The process and results of the calculation of this value are presented in Table 5.

Table 5 Willingness to pay (WTP) for saving 1000 birds for each artificial structure

| Artificial structures ^a | WTP for an increase of 1%p in the percentage of artificial structures with bird collision prevention tapes per year per household in Korean won (A) | Number of birds that save lives (B) | WTP for saving 1000 birds per year per household in Korean won (1000 × A/B) |
|------------------------------------|---|-------------------------------------|---|
| Expressway | 534 | 351 | 1,521.4 |
| Road | 233 | 1977 | 117.9 |
| Public | 1318 | 2034 | 648.0 |
| Private | 12,930 | 74,220 | 174.2 |

^aThe artificial structures are explained in Table 1. At the time of the survey, USD 1.0 was approximately equal to 1170 Korean won

The first column of Table 5 reports the four kinds of structures. The second column presents the values obtained in Table 4. Column 3 contains the number of birds saved by the bird collision prevention policy corresponding to column 2. In column 4, the annual household WTP values for implementing bird collision prevention to save 1000 birds are provided. Looking at the values presented in the last column, concerning the policy enforcement targets, people placed economic value on preventing bird collision in the order of expressways, public buildings, private buildings, and general roads.

It is necessary to establish whether these rankings are consistent with the government's policy direction. Currently, the government prioritizes the implementation of the bird collision prevention project on expressways. Surprisingly, the results presented in Table 5 are exactly consistent with this. In addition, among the four structures, general roads have the lowest priority for the bird collision prevention policy, and the results of this study are consistent with this. Since attaching bird collision prevention tapes to private buildings, which are private property, is somewhat troublesome, public buildings have a higher priority than private buildings, which the results of this study support well. The WTP for public buildings is about 3.7 times larger than that for private buildings. Therefore, the results of this study are consistent with the government's ongoing pilot project to prevent bird collisions and the government's policy direction. It

can be seen that the current government policy is consistent in terms of public preference and direction. This is an interesting discovery from this study.

Second, by expanding the results presented in Table 4 to the population, information on the total economic benefits could be derived. To this end, this study arbitrarily created three alternative scenarios related to bird collision prevention. The WTP for realizing these three scenarios, or the economic benefits arising from the realization of these three scenarios, was calculated. According to Statistics Korea, South Korea had 20,573,060 households in 2021. When expanding the information on the sample to the population, this value was used. The specific contents of each scenario and the process of computing the economic benefits are shown in Table 6.

The proportions of bird collision prevention tape installation were different for the four structures: expressways, general roads, public buildings, and private buildings. Scenarios A, B, and C indicate that the levels of each attribute have a combination of (7%, 4%, 1%, 0.1%), (3%, 1%, 5%, 0.3%), and (5%, 2%, 2.5%, 0.2%), respectively. The household WTP and national economic benefits for scenario A were calculated to be KRW 7281 (USD 6.22) and KRW 150 billion (USD 128 million) per annum, respectively. Those for scenario B are KRW 12,304 (USD 10.52) and KRW 253 billion (USD 216 million), respectively, and those for scenario C are KRW 9017 (USD 7.71) and KRW 186 billion (USD 159 million), respectively.

Table 6 Hypothetical scenarios of preventing bird collisions

| Attributes ^a | Scenario A | Scenario B | Scenario C |
|--|-----------------------------------|-----------------------------------|-----------------------------------|
| Expressway | 7% expansion | 3% expansion | 5% expansion |
| Road | 4% expansion | 1% expansion | 2% expansion |
| Public | 1% expansion | 5% expansion | 2.5% expansion |
| Private | 0.1% expansion | 0.3% expansion | 0.2% expansion |
| Yearly household economic benefits arising from a scenario | KRW 7281 (USD 6.22) | KRW 12,304 (USD 10.52) | KRW 9017 (USD 7.71) |
| Yearly national economic benefits arising from a scenario ^b | KRW 150 billion (USD 128 million) | KRW 253 billion (USD 216 million) | KRW 186 billion (USD 159 million) |

^aThe attributes are explained in Table 1. At the time of the survey, USD 1.0 was approximately equal to 1170 Korean won

^bSouth Korea had 20,573,060 households at the time of the survey

As the final step, the cost–benefit analysis for conducting a project of attaching bird collision prevention tapes to 1% of the four structures was attempted. The related cost for one building or 1 km of transparent noise barriers on a road was estimated to be KRW 15 million. Therefore, the cost involved in this project amounts to about KRW 1069 billion. The annual national WTP is about KRW 309 billion. This value is an annual benefit that occurs once a year during the period 2021–2025, a total of five times. Concerning the cost–benefit analysis, the Korea Ministry of Strategy and Finance has adopted two guidelines to use 4.5% as the social discount rate and to set the present value of costs and benefits at the end of the previous year.

All the cost and benefit values can be recalculated as present values as of the end of 2020 using this discount rate. The detailed process of recalculation is reported in Table 7. Table 8 summarizes the results of calculating the net present value, benefit/cost ratio, and internal rate of return as indicators of the cost–benefit analysis using the information presented in Table 6. These values are KRW 332.93 billion, 1.33, and 22.7%, which definitely exceed 0, 1.0, and 4.5%, respectively. Therefore, the implication is that this project needs to secure economic feasibility and be implemented immediately.

Conclusions

As bird deaths from collisions with artificial structures have recently emerged as a social issue in South Korea, this subject has attracted people’s interest. As the income level of South Koreans has increased, they have become interested not only in human welfare but also in the welfare of animals, in which they previously had no interest. Consequently, the government plans to expand the implementation of the bird collision prevention policy in the future. The core of the policy is to attach tapes to the glass windows of buildings and transparent soundproof wall windows to prevent collisions. Information on the economic benefits of the implementation is required. This research aimed to estimate the economic benefits ensuing from enforcing the bird collision prevention policy by applying a CE, an SP

Table 8 Summary of the results from the economic feasibility analysis

| Benefit/cost ratio | Net present value | Internal rate of return |
|--------------------|---------------------|-------------------------|
| 1.33 | KRW 332,933 million | 22.7% |

technique. More specifically, four objects for implementing the policy were selected as attributes, and data were collected by conducting a nationwide CE survey of 1000 households.

It is judged that this article can contribute to the literature from the perspective of policy as well as research. First, from a research perspective, to the best of the authors’ awareness, this study was the first attempt in the literature to estimate the economic benefits of implementing the bird collision prevention project. In particular, a CE, one of the SP techniques, was successfully applied. The respondents readily accepted the hypothetical market set up in the CE survey, and the main estimation results secured statistical significance at the significance level of 1%. In addition, to improve the rigor of the CE analysis, the utility function was derived by estimating the MXL model explicitly reflecting preference heterogeneity and not requiring IIA assumptions. However, it may be considered that there is an unpublished master’s thesis estimated in Canada in 2010 that the average annual WTP for reducing bird window collisions is USD 31 per household. If the unpublished master’s thesis is published as a literature, significant implications can be derived by comparing the results of this study and its results.

Second, from a policy perspective, the main results of the study had important implications. Through consultation with policy officials of the Korea National Institute of Ecology, the structures subject to bird collision prevention tape attachment were identified as consisting of four types: transparent noise barriers on expressways, transparent noise barriers on general roads, glass windows in public buildings, and glass windows in private buildings. For each of these four structures, the economic benefits of improving the ratio of the tape-attached building by 1%p were estimated. The results were in the order of private buildings, public buildings, expressways, and general roads. In the survey, respondents were not presented with information such

Table 7 Values for annual benefits and costs

| Year | Benefits ^a | | Costs ^a | | Net benefits ^a | |
|------|-----------------------|---------------|--------------------|---------------|---------------------------|---------------|
| | Current value | Present value | Current value | Present value | Current value | Present value |
| 2021 | 308,904 | 295,602 | 1,069,192 | 1,023,150 | − 760,288 | − 727,548 |
| 2022 | 308,904 | 282,873 | | | 308,904 | 282,873 |
| 2023 | 308,904 | 270,692 | | | 308,904 | 270,692 |
| 2024 | 308,904 | 259,035 | | | 308,904 | 259,035 |
| 2025 | 308,904 | 247,881 | | | 308,904 | 247,881 |
| Sum | 1,544,522 | 1,356,084 | 1,069,192 | 1,023,150 | 475,330 | 332,933 |

^aThe unit of the values is million Korean won. At the time of the survey, USD 1.0 was approximately equal to 1170 Korean won

as government policy priorities or budget allocation for various bird collision prevention projects. Therefore, the results of this study are the value of each attribute judged by the public regardless of the government policy direction. Of course, the public opinion may not be the truth, but it must be important information from the perspective of policymakers and decision-makers.

In addition, the economic benefits of preventing 1000 bird collisions for each structure were calculated in the order of expressways, public buildings, private buildings, and general roads. It was found that this order was generally consistent with the priorities of the government's investment in the attachment of tapes. These findings can be used as important references in prioritizing related budget inputs for each structure. For example, the cost–benefit analysis performed on a project of attaching bird collision prevention tapes to 1% of the total structures indicated that the economic feasibility of the project was secured and the project should be conducted.

Appendix

Visual aids used to describe bird collision to respondents.



Acknowledgements The authors would like to express our deepest gratitude to Young-Jun Kim, director of the animal management lab.

Author contribution This paper was written through the collaboration of the three authors. Chang-Min Kim prepared the survey instruments and analyzed and interpreted the collected data. Ju-Hee Kim estimated the model, interpreted the estimation methods, and wrote a significant portion of the paper. Seung-Hoon Yoo proposed the research ideas, secured the necessary budget for the survey, and supervised the entire process of the study. All authors read and approved the final manuscript.

Data availability The datasets used in the study are available from the corresponding author on reasonable request.

Code availability The code used in the study is available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

References

- Aanesen M, Armstrong C, Czajkowski M, Falk-Petersen J, Hanley N, Navrud S (2015) Willingness to pay for unfamiliar public goods: preserving cold-water coral in Norway. *Ecol Econ* 112:53–67
- Adamowicz W (1995) Alternative valuation techniques: a comparison and movement towards a synthesis in K Willis and J Corkindale eds *Environmental Valuation: New Perspectives* Oxford: CAB International
- Ahmed A, Masud MM, Al-Amin AQ, Yahaya SRB, Rahman M, Akhtar R (2015) Exploring factors influencing farmers' willingness to pay (WTP) for a planned adaptation programme to address climatic issues in agricultural sectors. *Environ Sci Pollut Res* 22:9494–9504
- Alcon F, Marín-Miñano C, Zabala JA, de-Miguel MD, Martínez-Paz JM (2020) Valuing diversification benefits through intercropping in Mediterranean agroecosystems: a choice experiment approach. *Ecol Econ* 171:106593
- American Bird Conservancy (2020) Legislation to reduce bird collisions passes the U.S. house of representatives. <https://abcbirds.org/article/Bird-Safe-Buildings-Act-Passes-US-House-of-Representatives> Accessed 20 July 2022
- Bersisa M, Heshmati A, Mekonnen A (2021) Households' willingness to pay and preferences for improved cook stoves in Ethiopia. *Environ Sci Pollut Res* 28:58701–58720
- Bing GC, Choi CY, Nam HY, Park JG, Hong GP, Sung JK, Choi YB (2012) Causes of mortality in birds at stopover islands. *Korean J Ornithol* 19:23–31
- Boyle KJ, Desvousges WH, Johnson FR, Dunford RW, Hudson SP (1994) An investigation of part-whole biases in contingent-valuation studies. *J Environ Econ Manage* 27:64–83
- Drewitt AL, Langston RH (2008) Collision effects of wind-power generators and other obstacles on birds. *Ann N Y Acad Sci* 1134:233–266

- Hanley N, Czajkowski M (2019) The role of stated preference valuation methods in understanding choices and informing policy. *Rev Environ Econ Policy* 13:248–266
- Hanley N, MacMillan D, Wright RE, Bullock C, Simpson I, Parsisson D, Crabtree B (1998) Contingent valuation versus choice experiments: estimating the benefits of environmentally sensitive areas in Scotland. *J Agric Econ* 49:1–15
- Hausman J, McFadden D (1984) Specification tests for the multinomial logit model. *Econometrica* 52:1219–1240
- Hensher DA, Greene WH (2003) The mixed logit model: the state of practice. *Transportation* 30:133–176
- Hess S, Bierlaire M, Polak JW (2005) Estimation of value of travel-time savings using mixed logit models. *Transp Res Part A Policy Pract* 39:221–236
- Huh SY, Shin J (2018) Economic valuation of noise pollution control policy: does the type of noise matter? *Environ Sci Pollut Res* 25:30647–30658
- Hynes S, Chen W, Vondolia K, Armstrong C, O'Connor E (2021) Valuing the ecosystem service benefits from kelp forest restoration: a choice experiment from Norway. *Ecol Econ* 179:106833
- Hynes S, Hanley N, Scarpa R (2008) Effects on welfare measures of alternative means of accounting for preference heterogeneity in recreational demand models. *Am J Agric Econ* 90:1011–1027
- Jin J, Wang W, He R, Gong H (2017) Valuing health risk in agriculture: a choice experiment approach to pesticide use in China. *Environ Sci Pollut Res* 24:17526–17533
- Johnston RJ, Boyle KJ, Adamowicz W, Bennett J, Brouwer R, Cameron TA, Hanemann WM, Hanley N, Ryan M, Scarpa R, Tourangeau R, Vossler CA (2017) Contemporary guidance for stated preference studies. *J Assoc Environ Resour Econ* 4:319–405
- Khan SU, Khan I, Zhao M, Chien H, Lu Q, Ali MAS, Khan AA, Fahad S (2019) Spatial heterogeneity of ecosystem services: a distance decay approach to quantify willingness to pay for improvements in Heihe River Basin ecosystems. *Environ Sci Pollut Res* 26:25247–25261
- Kim JH, Kim Y, Yoo SH (2021) Using a choice experiment to explore the public willingness to pay for the impacts of improving energy efficiency of an apartment. *Qual Quant* 55:1775–1793
- Kim JH, Yoo SH (2020) Public perspective on the environmental impacts of sea sand mining: evidence from a choice experiment in South Korea. *Resour Policy* 69:101811
- Klem D Jr (1990) Collisions between birds and windows: mortality and prevention (Colisiones de pájaros con ventanas: mortalidad y prevención). *J Field Ornithol* 61:120–128
- Klem Jr D (2007) Avian mortality at windows: the second largest human sources of bird mortality on earth. Pages 244–251 in T DRich, C. Arizmendi, D. Demarest, and C. Thompson, editors. *Tundra to tropics: connecting birds, habitats and people*. Proceedings of the 4th International Partners in Flight Conference, 3–16 February 2008, McAllen, Texas University of Texas-Pan American Press, Edinburg, Texas, USA
- Klem Jr D (2008) Avian mortality at windows: the second largest human source of bird mortality on earth. In *Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics* (Vol. 244251).
- Korea Ministry of Environment (2021) A project to support bird collision prevention tape for buildings and transparent soundproof walls in 2021 (in Korean)
- Korea National Institute of Ecology (2018) A study on establishing the measures to prevent the death of wild birds by artificial structures. Korea Ministry of Environment (in Korean)
- Kwak SY, Yoo SH, Kwak SJ (2010) Valuing energy-saving measures in residential buildings: a choice experiment study. *Energy Policy* 38:673–677
- Lancaster KJ (1966) A new approach to consumer theory. *J Polit Econ* 74:132–157
- Lee HJ, Yoo SH, Huh SY (2020) Public perspectives on reducing the environmental impact of onshore wind farms: a discrete choice experiment in South Korea. *Environ Sci Pollut Res* 27:25582–25599
- Lim SY, Kim HJ, Yoo SH (2018) Assessing the external benefits of contaminated soil remediation in Korea: a choice experiment study. *Environ Sci Pollut Res* 25:17216–17222
- Loss SR, Will T, Marra PP (2014a) Estimation of annual bird mortality from vehicle collisions on roads in the United States. *J Wildl Manage* 78:763–771
- Loss SR, Will T, Marra PP (2014b) Refining estimates of bird collision and electrocution mortality at power lines in the United States. *PLoS ONE* 9:e101565
- Loss SR, Will T, Marra PP (2015) Direct mortality of birds from anthropogenic causes. *Annu Rev Ecol Evol Syst* 46:99–120
- Machtans C, Wedeles C, Bayne E (2013) A first estimate for Canada of the number of birds killed by colliding with building windows. *Avian Conserv Ecol* 8:6
- Mariel P, Hoyos D, Meyerhoff J, Czajkowski M, Dekker T, Glenk K, Jacobsen JB, Liebe U, Olsen SB, Sagebiel J, Thieme M (2021) Environmental valuation with discrete choice experiments: guidance on design, implementation and data analysis. Springer, Dordrecht, Netherlands
- McFadden D (1974) Conditional logit analysis of qualitative choice models. *Frontiers in Econometrics*
- Mitchell RC, Carson RT (1989) *Using Surveys to Value Public Goods: The Contingent Valuation Method*, Resources for the future: Washington DC, USA.
- Naturing (2022) Investigation of wild bird window collision. <https://www.naturing.net/m/2137/summary>. Accessed 2 January 2022.
- Rebolo-Ifrán N, Di Virgilio A, Lambertucci SA (2019) Drivers of bird-window collisions in southern South America: a two-scale assessment applying citizen science. *Sci Rep* 9:1–10
- Revelt D, Train K (1998) Mixed logit with repeated choices: households' choices of appliance efficiency level. *Rev Econ Stat* 80:647–657
- Riding CS, O'Connell TJ, Loss SR (2021) Multi-scale temporal variation in bird-window collisions in the central United States. *Sci Rep* 11:1–12
- Train KE (2009) *Discrete choice methods with simulation*. Cambridge University Press
- Uribe-Morfin P, Gómez-Martínez MA, Moreles-Abonce L, Olvera-Arteaga A, Shimada-Beltrán H, MacGregor-Fors I (2021) The invisible enemy: understanding bird-window strikes through citizen science in a focal city. *Ecol Res* 36:430–439
- Yoo SH, Kwak SJ, Lee JS (2008) Using a choice experiment to measure the environmental costs of air pollution impacts in Seoul. *J Environ Manage* 86:308–318

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.