

Full Length Research Paper

A model for evaluating recreation benefits with reference dependent preference

Tadahiro Okuyama^{1*} and Yasuhisa Hayashiyama²

¹Department of Regional Policy, Faculty of Economics, University of Nagasaki, 123 Kawashimo-cho, Sasebo-Shi, Nagasaki, 858-8580; Japan.

²Faculty of Economics and Management, Tohoku University, 980-8576, Aoba-ku, Sendai, Miyagi, Japan.

Received 24 May, 2015; Accepted 27 July, 2015

In environmental valuation studies, it is commonly assumed that a utility arises from an absolute amount of environmental quality. This criterion, called absolute evaluation, is used in methods including the travel cost method and the contingent valuation method. Studies in experimental economics, however, have indicated that an individual's criterion depends on reference dependent preference (RDP)—a relative evaluation—rather than absolute evaluation. This criterion is used mainly in analysis of biases such as framing effects or brand choice. The purpose of this paper is to construct a model for evaluating recreational benefit with RDP. The model focuses mainly on RDP for an environmental quality so as not to conflict with the axiom of choices, and the travel cost method is used as the model's basis. First, a structure of utility function is discussed and the benefit with RDP is defined and analyzed based on the relation between the level of RDP and the magnitude of the benefit. Second, the calculating formula of the benefit is derived by the integrating-back method and tests for consistency between the results of static analysis and the numerical example are performed.

Key words: Benefit analysis, environmental quality, reference dependent preference, travel cost method.

INTRODUCTION

In environmental economics, it is a common assumption that a utility arises from the amounts of consuming a good and of an environmental quality (Freeman III et al., 2014). For example of the environmental quality, nitrogen or sulfur dioxide is used as index of air quality; biochemical oxygen demand or phosphorus as water quality; area or a number of species as forest or wetland qualities. Here, the weak complementarity assumption

that the increment of an environmental quality leads to the increment of the amount of demand enables researchers to measure the positive or negative benefit of the environmental quality change (Mäler, 1974). Thus, most environmental valuation studies have employed this assumption for valuation methods (Bockstael and McConnell, 2007; Freeman III et al., 2014). The travel cost method (hereafter TCM) is representative of this

*Corresponding author. E-mail: okuyama@sun.ac.jp. Tel./Fax: +08-956-47-6121.

JEL classification: Q26, Q51.

Authors agree that this article remain permanently open access under the terms of the [Creative Commons Attribution License 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

tendency because it relies on the assumption that there is a closed relationship between the amount of the recreational demand and the level of recreation site's environmental quality (Shrestha et al., 2002; Herriges et al. 2004; Phaneuf and Siderelis, 2003; Whitehead et al., 2009).

However, some experimental studies in economics and psychology pointed out that an individual's decision making is influenced by reference dependent preference (RDP), which has three characteristics. First, a visitor's behavior is influenced by facts including the reference point constructed by that visitor's previous purchase, knowledge, or initial endowment of a good. Second, a visitor's utility (value) function may enter the negative dimension (this is called a loss). Therefore, a visitor's preference is non-transitive. Third, a visitor's utility function is convex in the negative dimension. This is called loss aversion.

The purposes of this paper are 1) to formulate a recreation behavior model with RDP for environmental quality and 2) to formulate an application model for benefit calculation. As for the base model, the travel cost method is employed.

This form of preference was presented in the prospect theory by Kahneman and Tversky (1979) and Tversky and Kahneman (1991). In environmental valuation studies, RDP is a plausible cause of biases such as a framing effect ⁱ, a status quo bias ⁱⁱ, and an endowment effect ⁱⁱⁱ. These biases occur most often when a stated preference method (SPM) is used for valuing an environmental quality ^{iv}.

As for the theoretical studies, Munro and Sugden (2003) improved the (prospect) theory of Tversky and Kahneman (1991) and added restrictions to the preference condition to express an exogenous reference point. Bowman et al. (1999) used a gain-loss function to express RDP and analyzed the effect when the reference point is endogenously determined. Kőszegi and Rabin (2006) analyzed the effect of the reference level of consumption under uncertainty in the case that the reference points are exogenously determined. In empirical studies, Bateman et al. (1997) tested the impact of reference dependent preference on the exchange of private goods by experimental methods, and Herne (1998) estimated the property of loss aversion. Peters (2012), Zeisberger et al. (2012), and Li and Ling (2015) did recent empirical or theoretical studies on the RDP. Barberis (2013) describes the review on the prospect theory. These studies assumed RDP for the goods, discussed the form (preference structure) of individuals' utility (value) function, and performed empirical tests by experimental methods.

Some empirical studies on the visitor behavior with RDP in markets have examined RDP on prices. The reference point of this RDP is called a reference price, and a visitor purchases an item as the result of comparing the prices of goods with the reference prices.

A fundamental discussion on visitor behavior with RDP is offered by Winer (1986). It is called the reference price model (RPM) and is based on the assimilation contract theory (Sherif, 1963) and the adaptation level theory (Helson, 1964). A visitor gets a utility from the difference between the actual price and the reference price. A visitor's demand is also influenced by this difference. Winer (1986), Mayhew and Winer (1992), Lattin and Bucklin (1989), Greenleaf (1995), Ren et al. (2014) and Kumar (2014) conducted empirical studies and confirmed the reference price effect for purchasing a good.

Putler (1992) considered a visitor behavior theory for the RPM by using Kalman's (1968) utility function, which includes the prices of goods as a RDP variable (reference price) in its function. Putler (1992) considered the formulation of reference price effect in utility function and analyzed the substitution and income effect of reference price for the Marshallian and Hicksian demand functions. Putler's (1992) formulation of RPM has not been applied for bundles of goods. Thus, at least, it can be assumed that a visitor's preference satisfies the transitivity for the amount of goods.

Mayhew and Winer (1992, 62) explained the formulations of the internal and external reference prices; The internal reference price is the "prices stored in memory on the basis of perceptions of actual, fair, or other price concepts," thus, "people adapt to the level of past stimuli and judge new stimuli in comparison with the adaptation level." The external reference point is the one "provided by observed stimuli in the purchase environment." For example, "Point of purchase shelf tags that contain information about suggested retail price or the actual or unit price of another product against which a price can be compared."

The argument on the reference point of RPM relates to the discussion on RDP in experimental studies in the sense that the internal or external reference points are formed whether they are determined exogenously or endogenously. As the structures of a reference price in RPM, Bell and Bucklin (1999) assumed the (internal) reference price as a reference price from a visitor's previous purchase occasion; Emery (1970), Hardie et al. (1993), and Kalyanaram and Little (1994) assumed that the *present* reference point is the weighted average of the *past* prices of the item and/or the weighted average between the *past* price and the individual's *past* reference point.

The above arguments can be summarized as follows. The first is that although RDP has been confirmed in SPM or experimental studies, few have considered revealed preference methods (e.g., TCM) even if RDP is observed in RPM. The second is that although the reference price effect has been empirically indicated, few studies have considered the effect of RPD for the qualities of goods in a visitor's behavior ^v. In environmental valuation studies, because a main focus point is how changes in quality influence benefits, it is

useful for another analysis to consider recreation behavior with RDP.

The main hypothesis of this study is that a reference point (similar to RDP) for an environmental quality exists and relates closely to recreation behavior. Let us imagine a visitor's decision making when he or she chooses between recreation sites A and B (e.g., river A and river B), and the sites have similar qualities as Q_a and Q_b . Traditional recreation model assuming a single trip states that if an individual prefers Q_a to Q_b , he or she will choose to go to site A; his or her utility is defined as $u(Q_a)$. However, visitors can often be heard complaining 1) "This place was not as good as the last one", or, 2) "I have already been to that place, so let's go to a different one." These situations mean that the visitor does not judge the quality of sites in absolute terms. It is possible to consider that there is a reference point in the visitor's preference structure, e.g., the first case would relate the case that utility arises from $u(Q_a - Q')$ where Q' is the quality of the previous site, and the second case would relate the case that utility arises from $u(Q_a, Q_b - Q')$, where Q_b is the previously visited site and $Q' = Q_b$.

The organization of this study is as follows. Firstly, a visitor behavior model with the RDP is considered and analysis focuses on the relationship between RDP and demand, followed by the analysis of the benefits of RDP defined following the concept of welfare measures, and static analyses for the relationship between RDP and benefit. These analyses focus on the relationship between the position of the RDP (gain or loss) and the magnitude of the benefit because it is a fundamental consideration similar to price or income in empirical welfare studies. Also, an estimation model is considered and the total value is derived by an integrating-back approach (Larson 1992, Eom and Larson 2006, and von Haefen 2007), and numerical examples are performed to confirm consistency of the estimation model with the static analysis. Finally, the results and the unresolved issues of this study are discussed.

MATERIALS AND METHODS

Utility maximization problem with reference dependent preference

Formulation of reference dependent preference on environmental quality

In this section, a visitor's recreation activity with RDP is considered by following the consumer behavior model formulated by Putler (1992). A Main difference is that RDP consists of price in Putler (1992)'s model but quality in this model. First, the formulations of RDP are considered. Let z be the amount of a composite good and x be the number of recreation activities for a recreation site.

Respectively, the prices of these goods are p_z and p_x . Let Q be an environmental quality in a site in which a political project is

assumed to be implemented. Finally, a reference point (exactly to say, reference quality) to be compared with Q be considered. In this study, let RQ be the reference quality, and the value gained from comparing Q and RQ is the relative value.

Putler (1992), who also modeled the reference price effect^{vi}, broke the visitor's judgment on RDP into three stages. In the first stage, the visitor judges the level of relative value by comparing Q and RQ . In the second stage, the visitor evaluates the level. This means that the visitor evaluates the degree of relative value before evaluating it as his or her utility. In the third stage, the evaluated relative value is reflected in the visitor's utility function.

As for the first stage, let $DR = (-\infty, +\infty)$ be the domain of relative values and RE be an element of DR . RE is a gain when $RE \in DR^+$, and this means that a visitor judges $RE = Q - RQ > 0$. RE is a loss when $RE \in DR^-$, and this means that a visitor judges $RE = Q - RQ < 0$. Finally, RE is zero when $RE = Q - RQ = 0$. Let "zero" be included in gains for the sake of simplicity. In formulations, the notation g means $RE \in DR^+$, the notation l means $RE \in DR^-$, and the notation 0 means $RE = 0$.

In this study, RQ is assumed to be endogenously determined. For example, RQ consists of the average of all (homogeneous) environmental qualities (e.g., quality indicators of a river) that the visitor already knows. Thus, $Q - RQ > 0$ means that the environmental quality (Q) is judged to be *relatively* better than the (aggregate) qualities which this visitor has experienced or knows about. Otherwise, $Q - RQ < 0$ means that the environmental quality (Q) is judged to be relatively worse than the visitor's experience or knowledge.

Equation (1) represents gain, equation (2) represents loss, and equation (3) represents a dummy function for gain and loss because the visitor cannot experience gain and loss at the same time.

$$g = I \cdot (Q - RQ) \text{ if } Q - RQ \geq 0 \tag{1}$$

$$l = (1 - I) \cdot (Q - RQ) \text{ if } Q - RQ < 0 \tag{2}$$

$$I = \begin{cases} 1 & Q \geq RQ \\ 0 & Q < RQ \end{cases} \tag{3}$$

For the second stage, the evaluation for gain and loss, let $E(\cdot)$ be an evaluation function. The evaluation functions for gain and loss are represented as equation (4).

$$E(g, l) = \begin{cases} E_g(g) & Q > RQ \\ 0 & Q = RQ \\ E_l(l) & Q < RQ \end{cases} \tag{4}$$

$$E_g(g) > 0, \lim_{g \downarrow 0} E_g(g) = 0, E_l(l) < 0, \lim_{l \uparrow 0} E_l(l) = 0 \tag{5}$$

Equation (4) implies that the evaluation would be different for gain and loss. Equation (5) is the conditions on the limit in which case

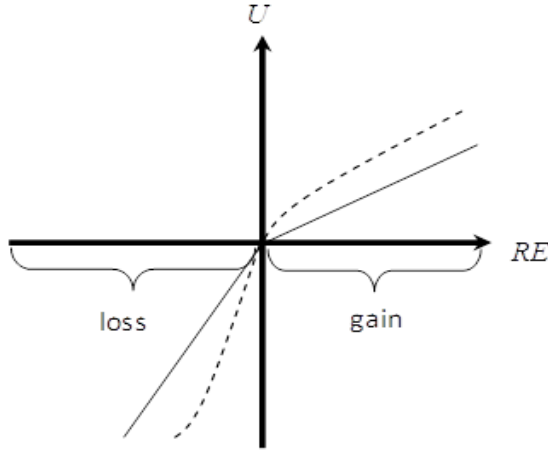


Figure 1. Example of the utility function with RDP.

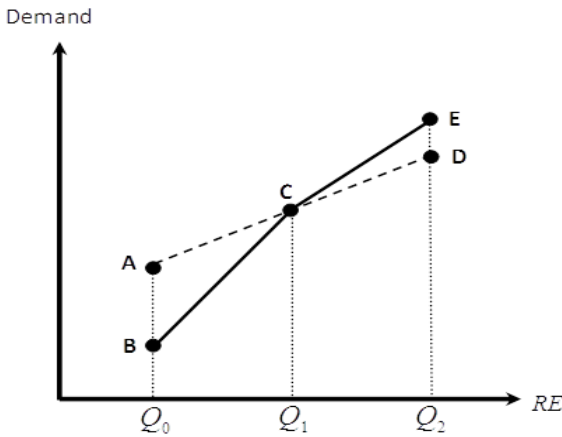


Figure 2. Recreation demand and reference dependent preference.

the utility function considered below becomes a traditional utility function that includes the absolute value of environmental quality only when the relative level is equal to zero^{vii}.

Here the recreation demand is x . So if a visitor uses the environmental quality x times, then he or she acquires the $x \cdot E(\cdot)$ amount of relative value. Let G be total gain and L be total loss defined as $G = x \cdot E_g(\cdot)$ and $L = x \cdot E_l(\cdot)$. Then, a visitor's utility function is defined as equation (6)^{viii}. Equation (6) implies that a visitor has preferences based on both absolute evaluation (Q) and relative evaluation (G, L). Thus, the visitor's utility function becomes the traditional one from equation (5) when $G = L = 0$.

$$U \equiv u(z, x, Q, G, L) \tag{6}$$

Here, $\partial^n U / \partial \omega^n$ denotes the n -times differentiation for variable $\omega \in \{z, x, Q, G, L, RQ, g, l\}$. As for the first and second

differentiations, the notations U_ω and $U_{\omega\omega}$ are also used for simplicity. The differentiated condition is a general one for z, x, Q , and G Twice differentiable; first differentiation is positive, and second one is negative or zero^{ix} (i.e. $\partial U / \partial z \equiv U_z > 0$, $\partial^2 U / \partial z^2 \equiv U_{zz} \leq 0$). The notations of differentiations on other functions follow these notations.

The property of loss (l) is considered by following an example of utility function that has the property of loss aversion (Figure 1). The dotted line is the utility function (value function) illustrated in Tversky and Kahneman (1991) and the solid line is the simplified case of the dotted line for an empirical analysis (of demand function) discussed above. In Figure 1, the first derivatives for losses in both cases are the same as the gain ($U_l > 0$). The second derivative for losses is summarized as $u_{ll} \geq 0$ ^x. Finally, differential conditions of a reference quality from the utility function are that $\partial U / \partial RQ \Big|_{RE \in DR^+} = -u_g < 0$ and $\partial^2 U / \partial RQ^2 \Big|_{RE \in DR^+} = u_{gg} \leq 0$ for the area of gains, and $\partial U / \partial RQ \Big|_{RE \in DR^-} = -u_l < 0$ and $\partial^2 U / \partial RQ^2 \Big|_{RE \in DR^-} = u_{ll} \leq 0$ for the area of losses. Figure 1 also illustrates that the increase of RQ correlates with the decrease of RE .

Utility maximization problem

From equation (6), the utility maximization problem is defined as equation (7). The Marshallian demand function for recreation activity is derived as equation (8). Notice that the demand is zero if a visitor's utility is negative when RE is a loss. Thus, the utility is assumed not to be negative even in the case of loss and the demand is a positive value^{xi}.

$$\text{Max}_{z,x} u(z, x, Q, G, L) \text{ s.t. } y = p_z z + p_x x \tag{7}$$

$$x^m = x^m(p_z, p_x, y, Q, g, l) \tag{8}$$

As for the Marshallian demand function, the weak complementarity defined below is assumed to hold for the environmental quality (Q), RE (even at gains and losses), and the recreation demand. From the complementarity, the Marshallian demand function increases when the environmental quality or RE increases. Otherwise the demand decreases when the reference quality increases.

To observe the difference between traditional demand functions and this model, Figure 2 illustrates a relation between the demand and the quality. Let the line from A to D be the line in which RDP is zero, namely, $Q - RQ = 0$ for all points on the line (this demand function is equivalent to the one from traditional economic theory since it is equivalent to assume $Q - RQ = 0$ with the absolute value of environmental quality only from equation (5)).

Next, let C be the point at which $Q_1 - RQ = 0$, and let B be the other point at which the quality is less than the point C ($Q_0 < Q_1 = RQ$). $Q_0 < RQ = 0$ implies that RE is at loss. Thus, the demand at point B is less than at point A because point A is the point at which RE is zero. Similarly, let E be the point at which the quality is greater than point C ($Q_1 < Q_2$). This implies

that RE is at gain. Thus, the demand at E is greater than the one at point D because point D is the point at which RE is zero. As a result, the demand function with RDP is the line BCE. As for the case in which Q is fixed and RQ increases, the change of the demand is symmetrical to the case of Figure 2 because the increase of RQ implies RE decreases (goes to loss) from the definition. As a result, the first derivatives of the demand function for RE are $\partial x^m(\cdot)/\partial g > 0$ and $\partial x^m(\cdot)/\partial l > 0$, and the second derivatives $\partial^2 x^m(\cdot)/\partial g^2 \leq 0$ and $\partial^2 x^m(\cdot)/\partial l^2 \geq 0$ are supposed (See Appendix A). So, the properties of RDP in the demand function are assumed to be equivalent to those of RDP in the utility function. In empirical studies, Winer (1986) and Putler (1992) employed the linear form and Suzuki et al. (2001) employed the logistic form to estimate demand functions. In addition, Suzuki et al. (2001) set $(\partial x^m(\cdot)/\partial g)/(\partial x^m(\cdot)/\partial l) < 1$ to test the loss aversion in the demand function^{xii}.

Finally, the indirect utility function is derived as $V = u(z^m(\cdot), x^m(\cdot), Q, g, l) = v(p_z, p_x, y, Q, g, l)$ and the expenditure function is derived as $y = e(p_z, p_x, U, Q, g, l)$.

Utility minimization problem and the Slutsky equation

Utility minimization problem

By a similar process, the utility minimization problem is defined as equation (9) and the Hicksian demand function is derived as $x^h = x^h(p_z, p_x, U, Q, g, l)$ ^{xiii}. Equation (10) is assumed to hold for $x^m(\cdot)$, $x^h(\cdot)$, and $e(\cdot)$. Finally, Shephard's Lemma ($\partial y / \partial p_x = x^h(\cdot)$) is assumed to hold.

$$\text{Min}_{z,x} p_z z + p_x x \text{ s.t. } \bar{U} = u(z, x, Q, g, l) \quad (9)$$

$$x^h = x^m(p_z, p_x, Q, g, l, e(\cdot)) \quad (10)$$

Let the first derivative of environmental quality for the Marshallian demand function be equation (11), that for the Hicksian demand function be equation (12), and that for the expenditure function be equation (13). In equation (13), $\partial e(\cdot)/\partial Q < 0$ is assumed (Mäler, 1974). The Slutsky equation is derived from equation (10) as equation (14). In equation (14), the first term is the substitute effect; the second term is the income effect; and the third and fourth terms are the gain/loss effects. In this study, the gain/loss effect is assumed to be positive.

$$\frac{\partial x^h}{\partial Q} = \frac{\partial x^m(\cdot)}{\partial Q} + I \frac{\partial x^m(\cdot)}{\partial g} + (1-I) \frac{\partial x^m(\cdot)}{\partial l} \quad (11)$$

$$\frac{\partial x^h}{\partial Q} = \frac{\partial x^h(\cdot)}{\partial Q} + I \frac{\partial x^h(\cdot)}{\partial g} + (1-I) \frac{\partial x^h(\cdot)}{\partial l} \quad (12)$$

$$\frac{\partial y}{\partial Q} = \frac{\partial e(\cdot)}{\partial Q} + I \frac{\partial e(\cdot)}{\partial g} + (1-I) \frac{\partial e(\cdot)}{\partial l} \quad (13)$$

$$\begin{aligned} \frac{\partial x^h}{\partial Q} &= \frac{\partial x^m(\cdot)}{\partial Q} + \frac{\partial x^m(\cdot)}{\partial y} \frac{\partial e(\cdot)}{\partial Q} + I \left[\frac{\partial x^m(\cdot)}{\partial g} + \frac{\partial x^m(\cdot)}{\partial y} \frac{\partial e(\cdot)}{\partial g} \right] \\ &+ (1-I) \left[\frac{\partial x^m(\cdot)}{\partial l} + \frac{\partial x^m(\cdot)}{\partial y} \frac{\partial e(\cdot)}{\partial l} \right] \end{aligned} \quad (14)$$

Static analysis on the Slutsky equation

Next the derivatives of RE for each function are considered. As for the indirect utility function, the first derivatives are $\partial V / \partial g > 0$, $\partial V / \partial l > 0$ and the second derivatives assume $\partial^2 V / \partial g^2 \leq 0$, $\partial^2 V / \partial l^2 \geq 0$. Those lead to the first derivatives of the expenditure function as $\partial y / \partial g < 0$, $\partial y / \partial l < 0$ and to the second derivatives as $\partial^2 y / \partial g^2 \leq 0$, $\partial^2 y / \partial l^2 \geq 0$ (See Appendix B). Therefore, equation (15) holds. Equation (15) indicates that the amount of expenditure at a loss is greater than at zero, and the expenditure at zero is greater than at a gain.

$$e(\cdot, l) > e(\cdot, 0) > e(\cdot, g) \quad (15)$$

Next, the derivatives of the reference quality are considered. The first derivative of the Marshallian demand function is equation (16); it is negative because $\partial x^m(\cdot)/\partial g > 0$ and $\partial x^m(\cdot)/\partial l > 0$. The first derivative of the expenditure function is equation (17); it is positive because $\partial e(\cdot)/\partial g < 0$ and $\partial e(\cdot)/\partial l < 0$. The first derivative of the Hicksian demand function is equation (18); whether it is positive or negative depends on the gain/loss effect. If the gain/loss effect is assumed to be positive, equation (18) is negative.

$$\frac{\partial x^m}{\partial RQ} = -I \frac{\partial x^m(\cdot)}{\partial g} - (1-I) \frac{\partial x^m(\cdot)}{\partial l} \quad (16)$$

$$\frac{\partial y}{\partial RQ} = -I \cdot \frac{\partial e(\cdot)}{\partial g} - (1-I) \cdot \frac{\partial e(\cdot)}{\partial l} \quad (17)$$

$$\begin{aligned} \frac{\partial x^h}{\partial RQ} &= -I \cdot \left[\frac{\partial x^m(\cdot)}{\partial g} + \frac{\partial x^m(\cdot)}{\partial y} \frac{\partial e(\cdot)}{\partial g} \right] \\ &- (1-I) \cdot \left[\frac{\partial x^m(\cdot)}{\partial l} + \frac{\partial x^m(\cdot)}{\partial y} \frac{\partial e(\cdot)}{\partial l} \right] \end{aligned} \quad (18)$$

Finally, the total effects on the demands and the expenditure from the increase of environmental quality and the reference point are calculated by equation (19) from equations (11), (13), (14), (16), (17) and (18). Then, it is summarized as equation (20).

$$\begin{aligned} \frac{\partial x^m}{\partial Q} + \frac{\partial x^m}{\partial RQ} &= \frac{\partial x^m(\cdot)}{\partial Q}, \\ \frac{\partial y}{\partial Q} + \frac{\partial y}{\partial RQ} &= \frac{\partial e(\cdot)}{\partial Q}, \\ \frac{\partial x^h}{\partial Q} + \frac{\partial x^h}{\partial RQ} &= \frac{\partial x^m(\cdot)}{\partial Q} + \frac{\partial x^m(\cdot)}{\partial y} \frac{\partial e(\cdot)}{\partial Q} \end{aligned} \quad (19)$$

$$\frac{\partial y}{\partial Q} + \frac{\partial y}{\partial RQ} = \frac{[\partial x^h / \partial Q + \partial x^h / \partial RQ] - [\partial x^m / \partial Q + \partial x^m / \partial RQ]}{\partial x^m(\cdot) / \partial y} \quad (20)$$

Corollary 1. If the increase of both the environmental quality and the reference point is equivalent, then the increase of (Hicksian) demands and the expenditure are equal to the increase of both function in which assume only absolute value of Q . That is, the marginal benefit with RDP is equivalent to the marginal benefit without RDP (the traditional benefit).

Equation (19) implies that RDP does not influence the amount of demand and expenditure if the environmental quality and the reference quality increase or decrease by the same degree. Equation (20) summarizes the total effect for the marginal benefit. The values of the first and the second parentheses on the right side are equal to the value without RDP. Thus, the benefit with RDP is equivalent to the benefit without RDP.

Finally, the choke price and the weak complementarity are considered. The choke price p_x^* is defined as equation (21), which implies that the choke price is the price at which the Hicksian demand is zero. Notice that the Hicksian demand includes a gain and a loss. Next, the weak complementarity is generally defined as $\partial e(\cdot) / \partial Q|_{p_x^*} \equiv 0$. However, the expenditure function of this model includes the gain and loss effect as equation (13). The modified version of the weak complementarity is defined as equation (22).

$$p_x^* \equiv \min \{ p_x | x^h(\cdot) = 0 \} \quad (21)$$

$$\left. \frac{\partial e(\cdot)}{\partial Q} \right|_{p_x^*} + I \cdot \left. \frac{\partial e(\cdot)}{\partial g} \right|_{p_x^*} + (1-I) \cdot \left. \frac{\partial e(\cdot)}{\partial l} \right|_{p_x^*} \equiv 0 \quad (22)$$

Definition of benefit and static analysis

Definition of total value

It is necessary to differentiate between situations in which a project is implemented and those in which no project is implemented to define the benefit from the change of an environmental quality with RDP^{xiv}. Let $s = wO$ be the superscript representing the quality level at which a project is implemented and $s = W$ be the one at which no project is implemented. Using the notation, the utility function (and other variables) are rewritten as $U^s = u(z^s, x^s, Q^s, G^s, L^s)$. Note that a visitor does not experience a gain and a loss at the same time, so RE differs based on whether or not the project is implemented. For example, in one case, RE gains when $s = wO$ and it will also gain when $s = w$; however, in another case, RE decreases when $s = wO$ and will be at zero when $s = w$.

The benefit from quality change is defined by equivalent variation (EV) as equation (27) and compensating variation (CV) as equation (29). EV and CV can be decomposed into three kinds of benefit from income change (equations (25) and (29)), and benefit from quality change (equations (26) and (30)). This study examines only the benefit from quality change^{xv}. Thus, the total value of environmental quality (hereafter TV) is summarized as equation (31)^{xvi}. Equation (31) implies EV when $s = w$ and CV when $s = wO$.

$$EV = e(p_z^{wO}, p_x^{wO}, U^w, Q^{wO}, g^{wO}, l^{wO}) - e(p_z^{wO}, p_x^{wO}, U^{wO}, Q^{wO}, g^{wO}, l^{wO}) \quad (23)$$

$$= \{ e(p_z^{wO}, p_x^{wO}, U^w, Q^{wO}, g^{wO}, l^{wO}) - e(p_z^{wO}, p_x^{wO}, U^{wO}, Q^{wO}, g^{wO}, l^{wO}) \} \quad (24)$$

$$+ \{ e(p_z^w, p_x^w, U^w, Q^w, g^w, l^w) - e(p_z^{wO}, p_x^{wO}, U^{wO}, Q^{wO}, g^{wO}, l^{wO}) \} \quad (25)$$

$$+ \{ e(p_z^w, p_x^w, U^w, Q^{wO}, g^{wO}, l^{wO}) - e(p_z^w, p_x^w, U^w, Q^w, g^w, l^w) \} \quad (26)$$

$$CV = e(p_z^w, p_x^w, U^w, Q^w, g^w, l^w) - e(p_z^w, p_x^w, U^{wO}, Q^w, g^w, l^w) \quad (27)$$

$$= \{ e(p_z^{wO}, p_x^{wO}, U^{wO}, Q^w, g^w, l^w) - e(p_z^w, p_x^w, U^{wO}, Q^w, g^w, l^w) \} \quad (28)$$

$$+ \{ e(p_z^w, p_x^w, U^w, Q^w, g^w, l^w) - e(p_z^{wO}, p_x^{wO}, U^{wO}, Q^{wO}, g^{wO}, l^{wO}) \} \quad (29)$$

$$+ \{ e(p_z^{wO}, p_x^{wO}, U^{wO}, Q^{wO}, g^{wO}, l^{wO}) - e(p_z^{wO}, p_x^{wO}, U^{wO}, Q^w, g^w, l^w) \} \quad (30)$$

$$TotalValue = e(p_z^s, p_x^s, U^s, Q^{wO}, g^{wO}, l^{wO}) - e(p_z^s, p_x^s, U^s, Q^w, g^w, l^w) \quad (31)$$

Equation (31) includes the quality itself (Q), the gain (g), and the loss (l). Equation (31) is thus a comprehensive formulation including the absolute evaluation (the evaluation for $Q^{wO} \rightarrow Q^w$) and the relative evaluation (the evaluation for $(g^{wO}, l^{wO}) \rightarrow (g^w, l^w)$).

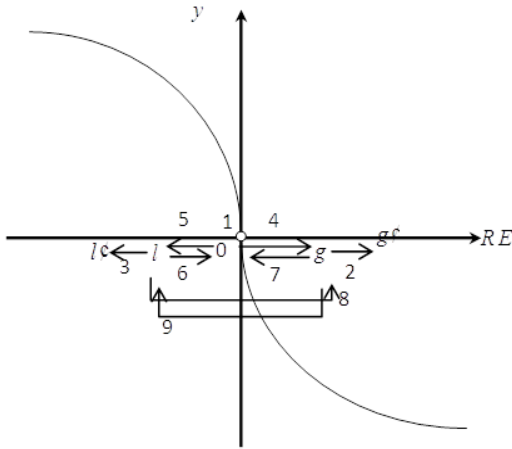
Influence of RDP for total value

Let p_z, p_x, y , and Q (the part of absolute evaluation in utility function) be fixed when $s = wO$ and $s = w$. As for locations of RE , there are three possible areas: gain, zero, and loss. Thus, there are 3x3 patterns to determine the value of TV (e.g., $TV = e(\cdot, g^{wO}) - e(\cdot, g^w)$, $TV = e(\cdot, 0^{wO}) - e(\cdot, l^w)$). Figure 3 shows these cases with a possible expenditure function. Let the origin of the arrow line correspond to the amount of expenditure when the project is not implemented (i.e., $e(\cdot, g^{wO}, l^{wO})$ in equation (31)) and the end point of the arrow line correspond to the amount of expenditure when the project is implemented (i.e., $e(\cdot, g^w, l^w)$). For example, the third case indicates the amount of expenditure change from $e(\cdot, l^{wO})$ to $e(\cdot, l^w)$, and the eighth case indicates the amount of change from $e(\cdot, l^{wO})$ to $e(\cdot, g^w)$.

In these cases, the second and fourth, third and fifth, sixth and eighth, and seventh and ninth cases mean the same changes of TV because each condition differs only in terms of whether the RE benefits: benefit from price change (equations (23) and (28)), goes from low to high or from high to low. Thus, the first, fourth, fifth, sixth, and seventh cases are considered. The case of zero to zero (first case) means there is no effect on the RE . The case of zero to gain (fourth case) means the increase of the benefit, and the case of zero to loss (fifth case) means the decrease of the benefit. The case of loss to zero (sixth case) means the increase of the benefit, and the case of gain to zero (seventh case) means the decrease of

Table 1. Benefit and positions of RE

	Without	Gain	Zero	Loss
With				
Gain		Increase	Increase	Increase
Zero		Decrease	No Effect	Increase
Loss		Decrease	Decrease	Decrease

**Figure 3.** Nine cases of relative evaluation.

the benefit. These results are summarized in Table 1.

Let us consider the implications of these benefits. In the cases in which the benefit increases, TV increases most in the case in which RE changes from a loss when $s = w0$ to a gain when $s = w$ since the difference of expenditure is biggest (that is, the eighth case in Figure 3). This case is interpreted to be a situation in which a visitor judges an objective environmental quality to be worse than other qualities (which are comprehensively denoted by RQ) when $s = w0$, and judges it to be better when $s = w$. In short, the impact of environmental quality change on a visitor's RDP is very big. The benefit is denoted by TV_{LG} and defined as equation (32).

$$TV_{LG} \equiv e(p_z^s, p_x^s, U^s, Q^{w0}, l^{w0}) - e(p_z^s, p_x^s, U^s, Q^w, g^w) \quad (32)$$

The case in which RE is zero when $s = w0$ and $s = w$ is interpreted to be a situation in which a visitor judges the quality to be equivalent to other qualities when $s = w0$ and $s = w$ because the visitor's reference quality (RQ) changes to the same degree as the quality change (Corollary 1). One example of such a situation would be of another project being implemented for other environmental quality at the same time. The benefit from this situation is denoted by TV_{00} and defined as equation (33).

$$TV_{00} \equiv e(p_z^s, p_x^s, U^s, Q^{w0}, 0) - e(p_z^s, p_x^s, U^s, Q^w, 0) \quad (33)$$

In cases in which TV decreases, TV decreases most in the case in which RE changes from a gain when $s = w0$ to a loss when

$s = w$ since the difference of expenditure is smallest (i.e., the ninth case in Figure 3). This case is interpreted to be a situation in which a visitor judges an objective environmental quality to be better than other qualities when $s = w0$, and judges it to be worse when $s = w$. One reason that a visitor might judge the quality to be worse despite environmental improvement could be that if other qualities are also improved at same time and those are more impressive to the visitor, the reference quality would increase more than the objective quality would increase. Another reason for such a judgement could be a gap between the quality change achieved by the project and the quality change the visitor imagines when $s = w0$. Therefore, the result of the project would have a negative impact for the visitor. The benefit from this situation is denoted by TV_{GL} and defined as equation (34).

$$TV_{GL} \equiv e(p_z^s, p_x^s, U^s, Q^{w0}, g^{w0}) - e(p_z^s, p_x^s, U^s, Q^w, l^w) \quad (34)$$

These results are summarized in equation (35). In addition, in the case of environmental deterioration, these inequalities became reverse (i.e. $TV_{LG} < TV_{00} < TV_{GL}$). Equation (35) implies that 1) the total value that is defined only by the absolute value of quality (TV_{00}) would be a part of the values and 2) there is a possibility that the total value can be negative even if the project aims to improve quality because there is no restriction on the reference quality change.

$$TV_{LG} > TV_{00} > TV_{GL} \quad (35)$$

Decomposition of use and non-use values and an interpretation of non-use value

The decomposition of use and non-use value is performed to investigate the relation between non-use value and RDP. Equation (31) decomposes TV into use value (equation (36)) and non-use value (equation (37)) by using the choke price (Neil, 1988; Larson, 1992).

$$TV = e(p_z^s, p_x^s, U^s, Q^{w0}, g^{w0}, l^{w0}) - e(p_z^s, p_x^s, U^s, Q^w, g^w, l^w) \\ = \left\{ \begin{array}{l} e(p_z^s, p_x^s, U^s, Q^w, g^w, l^w) - e(p_z^s, p_x^s, U^s, Q^w, g^w, l^w) \\ - \left\{ e(p_z^s, p_x^s, U^s, Q^{w0}, g^{w0}, l^{w0}) - e(p_z^s, p_x^s, U^s, Q^{w0}, g^{w0}, l^{w0}) \right\} \end{array} \right\} \quad (36)$$

$$+ \left\{ e(p_z^s, p_x^s, U^s, Q^{w0}, g^{w0}, l^{w0}) - e(p_z^s, p_x^s, U^s, Q^w, g^w, l^w) \right\} \quad (37)$$

Let us consider the definition of non-use value. Generally, the non-use value is defined from the properties of uniqueness and irreversibility (Krutilla, 1967). Regarding uniqueness, equation (37)

Table 2. Parameters.

α	β	γ_Q	γ_g	γ_l	δ	p_x	y	Q^{wo}	Q^w
-0.9534	-0.0163	0.0235	0.003	0.007	0.0526	29.91	2.384	14	17

includes the reference point so that the environmental quality is compared with others. There is a possibility that the uniqueness will not hold. However, Krutilla (1967) stated that uniqueness is not necessary condition for his argument. One reason is that there is a possibility that a similar environmental quality exists in another market which is difficult to access. Thus, a visitor can compare the objective environmental quality ^{xviii} of one place with others even if the other places are out of reach. If the existence value defined only by absolute evaluation (in this study, it is the case in which $RE = 0$) is the “pure” existence value, equation (37) would interpret the “impure” existence value.

Integrating-back approach

Von Haefen (2007) presented three methods to estimate the total value of environmental quality by market data. In this paper, the integrating-back approach is employed ^{xviii}. This approach is useful for obtaining the total value from a demand function. The central idea is to derive the quasi-expenditure function, which was developed by LaFrance (1985). Recently, Eom and Larson (2006) presented an estimation model based on the integrating-back approach. This method can calculate the use and non-use value from market data such as the formulations derived below.

Let the demand function be equation (38). Here $\tilde{Q} = \gamma_Q \cdot Q + I \cdot \gamma_g \cdot g + (1 - I) \cdot \gamma_l \cdot l$. As for the estimation, visit number (x), travel cost (p_x), income (y), and environmental quality (Q) are observed in the recreation market. In addition, other environmental qualities must be accounted for to determine the reference quality. It is necessary to research the data of visitors’ knowledge about other qualities, or their experience of sites they have visited. Then the reference quality is constructed as shown above and the data of gain (g) or loss (l) are calculated ^{xix}.

$$\ln[x(\cdot)] = \alpha + \beta p_x + \delta y + \tilde{Q} \tag{38}$$

The quasi-expenditure function is equation (39), where the constant of integration is $U \exp(\delta \tilde{Q})$ ^{xx}. The (indirect) utility function is equation (40). Let the price and the income be fixed for simplicity, and the notation s be omitted in these variables. Then the total value is derived as equation (41), where $x(\tilde{Q}^s) = \exp(\alpha + \beta p_x + \delta y + \tilde{Q}^s)$. TV consists of the demand ($x(p_x^s, y^s, \tilde{Q}^s)$) and the quality (Q^s). Finally, TV is decomposed into non-use value (NUV) as in equation (42) and use value (UV) as in equation (43).

$$e(p_x, U, \tilde{Q}) = -\frac{1}{\delta} \ln \left[\frac{-(\delta / \beta) \exp(\alpha + \beta p_x + \tilde{Q})}{-\delta U \exp(\delta \tilde{Q})} \right] \tag{39}$$

$$U = \left[-(1/\delta) \exp(-\delta y) - (1/\beta) \exp(\alpha + \beta p_x + \tilde{Q}) \right] \exp(-\delta \tilde{Q}) \tag{40}$$

$$TV = \frac{1}{\delta} \ln \left[\frac{-\frac{\delta}{\beta} x(\tilde{Q}^w) + \left[1 + \frac{\delta}{\beta} x(\tilde{Q}^{wo}) \right]}{\times \exp(\delta(\tilde{Q}^w - \tilde{Q}^{wo}))} \right] \tag{41}$$

$$NUV = \tilde{Q}^w - \tilde{Q}^{wo} \tag{42}$$

$$UV = TV - NUV = \frac{1}{\delta} \ln \left[-\frac{\delta}{\beta} x(\tilde{Q}^w) + \left[1 + \frac{\delta}{\beta} x(\tilde{Q}^{wo}) \right] \right] \tag{43}$$

Parameters for benefit calculation

A project concerning quality improvement is assumed. The simulation is focused only on the total value because non-use value is defined as merely the difference of quality change ^{xxi}.

Parameters are specified in Table 2. The parameters $\alpha, \beta, \gamma_Q, \delta, p_x$, and y are the same as those in Tables 1 and 2 of Eom and Larson (2006) (the results of estimation model for non-use value). The variables γ_g and γ_l are originally designed so as to satisfy the property of RDP of demand function ($(\partial x^m / \partial g) / (\partial x^m / \partial l) < 1$). For the quality level, Eom and Larson (2006) used biochemical oxygen demand (BOD) ^{xxii} for the estimation; $Q^{wo} = 14$ and $Q^w = 17$ are designed as these levels. Since positive utility does not arise for values (Q) under 10 in this model, the quality levels and reference qualities are set at values over than 10. Therefore, this formation cannot be used for arbitrary values of parameters. The simulation is thus performed for reference quality (RQ) ranging from 10 to 20 in one-point increases.

RESULTS AND DISCUSSION

The simulations were performed by each functions (equations (38) to (41)). The main focus of the discussion is to examine the differences between the traditional benefit calculation model and the model of this paper by analyzing the relations between RQ and TV.

Demand function

Figure 4 shows the change of the demand corresponding

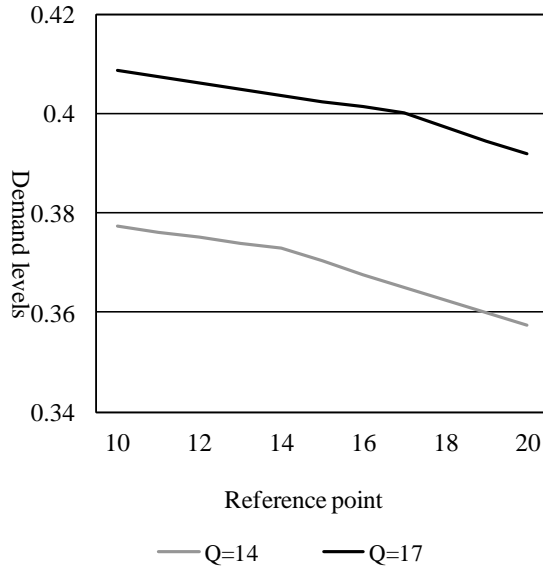


Figure 4. Reference quality and demand function.

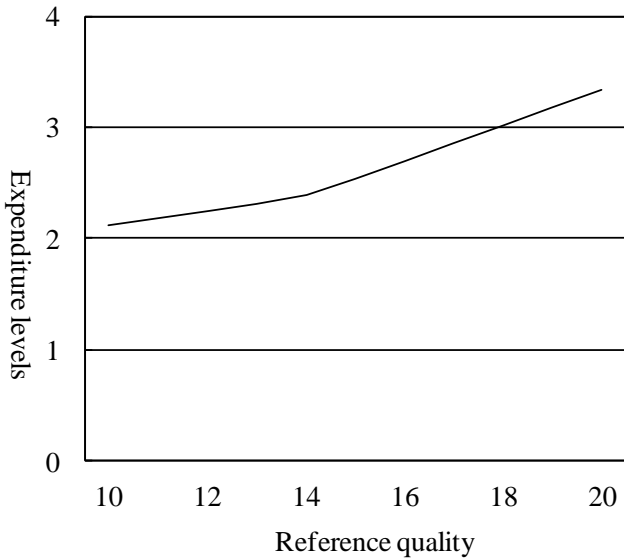


Figure 5. Reference quality and expenditure function.

to each reference point. The gray line is the demand function when the quality level is Q^{wo} and the black line is the demand function when the quality level is Q^w . The point 14 for the gray line and the point 17 for the black line are the points at which $RE = 0$ (i.e., the inflection points for each function). The inflection points are not discussed in previous section. However, this formulation is employed because it is commonly used in RPM models (for the formulation of demand function) and experimental studies (for the formulation of value function). In previous

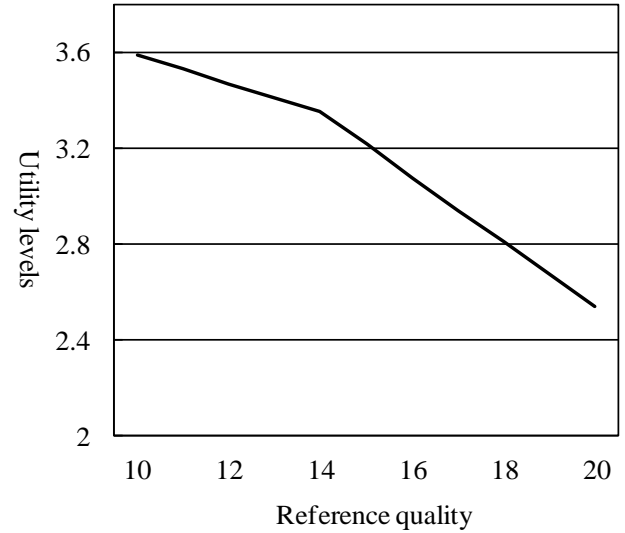


Figure 6. Reference quality and utility function.

section, the relation between the demand and RE was analyzed. The demand decreases when RE becomes negative in Figure 2. Figure 4 shows both demand levels decrease corresponding to the increase of RQ (the increase of RQ means that RE becomes negative).

This feature is the same in Figure 2.

Expenditure and utility function

The expenditure function (equation (39)) is shown in Figure 5. In previous section, the condition $\partial y / \partial RQ > 0$ is discussed (equation (17)) and it is reflected in Figure 5. Here, the U in the expenditure function is the utility at point 14 in Figure 6. As for the property of RDP, the gradient at the loss is greater than the gradient at the gain.

Similarly, the condition $\partial U / \partial RQ < 0$ for the (indirect) utility function is reflected in Figure 6. Especially, the properties of loss aversion ($\lim_{g \downarrow 0} u_g / \lim_{l \uparrow 0} u_l < 1$) are observed. That is, the properties of loss aversion in the demand function (e.g., $\gamma_g = 0.03$ and $\gamma_l = 0.07$) are also reflected in the utility function.

Benefit calculation

Figure 7 shows the change of TV corresponding to each level of reference point. The black line shows the case in which RE in the second term of equation (31) is fixed at zero and RE in the first term of equation (31) changes (exactly to say, RQ in the first term of equation (31) changes)^{xxiii}. As a result, the total value decreases

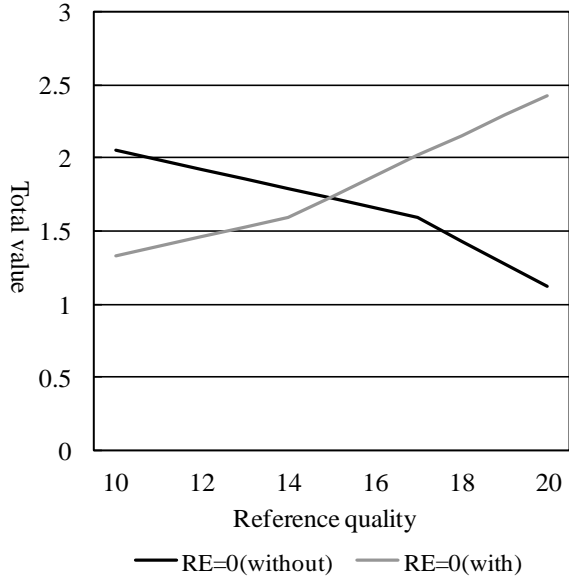


Figure 7. Reference quality and total value.

Table 3. Example for Table 1 from Figure 5.

	Without	Gain	Zero	Loss
With				
Gain		[8,10]	[7,10]	[5,10]
Zero		(1,3)	(3,3)[7,7]	[5,7]
Loss		(1,6)	(3,6)	(6,9)

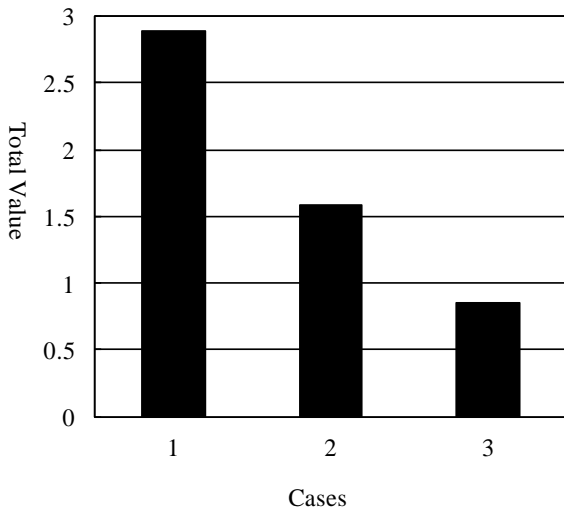


Figure 8. Relative evaluations and size of total value.

following the increase of RQ . This case corresponds to the fourth case in Figure 3. The increase of RQ in the first

term means that the value (the amount of expenditure) of the first term of equation (31) decreases, so the difference between the first and second terms of equation (31) is a decrease.

The black line also shows the relation between RE and the total value in Table 1. Let (row, column) be the element in the matrix corresponding to the row and column of Table 1. (e.g., (zero, loss) means “decrease” in Table 1). In Figure 5, for example, the difference between the value at point 3 and that at point 6 (hereafter abbreviated as (3, 6)) corresponds to (zero, loss) if the value at 3 is the one when $Q = Q^{wo}$ and the value at 6 is the one when $Q = Q^w$. Similarly, other situations can be considered (e.g., (6, 9) corresponds to (loss, loss)). Other examples are listed in Table 3.

The gray line in Figure 7 shows that RE in the first term of equation (31) is fixed and RE in the second term of equation (31) changes. As a result, the total value increases following the decrease of RQ . This case corresponds to the sixth case in Figure 3. The increase of RQ in the second term of equation (31) means that the value of the second term decreases, so the difference between the first and second terms of equation (31) is an increase (the total value increases).

The gray line also shows the relation in Table 1. Let [row, column]^{xxiv} be the element in the matrix corresponding to the row and column of Table 1 (e.g., [zero, gain] means “increase” from Table 1). In Figure 5, for example, the difference between the values at point 7 and point 10 (abbreviated as [7, 10] below) corresponds to [zero, gain] if the value (the amount of expenditure) at 7 is the one when $Q = Q^{wo}$ and the value at 10 is the one when $Q = Q^w$. Similarly, other situations can be considered (e.g., [8, 10] corresponds to [gain, gain]). Other examples are listed in Table 3.

Figure 8 shows the relation in equation (35). The situations (the amount of demand and environmental qualities when $Q = Q^{wo}$ and $Q = Q^w$) are given in Figure 7. Case 1 indicates the value of TV_{LG} when the first term of equation (32) is set as point 20 on the gray line and the second term of equation (32) is set as point 10 on the black line in Figure 7. Similarly, Case 2 indicates the value of TV_{00} when the first term of equation (33) is set as point 14 on the gray line and the second term of equation (33) is set as point 17 on the black line. Case 3 indicates the value of TV_{GL} when the first term of equation (34) is set as point 20 on the gray line and the second term of equation (34) is set as point 10 on the black line. The result of equation (35) is confirmed.

Figure 9 shows the price change and the total value. The black line is the same as in Figure 7, the gray line is the line when the price of the black line set 20, and the dotted line is the line when the price of the black line set 40. The total value decreases when the price increases.

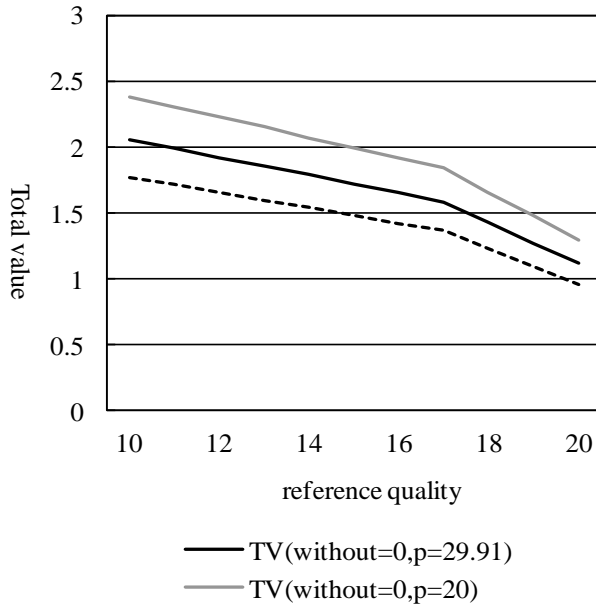


Figure 9. Price change and total value.

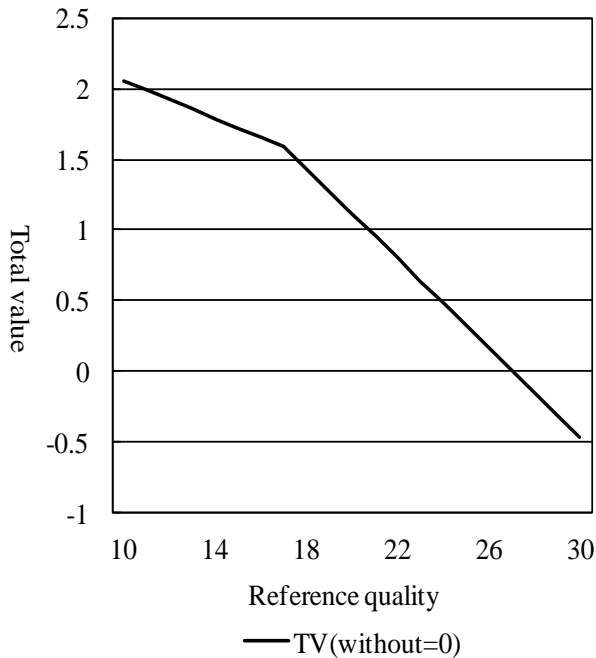


Figure 10. Extreme case of reference quality.

Finally, a problem on calculation is discussed. It is called the extreme moving to loss. Figure 10 shows the case (by using the black line from Figure 7) in which the reference quality changes extremely to loss. In this case, the value goes to negative such as at point 30 despite the project's aim of environmental improvement. This happens because there is no restriction on the value of

reference quality for $s = wo$ and $s = w$ (therefore, this case occurs in the case of the gray line, e.g., if RQ goes below 10). Thus, a boundary condition should be set for the reference quality or preference structures.

Estimation of demand function

Final section described how to estimate the demand function represented as equation (38). In estimating, an independent variable is the visit number (x); dependent variables are the travel cost (p_x) and household income (y) observed in the recreation market (or collected by a survey). The data on environmental quality (Q) in recreational sites are also used for a dependent variable. Here, the reference quality data (RQ) would be collected by asking respondents; For example, how much quality level (RQ) of the environment do you need? If $RQ < Q$, the respondents would be categorized as "gain-respondents". In the inverse case, "loss-respondents". Researchers would arbitrarily decide how to categorize the case of $RQ = Q$; either include it in gain-respondents or loss-respondents. Whether respondents' preferences are the absolute or relative valuation would be examined by comparing the demand functions; $x^m = x^m(p_z, p_x, y, Q)$ and $x^m = x^m(p_z, p_x, y, Q, g, l)$.

Conclusion

Most environmental valuation studies have employed absolute evaluation assumption for valuation methods. However, some experimental studies in economics and psychology pointed out that an individual's decision making is influenced by reference dependent preference, namely relative evaluation.

The purposes of this paper are 1) to formulate a recreation behavior model with RDP for environmental quality and 2) to formulate an application model for benefit calculation.

As for the base model, the travel cost method is employed as discussed below. First, the modeling of RDP in a visitor's utility function and the properties of RDP on demand and expenditure functions were examined. The analysis for the demand function revealed that the simultaneous changes of the environmental quality and the reference quality are equivalent to the condition in which only the absolute evaluation is considered. This implies that some effects (e.g., a framing effect) of RDP for the value of the benefit arise only when the quality and the reference point change in different directions.

Second, the definitions of the benefits and static analysis were considered. The finding was that the total value defined only by absolute evaluation is one of the

benefits that include RDP. Thus, it is necessary to determine whether the benefit (or, in terms of this study, visitor behavior) includes RDP or not. If the benefit includes RDP, then the benefit can change depending on the reference points. This paper compare the benefits 1) relative evaluation is loss before implementing a project and relative evaluation is gain after implementing a project, 2) relative evaluation is zero before implementing a project and relative evaluation is zero after implementing a project, 3) relative evaluation is gain before implementing a project and relative evaluation is loss after implementing a project. As a result, the benefit of first case is bigger that the second case and the second is bigger than the third case (equation (35)).

Third, this property was confirmed though simulations. Since the computable formulation reflects the theoretical findings, this model can be used to estimate the recreation demand function with RDP and to calculate the benefit.

Finally, some problems for empirical study should be mentioned. First, the recreation demand for a single site is assumed in this paper. However, the structure of reference quality needs the aggregation of other qualities that a visitor has already experienced or knows about. Thus, it is natural to assume there are multiple sites for recreation demand. One solution could be to use the multiple-site trip for travel cost method, e.g., the Kuhn-Tucker Model. Second, the loss effect cannot be estimated if there is no reservation utility (discussed in theoretical analysis). Since the loss effect means that the utility is at a negative value, it is possible for a visitor not to select such recreation sites. Third, if the influence of RDP is confirmed, there is a possibility that the benefit will change over a long period of time due to the change of the reference quality. Thus it may be necessary to consider the structures of RDP for a dynamic model.

Notes

- i. The framing effect is a phenomenon in which an individual's preference changes depending on how options are presented (framed) in a questionnaire (Tversky and Kahneman, 1991).
- ii. The status quo bias is a phenomenon in which an individual tends to prefer to remain at the status quo due to an aversion toward loss (Kahneman et al., 1991).
- iii. The endowment effect is a phenomenon in which an individual feels that a good has a higher value once he or she has become the owner of the good. This effect has been explained as being equivalent to status quo bias (Kahneman et al., 1991). However, since it is not clear in these studies whether or not the property right is the main component of the "status quo," these two biases are explained separately.
- iv. These biases are discussed extensively in the problem of the disparity between willingness to pay and willingness to accept. Mitchell and Carson (1989) present

cases of this disparity, and RDP is one of them. Hanemann (1991) demonstrated the cause theoretically without RDP. However, recent studies indicate RDP as the main cause of endowment effect (Horowitz and McConnell, 2002; Plott and Zeiler, 2005; Brow, 2005).

v. Suzuki et al. (2001) estimated the demand function with RDP for services' qualities in the airline market.

vi. Putler (1992) modeled the reference price effect as follows: let p be the price of a good, p^{ref} be the reference price of the good. Then the gain is $p^{ref} - p > 0$, and the loss is $p^{ref} - p < 0$. This implies that a visitor gains a utility if the price is more inexpensive than the reference point.

vii. Putler (1992) set $E(\cdot) > 0$. However, it is generally assumed that $E_g(g) > 0$ and $E_l(l) < 0$ in the utility function with RDP. Thus, those conditions are employed in such studies as Munro and Sugden (2003).

viii. In addition, since G and L are directly involved in the utility function, it may be useful to construct a utility function to assume functions F_g and F_l such as $G = F_g(x)E_g(g)$ and $L = F_l(x)E_l(l)$. An example of the Utility function is, where $F_g(x) = x^{1/2}$, $E_g(g) = 0.5 \cdot g$ and $F_l(x) = x^{1/2}$, $E_l(l) = 2 \cdot l$.

ix. As for the notation, the first derivatives are denoted as $\partial U / \partial z = u_z$, the second derivatives are denoted as $\partial^2 U / \partial z^2 = u_{zz}$, and the cross derivatives are denoted as $\partial^2 U / \partial z \partial x = u_{zx}$. Note that u_{gl} is not defined.

x. Formal conditions are based on a modified version of Bowman et al. (1999). The first is that U is strictly increasing in RE . The second is to express the relation between the marginal utility of a loss and the marginal utility of a gain, defined as $U(RE') + U(-RE') < U(RE) + U(-RE)$ for $0 < RE < RE'$. The third is to represent an assumption of diminishing marginal sensitivity defined as RE is strictly concave in $RE > 0$ and RE is strictly convex in $RE < 0$. The fourth is to represent that a person can evaluate losses even when comparing very small losses to very small gains, given that there exists a value M s.t. $\lim_{RE \rightarrow 0} (u_{RE} |_{RE \in DR^-}) / (u_{RE} |_{RE \in DR^+}) \equiv M$. In addition, if RE is the linear form, a simple condition to express loss aversion is $\lim_{g \downarrow 0} u_g / \lim_{l \uparrow 0} u_l < 1$.

xi. It is natural to think there is a value of RE' at which the value of the utility becomes positive if RE exceeds the value ($RE' < RE \rightarrow U > 0$). This implies that it is necessary to assume a reservation utility for a recreation activity (x) if a recreation activity occurs even in the case that RE is at loss. This study assumes that the absolute value of Q in the utility function will perform the role.

Thus, $u(\cdot, Q, L) > 0$ for $RE > RE'$ is assumed.

xii. Let β be each parameter. For examples, a linear form is $x = \beta + \beta_p p + \beta_y y + \beta_Q Q + \beta_g g + \beta_l l$ and a logistic form is $x = 1 / \{1 + \exp(\beta + \beta_p p + \beta_y y + \beta_Q Q + \beta_g g + \beta_l l)\}$ in the notation of this paper. The condition to express the loss aversion as $\beta_g / \beta_l < 1$ for the linear form and $-\beta_g x^m(\cdot) / -\beta_l x^m(\cdot) = \beta_g / \beta_l < 1$ for the logistic form. This implies that these demand functions must reflect the properties of utility function (although those would not be reflected exactly).

xiii. In addition, the expenditure function is defined as

$y = p_z z^h + p_x x^h$ by using the Hicksian demand function.

xiv. Whether the project is for environmental improvement or for environmental deterioration does not matter. The difference corresponds to the definition of willingness to pay and willingness to accept. However, the project is mainly assumed to be an environmental improvement project in this study, as discussed below.

xv. An additional decomposition is shown in Appendix C.

xvi. In empirical studies, equation (31) would be rewritten

as $TV = \int_{\varepsilon=Q^w}^{Q^{wo}} \partial e(\cdot) / \partial Q d\varepsilon$. It would be necessary to consider the kink at $RE = 0$ if the domain of RE changes between $s = wo$ and $s = w$. Thus, equation (31) is the definition when $e(\cdot)$ is differentiable at $RE = 0$.

xvii. He also cannot access to the objective environmental quality in the definition of equation (37). The reason why he cannot access is due to employing the choke price to define the equation. See equation (21). The choke price is defined as the price at which (Hicksian) demand is zero. This interpreted as being a situation in which a visitor cannot visit the recreation site because of high travel costs.

xviii. The related papers concerning this method are Neil (1988) and Bullock and Minot (2006). The problems are 1) there is no guarantee to derive the choke price from arbitrary functional form to determine the use value and non-use value, and 2) it is difficult to apply the method to the case of multi-site trips.

xix. For example, assume that the reference quality comes from the average of the qualities that a visitor has known. If visitor A—who plans to go to site 1, which has quality=2—knows site 2's quality=3, site 3's quality=1, and site 4's quality=5, then the visitor's reference quality is $11/4=2.75$ and $RE = 2-2.75=-0.75$. Thus, visitor A's RDP is at loss. If visitor B, who plans to go to site 5, has $RE = 5-2.75=2.25$, the RDP is at gain. For a data set, it is simple to set if a visitor's RE is at gain, then his or her data of loss is zero (Suzuki et al., 2001).

xx. Eom and Larson (2006) assumed the constant of integration as $U \exp(\delta \psi \tilde{Q})$. ψ is used to estimate the existence of non-use value. Thus, the model in this study assumes $\psi = 1$ and adds RE to their model.

xxi. In addition, the result of analysis for existence value are similar one for the total value since the difference of both definition (total value and the non-use value) are only the definition of price and the prices are fixed in each definition (See equation (31) and equation (37)).

xxii. BOD is an indicator of water pollution levels and it is generally assumed to have a negative effect on recreation demand. However, Eom and Larson (2006) used negative values of BOD for estimation. Thus, the estimated parameter is positive and is directly used for γ_Q in this study.

xxiii. In this case, the absolute value of the environmental quality is the value at point 14 because RE of the second term is fixed at zero. Similarly, the absolute value of the environmental quality is the value at point 17 in the gray bars.

xxiv. Note that parentheses () is used for black line and brackets [] is used for gray line.

Conflict of Interests

The authors have not declared any conflict of interest.

REFERENCES

- Barberis NC (2013). 'Thirty Years of Prospect Theory in Economics: A Review and Assessment', *J. Econ Perspect.* 27(1):173-196.
- Bateman I, Munro A, Rhodes B (1997). 'A Test of the Theory of Reference-Dependent Preferences', *Q J Econ.* 112(2):479-505.
- Bell DR, Bucklin RE (1999). 'The Role of Internal Reference Points in the Category Purchase Decision', *J Consum Res.* 26(2):128-143.
- Bockstael NE, McConnell KE (2007). 'Environmental and Resource Valuation with Revealed Preferences: A Theoretical Guide to Empirical Models', Springer. New York.
- Bowman D, Minehart D, Rabin M (1999). 'Loss Aversion in a Consumption Savings Model', *J. Econ. Behav. Organ.* 38(2):55-178.
- Brow TC (2005). 'Loss Aversion without the Endowment Effect, and Other Explanations for the WTA-WTP Disparity', *J. Econ. Behav. Organ.* 57(3):367-379.
- Bullock DS, Minot N (2006). 'On Measuring the Value of a Nonmarket Good Using Market Data', *Am. J. Agr. Econ.* 88(4):961-973.
- Emery F (1970). 'Some Psychological Aspects of Price', In Taylor B, Wills G (eds.) *Pricing Strategy*. Brandon/System Press pp.98-111.
- Eom YS, Larson DM (2006). 'Improving Environmental Valuation Estimates through Consistent Use of Revealed and Stated Preference Information', *J. Environ. Econ. Manage.* 52(1):501-516.
- Freeman III AM, Herriges JA, Kling CL (2014). 'The Measurement of Environmental and Resource Values: Theory and Methods (third edition)', Resource for the Future Press. Washington, DC.
- Greenleaf EA (1995). 'The Impact of Reference Effect on the Profitability of Price Promotions', *Market Sci.* 14(1):82-104.
- Hanemann WH (1991). 'Willingness to Pay and Willingness to Accept: How much can They Differ?', *Am. Econ. Rev.* 81(3):635-647.
- Hardie BGS, Johnson EJ, Fader PS (1993). 'Modeling Loss Aversion and Reference Dependence Effects on Brand Choice', *Market Sci.* 12(4):378-394.
- Helson H (1964). 'Adaptation-Level Theory', Harper and Row. New York.
- Herne K (1998). 'Testing the Reference-Dependent Model: An Experiment on Asymmetrically Dominated Reference Points', *J. Behav. Decis. Making.* 11(3):181-192.
- Herriges JA, Kling CL, Phaneuf DJ (2004). 'What's the use? Welfare estimates from revealed preference models when weak complementarity doesn't hold', *J Environ Econ Manage.* 47: 55-70.

- Horowitz JK, McConnell KE (2002). 'A Review of WTA / WTP Studies', *J. Environ. Econ. Manage.* 44(3):426-447.
- Kahneman D, Tversky A (1979). 'Prospect Theory an Analysis of Decision under Risk', *Econometrica* 47(2):263-291.
- Kahneman D, Knetsch JL, Thaler RH (1991). 'Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias', *J. Econ. Perspect.* 5(1):193-206.
- Kalman PJ (1968). 'Theory of Visitor Behavior When Prices Enter the Utility Function', *Econometrica* 36(3/4): 497-510.
- Kalyanaram G, Little JDC (1994). 'An Empirical Analysis of Latitude of Price Acceptance in Visitor Package Goods', *J. Consum. Res.* 21(3):408-418.
- Kőszegi B, Rabin M (2006). 'A Model of Reference-Dependent Preferences', *Q. J. Econ.* 121(4):1133-1165.
- Krutilla JV (1967). 'Conservation Reconsidered', *Am. Econ. Rev.* 57(4):777-786.
- Kumar MPS (2014). 'Brand Preference and Buying Decision: A Study with Reference to Organized Indian Edible Oil Brands', *Afr. J. Mark. Manage.* 6(2):17-26.
- LaFrance JT (1985). 'Linear Demand Functions in Theory and Practice', *J. Econ. Theory.* 37(1):147-166.
- Larson DM (1992). 'Further Results on Willingness to Pay for Nonmarket Goods', *J. Environ. Econ. Manage.* 23(2):101-122.
- Latrin JM, Bucklin RE (1989). 'Reference Effects of Price and Promotion on Brand Choice', *J. Market. Res.* 26(3):299-310.
- Li X, Ling W (2015). 'How Framing Effect Impact on Decision Making on Internet Shopping', *Open J. Bus. Manage.* 3:96-108.
- Mayhew GE, Winer RS (1992). 'An Empirical Analysis of Internal and External Reference Price using Scanner Data', *J. Consum. Res.* 19(1): 62-70.
- Mäler KG (1974). 'Environmental Economics: A Theoretical Inquiry', John Hopkins University Press; Baltimore.
- Mitchell RC, Carson RT (1989). 'Using Surveys to Value Public Goods: The Contingent Valuation Method', Resource for the Future Press, Washington.
- Munro A, Sugden R (2003). 'On the Theory of Reference Dependent Preference', *J. Econ. Behav. Organ.* 50(4):407-428.
- Neil JR (1988). 'Another Theorem on Using Market Demands to Determine Willingness to Pay for Non-traded Goods', *J. Environ. Econ. Manage.* 15(2):224-232.
- Peters H (2012). 'A Preference Foundation for Constant Loss Aversion', *J. Math. Econ.* 48(1):21-25.
- Phaneuf DJ, Siderelis C (2003) 'An Application of the Kuhn-Tucker Model to the Demand for Water Trail Trips in North Carolina', *Mar Resour Econ.* 18(1): 1-14.
- Plott CR, Zeiler Y (2005). 'The Willingness to Pay–Willingness to Accept Gap, the “Endowment Effect,” Subject Misperceptions, and Experimental Procedures for Eliciting Valuations', *Am. Econ. Rev.* 95(3):530-545.
- Putler D (1992). 'Incorporating Reference Price Effects into a Theory of Visitor Choice', *Market. Sci.* 11(3):287-309.
- Ren J, Zhao DM, Zhang XH (2014). 'Online Buying Decision Preference and Prospect Theory', *Adv. Mat. Res.* 926-930:3850-3853.
- Sherif CW (1963). 'Social Categorization as a Function of Latitude of Acceptance and Series Range', *J. Abnorm. Psychol.* 67(2):148-156.
- Shrestha RK, Seidl AF, Moraes AS (2002). Value of Recreational Fishing in the Brazilian Pantanal: A Travel Cost Analysis Using Count Data Models, *Ecol. Econ.* 42(1-2):289-299.
- Suzuki Y, Tyworth JE, Novack RA (2001). 'Airline Market Share and Customer Service Quality: A Reference Dependent Model', *Transport Res A-Pol.* 35(9):773-788.
- Tversky A, Kahneman D (1991). 'Loss Aversion in Riskless Choice: A Reference Dependent Model', *Q. J. Econ.* 106(4):1039-1061.
- Von Haefen RH (2007). 'Empirical Strategies for Incorporating Weak Complementarity into Visitor Demand Models', *J. Environ. Econ. Manage.* 54(1):15-31.
- Winer RS (1986). 'A Reference Price Model of Brand Choice for Frequently Purchased Products', *J. Consum. Res.* 13(2):250-256.
- Whitehead JC, Grootuis PA, Southwick R, Foster-Turley P (2009). 'Measuring the economic benefits of Saginaw Bay coastal marsh with revealed and stated preference methods', *J. Great Lakes Res.* 35(3):430-437.
- Zeisberger S, Vrecko D, Langer T (2012). 'Measuring the Time Stability of Prospect Theory Preferences', *Theory Decis.* 72(3):359-386.

Appendix A. Demand function

Let λ be the undetermined multiplier and the Lagrange equation be defined by equation (A.1). The first derivatives of equation (A.1) are summarized as equation (A.2). Let dp_z, dp_x, dy , and dQ be zero, and p_z be equal to 1. Then, the total derivative of the demand function is derived as equation (A.3) by using Cramer's rule. Here, $|A|$ is the determinant of the matrix (the first parenthesis of the left side of equation (A.2)).

$$\Omega \equiv u(z, x, Q, g, l) - \lambda(p_z z + p_x x - y) \quad (\text{A.1})$$

$$\begin{bmatrix} u_{zz} & u_{zx} & p_z \\ u_{xz} & u_{xx} & u_{xQ} \\ p_z & p_x & 0 \end{bmatrix} \begin{bmatrix} dz \\ dx \\ d\lambda \end{bmatrix} = \begin{bmatrix} \lambda dp_z - (u_{zQ} dQ + u_{zg} dg + u_{zl} dl) \\ \lambda dp_x - (u_{xQ} dQ + u_{xg} dg + u_{xl} dl) \\ dy - (z dp_z + x dp_x) \end{bmatrix} \quad (\text{A.2})$$

$$dx = \frac{1}{|A|} \{ (u_{xg} dg + u_{xl} dl) - u_{xQ} (u_{zg} dg + u_{zl} dl) \} \quad (\text{A.3})$$

The first derivatives are equation (A.4) from equation (A.3). It is necessary to hold $u_{xg} - u_{xQ}u_{zg} > 0$ for gains and $u_{xl} - u_{xQ}u_{zl} > 0$ for losses to satisfy the first differential condition discussed above. The second derivatives are equations (A.5) and (A.6). It is necessary to hold equation (A.5) as non-positive for gains and equation (A.6) as non-negative for losses to satisfy the second differential condition. These conditions are summarized as equation (A.7).

$$\frac{\partial x}{\partial g} \approx \frac{dx}{dg} = \frac{u_{xg} - u_{xQ}u_{zg}}{|A|}, \quad \frac{\partial x}{\partial l} \approx \frac{dx}{dl} = \frac{u_{xl} - u_{xQ}u_{zl}}{|A|} \quad (\text{A.4})$$

$$\frac{\partial^2 x}{\partial g^2} = \frac{\{ \partial(u_{xg} - u_{xQ}u_{zg}) / \partial g \} |A| - (u_{xg} - u_{xQ}u_{zg})(\partial|A| / \partial g)}{|A|^2} \quad (\text{A.5})$$

$$\frac{\partial^2 x}{\partial l^2} = \frac{\{ \partial(u_{xl} - u_{xQ}u_{zl}) / \partial l \} |A| - (u_{xl} - u_{xQ}u_{zl})(\partial|A| / \partial l)}{|A|^2} \quad (\text{A.6})$$

$$|A| \geq \frac{\{ \partial(u_{xg} - u_{xQ}u_{zg}) / \partial g \}}{(u_{xg} - u_{xQ}u_{zg})(\partial|A| / \partial g)}, \quad |A| \geq \frac{(u_{xl} - u_{xQ}u_{zl})(\partial|A| / \partial l)}{\{ \partial(u_{xl} - u_{xQ}u_{zl}) / \partial l \}} \quad (\text{A.7})$$

Finally, an example of demand function and the derivatives are illustrated by using the example of utility function in footnote 8; $U = z^{1/2} + x^{1/2}(Q + 0.5 \cdot g + 2 \cdot l)$. From the first derivatives of the Lagrange equation, the demand function is derived as equation (A.8), and the first and second derivatives for gains and losses are equations (A.9) and (A.10), where $B = p_x + C^{-2}p_x^2 > 0$ and $C = \{Q + 0.5 \cdot g + 2 \cdot l\} > 0$. $C = \{Q + 2 \cdot l\} > 0$ is assumed to ensure the utility is positive even if RE is at loss and the demand would be positive (see footnote 10). The first derivatives are satisfied in both gains and losses; however, the second derivatives need the conditions $p_x^2 B^{-1} C^{-2} - 1.5 \leq 0$ for gains and $4p_x^2 B^{-1} C^{-2} - 3 \geq 0$ for losses. This implies that the demand function satisfies the conditions when $3/4 \leq p_x^2 B^{-1} C^{-2} \leq 9/4$ holds.

$$x = \frac{y}{p_x + (Q + 0.5 \cdot g + 2 \cdot l)^{-2} p_x^2} \quad (\text{A.8})$$

$$\frac{\partial x}{\partial g} = 0.25 p_x^2 y B^{-2} C^{-3} > 0, \quad \frac{\partial^2 x}{\partial g^2} = 0.125 p_x^2 y [p_x^2 B^{-1} C^{-2} - 1.5] B^{-2} C^{-4} \quad (\text{A.9})$$

$$\frac{\partial x}{\partial l} = 4 p_x^2 y B^{-2} C^{-3} > 0, \quad \frac{\partial^2 x}{\partial l^2} = 8 p_x^2 y [4 p_x^2 B^{-1} C^{-2} - 3] A^{-2} B^{-4} \quad (\text{A.10})$$

Appendix B. Indirect utility and expenditure functions

The derivations of indirect utility function and expenditure function are considered. For simplicity, let the total gain and total loss be decomposed into (x, g) and (x, l) , respectively, in the utility function as in the example above. Let V be defined as equation (B.1), where * indicates the demands and the undetermined multiplier are at optimal level.

$$V \equiv u(z^*, x^*, Q, g, l) + \lambda^* (y - p_z z^* - p_x x^*) \quad (\text{B.1})$$

Then, $\partial V / \partial g$ and $\partial V / \partial l$ are equivalent to u_g and u_l by the envelope theorem. Thus, the second derivatives of the indirect utility function for losses also follow the condition of the utility function. Next, let us consider the expenditure function. As for the total differential equation of V , let the variables except for l and y be fixed. Then, $dy/dl = -u_l / \lambda^* < 0$ is derived due to $u_l > 0$, where the marginal utility of income (λ^*) is positive. The second derivative is $d(dy/dl)/dl = -u_{ll} / \lambda^* \leq 0$ due to $u_{ll} \geq 0$. By a similar process, the first derivative for gains is $dy/dg < 0$ and the second derivative is $d(dy/dg)/dg = -u_{gg} / \lambda^* \geq 0$ due to $u_{gg} \leq 0$.

Appendix C. Decomposition of total value

The decomposition of the benefits from RE and Q is considered by using equation (31). Equation (31) is decomposed into equation (C.1) and equation (C.2) by using additional expenditure $e(p_z^s, p_x^s, U^s, Q^w, g^{wo}, l^{wo})$ for (C.1) and $e(p_z^s, p_x^s, U^s, Q^w, g^w, l^w)$ for (C.2). The first term of each equation is defined as the benefit from environmental quality change since other variables are constant. Similarly, the second term of each equation is defined as the benefit from RE change. There are two ways to decompose TV.

$$TotalValue = \begin{bmatrix} e(p_z^s, p_x^s, U^s, Q^{wo}, g^{wo}, l^{wo}) \\ -e(p_z^s, p_x^s, U^s, Q^w, g^{wo}, l^{wo}) \end{bmatrix} + \begin{bmatrix} e(p_z^s, p_x^s, U^s, Q^w, g^{wo}, l^{wo}) \\ -e(p_z^s, p_x^s, U^s, Q^w, g^w, l^w) \end{bmatrix} \quad (\text{C.1})$$

$$TotalValue = \begin{bmatrix} e(p_z^s, p_x^s, U^s, Q^{wo}, g^w, l^w) \\ -e(p_z^s, p_x^s, U^s, Q^w, g^w, l^w) \end{bmatrix} + \begin{bmatrix} e(p_z^s, p_x^s, U^s, Q^{wo}, g^{wo}, l^{wo}) \\ -e(p_z^s, p_x^s, U^s, Q^{wo}, g^w, l^w) \end{bmatrix} \quad (\text{C.2})$$

The conditions are that the first term of (C.1) is equal to the first term of (C.2) and the second term of (C.1) is equal to the second term of (C.2) is $\partial e(\cdot) / \partial Q|_{RE^{wo}} = \partial e(\cdot) / \partial Q|_{RE^w}$. As for non-use value, this condition holds due to the choke price. For example, the decomposition is performed in equation (42) as the following equation.

$$NUV = [\gamma_Q \cdot Q^{wo} - \gamma_Q \cdot Q^w] + \left[\begin{array}{l} [I \cdot \gamma_g \cdot g^{wo} + (1-I) \cdot \gamma_l \cdot l^{wo}] \\ - [I \cdot \gamma_g \cdot g^w + (1-I) \cdot \gamma_l \cdot l^w] \end{array} \right]$$