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Economic Valuation Methods of Biodiversity

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Abstract

The valuation of biodiversity is a fundamental step in conservation. The useful framework for analysing the economic value of biological resources is that of total economic value (TEV) and TEV comprises both use and non-use values, the former related to an actual use made of the resource, the latter to a willingness to pay for the resource independently of any use made of it. There are several valuation approacher in environmental economics literature. However, stated preference approach should be introduced for valuation of biodiversity because it can estimate non-use value as well as use value. Contingent Valuation and Conjoint Analysis are representative methods in stated preference and Conjoint Analysis can be more useful for valuation of biodiversity. Futhermore, the combination of ecology and economics to assess biodiversity leads to an integrated framework. Thus, interdisciplinary work is required, involving both economists and ecologists transferring elements or even theories and models from one discipline to another and transforming them for their specific, mutually consistent purpose.

Keywords: Biodiversity, Economic valuation, Contingent valuation method, Conjoint analysis, Biodiversity index

1. Introduction

The Convention on Biological Diversity (CBD), which was signed at the Rio Summit in 1992 and came into effect at the end of 1993, is one of the most significant and far-reaching environmental treaties that ever have been developed. After the treaties, people began to realize the term "biodiversity". The term "biodiversity" generally refers to the number and variety of life forms that inhabit in an area. The CBD defines biodiversity as "the variability among living organism from all sources including, inter alia, terrestrial, marine and other aquatic ecosystem and the ecological complexes of which they are part". In addition US Congressional Biodiversity Act, HR 1268 (1990) proposed that biodiversity encompasses ecosystem (or community) diversity, species diversity, and genetic diversity.

- Ecosystem diversity encompasses the variety of habitats that occur within a region, or the mosaic of patches found within a landscape. A familiar example is the variety of habitats and environmental parameters that constitute the San Francisco Bay-Delta ecosystem: grasslands, wetlands, rivers, estuaries, fresh and salt water
- Species diversity is the variety and abundance of different types of organisms which inhabit an area.
- Genetic diversity is the combination of different genes found within a population of a single species, and the pattern of variation found within different populations of the same species.

Weitzman[1)] attempts to quantify diversity as the degree and distance of dissimilarity or difference between any pair of species. The preservation of biodiversity has an opportunity cost. This may be in terms of human welfare forgone or it may mean that whilst there is a greater diversity of flora and fauna, the total number of individuals in the species represented is reduced. One definition of an optimal biodiversity policy is one which yields the highest present discounted expected value of diversity. A major problem for such a definition occurs in specifying the benefits of biodiversity. Levels of biodiversity influence vital ecosystem services and thus play an important role in the maintenance of many fundamental systems and process. It is not clear, however, what levels of biodiversity are necessary to maintain these functions. Certain indications of the importance of biodiversity exist.

Pearce and Moran[2)] convincingly argues that demonstrating the value of biodiversity is a fundamental step in conservation. However, it is difficult to determine what exactly the object of value is. Extensive diversity of biological organisms renders any objective measurement problematic: diversity is not merely a function of the ultrametric distance along some taxonomic evolutionary tree and number of bifurcation nodes back to a common ancestor. There is also the question of genetic diver-

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sity within species and the interaction and role of species in forming an ecosystem. Even if a measure of biodiversity could be produced which commanded consensus, lay people would have tremendous difficulty in understanding the measure, assessing its consequences for future productive and consumptives uses, and assessing just how much benefit they derived what is a resonable cost for accepting various biodiversity measures, rather than trying to estimate what benefits biodiversity produces.

It is the objective of this study to introduce the quantitative valuation methods that are increasingly applied in general environmental issues and particularly in biodiversity. Although fairly common in the environmental economics literatures, the valuation techniques have remained somewhat peripheral to policy making on major environmental issues. The valuation of biodiversity is an essential step in conservation, because there are increasing pressures on declining biodiversity that it is likely to introduce the incentives in economic value of biodiversity.

2. What are the Economic Values of Biodiversity?

The usual framework for analysing the economic value of biological resources is that of total economic value (TEV). The TEV comprises of use and non-use value. The former related to an actual use made of the resource, and the latter related to a willingness to pay (WTP) for the resource independently of any use made of it (also known as passive use value). Use values may be direct, such as timber, fish, medicinal or edible plants, or indirect, such as the role played by the forest in regulating micro-climate or water flow. Direct use values have private good characteristics that most of them are traded in the markets. However, the market may not reflect the public good features of biological resources that policy should focus on the public good aspects of these resources.

Classifications of the various economic values of diversity varies. The importance of the use value can be illustrated in the context of mangroves. Bann[3] lists the potential benefits of a mangrove resources as shown in Table 1 (with slight modification). The table reveals the wide range of functions that can be served by any one ecosystem. In each case, the ecological functions have economic value.

Society must choose the quantity of environmental goods it wishes to conserve or produce other goods and services; and within this set of goods it must also select the desired quantity and quality of different environmental resources. Choices logically imply some form of valuation. A number of methods are available to value environmental goods in economic terms. Table 2 provides these methods and illustrates how they are related. Methods to value the environment can be broadly divided, following Turner et al.[4]

3. Review of Existing Research

There are a number of studies for valuation of environmental services or goods. Most studies tried to draw WTP for some environmental services which cannot obtain in real economic values. According to Ahn et al.,[5] the valuation research on environmental services or goods began early 1980s in Korea. The impact assessment due to changes in environmental quality or policy were main concerns. Until early 1990s, empirical valuation studies were conducted mostly on air quality, water quality and ecosystem using hedonic price method and travel cost method. The subjects of valuation studies were expanded to various areas from mid-1990s as contingent valuation method became widely used. In these days, some studies try to use conjoint analysis for overcoming weak point of contingent valuation

Table 1. Economic value of a mangrove resource - *Source: Bann (1998) (with modification)*

Use value			**Non-use value**
Direct value	Indirect value	Option value	
Timber, charcoal	Shoreline, riverbank, stabilisation	Future direct & indirect values	Cultural, aesthetic
Fisheries	Ground water recharge/discharge		Spiritual, religious
Forest products: food, medicine, wildlife etc	Flood & flow control		Global existence value
Agricultural resources	Waste storage & recycling		
Water supply	Biodiversity maintenance		
Water transport	Provision of migration habitat		
Genetic resources	Nusery/breeding grounds for fish		
Tourism & recreation	Nutrient retention		
Human habitat	Coral reef maintenance & protection		
Information	Prevention of saline water intrusion		

Table 2. Environmental valuation methods

REVEALED PREFERENCES (indirect approaches)				STATED PREFERENCES (direct approaches)			
				CONTINGENT VALUATION			
MARKET VALUES	HEDONIC MARKETS	TRAVEL COST METHODS	AVERTIVE BEHAVIOUR	Open/Closed ended	Bidding game	Payment Card	CONJOINT ANALYSIS

method. We summarize the valuation studies for environmental services or goods into 4 categories : air quality, water quality, ecosystem, and the rest.

In the Table 3 and 4, a few studies used the revealed preference approach on air and water quality valuation. Although the revealed preference approach has its advantages to use existing market prices, it has a limitation to estimate the non-use value. Therefore, the stated preference approach need to be used for valuation of extensive environmental services or goods. A number of studies used stated preference approach for the valuation of ecosystem and the contingent valuation method (CVM) is a representative method. However, the CVM can estimate just one attribute of environmental services or goods. Overcoming the limitation of CVM, conjoint analysis (CA) is recently used to estimate the values of the joint attributes of environmental services and goods. Of course, Stated preference approach is based on survey. Thus, that method require heavy budget and time. For overcoming these weakness, benefit transfer method has been evolved. Ahn et al.[5] said benefit transfer method means the use of existing information designed for one specific context to address policy questions in another context. Therefore, that method can be an alternative when conducting research is infeasible due to the limited budget and time constrains. In spite of this positive point, there are not many existing research for valuing biodiversity in Korea so we would like to except that method in this paper.

4. Stated Preference Theory: CVM and CA

To understand the methods in the stated preference approach, the theoretical explanation of CVM and CA are provided as follows:

4.1. Contingent Valuation Methods (CVM)

Table 3. Existing valuation studies on air quality

Name	Method	Result
Lim and Jun[6] (1993)	Hedonic price method	0.03 ppm to 0.02 ppm of O_3, in housing durability 30 years and discount rate 8%, WTP 17,170 won/household/month & 206,067 won/household/year
Kim[7] (1997)	Hedonic price method	The price of air quality to be contained in housing price is 2.950 million won and this is about 1.5% of housing price
Um[8] (1998)	Averting behavior method	For reducing ozone, respondents express WTP, monthly 2,098~2,832 won per head and 7,951~10,920 won per household
Yoo et al.[9] (1999)	Contingent valuation method	so2 261,940 won/ton, no2 742,176 won/ton, pm 2,923,743 won/ton, co2 2,548 won/ton in Seoul
Lee et al.[10] (2001)	Contingent valuation method	log-logistic function is 16,667 won per household and log-normal function is 16,153 won per household in metropolitan area
Choi and Shim[11] (2002)	Hedonic price method	In the discount rate 10%, housing durability 25 years, So2 10% improvement is 14,400~15,500 won and O_3 10% improvement is 13,800~14,900 won in Seoul
Shin[12] (2005)	Contingent valuation method	When 7 days reduction of yellow dust, individually 29,510 won of WTP and totally 4.441 billion won in South Korea
Cho, Chang, & Kim[13] (2006)	Conjoint analysis	The health effect of air quality is 38,856 won individually and 2.258 billion won in whole metropolitan area

Table 4. Existing valuation studies on water quality

Name	Method	Result
Kwhak[14] (1993)	Contingent valuation method	WTP for water rate in Seoul is 2,560 won/month/ household and 934,430 won/year/household
Kim and Kim[15] (1994)	Averting behavior method	When improve water service (trihalomethne 50% reduction), WTP is 2,003 won /person in Seoul
Lee and Kwak[16] (1996)	Contingent valuation method	The improvement of water quality in big 4 rivers values 5,960 won/person
Jung et al.[17] (1997)	Contingent valuation method	The improvement of water service in Dae-gu have a monetary benefit and this benefit is correlated by education and income level.
Shin[18] (1997)	Contingent valuation method	The total benefit of Han river's water quality improvement values 2.834 billion won.
Kim, Cho & Kwak[19] (2001)	Contingent valuation method	The value of Paldangho's water quality improvement is 1.292 billion won of 595 persons in metropolitan area
Um[20] (2001)	Contingent valuation method	The benefit of Mangyung river's water quality improvement(level which can swim in river) is 5,212 won/person
Cho & Shin[21] (2005)	Conjoint analysis	The suggestion of leisure, indicator species, price. 2.075 billion won/year in Seoul
Kim & Yoo[22] (2005)	Conjoint analysis	The suggestion of biodiversity, displeasure elimination. The total benefit of Paldang reservoir is 1.8~2.6 billion won/year in metropolitan area

Table 5. Existing valuation studies on ecosystem

Name	Method	Result
Hong[23] (1998)	Contingent valuation method	Youido park's benefit is 384 hundred million won in Seoul
Han & Choi[24] (1998)	Contingent valuation method	Manchurian black bear (endangered species) values 13,594 won/person of Mt. jiri's climber 358 persons
Yoo[25] (1998)	Contingent valuation method	Wet land in ganghwa island's value is 87~209 hundred million won in Incheon
Jung[26] (1999)	Contingent valuation method	"Mountain in front park" values 63~445 hundred million won/year
Lee & Shin[27] (2000)	Contingent valuation method	Greenbelt in metropolitan area values 3.083 billion won/year in Seoul
Lee & Lee[28] (1999)	Travel cost method	Mt. Palgong values 4.2 billion won to climbers
Kwon[29] (2000)	Conjoint analysis	Mt. Gwanggyo values 198 hundred million won
Lee[30] (2002)	Hedonic price method	Fishing site in Daegu and Gyungbuk values 2,950~5,550 won to residents
Kwon et al.[31] (2006)	Contingent valuation method	Dam reservoirs in Korea values 877 hundred million won
Shin & Min[32] (2005)	Contingent valuation method	First-grade area in ecological natural status of 100,000 pyongs value 1.707 billion won
Lim,Yoo & Kwak[33] (2006)	Contingent valuation method	Seoul forest provisions values 16.8~19.2 billion won to citizens in Seoul
Kwon[34] (2006)	Conjoint analysis	Dam lakes value 50,956 won/person to visitors

Table 6. Existing valuation studies of the rest

Name	Method	Result
Kim[35] (1995)	Hedonic price method	For generating waste without limitation values 5,300~6,300 won/household/month
Kim & Cho[36] (2005)	Contingent valuation method	An economic feasibility analysis of a public project show that sewer improvement project have WTP of 2,865 won/household/month to Gumi residents
Yoo[37] (2007)	Contingent valuation method	Urban noise reduction values 79.25~141.35 billion won to residents in metropolitan area

The term contingent valuation is derived from the nature of the method: response are sought from individuals as to their actions contingent on the occurrence of a particular hypothetical situation. For example, individuals might be asked their maximum willingness to pay (WTP) to protect an extinct animal contingent upon a charge being introduced. Alternatively they may be asked to state the minimum amount of compensation required to maintain their original utility level.

4.2. Conjoint Analysis (CA)

Conjoint analysis, called multi-attribute compositional models or stated preference analysis, is a statistical technique that originated in mathematical psychology. Today it is used in many of the social sciences and applied sciences including marketing, product management, and operations research. CA requires research participants to make a series of trade-offs. Analysis of these trade-offs will reveal the relative importance of component attributes. To improve the predictive ability of this analysis, research participants should be grouped into similar segments based on objectives, values and/or other factors.

4.3. Theoretical Considerations

Stevens et al.[38] show the theoretical evidence of CVM and CA. According to their study, from the perspective of neoclassical economic theory, the CVM and CA techniques should produce similar results, provided that the CVM and CA formats are properly specified. Suppose that individual utility associated with environmental quality, EQ, can be expressed as a function of income, *Y*, and EQ attributes such as water quality, wildlife habitat preserved, and cost. In dichotomous choice CVM, individuals are asked to undertake activities on their own property to improve EQ that cost them a predetermined amount, $*N*. The value of utility, observed by the researcher, when amount *N* is paid is:

$$U_1 = U(D_{1,} - Y - N) + e_1 \tag{1}$$

where D_1 is a vector of EQ attributes and e is a random variable. Utility when $$N$ is not paid is:

$$U_0 = U(D_0, Y) + e_0 \tag{2}$$

where D_0 represents EQ attributes for the status quo situation. The individual is assumed to pay if, and only if:

$$U_1 \geq U_0 \tag{3}$$

Utility difference, dV, can be expressed as:

$$dV = U_1 - U_0 \tag{4}$$

If utility is assumed to be linear, additive, and separable with respect to income and EQ attributes, dV is given by:

$$dV = U(D_1, Y-N) - U(D_0, Y) + e_1 - e_0 \tag{5}$$

The WTP probability can then be written as:

$$P_r = G(dv) \tag{6}$$

where G is the probability function for the random component of utility ($e_1 e_0$). Assuming a logit probability function for G, the WTP probability is:

$$Pr = (1 + e^{-dv})^{-1} \tag{7}$$

Median WTP for the EQ improvement, $D_1 - D_0$, can then be estimated by calculating the value of N, N*, for which $dV = 0$, i.e. at the point of indifference there is a 50% chance that the individual would pay amount N*.

Following Roe et al.[39] a CJ format which is conceptually consistent with the dichotomous choice CVM format (Eq. (7)) can be derived by asking individuals to rate the current situation without the EQ program as given by (Eq. (2)) and a set of EQ programs, (Eq. (1)). It is implicitly assumed that:

$$R_1 = h(U_1), \text{ and } R_0 = h(U_0) \tag{8}$$

where R_1, and R_0 are individual ratings and h is a transformation function. Utility difference, dV, is then approximated by the ratings difference $R_1 - R_0$:

$$dV = R_1 - R_0 = U(D_1, Y-N) - U(D_o, Y) + e_1 - e_0 \tag{9}$$

where Eq. (9) is the same as Eq. (5) and the WTP probability can therefore be represented by Eq. (7).

In other words, setting aside the issue of substitutes and respondent uncertainty for the moment, if individuals are asked, for example, to rate the status-quo, and programs which cost $\$N$ on a scale of 1 to 10 (10 indicating programs they would definitely undertake), a binary response CA model is obtained which is identical to the dichotomous choice CVM model (Eq. (7)) given the approximation in Eq. (9).

It is important to note that the CA model set forth in Eqs. (8) and (9) differs from the traditional CA format in that the dependent variable in Eq. (9) is the ratings difference from the status quo and independent variables are changes in program attributes from the status quo. The traditional conjoint model involves estimating the following relationship between ratings and program attributes:

$$U_i = R_i = V(Z^k) + P_z = b_0 P_z + b_1 Z_1^1 + \ldots b_n Z_n^1 + e_i \tag{10}$$

where U_i is individual i's utility for an attribute bundle; R_i is the individual's rating, V(·) is the non-stochastic component of the utility function, Z^K is a vector of attribute levels, P_z is the price for the attribute bundle Z, and b is the marginal utility or weight associated with each attribute (Johnson et al.[40]).

Setting the total differential of Eq. (10) to the point of indifference and solving:

$$dU_i = b_0 dP_z + b_1 dZ_1^1 + \ldots = 0 \tag{11}$$

yields marginal rates of substitution for the attributes Z^1_1. Since a price attribute, P_z, is included, the marginal utilities of all attributes can be re-scaled into dollars, and marginal willingness to pay for each attribute may be derived:

$$dP_z = -b_1 dZ_1^1 / b_0 \quad \text{or} \quad dP_z / dZ_1^1 = -b_1 / b_0 \tag{12}$$

As shown by Roe et al.,[39] this specification provides estimates of Hicksian surplus which can then be directly compared with CVM estimates (also see McKenzie,[41] Johnson et al.[40])

However, in empirical applications CVM respondents are typically presented with far fewer substitutes than are CA respondents. Boxall et al.[42] found that CVM respondents therefore tend to ignore substitutes, and if this difference is not taken into account, choice and CVM estimates are very dissimilar. Consequently, comparisons of the CVM and CA techniques requires that: (a) both formats convey the same information about substitutes; (b) the CA model is specified as outlined in Eqs. (8) and (9); and (12) respondent uncertainty is accounted for.

5. Valuation of Biodiversity Indices

Stated preference approaches are survey methods based on asking people hypothetical questions about how much they are willing to pay to obtain a more desirable level of environmental quality or to avoid a less desirable level of environmental quality. However, there is some problem for valuation of biodiversity. This is because respondents have a difficulty to measure the value of biodiversity. People recognize the importance of biodiversity but they don't know how to value. In the environmental economics literature, most research has focused on developing monetary measures of vale, rather than integrating of ecological biodiversity indices and monetary value. Therefore, we suggest that ecological indicators of biodiversity can be a good source of economic values.

System dynamics is a general method to integrate ecological biodiversity and monetary measures. This method can be used to generate detailed scenarios that enter valuation experiments. In other words, the study can imply the human economic activities, their relationship to biodiversity and the structure and functions of ecosystem. For example, environmental or ecosystem change from development can be described as an input scenario through system dynamics. The system dynamic approach is suitable for integrating existing models and incorporating temporal as well as spatial processes. Costanza et al.[43] distinguish economic, ecological and integrated approached on the basis of the following criteria : (1) generality, characterized by simple theoretical or conceptual models that aggregate, caricature and exaggerate ; (2) precision, characterized by statistical, short-term, partial, static or linear models with one element examined in much detail ; and (3) realism, characterized by causal, non-linear, dynamic-evolutionary, and complex models.

Because of the importance to integrate monetary valuation and ecological indices of biodiversity, it is our objective to assess the human welfare significance of biodiversity change under consideration. In the course of the assessment process, it is important to determine the changes in provision of biodiversity related goods and services and consequent impacts on the well-being of humans who enjoy both use or non-use benefits from such a provision. Thus, biodiversity indices and related goods are introduced.

There are several indices for measurement of biodiversity and we divide them into three categories. First, Richness Index (RI) shows the total number of individual or species. Second, Evenness Index (EI) is a measure of biodiversity which quantifies how equal the community are numerically. Lastly, Dominance Index（DI）gives the information if there is one dominant class in the image or if all classes have more or less the same relative class proportions. Kim et. al.[44] summarized widely used biodiversity indices as in the Table 7.

Among these indices, Species Richness (S), Shannon-Weaver Index (H), Simpson Index of Diversity (D) are widely used. Species Richness (S) is the simplest measure of biodiversity and is simply a count of the number of different species in a given area.

$$D^{R}(\Omega) = n \tag{13}$$

Shannon-Weaver Index (H) show the correlation between the number of species and the range of each species. This index is a quantitative measure of habitat diversity. Diversity of species in a community is in part a function of diversity of the habitat.

$$H = -\sum Pi \log_2 Pi \tag{14}$$

Simpson Index of Diversity (D) considers the number of species, the total number of individuals and proportion of the total that occurs in each species. This index is a measure of dominance. A collection of species with high diversity will have low dominance.

$$\lambda = \sum Pi^2 \tag{15}$$

We can use these indices when conduct survey by show the influence of some activities or works. However, these indices are unfamiliar to respondents. The most importance in the survey question is that all respondents should know well about the goods and questionnaire. Thus, we should be careful when design the survey. That is, we should explain the meaning of that indices and why use these indices in the survey.

6. Conclusion

The estimation of direct and indirect use values of biodiversity has proven to be the most important task. Although there are a number of valuation methods in environmental economics, many of them are not an appropriate method to derive the values. Thus, we should be careful to choosing an appropriate method. Conjoint analysis is proved to be a very useful method in the valuation of biodiversity. Conjoint analysis can estimate the indirect value which cannot estimate by revealed preferences and has

Table 7. Biodiversity indices

Indices	Discriminant ability	Sensitivity to sample size	Richness or evenness or dominance	Calculation	Widely used?
α (log series)	Good	Low	Richness	Simple	Yes
λ (log normal)	Good	Moderate	Richness	Complex	No
Q statistic	Good	Low	Richness	Complex	No
S (species richness)	Good	High	Richness	Simple	Yes
Margalef index	Good	High	Richness	Simple	No
Shannon index	Moderate	Moderate	Richness	Intermediate	Yes
Brillouin index	Moderate	Moderate	Richness	Complex	No
Mclntosh U index	Good	Moderate	Richness	Intermediate	No
Simpson index	Moderate	Low	Dominance	Intermediate	Yes
Berger-parker index	Poor	Low	Dominance	Simple	No
Shannon evenness	Poor	Moderate	Evenness	Simple	No
Brllouin evenness	Poor	Moderate	Evenness	Complex	No
Mclntosh D index	Poor	Moderate	Dominance	Simple	No

the potential to avoid many of the biases associated with other stated preference method (i.e. contingent valuation method).

Besides, if we consider biodiversity indices when design the survey questionnaire, we will be able to draw out the result which is integrated between ecological and economic field. In other words, the combination of ecology and economics to assess biodiversity leads to an integrated framework. Thus, interdisciplinary work is required, involving both economists and ecologists transferring elements or even theories and models from one discipline to another and transforming them for their specific, mutually consistent purpose.

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References

1. Weitzman, and Martin, L., "On diversity," *Quarterly journal of Economics*, **107**, 363-405 (1992).
2. Pearce, D. W., and Moran, D., The economics of biological diversity conservation, In P. Fiedler and P. Kareiva (eds), Conservation Biodiversity for the Coming Decades, Chapman and Hall, London, pp. 384-409 (1998).
3. Bann, C., The economic valuation of Mangroves: a Manual for Researches, Economy and Environment Program for Southeast Asia, Singapore (1998).
4. Turner, R. Kerry, David Pearce and Ian bateman, Environmental Economics, Harvester Wheatsheaf, London (1994).
5. Ahn, S. E., and Kim, J. K., An Application of Benefit Transfer to Outdoor Recreation Values in Korea, Korea Environment Institute (2006).
6. Lim, Y. S., and Jun, Y. S., "The benefit of air quality improvement using hedonic price method," *Environmental and Resource Economics*, **3**(1), 81-106 (1993).
7. Kim, J. W., "Measuring the price of air quality in housing price : using spatial econometrics," *Environmental and Resource Economics*, **7**(1), 61-85 (1997).
8. Um, Y. S., "Valuing the health effects on air pollution : using averting behavior method," *Environmental and resource economics review*, **7**(1), 1-23 (1998).
9. Yoo, S. H., Kwak, S. J., and Kim, T. Y., "Measuring air quality in Seoul : using CVM on multi-attribute utility theory," *Environmental economic review*, **7**(2), 243-270 (1999).
10. Lee, H. C., Chung, H. S., and Kim, T. Y., "Valuation of Air Quality in the Metropolitan Seoul," *Environmental and resource economics review*, **13**(3), 387-415 (2004).
11. Choi, J. I., and Shim, S. H., "An effect of air quality on the apartment prices in Seoul : using hedonic price method," *Environmental and resource economics review*, **11**(2), 261-278 (2002).
12. Shin, Y. C., "Estimating the cost of air pollution on morbidity : focusing on hospital visit for acute respiratory disease," *Environmental and resource economics review*, **14**(3), 673-697 (2005).
13. Cho, S. G., Chang, J. I., and Kim, J. I., "Valuing the health effects on air quality improvement," *Environmental and resource economics review*, **15**(5), 859-884 (2006).
14. Kwak, S. J., "Estimation of water quality improvement : application of CVM and nonparametic approach," *Environmental and Resource Economics*, **3**(1), 183-198 (1993).
15. Kim, D. Y., and Kim, G. H., "Estimation of tap water quality improvement using averting behavior method," *Environmental and Resource Economics*, **3**(2), 337-358 (1994).
16. Lee, K. H., and Kwak, S. J., "Economic value of water quality improvement : CVM and non-division effect," *Environmental and Resource Economics*, **6**(1), 87-109 (1996).
17. Jung, K. H., Kim, S. W., and Kwak, S. J., "The benefit of tap water quality improvement in Daegu : application parametic and non-parametic approach," *Environmental and resource economics review*, **6**(2), 223-257 (1997).
18. Shin, Y. C., "Estimation of Han River water quality improvement using two bounded dichotomous choice model," *Environmental Economic Review*, **6**(1), 171-192 (1997).
19. Kim, B. G., Cho, Y. S., and Kwak, J. E., "Estimation of WTP for water quality improvements in Paldang reservoirs using contingent valuation," *Environmental and resource economics review*, **10**(3), 433-459 (2001).
20. Um, Y. S., "Empirical evidence on scope effects in contingent valuation of water quality improvement in Man gyung river," *Environmental and resource economics review*, **10**(3), 387-411 (2001).
21. Cho, S. G., and Shin, C. O., "Economic value of Han River's water quality attribute using conjoint analysis," *Environmental and resource economics review*, **14**(3), 655-672 (2005).
22. Kim, Y. J., and Yoo, Y. S., "Valuing Non-market benefits of water quality improvements in Paldang reservoir and Han river's Choice experiments study," *Environmental and resource economics review*, **14**(2), 337-379 (2005).
23. Hong, S. G., "Economic valuation of Yeoido park : application of double bounded dichotomous choice contingent valuation method," *Journal of Korean Institute of Landscape Architecture*, **26**(3), 90-103 (1998).
24. Han, S. Y., and Choi, G., "New approach to value outdoor recreational benefits of forest : an application of CVM," *Korea journal of Forest Recreation*, **2**(3), 39-51 (1998).
25. Yoo, B. G., "Regional valuation of environmental value : estimation of recreation value of Mud Flats in southern region of Kangwha-do," *Journal of Korean Regional Development Association*, **10**(3), 19-38 (1998).
26. Jung, K. H., "Economic value of natural park conservation," *Public Economics*, **4**, 119-137 (1999).
27. Lee, J. G., and Shin, Y. C., "Economic valuation of greenbelt : focus on the conservation value of green belt in grea-

ter seoul," *Environmental and resource economics review*, **9**(4), 773-799 (2000).
28. Lee, S. T., and Lee, M. H., "Estimation of Dae-gu Mt. Palgong's benefit : using travel cost method," *Environmental Economic Review*, **7**(2), 211-228 (1999).
29. Kwon, O. S., "Economic valuation of ecology using choice ranking method," *Study of Economics*, **48**(3), 177-196 (2000).
30. Lee, B. S., Jung, E. C., and Kim, Y. H., "Analysis the effect of an apartment complex characteristics on the price of apartment," *Kukje Kyungje yongu*, **8**(2), 21-45 (2002).
31. Kwon, O. S., Lim, W. A., and Kim, W. H., "Economic values of recreational water : Rafting on Han River," *Environmental and resource economics review*, **16**(3), 427-449 (2007).
32. Shin, Y. C., and Min, D. G., "Estimating economic value of first-grade area in ecological nature status," *Environmental and resource economics review*, **14**(1), 25-50 (2005).
33. Lim, H. J., Yoo, S. H., and Kwak, S. J., "Measurement of the economic benefits for seoul forest provisions in seoul," *Journal of the KRSA*, **22**(2), 225-250 (2006).
34. Kwon, O. S., "Valuing recreational benefits of Dam lakes using choice experiment approach," *Environmental and resource economics review*, **15**(3), 555-573 (2006).
35. Kim, K. L., A study of a reclaimed land of scrapped material's economic value, Korea Environmental Technical Research Institute (1995).
36. Kim, J. D., and Cho, M. K., "An economic feasibility analysis of a public project using contingent valuation method," *Environmental and resource economics review*, **14**(1), 101-134 (2005).
37. Yoo, S. H., "Using one and one-half bounded dichotomous choice model to measure the economic benefits of urban noise reduction," *Environmental and resource economics review*, **16**(3), 451-483 (2007).
38. Stevens, T. H., Belkner, R., Dennis, D., Kittredge, D., and Willis, C., "Comparison of contingent valuation and conjoint analysis in ecosystem management," *Ecological Economic*, **32**, 63-74 (2000).
39. Roe, B., Boyle, K., and Teisl, M., "Using conjoint analysis to derive estimates of compensating variation," *Journal of Environmental Economics*, **31**, 145-159 (1996).
40. Johnson, R., Desvougesm, W. H., Fries, E., and Wood, L., "Conjoint analysis of individual and aggregate preferences," *Triangle Economic Research*. Working Paper T-9502. Research Triangle, NC (1995).
41. Mackenzie, J., "Conjoint analysis of deer hunting," *Northeastern Journal of agricultural economics*, **75**, 593-603 (1990).
42. Boxall, P., Adamowicz, W., Swait, J., Williams, M., and Laviere, J., "A comparison of stated preference methods for environmental valuation," *Ecological economics*, **18**, 243-253 (1996).
43. Costanza, R., R. D'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Suotton, and M. van den Belt, "The value of the World's Ecosystem Services and Natural Capital," *Nature*, **387**, 253-260 (1997).
44. Kim, S. h., Kim, J. H., and Heo, J., "Study on standardization of biodiversity for environmental value assessment," *KSCE conference and civil expo*, Republic of Korea (2007).