

MEASURING VALUES OF ENVIRONMENTAL QUALITY IMPROVEMENT AND LEISURE TIME THROUGH COMBINING CONTINGENT VALUATION AND TRAVEL COST DATA*

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This paper demonstrates a utility-theoretic empirical framework for estimating values of environmental quality improvement by combining travel cost and contingent valuation data in a two-constraint (time and money) budget framework. Recognizing the role of time "prices" and time budget, the recreation demand and willingness to pay (WTP) functions are specified with full price and full budget arguments, with the opportunity cost of time being a fraction of wage rate. When applied to the case of water quality improvement of the Man Kyoung River basin in the Chollabukdo province, the joint model of actual demand, contingent WTP, and marginal value of time is highly significant with correct signs on the principal economic variables. The WTP estimate is about \$34 for a water quality improvement to the swimmable level. The value of leisure time is 90% of the market wage.

JEL Classification: Q26, J22

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I. INTRODUCTION

Two broad approaches have been commonly used to value changes in environmental quality. The revealed preference (RP) method, like travel cost method (TCM), relies on observation of individuals' actual behavior to model

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individual preferences (in related markets). On the other hand, the contingent valuation method (CVM) directly elicits individuals' willingness to pay for changes in environmental qualities without making any actual behavioral changes. In spite of their well acknowledged advantages, both methods have been open to criticisms, which make vulnerable each valuation method to be an adequate non-market valuation method for environmental goods. The CVM studies have been criticized by its hypothetical nature and several potential sources of bias (Diamond and Hausman 1994). The TCM studies are also sensitive to important specification issues such as how to model and measure opportunity costs of individuals' leisure time (Randall, 1994).

To address these concerns about limitations of individual non-market valuation methods, this paper develops and implements a theoretically-consistent empirical framework for estimating values of quality changes and opportunity costs of leisure time by combining travel cost and contingent valuation data from the same individuals. Beginning from a commonly-used Marshallian recreation demand function (a semi-log function) and integrating back to recover the implied quasi-expenditure function, the compensating variation expression is derived. Using the resulting empirical form of the quasi-expenditure function to derive compensating variation expressions, functional forms for WTP for environmental quality changes that are consistent with the demand function are obtained. When demand and WTP are jointly estimated with cross-equation parameter restrictions, the CVM responses may be disciplined by the revealed preference (TCM) data, which may improve the internal validity and reduce biases or variance of the CV estimates (Cameron, 1992, Larson, 1990, Kling, 1997).

Recognizing the role of both time price and time budget in recreation demand, empirical specifications of recreation demand were specified using "full" price and "full" income, which is consistent with a two constraint framework (Larson and Shaikh, 2001). Several previous studies have followed the basic logic of Becker's early paper (1965), assuming that the opportunity cost of recreation time is an exogenous parameter such as the average wage rate or, more commonly, some fraction thereof. This fraction is either chosen arbitrarily or estimated as part of the recreation demand model (e.g. Cesario, 1976, McConnell and Strand, 1981, Shaikh and Larson, 2004)

The joint estimation process developed in this paper explicitly specifies these different treatments of measuring opportunity cost of leisure time, which are statistically tested of which approach best explains the data. While several recent papers have attempted to combine different data sources to improve the validity of CVM or stated preference data,¹ this paper is the first to incorporate the

¹ For example, Cameron (1992) estimated a model of demand and WTP based on a quadratic direct utility function; Eom and Smith (1994) combined a semi-log demand function with an ex ante indirect utility difference function; Nitklitschek and Leon (1995) combined WTP statements with statements of intended use; and Huang et al (1997) estimated a demand function and a

time constraint (in addition to usual money budget constraint) into the joint estimation of actual recreation demand and contingent WTP functions in a utility-consistent framework. This paper is also the first Korean application of jointly estimating TCM and CVM data to measure values that individuals place on changes in environmental quality.

Section II reviews a model of consumer choice subject to two binding constraints and demonstrates welfare measures for quality improvement, while Section III lays out the estimation model. The data used in the empirical application are described in Section IV, and Section V presents and discusses the empirical findings. Section VI concludes.

II. A TWO-CONSTRAINT RECREATION-CHOICE MODEL

The standard consumer-choice problem with two binding constraints provides the appropriate theoretical foundation for recreation demand models because recreation is a time-intensive activity so that the opportunity cost of the time spent in recreation would be expected to play a large role in its overall value.² Let X be recreational services requiring time and money costs per unit of consumption (i.e. per trip) given by t_X and p_X respectively. For simplicity, Z is assumed to be a numeraire good with corresponding prices p_Z and t_Z . Consumer choices are made subject to a money budget constraint $M = p_X X + p_Z Z$ and a time constraint $T = t_X X + t_Z Z$, both of which are strictly binding. Following the common assumption that recreation is chosen conditional upon, not jointly with, primary labor supply, recreation choices are made in the second stage of a two-stage model.³ That is, in the second stage decision, the money and time budget, M and T , can be thought of as resulting from predetermined labor-supply decision by the individual, which results in discretionary income and time to be allocated to leisure-time activities and goods consumption. With this assumption, the consumption decision can be written as (Larson, 1993, Larson and Shaikh, 2001).

variation function (which generates Marshallian estimates of WTP).

² The two-constraint model used to motivate this analysis has its origins in the work of Becker (1965) and Deserpa (1971), and was used to analyze recreation choices by Bockstael et al., (1987). Larson and Shaikh (2001) provided empirical restrictions on recreation demand functions that can be consistent with the two-constraint models.

³ It is a common practice in recreation analysis to model choices conditional on labor supply decisions. It is generally assumed that leisure is allocated after a labor supply choice has been made; however, this assumption has been recently investigated in the literature. Bockstael, et al., (1987) and Larson and Shaikh (2004) have allowed different value of time specifications for those trading work for leisure at the margin versus those with fixed work schedules. Feather and Shaw (1999) have explored joint estimation of labor supply and recreation choice.

$$\underset{X, Z}{\text{Max}} \quad U(X, Z, q) + \lambda [M - p_X X - p_Z Z] + \mu [T - t_X X - t_Z Z] \quad (1)$$

where the variable q represents a water quality variable and is assumed to be a public good not chosen by the individual. The Lagrange multipliers λ and μ represent the shadow values of money and leisure time. Therefore, the ratio of the Lagrange multipliers on the time and money constraints, μ/λ , is the marginal money value of time, τ . The utility function is the individual's continuous, differentiable and quasi-concave utility function. Water quality, q , is assumed to be a good, so that it enters the preference structure such that $\partial U/\partial q > 0$. Moreover, the water quality is assumed to be weakly complementary to a private good X .⁴

Normalizing p_X and t_X with respect to p_Z and t_Z and solving the constrained utility maximization problems yield a Marshallian demand for recreational services $X(p, t, q, M, T)$ and the corresponding indirect utility function $V(p, t, q, M, T)$, which are functions of both time and money prices and time and money budget. The presence of an additional binding (time) constraint implies additional structure on the consumer choice problem, as there are two version of Roy's Identity for this model. From the envelope theorem applied to the indirect utility function $V(p, t, q, M, T)$, $\partial V/\partial p = -\lambda X$, $\partial V/\partial t = -\mu X$, $\partial V/\partial M = \lambda$, and $\partial V/\partial T = \mu$, so that the recreation demand can be written as

$$X(p, t, q, M, T) \equiv -\frac{\partial V/\partial p}{\partial V/\partial M} \equiv -\frac{\partial V/\partial t}{\partial V/\partial T} \quad (2)$$

These two Roy's Identities are sources of parameter restrictions in the empirical demand. In studying the structure of two-constraint choice problems, Larson and Shaikh (2001) showed that a sufficient condition ensuring the symmetry restrictions of the two-constraint model is that the demand arguments in $X(p, t, q, M, T)$ are expressed as functions of not only "full" price ($p^f = p + \tau t$) but also "full" budget ($M^f = M + \tau T$),⁵

⁴ Weak complementarity, introduced by Maler (1974), is an intuitively appealing and often plausible condition on preferences that permits the measurement of WTP for quality changes. The assumption that q is weakly complementary to X implies that an individual's welfare is unaffected by changes in q when the consumption of X is zero. That is, $U(X=0, Z, q=0) = U(X=0, Z, q=1)$, $\partial U(\cdot)/\partial q \neq 0$ when $X > 0$, but $\partial(U_X/U_Z)/\partial q = 0 = \partial(MRS_{XZ})/\partial q$ when $X=0$ (see Bockstael and McConnell, 1993, Larson, 1991).

⁵ The construction of a full price by adding money prices and time prices converted to money units by the marginal value of time has long been recognized as an appropriate way to avoid multicollinearity issues in estimation (Cesario and Knetsch, 1970). However, this common practice of including only a time price (as a component of full price) without a time budget (money income only) is of the form $X(p, t, q, M)$. This clearly does not satisfy (3) and is inconsistent with two-constraint choice.

$$X(p, t, q, M, T) = X(p^f, q, M^f) = X(p + \tau t, q, M + \tau T) \quad (3)$$

where the full price of X , p^f , consists of the money price of X plus its time price monetized as its marginal value of time (i.e., $p^f = p + \tau t$), and the full budget, M^f , is money income plus time constraint monetized at its marginal value of time (i.e., $M^f = M + \tau T$). In this application, the common assumption that the marginal value of time τ is a fraction of individuals' wage rates (i.e., $\tau = \kappa w$) is made (Cesario, 1976 and McConnell and Strand, 1981; Shaikh and Larson, 2004). This assumption is also consistent with the two-constraint requirements identified by Larson and Shaikh (2001).⁶ Substituting this formulation of τ into equation (3), the Marshallian demand function becomes $X(p + \kappa wt, q, M + \kappa wT)$.

For the empirical specifications, suppose that a semi-log function adequately characterizes the recreation demand,⁷

$$X(p^f, q, M^f) = \exp(\alpha + \beta p^f + \gamma q + \delta M^f) \quad (4)$$

where α , β , γ , and δ are demand parameters, $p^f = p + \tau t$ and $M^f = M + \tau T$. Substituting this recreation demand into the utility function yields the indirect utility function $V(p^f, q, M^f) = U(X(p^f, q, M^f), M^f - p^f X(p^f, q, M^f), q)$, whose inverse with respect to income argument is the "full price and full budget" version of minimum expenditure function $E(p^f, q, U)$ ⁸

$$E(p^f, q, U) = \min \{ p^f X + Z : U(X, Z, q) = U_0 \},$$

which is used for measuring welfare changes. Given the assumptions that q is a good, $E(p^f, q, U)$ is decreasing in q (i.e. $\partial E / \partial q < 0$).

To obtain the quasi-expenditure function implied by (4), one can note the

⁶ In addition to the common assumption of τ being a fraction of the wage, Larson and Shaikh (2001) also showed that the marginal money value of time, τ , can be defined as functions of observable arguments $\tau(s)$, where s denotes a vector of preference related variables, because μ and λ , as the Lagrange multipliers, are functions of these observable arguments.

⁷ Among commonly used simple functional forms for single-equation demand (such as linear, quadratic, and Cobb-Douglas), researchers have tended to conclude that semilog functions perform better in terms of goodness-of-fit and the magnitude of estimated welfare measures (Ziemer, Musser, and Hill, 1980; McConnell, 1985, and Strong, 1983). Integrating back to recover quasi-preferences is also straightforward (LaFrance, 1990).

⁸ Because choice is subject to two constraints, one can specify two dual expenditure functions, one minimizing money expenditure subject to utility and time constraints (i.e., $E(p, t, q, T, U)$), the other minimizing time expenditure subject to utility and money constraints (i.e., $E(p, t, q, M, U)$). However, in this application, we defined a "full" expenditure function as shown, because in the case of full price and full budget, the two constraints can also be represented by a single full budget constraint, as specified by Becker (1965).

identity (through Shephard's Lemma) of the price slope of the expenditure function to Hicksian demand, and the identity relating Hicksian demand to Marshallian demand when money income is replaced by the expenditure function:

$$\partial E(p^f, q, U) / \partial p^f = X^h(p^f, q, U) = X(p^f, q, E(p^f, q, U)) \quad (5)$$

where $E(p^f, q, U)$ is the expenditure function and $X^h(p^f, q, U)$ is the Hicksian or compensated demand function.

Given the semi-log specification of recreation demand X , equation (5) solves for the quasi-expenditure function (Hausman, 1981)

$$\hat{E}(p^f, q, U) = -\frac{1}{\delta} \ln \left(-\frac{\delta}{\beta} e^{(a + \beta p^f + \gamma q)} - \delta K \right) \quad (6)$$

where K is the constant of integration that, in general, depend on quality q and other shift variables. However, with assumption of weakly complementarity between X and q , K does not depend on q and could be set to the utility index U (Larson, 1991).⁹ This quasi-expenditure function is defined for $0 \leq X < -\beta/\delta$; i.e., $E_{pp} < 0$ and $X \geq 0$ over this range.

Now suppose that water quality is improved from q^0 to q^1 due to the implementation of a government policy. Welfare measures of this quality improvement can be obtained from the quasi-expenditure function. Individuals' willingness to pay (WTP) for this quality change can be represented by a compensating variation measure, defined as the maximum amount of income that individuals would give up in order to enjoy the quality improvement, holding utility constant. It can be expressed as the change in the expenditure function as quality changes from q^0 to q^1 given utility is held constant at the reference level U_0 . Given equation (6), this is

$$\begin{aligned} CV(q^0, q^1) &= \hat{E}(p^f, q^0, U_0) - \hat{E}(p^f, q^1, U_0) \\ &= M^f - \left\{ -\frac{1}{\delta} \ln \left[-\frac{\delta}{\beta} e^{(a + \beta p^f + \gamma q^1)} - \delta U_0 \right] \right\} \end{aligned} \quad (7)$$

since $\hat{E}(p^f, q^0, U_0) = M^f$ by definition. The reference level of utility, U_0 , is obtained from the quasi-indirect utility function corresponding to equation (6) and evaluated at the initial quality level:

⁹ One way of defining weak complementarity is to use the expenditure function; $d\hat{E}(\hat{p}(0, q, U), q, U)/dq = 0$, where \hat{p} is the Hicksian choke price, making the consumption of X to be zero. Using this definition and the fundamental theorem of calculus, we can show that the change in expenditure with a change in quality, as consumption of X is held at zero, is $\hat{E}(\hat{p}^0, q^0, U) - \hat{E}(\hat{p}^1, q^1, U) = 0$ under weak complementarity (see Larson (1991) for derivation).

$$U_0 = \tilde{V}(p^f, q, M^f) = -\frac{1}{\delta} e^{-\delta M^f} - \frac{\delta}{\beta} e^{(\alpha + \beta p^f + \gamma q^0)} e^{-\delta M^f}$$

substituting this into (7) and rearranging it yields equation (8),

$$\begin{aligned} CV(q^0, q^1) &= \frac{1}{\delta} \ln \left[-\frac{\delta}{\beta} e^{(\alpha + \beta p^f + \gamma q^1 + \delta M^f)} + \frac{\delta}{\beta} e^{(\alpha + \beta p^f + \gamma q^0 + \delta M^f)} + 1 \right] \\ &= \frac{1}{\delta} \ln \left[\frac{\delta}{\beta} (X_0 - X_1) + 1 \right] \end{aligned} \quad (8)$$

where $e^{(\alpha + \beta p^f + \gamma q^1 + \delta M^f)} = X_1$ is the Marshallian quantity demanded after the quality change and $e^{(\alpha + \beta p^f + \gamma q^0 + \delta M^f)} = X_0$ is the Marshallian quantity demanded before the quality change.

III. EMPIRICAL MODEL

The data used in the empirical application of joint estimation methodology were collected from households of the Man Kyoung River basin in the Chollabukdo province. Respondents were asked about their river use, and answered a sequence of dichotomous choice contingent valuation questions about whether they were willing to pay specific amounts of money for river water quality improvement. Since each person was faced with both actual recreation demand and contingent discrete choice decisions, one can reasonably assume that both are motivated by the same preference structure. Use of a unified preference structure for analysis provides an opportunity to jointly estimate the actual recreation demand and contingent discrete choice models, and to formally evaluate the hypotheses that the data are mutually consistent with a well-behaved underlying preference function.

For estimation, equations (4) and (8) are assumed to represent the systematic part of preferences. The demand parameters, α , β , γ , and δ appear in both choice functions. Appending a demand error η and a discrete choice error ε , the system of equations to be estimated can be written as

$$\begin{aligned} \ln [X(p^f, q, M^f, s)] &= \alpha + \beta p^f + \gamma q + \delta M^f + ds + \eta \\ &= \alpha + \beta(p + \tau t) + \gamma q + \delta(M + \tau T) + ds + \eta \\ &= \alpha + \beta(p + \kappa wt) + \gamma q + \delta(M + \kappa wT) + ds + \eta \end{aligned} \quad (9)$$

$$\begin{aligned} WTP &= \frac{1}{\delta} \ln \left[-\frac{\delta}{\beta} e^{(\alpha + \beta p^f + \gamma q^1 + \delta M^f + dS)} + \frac{\delta}{\beta} e^{(\alpha + \beta p^f + \gamma q^0 + \delta M^f + dS)} + 1 \right] + \varepsilon \\ &= CV + \varepsilon = f(p^f, q, M^f, s) + \varepsilon \end{aligned} \quad (10)^{10}$$

¹⁰ The CV in equation (10) is indeed a Hicksian variation function suggested by Cameron

where s are a vector of preference shift variables and w denotes the individuals' wage rates and κ is a fraction of wage rates, either exogenously chosen or endogenously estimated from the sample data. Unobservable factors associated with the two joint decisions, actual demand and contingent WTP , are likely correlated each other. Thus, η and ε are assumed to follow a bivariate normal distributions $N(0, 0, \sigma_\eta^2, \sigma_\varepsilon^2, \rho)$ with different scale parameters and correlation parameter ρ . The different scale parameters (σ_η^2 and σ_ε^2) indicate the possible heteroscedastic errors between the two decisions.

The *CVM* portion of the survey followed a double-bounded dichotomous choice format, with an initial *yes-no* response to an initial bid, with a follow up *yes-no* question to a second bid that was higher or lower than the first, depending on the person's response to the first question. In this discrete *CVM* question with follow-up format, response combinations are *yes/yes*, *yes/no*, *no/yes*, and *no/no* for a sequence of two bids, b_1 and b_2 , presented to a respondent to bound WTP . Using an experimental design in the survey, if a respondent answered *yes* to the first bid amount, he/she was offered with higher bid amount in the second WTP question ($b_2 > b_1$). Likewise, a respondent saying *no* for the first bid was assigned with lower bid amount for the second WTP question ($b_2 < b_1$). Assuming an identical error structure for both discrete WTP responses, probability functions for the four responses patterns are $P(\text{yes/yes}) = P(WTP > b_2)$, $P(\text{yes/no}) = P(b_1 < WTP < b_2)$, $P(\text{no/yes}) = P(b_2 < WTP < b_1)$, and $P(\text{no/no}) = P(WTP < b_2)$, respectively.

Combining respondents' actual numbers of trips taken and double-bounded discrete choice *CVM* responses generate four possible joint outcomes, yielding the likelihood function of the joint decisions as

$$\mathcal{L} = \prod_{i \in \text{no/no}} P(X, \text{no/no}) \prod_{j \in \text{no/yes}} P(X, \text{no/yes}) \prod_{k \in \text{yes/no}} P(X, \text{yes/no}) \prod_{l \in \text{yes/yes}} P(X, \text{yes/yes}) \quad (11)$$

The joint distribution of the first term in equation (11), $P(X, \text{no/no})$, can be written as the product of the conditional distribution of a *no/no* *CVM* response given X trips taken, $P((X, \text{no/no}) | X)$, and the marginal distribution of trips, $\Phi(X)$. Extending this decomposition of joint distributions to other three

(1987) to estimate a dichotomous choice contingent valuation. Suppose that a respondent is asked to answer *yes* or *no* to a payment (b) for a water quality improvement. A respondent would say 'yes' if his/her true WTP for the quality improvement is greater than the preoffered bid amount b (i.e., $WTP > b$). The probability of 'yes' or 'no' can be specified based on the assumption about random error term, ε , resulting in either logit or probit models. Alternatively, the same dichotomous choice contingent valuation question can be specified using a difference in indirect utility functions as suggested by Hanemann (1984). McConnell (1990) provides a detailed description of comparing these two discrete choice models for contingent valuation.

outcomes, the likelihood function can be rewritten as

$$\begin{aligned} \mathcal{L} = & \prod_{i \in \text{no/no}} \phi(X) P(WTP \leq b_2 | X) \prod_{j \in \text{no/yes}} \phi(X) P(b_2 < WTP < b_1 | X) \\ & \prod_{k \in \text{yes/no}} \phi(X) P(b_1 < WTP \leq b_2 | X) \prod_{j \in \text{yes/yes}} \phi(X) P(WTP > b_2 | X) \end{aligned} \quad (12)$$

where $\phi(\cdot)$ is the normal density function.

For the first element of equation (12), the conditional probability function of *no/no* given X can be specified as

$$\begin{aligned} P(WTP < b_2 | X) &= P(CV + \varepsilon < b_2 | X) = P\left(\frac{\varepsilon}{\sigma_\varepsilon} < \frac{b_2 - CV}{\sigma_\varepsilon} | X\right) \\ &= \Phi\left(\frac{(b_2 - CV)/\sigma_\varepsilon - \rho(\eta/\sigma_\eta)}{(1 - \rho^2)^{1/2}}\right) \end{aligned}$$

where $\Phi(\cdot)$ is a standard univariate normal cumulative distribution function.

Applying this process to other response categories of equation (12), the log likelihood function of the joint decisions associated with actual recreation demand and contingent *WTP* responses can be expressed as

$$\begin{aligned} \text{Log } \mathcal{L} = & -\frac{1}{2} \log(2\pi\sigma_\eta^2) - \frac{1}{2} \sum_{i=1}^n \left[\frac{\ln X - (\alpha + \beta p^f + \gamma q + \delta M^f)}{\sigma_\eta} \right]^2 \\ & + \sum_{i=1}^n (1 - I_1)(1 - I_2) \log \left[\Phi\left(\frac{(b_2 - CV)/\sigma_\varepsilon - \rho(\eta/\sigma_\eta)}{(1 - \rho^2)^{1/2}}\right) \right] \\ & + \sum_{i=1}^n (1 - I_1)I_2 \log \left[\Phi\left(\frac{(b_1 - CV)/\sigma_\varepsilon - \rho(\eta/\sigma_\eta)}{(1 - \rho^2)^{1/2}}\right) \right. \\ & \quad \left. - \Phi\left(\frac{(b_2 - CV)/\sigma_\varepsilon - \rho(\eta/\sigma_\eta)}{(1 - \rho^2)^{1/2}}\right) \right] \\ & + \sum_{i=1}^n I_1(1 - I_2) \log \left[\Phi\left(\frac{(b_2 - CV)/\sigma_\varepsilon - \rho(\eta/\sigma_\eta)}{(1 - \rho^2)^{1/2}}\right) \right. \\ & \quad \left. - \Phi\left(\frac{(b_1 - CV)/\sigma_\varepsilon - \rho(\eta/\sigma_\eta)}{(1 - \rho^2)^{1/2}}\right) \right] \\ & + \sum_{i=1}^n I_1I_2 \log \left[1 - \Phi\left(\frac{(b_2 - CV)/\sigma_\varepsilon - \rho(\eta/\sigma_\eta)}{(1 - \rho^2)^{1/2}}\right) \right] \end{aligned} \quad (13)$$

where CV is defined in equation (10), and $\eta = \ln X - (\alpha + \beta p^f + \gamma q + \delta M^f + ds)$, from equation (9). The variables I_1 and I_2 are dummy indicators for the discrete choice *CVM* responses to the first and second bid amounts, respectively (1 for yes, 0 for no).

One distinctive feature of the joint choice model developed in this section is that two behavioral responses -- *TCM* and *CVM* data -- are derived from a unified underlying preference structure, allowing cross-equation restrictions on parameters of both continuous recreation demand model and the discrete *WTP*

function. The parameters of (13) were estimated using the maximum likelihood module (MKR) of GAUSS.

IV. SURVEY DESIGN AND DATA

1. Water Quality of the Man Kyung River Basin

The joint model of combined actual demand and contingent *WTP* functions is illustrated by a case study of the Man Kyung River (MKR) basin area in the south-western part of the country. The Man Kyung River originates from inland in the Chollabukdo province and is joined by several branch streams before reaching the Yellow Sea. The MKR has provided irrigation water for agriculture in the province as well as recreational sites for people residing within the river basin. However, there have been growing concerns about deterioration of water quality of the MKR due to sewage and industrial waste water from urban area, along with livestock manure and other runoffs from agricultural farms.

Over the years, waters in the downstream reaches of the MKR have been graded to be below Class V, which designates water quality not good enough even for agricultural use.¹¹ Especially recently, water quality levels of the MKR have been at the center of controversy associated with a large reclamation project (the Sae Man Kum Project).

The Sae Man Kum project is a large-scale reclamation project which is designed to construct a 33 km dike downstream of the MKR during the period of 1991-2006. The completion of the dike is expected to create some 40,100 hectares(ha) of reclaimed land: agricultural land of approximately 28,300 ha and a man-made lake of some 11,800 ha. However, there has been outrage and apprehension that the man-made lake will be dead within just a few years if polluted water from the MKR, which is upstream of the lake, continues to flow into the lake. In response to those concerns, the government--both local and federal levels--initiated several clean-up plans intended to improve water quality of the MKR to the level of Class II (swimmable). Since the government anticipates that implementing those plans will cost at least \$450 million,¹² it is important to compare those costs with benefits that residents in the river basin would place on the water quality improvement.

¹¹ Water quality standards for surface waters in Korea follow a five-tier system. Class I water is considered drinkable when boiled. Class II is swimmable waters, and people would be safe swimming in the river. Class III is fishable, in that game fish can survive in the water and be eaten without endanger human health. Water in Class IV is boatable, and people would not experience harm to their health if they happened to fall into the river for a short time while boating. Water in Class V does not allow any of these activities (Ministry of Environment, 2001).

¹² Converted to \$US at the exchange rate of approximately 1,300 won/US\$1 in November of 2000, the time that survey work was completed.

2. Sampling Design

The extent of market for this study naturally consists of residents along the MKR basin which penetrates 4 cities and 1 county in the Chollabukdo province. An in-person household survey of 800 residents along the MKR basin was conducted during October and November of 2000. The sample of 800 residents over 20 years of age consisted of 500 respondents from urban areas and 300 from rural areas. The survey questionnaires were allocated across the sampling area according to the population composition of age and gender. 10 Interviewers were selected from graduate students of Chon Buk National University, and completed a four-hour training session. The training session covered technical details of the survey procedure and trial practices of interviews. A supervisor inspected each answered questionnaire and verified for missing and inconsistent items before entering the data.

3. CVM and TCM Survey Design

CVM Survey Design

As mentioned earlier, the use of *CVM* to elicit welfare measures has been susceptible to various potential biases (strategic, hypothetical, and information bias as well as embedding effects). To minimize these potential problems, the a National Oceanic and Atmospheric Administration (NOAA) blue ribbon panel provided a list of recommendations and guidelines (Arrow et al., 1993).¹³ The design of *CVM* survey in this study closely followed the NOAA panel guidelines in three interrelated stages of constructing a contingent commodity to be valued, additional questions to improve the validity of *CVM* questions, and pre-testing and revising the survey questionnaire.

The goods to be valued in this study is the water quality improvement in the

¹³ The NOAA blue ribbon panel was formed to moderate hot debates among the profession at large, which were invoked from the Exxon Valdez oil spill accident in Alaska in the early 90's. Co-chaired by two Nobel prize laureates (Arrow and Solow), the panel critically evaluate the validity and reliability of *CVM* studies and suggested practical guidelines to reduce potential biases (including strategic bias) in conducting *CVM* surveys. The main recommendations are summarized as follows (Arrow et al., 1993, 4608-4610): (1) in-person interviews are preferred; (2) the use of *CVM* on ex ante evaluation of projects are preferred to the use on ex post damage assessments; (3) the willingness to pay (*WTP*) format should be used instead of willingness to accept (*WTA*) format; (4) The changes in environmental quality from the implementation of policies or programs should be accurately described using visual aids so on; (5) the elicitation format for valuation should be a dichotomous choice format because of its advantages in terms of incentive compatibility; (6) alternative expenditure possibilities for private goods should notified before answering the valuation questions; (7) debriefing questions about non-responses and checks on understanding and acceptance of the *CVM* questions should be added; (8) careful pretesting of a *CVM* questionnaire should be conducted before the main survey.

MKR basin. Following questions eliciting respondents' knowledge of, and subjective perceptions about, water pollution levels of the MKR, respondents were presented with a map of the Man Kyoung River area in which each branch stream was depicted with different colors depending on its water quality level. After looking at the map, respondents were provided with up-to-date information about the MKR area, including water pollution levels of downstream, causes of water degradation, and potential government policies to clean up the river system. The current water quality level of downstream reaches was described to be worse than Class V according to the river water quality standards, with the additional information that no use for fishing, swimming, or other water contact was possible.¹⁴ A sample of *CVM* question is attached in Appendix A.

Because of controversies among experts about whether the government policies would achieve the goal of recovering water quality of the MKR to swimmable (Class II), the target sample was divided into two groups and presented two different versions of water quality improvement levels. About a half of respondents were informed that the government policy implementation would improve water quality of down stream in the MKR to Class II (swimmable) levels, while the other half were informed that water quality would be improved to Class III (fishable) level.

In addition to providing verbal explanations of the current and improved water quality levels, interviewers showed respondents a water quality ladder as a visual aid to help them understand the relative changes in water quality. In the light of responses from focus group discussions and pre-test results, the payment vehicle was chosen to be monthly charges for water quality improvement as a specifically-designed object tax. After reminding respondents to consider their household income and expenditures, respondents were asked if they would pay the suggested monthly charges. In the experimental design, respondents were randomly assigned one of 7 bid values ranging from 75 cents to \$15 per month.¹⁵ Again following the NOAA panel's recommendations, a double-bounded discrete choice question format were chosen to elicit respondents' WTP for the water quality improvement. If respondents answered yes to the first discrete *CVM* question, the bid amount was approximately doubled for the second *CVM* question. Otherwise, the bid amount was approximately halved.

Following the NOAA panel's recommendations, various types of debriefing

¹⁴ Participants of focus group discussions expressed that it was easier to connect water quality standards with allowable activities than with BOD levels of each class. Reflecting these responses, a water quality ladder presented to respondents as a visual aid added the descriptions of allowable activities for each class of water.

¹⁵ The bid amounts presented in *CVM* questions play a role of 'prices' for the contingent commodity, water quality improvement. As reported in Appendix B, the rate of 'no' response gets larger as the bid amount gets higher, suggesting no apparent strategic behavior in answering the *CVM* question.

questions were followed right after the *CVM* question. For the respondents who answered 'no/no' for the double-bounded discrete choices, a question was added to identify reasons why they did not wish to pay for improved water quality. After this debriefing question, respondents were asked to state which level of water quality they thought would be achieved (Class II or Class III) if the government policy programs were implemented. In addition, several questions on attitude, knowledge and perceptions about the current water quality of the MKR were asked before presenting the *CVM* question. The survey instrument also included questions on the socio-economic and demographic characteristics of respondents such as age, gender, education, occupation, family size and household income. Table 1 defines selected variables used in this analysis and provides summary statistics. Two focus group discussions and a pilot survey with 50 potential respondents were conducted to detect potential sources of bias and to identify unclear wording and meaning. These pre-testing procedures also helped to identify appropriate payment vehicle and realistic range of bid amounts. The survey instrument was revised several times based on the feedback from findings from these pre-testing procedures.

[Table 1] Definitions of Variables and Sample Characteristics

Variables	Description	Mean	S.D.
Travel Cost p^f	Imputed money cost+ time cost (\$)	29.91	21.34
WQuality q	Negative of BOD levels matched with the most frequently visited site by respondents (<i>ppm</i>)	-5.75	3.61
Income M^f	Households' before tax income in 2000 plus monetized time budget (\$1000/mo)	2.384	1.269
Memory s_1	=1 if respondents remembered swimming in the MKR in their youth; =0 otherwise	0.4	0.5
Children s_2	Numbers of children under 18 years old	1.34	1.01
Bid1 b_1	Monthly charges for the 1st <i>WTP</i> question (\$)	5.96	5.72
Bid2 b_2	Monthly charges for the 2nd <i>WTP</i> question (\$)	5.05	5.78
Yes1 I_1	Binary response to the first <i>WTP</i> question (yes=1, no=0)	0.38	0.49
Yes2 I_2	Binary response to the second <i>WTP</i> question (yes=1, no=0)	0.28	0.45
<i>Policy Scenario Variables:</i>			
WQCV q^0	Initial water quality mainstream in the <i>CVM</i> scenario (<i>ppm</i>)	10	
WQCV q^1	Subsequent water quality in the <i>CVM</i> scenario	3 or 6	
WQD $q^1 - q^0$	Quality improvement presented in the <i>CVM</i> scenario (<i>ppm</i>)	7 or 4	

TCM Survey Design and Recreation Demand

To obtain revealed preference data associated with recreational use of the MKR, recreational participation and visit frequency for the previous year were elicited for six sites that stretched from upper tributaries to downstream reaches of the MKR. The main recreational activities enjoyed at those six sites are

swimming, playing in the water, family picnics, and fishing. The six sites could be considered close substitutes for each other but are differentiated by water quality. Therefore, the recreation demand function (X) was estimated based on the number of visits to a 'typical site,' where the typical site is defined to be the site most frequently visited by a respondent (Caulkins, et al., 1986, Freeman 1993).

Of 800 respondents in the sample, 510 (64%) had visited at least one of the six sites along the MKR during the previous year. Those 510 visitors were considered as users of the MKR and formed the sample for empirical analysis. However, including only users in the sample can introduce a sample selection bias. To correct for this, a probit model of the participation decision was used to calculate the inverse Mills ratio (λ) for each user, and this was included as an instrument in both the recreation demand and WTP equations. The results for the probit model for participation are attached in Appendix C.¹⁶

To reflect the variation in the water quality variable among respondents, the annual mean of BOD(biochemical oxygen demand)¹⁷ for a respondent's typical site was used as the water quality variable for that respondent's recreational demand. Also, the changes in water quality presented in the *CVM* questions (i.e. from Class V to Class II) were converted into changes in BOD levels.

To measure the full price variable in the recreation demand, the money and time cost of travel were based on round trip distance for the site, which was measured by distances on the map using respondents' detailed residence information.¹⁸ A measure of each respondent's non-work time budget was calculated based on the hours worked per week, with the mean of 556 hours per month. Of the 510 users in the sample used, 376(74%) respondents were currently employed. Wage rates for those employed were calculated based on their occupation, which was elicited in the survey. The average wage of each occupation category was weighted by the respondent's gender, education and experience.¹⁹ Imputed hourly wages ranged from \$2.19 to \$22.17 with the mean

¹⁶ Since the inverse Mills ratio (λ) was used as an instrument variable, some of variables in the participation model were not overlapped with those in the joint model.

¹⁷ A widely used way of measuring pollution levels of the surface water system is through BOD (biochemical oxygen demand), the amount of oxygen required to decompose the organic material under specified conditions of temperature and time. According to the BOD standards, for Class I, the BOD level required should be below 1 ppm(mg/l) of BOD, below 3 ppm for Class II, below 6 ppm for Class III, below 8 ppm for Class IV, and below 10 ppm for Class V (Ministry of Environment, 2001). In addition to BOD levels, other water quality criteria such as DO (dissolved oxygen) and COD (chemical oxygen demand) were also matched to each site. However, the BOD level outperformed other criteria in the empirical estimation of recreation demand.

¹⁸ Most respondents in the sample spent about a half day at the sites they visited. Since there were not much variations in on-site time among respondents, we decided not to include their on-site time costs as part of travel costs.

¹⁹ The average wage of each occupation and weights for gender, education and experience

of \$7.70 Market wage rates of housewives, students and unemployed respondents were assumed to be zero.

V. RESULTS

Table 2 reports the results of the joint estimation of actual recreation demand, contingent WTP functions and the marginal value of leisure time, as defined in equations (9) and (10). Four alternative specifications of the joint model varied the way in which the money value of time, τ , (more specifically a fraction of wage rate, κ) enters the model. Models (1)-(3) are constrained models with the restrictions on the money value of time. Model (1) assumes that the opportunity cost of time is zero (i.e., $\kappa=0$) and considers only money price and money income. Model (2) treats the fraction of wage rates to be 0.3, which was suggested by Cesario (1976) and was commonly adopted in many recreational demand models. Model (3) assumes that the money value of time equals wage rates (i.e. $\kappa=1$), as presented in Becker (1965). On the other hand, Model (4) is an unconstrained model treating the fraction of wage rates, κ , as an additional parameter to be estimated.

Overall, most explanatory variables significantly influenced both recreation demands and WTP functions with the expected signs. Travel costs had significant negative effects on both the number of visits to the typical site and on the probability of being willing to pay a given bid amount. The coefficients of the bid variables (b_1 and b_2) presented in the CVM question were also significantly different from zero. Water quality was important in both decisions too; better water quality (lower BOD level) induced more frequent trips to the site as well as a higher probability of saying yes to the CVM question. As an important economic variable along with price, income had also significant positive influences on both trip demand and WTP except in Model (1) with no time budget component. Respondents who had memories of swimming along the MKR in their youth tended to visit the site more frequently. Households with children also inclined to visit the MKR site more often. Selection effects were significant in both the recreation demand and WTP functions, as indicated by the significance of the inverse Mills ratios in both.

The significantly different scale parameter estimates (σ_η and σ_ϵ) indicate the possible heteroscedastic errors between the actual demand and contingent WTP decisions. The statistically insignificant correlation parameter estimate (ρ) implies that the unobservable factors that affect the decisions of how to answer the WTP question and how many trips to take are likely to be independent each other. Combining with the observed heteroscedastic error terms (σ_η and σ_ϵ),

were based on "tables for average monthly wage by occupation, gender, and experience" in the Statistical Report for Wage Structure (1999), an annual publication of the Ministry of Labor in Korea.

this result makes the joint estimation of the two different preference data more valuable in terms of efficiency and bias gains (Kling, 1997, p.437).

[Table 2] Joint Estimation of Revealed and Stated Preference Data

		Constrained Models			Unconstrained
		(1)	(2)	(3)	(4)
		$\kappa = 0$	$\kappa = 0.3$	$\kappa = 1$	κ estimated
Intercept	α	-1.0619 (-4.824) ^a	-1.363 (-6.017)	-1.498 (-7.258)	-1.492 (-6.981)
Travel Cost	β	-0.0126 (-6.909)	-0.0114 (-6.994)	-0.0094 (-7.181)	-0.0096 (-5.294)
WQuality	γ	0.0753 (7.963)	0.0718 (7.691)	0.0671 (7.269)	0.0675 (6.986)
Income	δ	0.0531 (1.330)	0.1018 (3.268)	0.0737 (4.913)	0.0768 (2.907)
Memory	d_1	0.244 (3.184)	0.243 (3.240)	0.224 (2.979)	0.225 (2.995)
No. of Child	d_2	0.110 (2.609)	0.115 (2.724)	0.111 (2.696)	0.112 (2.8668)
Wage Fraction	κ				0.928 (1.976)
<i>Inverse Mills Ratios</i>		0.606 (2.611)	0.799 (3.435)	0.839 (3.797)	0.8394 (3.758)
Demand	λ_{RP}				
WTP	λ_{SP}	-2.041 (-4.135)	-1.927 (-3.857)	-2.129 (-4.128)	-2.102 (-3.854)
<i>Standard Errors</i>		0.886 (31.858)	0.885 (31.857)	0.886 (31.846)	0.886 (31.818)
Demand	σ_η				
WTP	σ_ϵ	5.807 (17.901)	5.774 (17.962)	5.740 (18.026)	5.741 (18.020)
Correlation	ρ	-0.0502 (-0.930)	-0.0587 (-1.080)	-0.0667 (-1.227)	-0.0665 (-1.221)
LogL		-827.53	-825.25	-823.41	-823.39
χ^2 Statistic (1) vs. (4)		8.273			
χ^2 Statistic (2) vs. (4)			3.70		
χ^2 Statistic (3) vs. (4)				0.024	
Welfare Measures		\$28.38 ^b (6.83) ^c	31.35 (5.71)	34.66 (4.86)	34.18 (4.95)

^a: Student's t statistics in parentheses.

^b, ^c: Welfare measures and their standard deviations were calculated from the empirical distribution of 1000 replications using the Krinsky-Robb approximation approach.

Tests for Consistency of the Two Data Sets with Preferences

Previous studies suggest that combining stated data with revealed preference data may not be appropriate if they are not internally consistent with one another (Huang, et al., 1997, Azevedo et al., 2003). Thus, the assumption that the two types of decisions associated with water quality arise from a single underlying preference function was statistically tested. The unrestricted version of each model allowed the estimates of $\alpha, \beta, \gamma, \delta, d_1$, and d_2 which appear in both the demand and *WTP* functions, to take on different values in each equation, while the restricted model required them to be the same. Appendix C reports the constrained and unconstrained joint estimation of the demand and *WTP* functions using Model (2) as an example. As suggested by Cameron (1992), the actual demand data appeared to discipline the discrete *CVM* responses in the constrained joint model, although some information from the *CVM* responses (i.e., Income and Memory variables) had independent significant effects on the unrestricted contingent *WTP* function. In a likelihood ratio test for the parameter equality across equations, the χ^2 test statistic was 10.6, compared with a critical value of $\chi^2_{0.05, 6df}$ of 12.59. This test result implies that the data do not reject the hypothesis that demand and *WTP* functions come from the same underlying preferences.

Test for the Two-Constraint Model and Estimates of Opportunity Cost of Time

As mentioned earlier, Model (1) is based on the standard one constraint model with only money price and money budget, whereas Models (2)-(4) are based on the two constraint models. As argued by Cesario and Knetch (1970), the effects of price variation seemed to be slightly overstated in a model ignoring time costs. Moreover, as the opportunity cost of time gets larger with larger fraction of wage rates in "full price and full budget" models, price coefficients get smaller, as we anticipated it. Furthermore, the money income variable ignoring the role of time was not significant in Model (1), whereas the full income variables in Models (2)-(4) were significant. This result emphasizes the importance of time budget component as a resource constraint in recreation demand models.

The bottom of Table 2 presents the result of hypothesis tests on the treatment of the money value of time. First of all, based on the likelihood dominance criterion (Pollak and Wales, 1983), Model (2) with the restriction of $\kappa=0.3$ is preferred to Model (1) with $\kappa=0$. In other word, including opportunity cost of time in both the prices and budget constraint significantly improves the fit of the model compared with the model ignoring those components under the same degree of freedom. Regarding to the selection of the fraction of wage rates as opportunity cost of time, Model (3) with full wage rates is preferred to Model (2) with 30% of wage rates, again based on the likelihood dominance criterion. Similar results were obtained when we estimate the wage fraction, κ , as an

unconstrained model in Model (4). Respondents seemed to evaluate leisure time to be about 90% of their wage rates, whose value is more closed to the restriction imposed on Model (3) compared with Models (1) or (2). The χ^2 test statistics for likelihood ratio tests of the null hypotheses are given at the bottom of Table 2. The null hypotheses of the restrictions $\kappa=0$ and $\kappa=0.3$ were rejected at the 1% and 10% significance levels respectively. However, the null hypothesis of $\kappa=1$ was not rejected in Model (3).

Welfare Measures of Water Quality Improvement

Using the parameter estimates from Table 2, theoretically-rigorous welfare measures of water quality improvement are presented at the bottom of Table 2. Welfare measures that users of the MKR basin place on the water quality improvement are estimated for a policy relevant change: the improvement to swimmable level, a 7 parts-per-million (ppm) reduction in BOD. Annual total *WTP* ranged from \$28.38 to \$34.66 to improve water quality to the swimmable level. Asymptotic standard errors were estimated using the Krinsky-Robb (1986, 1990) simulation approach. As anticipated, the *WTP* measures using parameter estimates from Model (1) excluding time costs was slightly smaller than the *WTP* measures base on the other models with two constraints. Nonetheless, the differences of *WTP* between Model (1) and the other models were not statistically significant in each case. For example, the *t* statistic for the difference between \$28.38 from Model (1) and \$34.18 from Model (4) for water quality improvement to swimmable level was 0.688.

VI. CONCLUDING REMARKS

This paper has developed and demonstrated a convenient, utility-theoretic approach to combine information from multiple methods (in this case, *CVM* and *TCM* data) for the purpose of assessing the welfare measures of environmental quality improvements and value of leisure time. The approach begins with a statement of behavior subject to two binding constraints, via a demand function. Integrating back identifies the underlying "full price and full budget" quasi-expenditure function. Subsequently the quasi-expenditure function is used to define the compensating variation of a quality change, which represents the willingness to pay that individuals express in stated preference experiments such as contingent valuation.

This leads to a two-equation system that represents preferences for environmental quality, as expressed in both the individual's behavior and in their statements of willingness to pay. Empirical specifications that are consistent with the two-constraint models use full prices and full budgets in both demand and *WTP* functions. In addition to the conventional approach of selecting the opportunity cost of time exogenously, the money value of leisure time (defined

as a fraction of wage rate) was jointly estimated along with the parameters of actual recreation demand and contingent *WTP* functions.

The method was applied to an important case study on the Man Kyoung River system, where a public reclamation project affects water quality and, therefore, current users' recreation behavior and their *WTP* for water quality improvement. The joint estimation results show that relevant economic variables such as price and income had significant influence on both recreation demand and *WTP* for water quality improvement as anticipated by the economic theory. Water quality of the "typical" site for each respondent had significant impact on trip frequencies to the site, and the scope of water quality improvement conveyed in the *CV* question also had significant influence on respondents' *WTP*. Moreover, a statistical consistency test exhibited that the two different sources of data -- actual demand and contingent *WTP* responses -- were consistent within the assumed form of preferences implied by a semi-log demand function. In the preferred model, the mean willingness to pay was about \$34/year for a water quality improvement to the swimmable level.

Equally important, the two-constraint models of recreation demand and *WTP* functions fit the data better than the one-constraint model, whether the money value of time was exogenously given or endogenously determined. This result highlights the empirical evidence on the importance of time in consumer choices. A representative individual in the sample appears to value leisure time at about 90% of his or her wage rate, whose value is more closed to the treatment of opportunity cost of time in the Becker model than that in the recreation demand literature. It is interesting to observe that the wage fraction (0.9) estimated in this paper is higher than the wage fractions (0.5 to 0.6) estimated in the US recreation demand studies (Shaikh and Larson, 2004, McConnell and Strand, 1981), which implies higher opportunity costs of leisure time in Korea compared with those of US.

Overall, the results from this paper illustrate how multiple windows of eliciting individual preferences can be effectively combined with the help of basic microeconomics theory to improve the validity of non-market valuation methods. Nonetheless, the joint estimation approach developed in this paper could be extended to explore alternative maintained hypotheses for functional forms. For the recreation demand which serves as a starting point for the integrated demand- *WTP* model, other functional forms can be used, such as linear or Cobb-Douglas (LaFrance 1985, 1986). Given data on multiple demands or willingness to pay for quality characteristics, demand systems (Deaton and Muellbauer, 1980; von Haefen, 2002) can be used to identify and estimate the site-specific welfare measures, instead of constructing typical sites.

Assuming that the opportunity cost of leisure time is some fraction of wage rates, whether arbitrarily chosen or endogenously estimated, may not reflect the complex variations in institutional, social and economic situations across individuals. Moreover, individuals who are not working were assumed to have

zero opportunity cost of time because market wage rates for unemployed people are not observed. Thus, another productive direction of extension would be to incorporate individuals' economic and demographic characteristics in the endogenous money value of leisure time, which will allow us to infer shadow values of leisure time for unemployed people as well as employed people.

Appendix B: The Distribution of 'NO' Responses in the *CVM* Question

Bid Amounts	User Group			Whole Sample		
	No	Percent	Total	No	Percent	Total
\$0.76	24	30	79	43	33	130
\$1.50	35	47	74	58	45	130
\$2.30	40	56	71	62	56	110
\$3.80	31	60	52	53	66	80
\$5.40	57	76	75	85	77	110
\$7.70	68	80	85	111	85	130
\$15.40	63	85	74	104	94	130
Total	318		510	516		800

Out of the whole sample (800), the user group (510) were used for the empirical estimation. In the whole sample, the rate of NO response gets larger as the bid amounts get higher, as anticipated. Moreover, selecting only the user group didn't seem to distort this pattern of NO responses over the range of bid amounts presented.

Appendix C: Probit Estimates for Participation

	Parameter Estimates	t-ratio
Intercept	0.1956	1.062
Income	0.069	1.534
Gender	-0.171	-1.748
Urban	0.358	2.541
Years of Residence	-0.0102	-2.821
No. of Children	0.114	2.260
N	800	
Log L	-478.77	

Appendix D: Consistency Test for TCM and CVM data

		Restricted Joint Model	Unrestricted Joint Model	
			Demand	WTP
Intercept	α	-1.363 (-6.017) ^a	-1.282 (-4.783) ^a	0.914 (0.010)
Travel Cost	β	-0.0114 (-6.994)	-0.0135 (-6.424)	-0.0042 (-0.823)
WQuality	γ	0.0718 (7.691)	0.0686 (5.886)	0.00147 (0.011)
Income	δ	0.102 (3.268)	0.0806 (2.019)	0.124 (1.698)
Memory	d_1	0.243 (3.240)	0.171 (2.043)	0.0645 (2.996)
No. of Child	d_2	0.115 (2.724)	0.125 (2.713)	0.0375 (0.286)
<i>Inverse Mills Ratios</i>		0.799	0.817	
Demand	λ_{RP}	(3.435)	(3.249)	
WTP	λ_{SP}	-1.927 (-3.857)		-2.129 (-4.128)
<i>Standard Errors</i>		0.885	0.883	
Demand	σ_η	(31.857)	(30.921)	
WTP	σ_ϵ	5.774 (17.962)		5.740 (18.026)
Correlation	ρ	-0.0587 (-1.080)	-0.0511 (-0.872)	
Log L		-825.24	-819.94	
χ^2 Statistic		10.6		

^a: Student's t statistics in parentheses.

REFERENCES

- Arrow, K., R. Solow, P. Portney, E. Leamer, R. Radner and H. Shuman (1993), "Report of the NOAA Panel on Contingent Valuation," *Federal Register*, US. Department of Commerce, National Oceanic and Atmospheric Administration, FR 58, 4601-4614.
- Azevedo, C., J. Herriges and C. Kling (2003), "Combining Revealed and Stated Preferences: Consistency Tests and Their Interpretations," *American Journal of Agricultural Economics*, 85, 525-537.
- Becker, G. (1965), "A Theory of the Allocation of Time," *Economic Journal*, 75, 493-517.
- Bockstale, N.E., I.E. Strand and W.M. Hanemann (1987), "Time and the Recreation Demand Model," *American Journal of Agricultural Economics*, 293-302.
- Bockstale, N.E. and K.E. McConnell (1993), "Public Goods as Characteristics of Nonmarket Commodities," *Economic Journal*, 103, 1244-1257.
- Cameron, T.A. (1988), "A New Paradigm for Valuing Non-market Goods Using Referendum Data," *Journal of Environmental Economics and Management*, 15, 355-379.
- Cameron, T.A. (1992), "Combining Contingent Valuation and Travel Cost Data for the Valuation of Nonmarket Goods," *Land Economics* 68, 302-317.
- Caulkins, P., R. Bishop and N. Bouwes (1986), "The Travel Cost Models for Lake Recreation: A Comparison of Two Methods for Incorporation Site Quality and Substitution Effects," *American Journal of Agricultural Economics*, 68, 291-297.
- Cesario, F.J. (1976), "Value of Time in Recreation Benefit Studies," *Land Economics*, 52, 32-41.
- Cesario, F.J. and J.L. Knetsch (1970), "Time Bias in Recreation Benefit Estimation Models," *Water Resources Research*, 6, 700-704.
- Deaton, A. and J. J. Muellbauer (1980), "An Almost Ideal Demand System," *American Economic Review*, 70, 312-326.
- DeSerpa, A.C. (1971), "A Theory of the Economics of Time," *Economic Journal*, 81, 828-846.
- Diamond, P.A. and J.A. Hausman (1994), "Contingent Valuation: Is Some Number Better Than No Number?" *Journal of Economic Perspectives*, 8, 45-64.
- Earnhart, D. (2001), "Combining Revealed and Stated Preference Methods to Value Environmental Amenities at Residential Locations," *Land Economics*, 77, 12-29.
- Eom, Y.S. and V.K. Smith (1994), "Calibrated Nonmarket Valuation," Discussion Paper, 94-21, Resources for the Future, Washington, D.C.
- Feather, P. and W.D. Shaw (1999), "Estimating the Cost of Leisure Time for Recreation Demand Models," *Journal of Environmental Economics and*

- Management*, 30, 49-65.
- Freeman, A.M. (1993), *The Measurement of Environmental and Resource Values: Theory and Methods*. Washington, D.C.: Resources for the Future.
- Hanemann, W.M. (1984), "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses," *American Journal of Agricultural Economics*, 66, 322-341.
- Hausman, J. (1981), "Exact Consumer's Surplus and Dead Weight Loss," *American Economic Review*, 71, 662-676.
- Heckman, J.J. (1979), "Sample Selection Bias as a Specification Error," *Econometrica*, 47, 153-161.
- Huang, J.C., T.C. Haab and J.C. Whitehead (1997), "Willingness to Pay for Quality Improvement: Should Revealed and Stated Preference Data Be Combined?" *Journal of Environmental Economics and Management*, 34, 240-255.
- Joint Committee for Environmental Impacts of the Sae Man Kum Project (2000), Subcommittee for Economic Analysis, Reevaluating Benefits and Costs of the Sae Man Kum Reclamation Project: Final Report, Seoul, South Korea.
- Kling, C. (1997), "The Gains from Combining Travel Cost and Contingent Valuation Data to Value Nonmarket Goods," *Land Economics*, 73, 428-439.
- Krinsky, I. and A. Robb (1986), "An Approximating the Statistical Properties of Elasticities," *Review of Economics and Statistics*, 68, 715-719.
- Krinsky, I. and A. Robb (1990), "An Approximating the Statistical Properties of Elasticities: A Correction," *Review of Economics and Statistics*, 71, 189-190.
- LaFrance, J.T. (1985), "Linear Demand Functions in Theory and in Practice," *Journal of Economic Theory*, 37, 147-166.
- LaFrance, J.T. (1990), "Incomplete Demand Systems and Semilogarithmic Demand Models," *Australian Journal of Agricultural Economics*, 34, 118-31.
- LaFrance, J.T. and W.M. Hanemann (1989), "The Dual Structure of Incomplete Demand Systems," *American Journal of Agricultural Economics*, 71, 262-274.
- Larson, D.M. (1990), "Testing Consistency of Direct and Indirect Methods for Valuing Nonmarket Goods," Working paper, University of California, Davis.
- Larson, D.M. (1991), "Recovering Weakly Complementary Preferences," *Journal of Environmental Economics and Management*, 21, 97-108.
- Larson, D.M. and S.L. Shaikh (2001), "Empirical Specification Requirement for Two-Constraint Models of Recreation Choice," *American Journal of Agricultural Economics*, 83, 428-440.
- Larson, D.M. and S. L. Shaikh (2004) "Recreation Demand Choices and Revealed Values of Leisure Time," Forthcoming in *American Journal of Agricultural Economics*.
- Maler, K.-G. (1974), *Environmental Economics: A Theoretical Inquiry*, Baltimore: Johns Hopkins Press for Resources for the Future.
- McConnell, K.E. (1990), "Models for Referendum Data: The Structure of Discrete Choice Models for Contingent Valuation," *Journal of Environmental*

- Economics and Management*, 18, 19-34.
- McConnell, K.E. (1985), "The Economics of Outdoor Recreation," *Handbook of Natural Resources and Energy Economics*, eds. A. Kneese and J. Sweezy, New York: Elsevier Science Publishers.
- McConnell, K.E. and I. Strand (1981), "Measuring the Cost of Time in Recreation Demand Analysis: An Application to Sportfishing," *American Journal of Agricultural Economics*, 63, 153-156.
- Ministry of Environment (2001), *Annual Environmental Report*, Seoul, South Korea.
- Ministry of Labor (2001), *Statistical Report for Wage Structure*. Seoul, South Korea.
- Niklitschek, M. and J. Leon (1996), "Combining Intended Demand and Yes/No Responses in the Estimation of Contingent Valuation Models," *Journal of Environmental Economics and Management*, 31, 387-402.
- Randall, A. (1994), "Difficulty with the Travel Cost Method," *Land Economics*, 70, 88-96.
- Shaikh, S.L. and D.M. Larson (2004), "A Two-Constraint Almost Ideal Demand Model of Recreation and Donations," Forthcoming in *Economic Journal*.
- Strong, E.J. (1983), "Note on Functional Form of Travel Cost Models with Zones of Unequal Populations," *Land Economics*, 59, 342-349.
- von Haefen, R.H. (2002), "The Complete Characterization of the Linear, Log-Linear, and Semi-Log Incomplete Demand System Models," *Journal of Agricultural and Resource Economics*, 27, 281-319.
- Ziemer, R.F., W.N. Musser and R.C. Hill (1980), "Recreation Demand Equations: Functional Form and Consumer Surplus," *American Journal of Agricultural Economics*, 62, 136-141.