The Dynamic Formation of Willingness to Pay: An Empirical Specification and Test

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Abstract

In a static setting, willingness to pay for an environmental improvement is equal to compensating variation. However, in a dynamic setting characterized by uncertainty, irreversibility, and the potential for learning, willingness to pay may also contain an option value. In this paper, we incorporate the dynamic nature of the value formulation process into a study using a contingent valuation method, designed to measure the value local residents assign to a north-central Iowa lake. Our results show that willingness to pay is highly sensitive to the potential for future learning. Respondents offered the opportunity to delay their purchasing decisions until more information became available were willing to pay significantly less for improved water quality than those who faced a now-or-never decision. The results suggest that welfare analysts should take care to accurately represent the potential for future learning.

Keywords: Clear Lake, contingent valuation, water quality, willingness to pay.

JEL: Q26, C42, D60

THE DYNAMIC FORMATION OF WILLINGNESS TO PAY: AN EMPIRICAL SPECIFICATION AND TEST

The maximum amount a consumer is willing to pay for a good is a core economic concept that is regularly estimated in empirical demand studies, experimental laboratory settings, and stated preference surveys. The theoretical basis from which the properties of willingness to pay (WTP) are understood comes from the equivalence of this measure with compensating (or equivalent) variation.[1] Hicksian welfare theory further provides a formal basis for how these measures vary with prices and the base utility level.

The equivalence between the variation concepts and WTP comes from the elegant, but static, neoclassical model. In contrast, the real world is a dynamic environment where consumers may have the ability to delay purchase decisions until more information is gathered about a good, its substitutes, market conditions, and other relevant factors. Although static Hicksian theory has little to say about how the potential arrival of new information and/or the ability to delay a purchase decision might affect the WTP value, recent work by Zhao and Kling (2001, 2002) systematically investigates learning opportunities in the formation of WTP.

In an explicitly dynamic setting characterized by uncertainty, irreversibility, and the potential for future learning, WTP for a good diverges from the standard variation measures. Given that an agent is uncertain about the actual value of the good she is interested in buying, delaying the transaction may be in her best interest if more information regarding the good's value can be gained by waiting. Therefore, in order for the agent to commit to purchase now and to forgo future learning opportunities, she must be compensated by being offered a lower price than would have been acceptable were future learning not an option. Zhao and Kling refer to the required compensation as the commitment cost, a concept that is parallel to the quasi-option value in Arrow and Fisher 1974, Viscusi 1988, and Hanemann 1989. Empirical support for the importance of information in the formation of WTP values is provided by the numerous experiments and stated preference surveys that have found that WTP values can vary significantly with the amount of information provided about the good. Examples include Samples, Dixon, and Gowen 1986; Bergstrom, Stoll, and Randall 1990; Whitehead and Blomquist 1997; Blomquist and Whitehead 1998; Cummings and Taylor 1999; and List 2001.[2]

A key prediction from this theory is that commitment cost increases, as it is easier for an agent to delay making a decision and therefore collect relevant information before committing to a purchase decision. That is, the WTP for a good *today* will decline when there are additional opportunities to purchase the good or a near substitute in the future. In this case, today's WTP is not comprised simply of the expected surplus from consuming the good. Rather, WTP includes commitment cost and is a dynamic measure that may change daily as consumers update their information about the surplus the good might yield them. WTP also depends on the fundamental properties of the market environment, such as the ability to reverse or delay the purchase.

If the dynamic elements are of sufficient empirical magnitude, the theory may provide critical insight into several important and thorny issues related to welfare measurement. These include the striking divergences found between WTP and willingness to accept (for an excellent assessment and summary, see Horowitz and McConnell 2000); the appropriate type and amount of information to provide in valuation exercises; and, even more fundamentally, the appropriate definition of the welfare measures for benefit-cost assessment under uncertainty. While careful empirical research concerning key estimation choices in environmental valuation have been undertaken (see, for example, Carson et al. 1997, 1998), the empirical consideration of the dynamic formation of WTP values has not been studied.

The purpose of this paper is to develop and implement a test of whether WTP values are formed dynamically as the theory predicts and whether the magnitude of the dynamic component, the commitment cost, is sufficiently large to merit further understanding and research. We develop an empirical specification of dynamic WTP derived directly from the theory and use this specification to test whether the opportunity to delay the decision to "purchase" improved environmental quality affects WTP and, in particular, whether the effects are consistent with the predictions of the commitment cost model. Data for this analysis were collected in the fall of 2000 using a survey designed to estimate the value area residents place on improved water quality in Clear Lake, a spring-fed, glacial lake located in north-central Iowa. In order to gauge the impact of potential learning on WTP, some respondents were told that the hypothetical referendum contained in the survey instrument represented their final chance to vote on improving water quality. Others were told that, should the referendum fail, they would be given a second chance to vote on the same initiative once further research had been conducted into improving water quality. The survey's results indicate that offering respondents the ability to delay their decision *significantly* reduces WTP, confirming the predictions of the theory.

Dynamic Formation of Willingness to Pay

Consider an individual making decisions to purchase a higher level of environmental quality within two periods. Her utility function is time separable:

$$u(m_1, g_1) + \beta u(m_2, g_2), \tag{1}$$

where m_t represents period t income, g_t represents period t environmental quality, and β is the discount factor. The status quo level of environmental quality is denoted G_0. A higher level of environmental quality, G, can be purchased in the current period, in the second period, or not at all. The purchase decision is irreversible. If G is purchased in the current period, it can also be enjoyed in the future at no additional cost. For example, G might be achieved by dredging a lake, cleaning up a toxic waste site, or building a park facility. For simplicity, we assume away income smoothing: if G is purchased in period t at price p, m_t will be reduced by p and income in the other period is not affected.

The agent is uncertain about the value of G resulting from the improvement or policy. This may be attributable to her uncertainty regarding the degree to which water quality would be improved if the proposed policies were implemented.[3] Her beliefs regarding G are represented by the distribution function $F_0(G)$ and the corresponding density $f_0(G)$ on $[\underline{G}, \overline{G}]$, with $\underline{G} \geq G_0$. However, she can learn more about G in the second period: for example, on-going research may, by the next period, provide more accurate information regarding the degree of water quality improvement brought about by proposed mitigation efforts. We represent the new information with a signal

$s \in S \subset \mathbb{R}$, where S is the set of all possible signals. Conditional on the true value of G, the distribution of the signals is described by the conditional density function $h_{s|G}(s)$. The unconditional density function for s is $h(s) = \int h_{s|G}(s) dF_0(G)$. Observing s, the agent updates her beliefs about G according to Bayes's rule: $f_{G|s}(\cdot) = h_{s|G}(s) f_0(\cdot) / h(s)$.

Let EU_1 denote the agent's expected utility if she purchases G in the current period. Because the new level of environmental quality can be enjoyed now and in the future, we know

$$EU_1(p) = E_G\left(u\left(m_1 - p, G\right) + \beta u\left(m_2, G\right)\right), \tag{2}$$

where p is the price of implementing the new environmental policy and $E_G(\cdot)$ represents expectation over G. Let $V(p,s)$ be the agent's expected gain from making the purchase after observing s:

$$V(p,s) = \int \left(u(m_2 - p, G) - u(m_2, G_0)\right) dF_{G|s}(G). \tag{3}$$

She will buy G if and only if $V(p,s) \geq 0$. Let $S_{P1}(p) = \{s \in S \mid V(p,s) \geq 0\}$ be the set of signals that will induce the agent to purchase G, and $S_{P2}(p)$ be the complement of $S_{P1}(p)$, or the set of signals that will lead the agent to opt for the status quo level of environmental quality G_0. Then the agent's expected utility if she delays the purchasing decision is

$$EU_2(p) = u\left(m_1, G_0\right) + \beta \Pr(S_{P1}) E_G\left(u\left(m_2 - p, G\right) \mid s \in S_{P1}\right) + \beta \Pr(S_{P2}) u\left(m_2, G_0\right). \tag{4}$$

To obtain closed-form solutions, we assume

$$u(m_t, g_t) = \alpha \frac{m_t^\rho}{\rho} + (1-\alpha)\frac{g_t^{\rho}}{\rho}, \quad t = 1, 2. \tag{5}$$

This is a monotonic transformation of the familiar constant elasticity of substitution (CES) utility function, where $\alpha \in [0,1]$ is the weight the agent puts on income, and $\rho \leq 1$ relates to the agent's elasticity of substitution (the elasticity is $\sigma = 1/(1-\rho)$). We also assume that $m_1 = m_2 = m$.

Taking into account uncertainty, irreversibility, and the opportunity for learning, the agent's decision in the current period is whether to buy now or to delay the decision until the next period when more information will become available. In this dynamic framework, the rational agent's maximum WTP today, wtp^L, is the critical price p^L that leaves her indifferent between committing to *G* in the current period and delaying her decision until period two.

Equating $EU_1(p^L)$ and $EU_2(p^L)$ and solving for p^L, we get

$$wtp^L \equiv p^L = m - \left(m^\rho - \frac{A}{\left(1-\beta\Pr(S_{P1})\right)} \right)^{\frac{1}{\rho}}, \tag{6}$$

where

$$A = (1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^\rho) - G_0^\rho\right) - \beta\Pr(S_{P1})\frac{1-\alpha}{\alpha}\left(E_G(G^\rho \mid s \in S_{P1}) - G_0^\rho\right). \tag{7}$$

On the other hand, in the absence of learning, the agent sees her decision as being whether to buy in the current period or never to buy. While we assume the learning-constrained agent recognizes that the benefits from purchasing *G* in the current period can be enjoyed in the future period, we also assume that she does not realize that delaying her purchasing decision may allow her to avoid a "bad purchase" (i.e., a purchase that yields negative surplus). Thus, in the absence of learning, the agent's WTP wtp^{NL} is the critical price p^{NL} such that the she is indifferent between purchasing the environmental improvement in the current period and never purchasing it. That is,

$$E_G\left(u\left(m - p^{NL}, G\right) + \beta u\left(m, G\right)\right) = (1+\beta)u\left(m, G_0\right), \tag{8}$$

or

$$wtp^{NL} \equiv p^{NL} = m - \left(m^\rho - (1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^\rho) - G_0^\rho\right) \right)^{\frac{1}{\rho}}, \tag{9}$$

where superscript *NL* stands for no-learning.

Zhao and Kling (2001, 2002) show that $wtp^L \leq wtp^{NL}$, and the inequality is strict if $\Pr(S_{P1}) > 0$, or if the signal has a positive probability of being "useful." Note that wtp^{NL} is a static measure; no consideration of future options is incorporated into its formation. However, offered the opportunity for learning, the rational agent's WTP falls to $wtp^L \leq wtp^{NL}$. In this context, the commitment cost can be thought of as the amount by which the price of the environmental improvement must be reduced in both periods to make the rational agent indifferent between purchasing now and delaying the decision until more information becomes available. In other words, commitment cost is the difference between wtp^{NL} and wtp^L. Thus, we can write *CC* as the following closed-form expression:

$$CC = wtp^{NL} - wtp^L = \left(m^\rho - \frac{A}{\left(1-\beta \Pr(S_{P1})\right)} \right)^{\frac{1}{\rho}} - \left(m^\rho - (1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^\rho) - G_0^\rho\right) \right)^{\frac{1}{\rho}}. \quad (10)$$

Equation (10) contains an explicit representation of commitment cost, thus allowing us to understand the factors that affect its magnitude. In the next section, we discuss the design of an empirical test of whether dynamic behavior is present in the formation of WTP values.

Design of the Empirical Test

To test whether the effects of potential learning and uncertainty influence WTP as predicted by the commitment cost theory, we estimate respondent *i*'s stated WTP as

$$WTP_i = wtp_i^{NL} - CC_i + \varepsilon_i, \quad (11)$$

where wtp_i^{NL} is the non-learning agent's WTP as defined in (9), ε_i is a mean-zero error term, and CC_i captures respondent *i*'s commitment cost. The value of CC_i will be positive if WTP is formed dynamically and will be zero otherwise.

While we use the exact theoretical representation for wtp^{NL} derived from the CES model in (9) (see Mansfield 1999 for a similar approach, but without commitment costs), we employ the following simplified expression for CC_i:

$$CC_i = D_i^{Delay}\left(\gamma^{Delay} + \gamma^{HiVar} D_i^{HiVar}\right), \tag{12}$$

where D_i^{Delay} is a dummy variable equal to one if respondent *i* can potentially delay her decision, and D_i^{HiVar} is a dummy variable equal to one if respondent *i* faces a high degree of uncertainty regarding water quality after the proposed improvements. Although simple, this formulation takes into account the two key relationships identified in the theory above: commitment cost is present only when there is potential for future learning, and commitment cost varies according to the degree of uncertainty the respondent faces.

Following Cameron (1988), WTP_i can be estimated from dichotomous choice data by noting that the probability that agent *i* votes yes ($Y_i = 1$) on a referendum to improve environmental quality is

$$\begin{aligned}\Pr\left(Y_i = 1\right) &= \Pr\left(WTP_i \geq T_i\right) \\ &= \Pr\left(wtp_i^{NL} - CC_i + \tau\varepsilon_i \geq T_i\right) \\ &= 1 - \Pr\left(\varepsilon_i \leq \frac{T_i - wtp_i^{NL} + CC_i}{\tau}\right),\end{aligned} \tag{13}$$

where T_i is the policy price faced by respondent *i* and τ is the standard error of ε_i. Assuming ε_i is drawn from the extreme-value error distribution yields, the logistic model and parameter estimates can be readily obtained from maximum likelihood estimation. An estimate of respondent *i*'s WTP, $W\widehat{T}P_i$, can be calculated as follows:

$$W\widehat{T}P_i = w\widehat{t}p_i^{NL} - \widehat{CC}_i\,. \tag{14}$$

A survey instrument was designed to value various plans for improving water quality at Clear Lake in north-central Iowa. The survey first described the lake's current condition in terms of water clarity, color, odor, fish catch, and the frequency of algae blooms and beach closings. Next, the survey described three future water quality scenarios corresponding to different degrees of environmental mitigation. Each of these scenarios was followed by a contingent valuation method (CVM) question in a referendum format, designed to elicit respondents' WTP in order to achieve the conditions described. A copy of the survey instrument is available from the authors.

Before the actual mailing of the survey, the instrument was presented to a focus group of local residents to test its clarity and realism. This was followed by a mailed pretest. In its final form, the survey instrument was sent to a random sample of households in the cities of Clear Lake and Ventura, Iowa, both of which are located on Clear Lake. Following the procedure in Dillman 1978, a follow-up postcard and survey instrument were sent to those households that did not respond to the initial mailing. The eventual response rate among surveys successfully delivered was about 70 percent.

Four versions of the survey instrument were sent out, each differing in terms of the potential for future learning and the degree of uncertainty surrounding water quality after the proposed improvement while holding constant the mean value of the improvement. Survey version 1 presented respondents with a low degree of variance (e.g., water clarity between 6 and 8 feet after improvements) and no potential for future learning. The color photo and diagram used to depict this low level of uncertainty can be found in Appendix A. The absence of future learning potential was written into the CVM question as follows:

> Further, suppose this survey represents the State's only chance to gather information about what kind of value people put on Clear Lake. Please respond as if this will be your final opportunity to vote on the issue, and that if the following referendum fails to pass, there will be no future programs to improve water quality at Clear Lake. Would you vote "yes" on a referendum that would *adopt* the proposed program but *cost* you $\$p$ (payable in five $\$p/5$ installments over a five year period)?

Version 2 again presented respondents with low variance but allowed for potential future learning by offering respondents a second chance to vote on the referendum:

> Further, suppose that if the referendum passes, the improvements would proceed immediately. However, if the referendum fails, any plans to improve the lake would be delayed for *five years* while further research takes place into the causes of lake pollution as well as alternative clean-up approaches. After this delay, any new information from studying the lake will be made available and you will then get a final chance to vote on the same referendum. Would you vote "yes" on

> a referendum that would *adopt* the proposed program but *cost* you $*p*
> (payable in five $*p*/5 installments over a five year period)?

Versions 3 and 4 were analogous to 1 and 2 except that respondents faced a higher degree of uncertainty in terms of the expected water quality (e.g., water clarity between 2 and 12 feet after the proposed improvements).[4] The color diagram used to depict this higher level of uncertainty appears in Appendix B.

Using these data, we test for the presence of a dynamic element in the formation of the WTP values by testing whether *CC* in (11) is significantly different from zero. We further test two comparative static predictions of the theory: first, that *CC* is only positive in the presence of delay and learning (i.e., $\gamma^{Delay} > 0$), and second, that *CC* increases when the consumer is more uncertain (faces higher variance) about the level of *G* after the proposed improvement (i.e., $\gamma^{HiVar} > 0$).

Empirical Findings

A total of 274 respondents provided completed surveys. Of these, thirty-three respondents answered a follow-up question in such a way as to indicate that they did not understand the CVM question or considered it unrealistic. These respondents may not have given serious consideration to the policy price, in which case their responses to the CVM question would contain little or no information regarding their valuation of the resource. Therefore, we treat such answers as protest responses and exclude them from the following analysis. While we view these as the cleanest estimates, results including the protest responses are qualitatively unchanged from those presented here. A summary of the respondents' socioeconomic characteristics can be found in Table 1.

Table 2 presents the results of the logistic regression described in the preceding section. To form the wtp^{NL} equation for estimation, the discount factor β was set to 0.758.[5] Qualitative results were unaffected by the choice of β. To form the expression $\left(E_G(G^\rho) - G_0^\rho\right)$, a uniform distribution over the range of water clarity values reported in the respondent's survey instrument was computed as described earlier.

TABLE 1. Characteristics of survey respondents (n = 274)

Variable	Definition	Mean	Standard Deviation	County Average
Income	Total household income	56,000	44,000	51,000
Education	1 if college graduate	0.36	0.48	0.16
Age	The respondent's age	55	15	47
Gender	1 if male	0.65	0.48	0.47
Family size	Includes adults and children	2.6	1.3	2.3
Homeowner	1 if own home	0.91	0.29	0.72
Year-round resident	1 if year-round resident	0.95	0.22	—

TABLE 2. Regression results

	Basic CES Preferences	Heterogeneous CES Preferences
τ	0.00129*** (3.51)[a]	0.00100** (2.42)
α	0.985*** (4.23)	—
$\alpha_{Intercept}$	—	1.03*** (149)
α_{Income}	—	-0.00124*** (-3.95)
ρ	0.277 (1.03)	—
$\rho_{Intercept}$	—	0.610*** (2.59)
ρ_{Income}	—	-0.0281*** (-3.76)
γ_{Delay}	0.918** (2.48)	0.831** (2.14)
γ_{HiVar}	-0.550 (-1.29)	-0.440 (-0.997)
Percent correct	64%	66%

Note: ** Significant at the 0.05 level. *** Significant at the 0.01 level.
[a]Asymptotic t ratios are in parentheses.

The results in the second column correspond to the basic CES model.[6] To investigate the robustness of the results, we also estimate a random parameters specification that allows α and ρ to vary with income, ignoring the interval restriction in the case of α. More specifically, α_i is estimated as $\alpha_{Intercept} + \alpha_{Income} m_i$ and ρ_i is estimated as $-\exp(\rho_{Intercept} + \rho_{Income} m_i) + 1$.[7]

As seen in Table 2, the estimate of τ is positive and highly significant in both models, indicating the demand curve for improved environmental quality is downward sloping (cf. (13)). The estimate for α reported in the second column is very close to one as expected, indicating that agents put a small weight overall on water quality. In the case where α varies across individuals, the coefficient α_{Income} is negative and highly significant, indicating that respondents put more weight on environmental quality as their income increases. The average value for α is 0.959 with a 95 percent confidence interval of (0.929, 0.985) which we calculated using a bootstrapping technique. Specifically, 1,000 realizations of $\alpha_{Intercept}$ and α_{Income} were drawn from a multivariate normal distribution with a variance-covariance matrix and mean vector taken from the maximum likelihood estimation whose results are presented in Table 2. For each of these draws, we calculated a sample average for $\hat{\alpha}$. The reported confidence interval is generated by ranking these 1,000 $\hat{\alpha}$ estimates and deleting the highest and lowest twenty-five.

The estimate of ρ reported in the second column of Table 2 is significantly different from one, indicating that while there is some degree of substitutability between money and environmental quality, the two are certainly not perfect substitutes.[8] The average estimated value for ρ from the second model is 0.410 with an associated 95 percent confidence interval of (0.149, 0.595) which follows from the $\rho_{Intercept}$ and ρ_{Income} estimates reported in the third column. As described for α, this confidence interval was calculated by bootstrapping. The estimate for ρ_{Income} is negative and highly significant, resulting in the conclusion that respondents with higher income are more willing to substitute money for environmental quality.

We turn now to testing for the presence of dynamic components in the formation of WTP, which depends critically on the sign and significance of the γ parameters. The estimate of γ^{Delay} is positive and highly significant in both specifications. Thus, offering respondents the opportunity to delay their decision until more information becomes available increases commitment costs. However, estimates of γ^{HiVar} are not significantly different from zero in either of the regressions. For both regressions, a chi-squared test rejects the null hypothesis that the γ coefficients jointly equal zero at the 0.05 level in the basic case and at the 0.07 level in the heterogeneous case (χ^2 = 6.77 [2] and χ^2 = 5.31 [2], respectively). Using the same bootstrapping technique discussed earlier to generate 1,000 estimates of mean CC_i, 99 percent of the realizations were greater than zero in the basic case, as were 97 percent in the heterogeneous case. These results indicate that there is a statistically significant, dynamic component to WTP.

Further, the comparative static prediction that introducing delay and the subsequent potential learning yields positive commitment costs is also confirmed in the data. However, the lack of significance of the γ^{HiVar} parameter does not provide strong support for the comparative static prediction related to the variance of the uncertainty. This may seem surprising given that uncertainty is a necessary condition for the existence of commitment cost. One explanation may be that the uncertainty concerning the expected degree of water quality improvements is only one source of the uncertainty respondents face. Specifically, the water quality variable does not measure the uncertainty in value respondents might eventually derive from the improvements. Therefore, finding that γ^{HiVar} is not significantly different from zero may indicate that the latter type of uncertainty is driving the presence of commitment costs. Another possible explanation is that, as mentioned in endnote 5, the mean water quality characteristics are not precisely identical across the two uncertainty levels (recall that while the two primary measures were varied by mean-preserving spreads, two others could not be and still be consistent with the underlying limnology). Thus, respondents may have responded to both changes in uncertainties and mean water quality levels.

Table 3 shows estimates of mean WTP conditional on both the opportunity for learning and the level of uncertainty. Again, for the sake of comparison, we include the results of both regressions.

These results indicate that reported WTP for environmental quality changes can have a large option value component. As a percentage of the no-learning WTP, the commitment costs range from 25 to 57 percent. If researchers are to properly interpret empirical welfare measures, it is critical that they recognize the existence of these options and understand their significance in welfare assessment.

Policy Implications and Conclusions

These results have important implications for the design of stated preference surveys in applied welfare studies. Some policy analysis requires an estimate of the welfare effects of certain policy *decisions*, for example, the welfare effects of improving water

TABLE 3. Willingness to pay and commitment costs

	Basic CES Preferences			Heterogeneous CES Preferences		
	WTP^{L}	***CC***	***WTP^{NL}***	***WTP^{L}***	***CC***	***WTP^{NL}***
Sample average	661 (467, 2277)[a]	475 (34, 1047)	1136 (948, 3079)	683 (338, 1652)	476 (-10, 1151)	1159 (836, 2404)
Low variance	494 (259, 2110)	663 (179, 1401)	1157 (985, 3259)	532 (173, 1470)	639 (22, 2104)	1171 (831, 2678)
High variance	833 (502, 2908)	282 (-257, 948)	1115 (929, 3235)	834 (389, 2463)	313 (-313, 1317)	1147 (793, 2693)

[a]Numbers in parentheses are 95% confidence intervals calculated via bootstrapping.

quality in a lake *now*. If uncertainty, irreversibility, and the potential for future learning are inherent to the policy under consideration, then commitment cost is relevant to the eventual policy decision, and WTP^{l} should be estimated. Further, the survey instrument should accurately convey the potential for delaying the decision, as well as describing what kind of information will be available in the future. Additionally, *ex post* analysis based on observed behavior (such as travel cost or hedonics) will be unable to capture this policy-relevant commitment cost.

However, if the policy-relevant level of uncertainty and/or options for delay differ from those perceived by survey respondents (either because respondents do not believe the information presented in the survey or because they use other sources of information to form their beliefs about delay options and future learning), researchers may need to be careful in using WTP^{l} values directly in benefit-cost assessment, as the values may include discounts for commitment costs that are not appropriate for inclusion in benefit-cost analysis.

Suppose, for example, policymakers are considering converting an empty commercial lot into a public park. Assuming that money spent on the project cannot be recouped, that there is some degree of uncertainty regarding the benefit local residents will derive from the park if it is built, and that the project can reasonably be delayed until some future date when residents may have a better estimate of the park's value, then commitment cost is policy relevant; that is, the appropriate value for use in a benefit assessment regarding a decision on the project today would include a discount for the lost delay opportunities. To avoid overestimating WTP, a survey instrument intended to estimate the value of the proposed project must be written so that it captures commitment cost. In particular, the instrument should note explicitly the potential for delay and subsequent learning.

Further, respondents may demand options that reflect their own level of uncertainty about the good at the time of the survey, rather than the best scientific information available. In the extreme, there may be cases where the results of an action are very certain to the scientific community, but the issue described in a survey may be new to respondents and therefore the information provided may be assumed to be uncertain. In this case, respondents might demand compensation for losing the option to better inform themselves about the good, even though no real uncertainty about the project exists.

On the other hand, suppose the issue under consideration is whether to save a pristine wilderness area from imminent and irreversible commercial development. In this case, there is no potential for delaying the decision and, thus, no potential for future learning. Here, commitment cost is not policy relevant. Instead, the appropriate measure of welfare change is simply the expected equivalent variation. A study that does not convey the immediacy of the decision may mistakenly capture commitment cost as part of its estimate of WTP, thus biasing the estimate downward. If respondents mistakenly believe that there are delay options and future learning opportunities, the WTP values estimated from a stated preference exercise will inaccurately reflect the value of the resource.

Many applied welfare analyses require the estimate of the value of an environmental service or improvement, regardless of the decision framework. For example, a decision-maker may be simply interested in knowing the welfare effects of having a better water quality in a local lake, without plans to take any action now or in the future. In this case, the relevant value should be without the commitment costs, or WTP^{NL}. However, survey questions in CVM studies are framed mostly as hypothetical *decisions*, and commitment costs may arise if the respondents think that there is future learning. Then it is important that the survey be designed to remove or minimize the commitment costs by, for example, reminding the respondents that they take the action as the only and last decision.

In this paper, we test for the effects of potential future learning on WTP in the presence of uncertainty and irreversibility and for whether those effects are consistent with the presence of commitment costs. Using a survey instrument designed specifically for measuring WTP given varying degrees of uncertainty and learning potential, we collected data from Clear Lake–area residents regarding their valuation of a proposed project to improve water quality in Clear Lake. Our findings show that respondents' WTP is indeed sensitive to the potential for future learning. This is consistent with the dynamic formation of WTP values and suggests that welfare analysts must take care to accurately represent the potential for future learning.

Endnotes

1. WTP is equivalent to compensating variation for a price decrease or quality increase, and to equivalent variation for the opposite cases.

2. For counter results, see Boyle, Reiling, and Phillips 1990, and Loomis, Gonzalez-Caban, and Gregory 1994.

3. The model can also be extended to the case where the agent is uncertain regarding utility she would receive from the improvement.

4. Because of limnological realities, when we conduct mean-preserving spreads on the two key water quality variables, water clarity and algae blooms, the implied changes on the remaining variables are not mean-preserving. That is, strictly speaking, we are not able to control the uncertainties independent of the mean water quality levels.

5. Unfortunately, since α and β always appear together in the expression for *wtpNL*, the two parameters cannot be estimated separately in the basic CES preferences case. The parameter estimates reported in Table 2 were calculated by setting $\beta = 0.758$. This corresponds to a riskless rate of return of 5.70 percent, which is equal to the return on a five-year Treasury note issued November 1, 2000. In the basic CES case, the only estimate affected by the choice of β is α. The sensitivity of the results to this assumption was tested using values for β between zero and one. The results from this analysis can be found in Appendix C.

6. In order to confine α to the unit interval as indicated by the theory, we set $\alpha = e^x/(1+e^x)$ and estimate *x*. Likewise, to restrict ρ to the $(-\infty,1]$ interval, we set $\rho = -e^y + 1$ and estimate *y*.

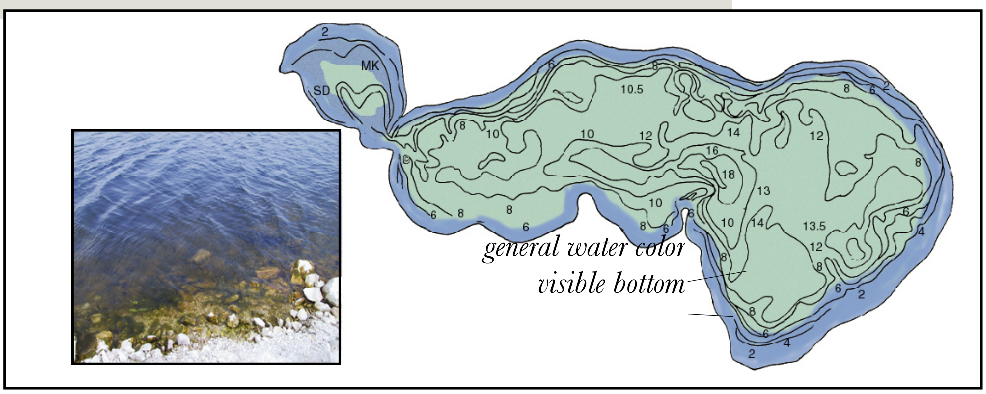
7. A third model was estimated allowing α, ρ, γ^{Delay} and γ^{HiVar} to vary with income. The results are not reported here since the restriction $\gamma^{Delay}_{Income} = \gamma^{HiVar}_{Income} = 0$ could not be rejected at conventional significance levels ($\chi^2 = 0.86$ [2]).

8. One of the appealing features of the CES form is that it allows explicit estimation of this degree of substitution, which Randall and Stoll (1980) and Hanemann (1991) have shown to be key to the formation of WTP values for quality changes.

Appendix A: Low-Variance Graphic

Plan C

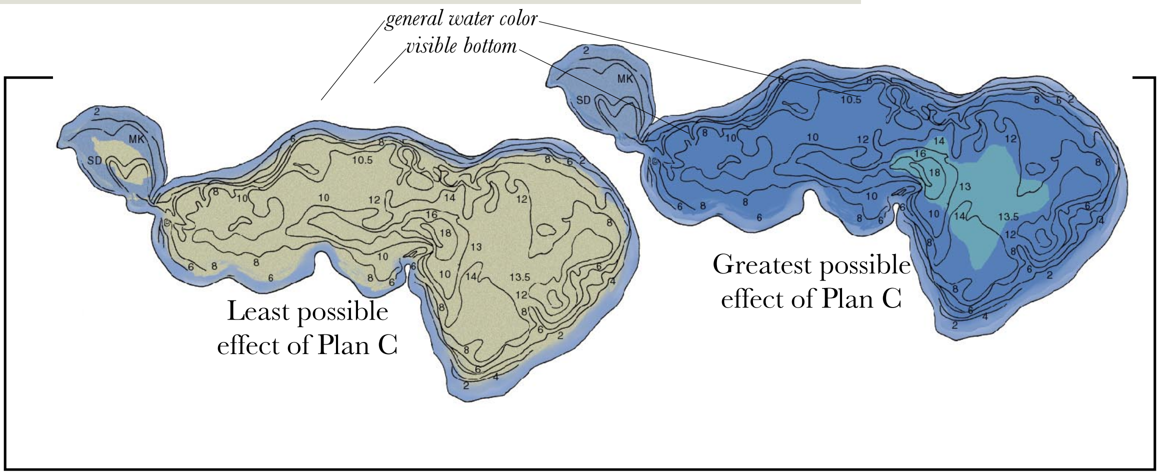
Water clarity	objects distinguishable 6 to 8 feet under water
Algae blooms	3 to 4 per year
Water color	green to blue
Water odor	occasional mild
Bacteria	infrequent swim advisories
Fish	high diversity



Appendix B: High-Variance Graphic

Plan C

Water clarity	objects distinguishable 2 to 12 feet under water
Algae blooms	0 to 8 per year
Water color	greenish brown to blue
Water odor	occasional mild to no odor
Bacteria	infrequent swim advisories to no advisories
Fish	low to high diversity



Appendix C: The Relationship between β and α

β Value	Estimate of α Homogeneous Parameters	Estimate of α Heterogeneous Parameters
1.0	0.987	0.963
0.9	0.986	0.961
0.8	0.985	0.960
0.7	0.984	0.958
0.6	0.983	0.956
0.5	0.982	0.953
0.4	0.981	0.950
0.3	0.980	0.951
0.2	0.978	0.948
0.1	0.976	0.945
0.0	0.974	0.937

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