Willingness to Pay and the Cost of Commitment: An Empirical Specification and Test

Abstract

In a static setting, willingness to pay for an environmental improvement is equal to compensating variation. In a dynamic setting, however, willingness to pay may also contain a commitment cost. In this paper we incorporate the dynamic nature of the value formation process into a stated preference study designed to test whether there is an important dynamic component (commitment cost) in stated preference values. The results clearly indicate that stated preference values can contain commitment costs and that these can be quite large: 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 facing a now-or-never decision. These results have important consequences for the design and interpretation of stated preference data. (*JEL* Q26, C42, D60)

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 WTP, work by Zhao and Kling (2001, 2004) systematically investigates learning opportunities in the formation of WTP.

In a 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 to commit to a purchase now and forgo future learning opportunities, the agent 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), Henry (1974), Hanemann (1989), and Dixit and Pindyck (1994). Numerous experiments and stated preference surveys 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); List (2001); and Hoehn and Randall (2002).

A key prediction from Zhao and Kling's model is that commitment cost increases as it is easier for an agent to delay making a decision and collect more information prior to committing to a purchase decision. Therefore, the willingness to pay 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 solely of the expected surplus from consuming the good. Rather, WTP is reduced by the commitment cost and is a dynamic measure that may change over time as consumers update their information about the surplus from purchasing the good. 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, including the striking divergences found between WTP and willingness to accept compensation,[2] 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 other key estimation choices in environmental valuation has been undertaken (see, for example, Carson *et al*. 1997, 1998), the impact of dynamic decision making on 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. To do so, 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 leads to a significant reduction in today's WTP, confirming the predictions of the theory.

The paper proceeds as follows. Section 1 provides a brief review of the related empirical literature. Section 2 develops a simple, theoretical representation of WTP formation under dynamic conditions that explicitly relates the magnitude of commitment cost to learning and future information. Section 3 describes the design of the stated preference instrument and empirical test, while Section 4 presents the key findings and test results. Concluding remarks follow in Section 5.

1. The Empirical Literature on Commitment Cost

Kling, List, and Zhao (2003) conducted a field auction experiment where they compared participants' WTP bids for sportscards with their self-reported perceptions regarding the difficulty of delaying or reversing the transaction outside of the experiment. Consistent with the predictions of the commitment cost model, participants who believed that delaying the sportscard purchase would be relatively difficult submitted significantly higher WTP bids. In particular, the authors found that among participants who believed that delaying the transaction would be more difficult than reversal, average WTP was about 140% greater than among participants who believed that delaying the transaction would be relatively easy.

Corrigan (2005) used similar methodology but in a laboratory setting. He found that among participants who believed that delaying the transaction would be more difficult than reversal, average WTP for a private good was 71% greater than among participants who believed that delaying the transaction would be relatively easy.

Lusk (2003) focuses on WTP for lotteries in a laboratory setting. While his findings are not strongly supportive of all the commitment cost model's predictions, they support one prediction that is key from the standpoint of the CVM practitioner. In particular, Lusk's conditional results show that experimental participants are willing to pay significantly less when offered the ability to delay a transaction until a second auction round where more information is available about the value of the lottery.

2. WTP in a Dynamic Setting

In this section we develop a model to describe a respondent's answer to a CVM question. This work extends the model presented by Zhao and Kling (2004) in two important ways. First, we treat the environmental good (G) as durable. If G is purchased in the current period, it can also be enjoyed in the future at no additional cost. Second, we assume that if an agent chooses to delay the purchasing decision, she will not necessarily be given the chance to purchase the good in the future. Instead, she has another chance to purchase the good only with probability q. Throughout the paper we use the terms "purchase" and "vote yes" interchangeably: a respondent who votes yes on a WTP question is said to be choosing to purchase the environmental good. While CVM questions in our survey are presented as votes, it is easier and more intuitive to model a purchase decision.

The commitment cost model of Zhao and Kling (2004) is related to but distinct from the voluminous literature on investment under uncertainty (in particular real option theory, e.g., Dixit and Pindyck (1994)). From a pure modeling perspective, real option theory addresses the question of "when to purchase a good given the payoffs and current and future information," while the commit cost model addresses the mirror question of "what price is needed to induce the agent to purchase the good now, given the payoffs and current and future information." More importantly, the answer to the second question provides researchers with a WTP measure (i.e., the price at which the agent will purchase the good), a measure that is routinely used in welfare analysis. This point is especially relevant for CVM practitioners given that they only observe WTP.

A key message from the commitment cost model is that the WTP measure obtained above is *different* from compensating variation (for environmental improvement), because the purchase decision depends not only on the true valuation of the good (i.e., CV), but also on current and future information and thus on the option of delay. WTP is formed in a dynamic process in which CV is just one component. To back out CV, the welfare measure that researchers are after, the commitment cost has to be estimated and removed. The magnitude of this dynamic component of WTP is an important empirical question, and is the focus of this paper.

We begin by considering an individual who must choose whether to vote in favor of a proposed environmental improvement in either of 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, t = 1, 2, and β is the discount factor. The status quo level of environmental quality is denoted G_0. The proposed program will lead to a higher level of environmental quality G. For example, the program may involve dredging a lake, cleaning up a toxic waste site, or building a park facility. The program, or the higher quality G, can be purchased in the current period, the future period, or not at all. The purchase decision is irreversible. 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 program. This may be due to uncertainty regarding the degree to which the environmental good, such as water quality, would in fact be improved if the proposed actions 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, ongoing research may, by the next period, provide more accurate information regarding the degree of water quality improvement brought about by the proposed mitigation efforts. We represent the new information by 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' 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 at price *p*. Since 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 $E_G(\cdot)$ represents expectation over *G*. Suppose the agent delays her decision until period 2. With probability $(1-q)$, no new referendum is presented and her second period payoff is $E_G u(m_2, G_0)$. With probability q, the agent is offered a new referendum after receiving new information about G. Let $V(p,s)$ be her expected gain if she decides to purchase the good after observing s:

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

She will buy G if and only if $V(p,s)\geq 0$. Let $S_{p1}(p)=\{s\in S:V(p,s)\geq 0\}$ be the set of signals that will induce the agent to purchase G and $\Pr(S_{P1}(p))$ be the ex ante probability of $s\in S_{P1}(p)$. Then the agent's expected utility if she delays the purchasing decision is

$$\begin{aligned} EU_2(p) &= u\left(m_1,G_0\right)+\beta(1-q)u(m_2,G_0) \\ &\quad +\beta q\left[\Pr(S_{P1}(p))E_G\left(u\left(m_2-p,G\right)|\, s\in S_{P1}\right)+\left(1-\Pr(S_{P1}(p))\right)u\left(m_2,G_0\right)\right], \\ &= U_0+\beta q\Pr(S_{P1}(p))\left[E_G\left(u\left(m_2-p,G\right)|\, s\in S_{P1}\right)-u(m_2,G_0)\right], \end{aligned} \tag{4}$$

where

$$U_0=u(m_1,G_0)+\beta u(m_2,G_0)$$

is the expected utility of never purchasing the good. From the definition of $S_{p1}(p)$, we know the last term in (4) is non-negative, and thus $EU_2(p)\geq U_0$.

Under 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 willingness to pay 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 2: $EU_1(p^L)=EU_2(p^L)$, where the superscript L represents learning. 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. Then her willingness to pay wtp^{NL} is the critical price p^{NL} that leaves her indifferent between purchasing the environmental improvement in the current period and never purchasing it: $EU_1(p^{NL}) = U_0$, where the superscript *NL* represents no learning.

Zhao and Kling (2004) show for the case of $q = 1$ that $wtp^L \le wtp^{NL}$, and that the inequality is strict if $\Pr(S_{P1}) > 0$ (*i.e.*, if the signal has a positive probability of being "useful"). We can show that this result holds true as long as $q > 0$. In this case, $EU_2(p) \ge U_0$. Since $EU_1(\cdot)$ and $EU_2(\cdot)$ are both decreasing, we know $p^L \le p^{NL}$. Further, the inequalities are strict if $\Pr(S_{P1}) > 0$. These observations immediately lead to a testable prediction: *facing a referendum with any given price, agents with delay opportunities are less likely to vote yes.*

As the price increases, the probability of observing "favorable signals" $\Pr(S_{P1})$ becomes smaller, and the probabilities of observing yes votes by agents with and without delay opportunities decrease and converge. It is obvious that for sufficiently high prices respondents will vote no under both treatments. However, in our model the probabilities of voting yes may converge (which occurs when $\Pr(S_{P1})$ becomes small) even without both being zero. The reason is that the critical price that leads to a "no" vote without delay opportunities could be different from the price that leads to vanishing $\Pr(S_{P1})$.[1] This discussion leads to another testable prediction: *the difference between the yes votes under the two treatments is likely to decrease as the price increases.*

The magnitude of the effects of delay and learning opportunities is measured by the commitment cost, defined as $wtp^{NL} - wtp^L$. This 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. To obtain a closed-form representation of the commitment cost, we assume the following convenient specification for $u(\cdot)$:

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

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

Given (5), we can solve $EU_1(p^L) = EU_2(p^L)$ and find that

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

where

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

From $EU_1(p^{NL}) = U_0$, or

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

we get

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

The commitment cost is

[1] To see this, note that the condition required for a "no" vote without delay is $EU_1(p) < U_0$, while the condition for $\Pr(S_{P1}) = 0$ is $E_G(u(m_2 - p, G) \mid s) < u(m_2, G_0)$ for all *s*. The first condition is derived from payoffs in two periods while the second is from payoff in the second period only.

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

CC is strictly positive as long as q and $\Pr(s \in S_{P1})$ are strictly positive. Conversely, *CC* will be zero if either q or $\Pr(s \in S_{P1})$ equal zero.

In the next section we discuss the design of an empirical test of whether dynamic behavior is present in the formation of WTP in a CVM setting. We also estimate the magnitude of commitment cost if dynamic behavior is present.

3. Design of the Empirical Test

In consultation with ecologists familiar with Clear Lake in Iowa, we designed a survey instrument to value various plans for improving the water quality at the lake. 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 (i.e., the current values of *G*, a vector). Next, following Loomis (1990), the survey described three future scenarios corresponding to different and uncertain degrees of environmental improvement (i.e., the uncertain values of *G* after improvement). To underscore the existence of uncertainty regarding the lake's future water quality, we were careful to describe water quality after the proposed improvements in terms of *ranges* (e.g., 6 to 8 feet of water clarity, 3 to 4 algae blooms per year, green to blue water color). Each proposed future scenario was followed by a referendum-format CVM question designed to elicit respondents' WTP in order to achieve the conditions described. To encourage accuracy in responses, the survey instrument also contained a "cheap talk" section based on Cummings and Taylor (1999). Respondents were instructed to treat each individual referendum as if it were the only referendum under consideration. The results from the first two referenda were used as part of a different study and therefore are not reported here. Since we only consider the results from the third referendum, any order effects are consistent across our sample. A copy of the survey instrument is available from the authors upon request.[4]

Prior to 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 next to 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 69%. Table I presents a summary of the respondents' socioeconomic characteristics. A total of 158 respondents completed the survey. Only year-round residency differed significantly across survey versions, with respondents completing the no-delay version being significantly less likely to be year-round residents ($p = 0.01$).

Two versions of the survey instrument were employed, differing in terms of the stated potential for future learning. Version 1 presented respondents with no potential for future learning. The absence of future learning potential was written into the CVM question as follows:

> 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 \$$T_i$ (payable in five \$$T_i$/5 installments over a five year period)?

Version 2 allowed for potential future learning by offering respondents a second chance to vote on the referendum:

> 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 *one year* 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 \$$T_i$ (payable in five \$$T_i$/5 installments over a five year period)?

Values for T_i ranged from \$315 to \$1860. At the time the survey was conducted, the state government was actively planning to clean up the lake but the schedule was not yet finalized. Therefore, both the delay and no-delay versions of the survey should have been highly credible.

To see whether the effects of potential learning and delay influence WTP as predicted by the commitment cost model, we will test the following two-part hypothesis:

> **Hypothesis:** (i) Facing a referendum with the same price or cost, respondents who are presented with the delay opportunities are less likely to vote yes than respondents without delay opportunities. (ii) If the price or cost is too high, the difference between the likelihoods of yes votes in the two groups will vanish.

We then go a step further and estimate the magnitude of the commitment cost. Ideally we would estimate a closed-form expression for both wtp^{NL} and wtp^{L}, where the difference is the commitment cost. But as seen in equations (6) and (7), the expression for wtp^{L} contains probabilities that are not known analytically. However, these expressions make clear that the key difference between wtp^{NL} and wtp^{L} depends on the ability to delay. Thus, we estimate respondent *i*'s true (or dynamic) WTP as

$$WTP_i = \beta' X_i - \gamma D_i^{Delay} + \varepsilon_i, \tag{11}$$

where X_i is a vector of the socioeconomic characteristics presented in Table I, D_i^{Delay} is a dummy variable equal to one if respondent *i* can potentially delay her decision, and ε_i is a mean-zero error term. The commitment cost is then γD_i^{Delay}.

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

$$\begin{aligned}\Pr\left(Y_i = 1\right) &= \Pr\left(WTP_i \geq T_i\right),\\ &= \Pr\left(\beta' X_i - \gamma D_i^{Delay} + \varepsilon_i \geq T_i\right),\\ &= \Pr\left(\beta' X_i - \gamma D_i^{Delay} + \kappa u_i \geq T_i\right),\\ &= 1 - \Pr\left(u_i \leq \frac{1}{\kappa} T_i - \frac{\beta'}{\kappa} X_i + \frac{\gamma}{\kappa} D_i^{Delay}\right),\end{aligned} \tag{12}$$

where T_i is the policy price faced by respondent *i*. Assuming a logistic distribution for the error term u_i, the parameter estimates can be readily obtained from maximum likelihood estimation, and an estimate of WTP_i can be calculated as follows:

$$W\hat{T}P_i = \frac{\left(\widehat{\frac{\beta'}{\kappa}}\right) X_i - \left(\widehat{\frac{\gamma}{\kappa}}\right) D_i^{Delay}}{\left(\widehat{\frac{1}{\kappa}}\right)}. \tag{13}$$

This equation also shows another way of testing the presence of dynamic effects, by testing whether $\widehat{\frac{\gamma}{\kappa}}$ in (13) is significantly different from zero.

4. Empirical Findings

To test the Hypothesis, Table II presents the overall ratio of yes votes to no votes, as well as the ratio for three policy-price ranges, $300-$899, $900-$1299, and $1300-$1899.[5] In every case, respondents were less likely to vote yes when presented with the possibility of a future referendum. Using a one-sided Fisher's exact test to compare the yes-vote ratios, we find that this difference is statistically significant on the whole and for the first two of the three policy-price ranges.[6]

These results confirm the Hypothesis. When the prices are not too high (i.e., for the first two groups of policy prices) respondents are less likely to vote yes if they are presented with the option to delay. More importantly, the difference between the proportions of yes votes vanishes for the highest prices (i.e., the third group of policy prices) without the proportions themselves being zero, consistent with the predictions of commitment cost theory. These results can also be seen graphically in Figures 1 and 2. Figure 1 presents the cumulative proportion of respondents voting yes among the subset of respondents facing a price lower than a certain level. Consistent with part (i) of the Hypothesis, respondents offered the option of a one-year delay are less likely to vote yes on a referendum today. Figure 2 presents the proportion of the respondents voting yes among the subset of respondents facing a price within a $300 trailing range. For instance, the figures reported for the $1,200 policy price represent the proportion of the of respondents voting yes among the subset facing policy prices between $900 and $1,200. According the figure, 56% of respondents in the no-delay treatment voted yes when facing prices in this range, compared with just 26% of respondents in the delay treatment. Consistent with part (ii) of the

Hypothesis, the proportion of respondents voting yes in the delay and no-delay treatments converges as the policy price increases.

Column (1) of Table III presents the results of the logistic regression described in equation (12).[7] The coefficient associated with the possibility of delay is significantly greater than zero at the 0.05 level. The coefficients associated with education and income (scaled by 10,000) are positive, suggesting that WTP increases with educational attainment and income. In particular, attending college results in an $880 increase in estimated WTP, while an additional $10,000 in household income results in a $110 increase in estimated WTP. As expected, the policy-price coefficient is significantly greater than zero (at the 0.03 level in a one-sided test). Given our specification, this suggests that the likelihood of a yes vote falls as the policy price increases.

We estimate mean WTP conditional on the opportunity for learning as

$$\text{Mean WTP} = \frac{\left(\widehat{\dfrac{\beta}{\kappa}}\right)\bar{X} - \left(\widehat{\dfrac{\gamma}{\kappa}}\right)D^{Delay}}{\left(\widehat{\dfrac{1}{\kappa}}\right)}, \tag{14}$$

where $\bar{X}$ is a vector of the sample means of the socioeconomic variables, and D^{Delay} equals one in the delay case, zero otherwise. Table IV reports estimates of mean WTP. These results indicate that willingness to pay for improved environmental quality has a large commitment cost component. Specifically, we find that the commitment cost accounts for 76% of no-learning WTP. We also estimate commitment cost as

$$\widehat{CC} = \left(\widehat{\frac{\gamma}{\kappa}}\right) \Big/ \left(\widehat{\frac{1}{\kappa}}\right). \tag{15}$$

Using a parametric bootstrap procedure (Park, Loomis, and Creel 1991) to assess the distribution of the commitment cost, 96% of realizations of $\widehat{CC}$ are positive.

We also estimate WTP allowing for commitment cost to vary as a function of respondents' socioeconomic characteristics. These results are presented in columns (2) and (3) of Table III. The coefficient associated with the possibility of delay has the same sign and magnitude for the regressions reported in columns (1) and (2). The delay coefficient is smaller and statistically insignificant for the regression reported in column (3). This is most likely due to the decrease in degrees of freedom. In no case are the coefficient estimates for the interacted socioeconomic terms statistically significant.

The results presented in this section suggest that if researchers are to properly interpret empirical welfare measures, it is critical to recognize the existence of these options and to understand their significance in welfare assessment.

One possible counter explanation for our findings is that the project with the delay opportunity simply represents another good, a good that is in some sense perceived as being "better." Facing a choice between the two goods, the proposed project (available immediately if the current referendum passes) and the "better" project (available in the future if the current referendum fails), respondents tend to choose the latter and thus vote no. While this argument predicts that respondents offered the opportunity for delay will be less likely to vote yes (as in Hypothesis item (i)) and is therefore consistent with the results presented in Table III and Figure 1, it does not predict that the proportion of respondents voting yes in the two treatments will converge as the policy price rises (as in Hypothesis item (ii)) and is therefore inconsistent with the results presented in Table II and Figure 2.

Another counter explanation is that the language used to explain to respondents whether they had the ability to delay their decision introduced an added hypothetical element to the survey, thereby causing respondents to take the no-delay version of the survey less seriously. However, there is no evidence that either version of the survey was viewed as less credible. As noted earlier, both the delay and no-delay scenarios were quite plausible given the early stage of the state's clean-up efforts and the speed at which water quality in Clear Lake was deteriorating. Further, the results from a follow-up question posed to recipients of both versions of the survey strongly suggest that neither version was perceived as more hypothetical or unrealistic than the other. Specifically, respondents were asked to indicate the "most important reason" for their response to the CVM question. Six out of 82 respondents completing the no-delay version of the survey indicated that "the plan is not realistic or is unclear," compared with nine out of 83 completing the delay version. Using a Fisher's exact test we cannot reject the null hypothesis that respondents to both versions were equally likely to indicate that the plan was unrealistic or unclear ($p = 0.59$). Similarly, using a Fisher's exact test we cannot reject the null hypothesis that respondents were equally likely to return a completed survey regardless of the version they received ($p = 0.91$). Thus, differences in perceived delay opportunities are driving the results rather than differences in realism between the two treatments.

5. Policy Implications and Conclusions

In this paper we test for the effects of potential future learning on WTP in the presence of uncertainty and irreversibility, and whether those effects are consistent with the presence of commitment costs. Using a survey instrument designed specifically to measure WTP given varying degrees of learning potential, we collected data from lake-area residents regarding their valuation of a proposed project to improve water quality in a local lake. Our findings show that respondents' WTP is indeed sensitive to the potential for future learning. This is consistent with the commitment cost model's prediction that WTP is influenced by dynamic considerations, and it suggests that welfare analysts must take care to accurately represent the potential for future learning.

These results have important implications for the design of stated preference surveys in applied welfare studies. 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 describe what kind of additional information will be available in the future. It is especially important that these issues be addressed in ex ante stated preference studies, since 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 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 inappropriate commitment costs.

Suppose, for example, policymakers interested in reducing greenhouse gas emission are considering subsidizing the installation of a 100-acre array of solar panels. Money spent on the project cannot be recouped and there is some degree of uncertainty regarding the extent of the risk posed by global warming, the future price of fossil fuels, the future price of solar panels, and the future price of alternative technologies for reducing carbon emissions. In this situation there is undoubtedly value associated with information that will become available in the future. The commitment cost, therefore, is policy relevant. 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 explicitly note the potential for delay and subsequent learning.

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 to be incorporated into an improved decision later. Here, there is no role for commitment cost and the appropriate measure of welfare change is simply the expected equivalent variation. However, if a stated preference instrument does not convey the immediacy of the decision, respondents may mistakenly believe that there is an opportunity for delay and incorporate a commitment cost into their reported WTP. In this case, the reported WTP will be biased downward. In sum, 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.

Notes

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

[2] For an excellent assessment, see Horowitz and McConnell (2002). For an analysis of whether the divergence between WTP and WTA can be explained by substitution effects only, see Horowitz and McConnell (2003).

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

[4] Note to reviewers: A copy of the survey instrument is included in the Reviewer's Appendix.

[5] Note that because the policy prices were drawn from a triangular distribution, the first and third policy-price ranges are somewhat wider in order to ensure that roughly the same number of respondents fall into each of the three ranges. Our empirical results do not change if different policy-price ranges are used.

[6] Another group of survey respondents was presented with the possibility of a five-year wait before the next referendum. Comparing these responses with those from the no-delay version yields qualitatively similar results ($p < 0.01$ for all prices, and $p = 0.01$, 0.08, and 0.32 for the first, second, and third policy-price ranges, respectively).

[7] In addition, we estimated equation (12) using data collected from a group of survey respondents who had been presented with the possibility of a five-year wait before the next referendum. Comparing these responses with those from the no-delay version, we again find that the delay coefficient is significantly greater than zero ($t = 3.06$). Another group was presented with the possibility of a five-year wait and a high degree of uncertainty regarding the degree of water quality (i.e., 2 to 12 feet or water clarity after the proposed improvements as opposed to 6 to 8 feet or water clarity). In this case, the delay coefficient is not significantly different from zero ($t = -0.63$). We speculate that this may be due to the range of possible outcomes not being viewed as credible.

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Table I. Characteristics of Survey Respondents ($n = 158$)

Variable	Definition	Mean	Standard Deviation	County Average
Income	Total household income	54,000	41,000	51,000
Education	1 if some college education	0.53	0.50	0.54
Age	Respondent's age	55	16	47
Gender	1 if male	0.63	0.48	0.47
Homeowner	1 if own home	0.91	0.29	0.72
Year-round resident	1 if year-round resident	0.95	0.21	0.95

Table II. Ratio of Yes Votes to Total Votes

	No delay			One-year delay			
Policy Price	Yes	Total	Ratio	Yes	Total	Ratio	*p*-value[a]
\$300-\$899	14	21	0.67	13	30	0.43	0.09
\$900-\$1,299	19	34	0.56	7	28	0.25	0.01
\$1,300-\$1,899	8	23	0.35	7	22	0.32	0.54
All prices	41	78	0.53	27	80	0.34	0.01

[a] *p*-value comparing yes-vote ratios calculated using a one-sided Fisher's exact test.

Table III. Regression Results

Variable[a]	(1)	(2)	(3)
Constant	1.20*	1.23*	1.25**
	(1.91)[b]	(1.94)	(1.95)
Delay	0.92**	0.90**	0.23
	(2.46)	(2.42)	(0.17)
Income	0.11*	0.10	0.10
	(1.87)	(1.33)	(1.34)
Education	0.88**	1.05**	1.05*
	(2.22)	(1.97)	(1.92)
Age	-0.02	-0.02	-0.01
	(-1.39)	(-1.44)	(-0.66)
Gender	0.56	0.52	0.52
	(1.47)	(1.30)	(0.90)
Homeowner	0.21	0.17	0.37
	(0.30)	(0.24)	(0.31)
Year-round resident	-1.02	-1.06	-1.00
	(-1.06)	(-1.08)	(-1.02)
Income×Delay	----	0.03	0.02
		(0.28)	(0.28)
Education×Delay	----	-0.42	-0.45
		(-0.51)	(-0.54)
Age×Delay	----	----	-0.01
			(-0.51)
Gender×Delay	----	----	-0.02
			(-0.02)
Homeoner×Delay	----	----	-0.27
			(-0.18)
Year-round resident×Delay	----	----	-15.76
			(-0.52)
Policy price	0.001*	0.001*	0.001*
	(1.87)	(1.89)	(1.92)
Log likelihood	-92.5	-92.3	-92.1
Percent correct predictions	68.4	70.2	68.9

[a] All socioeconomic variables are mean deleted. Income is scaled by 10,000.
[b] *t* statistics in parentheses.
* Significant at the 0.10 level.
** Significant at the 0.05 level.

Table IV. Willingness to Pay and Commitment Cost

	WTP with one-year delay	Commitment cost	WTP with no delay
Estimate	\$285	\$906	\$1,191

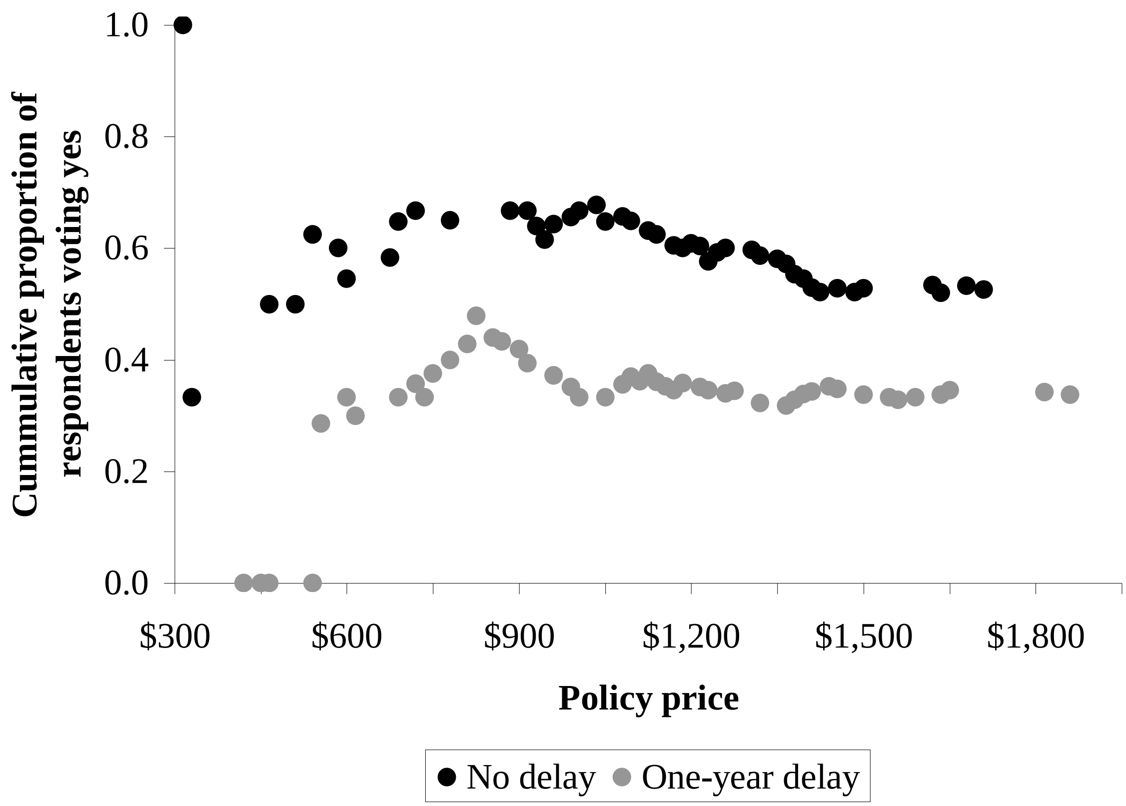

Figure 1. Cumulative Proportion of the Respondents Voting Yes

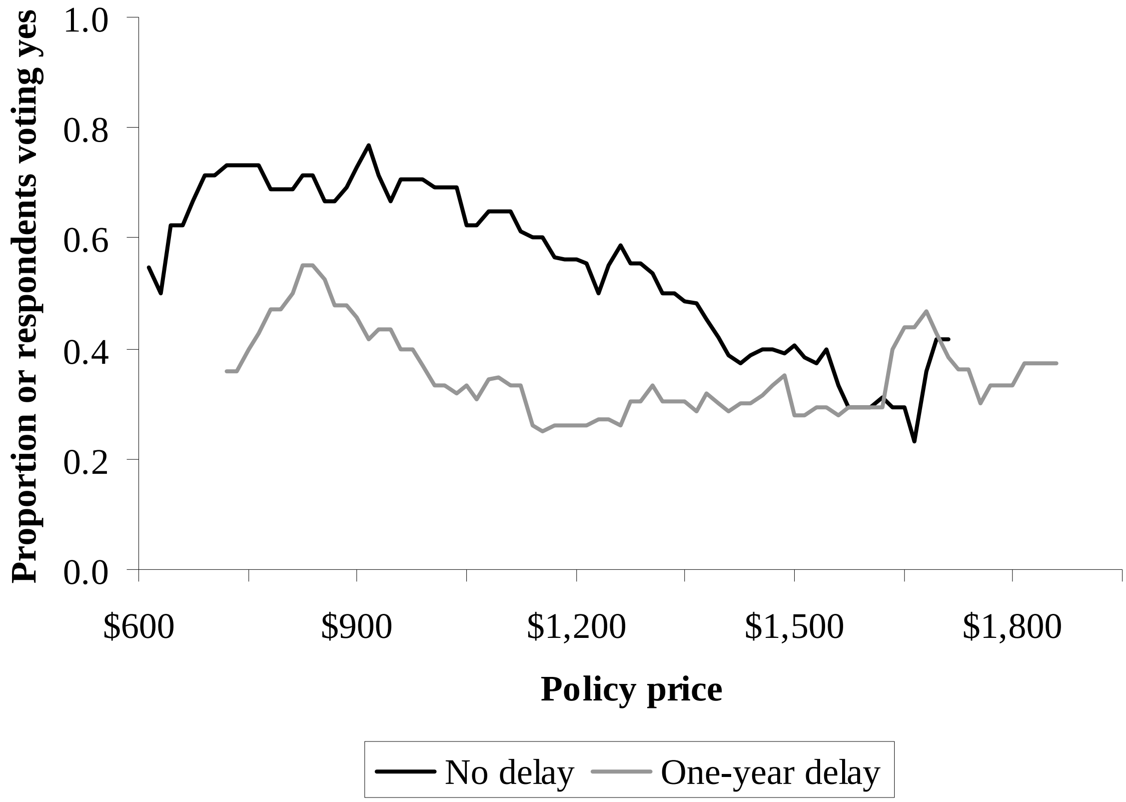

Figure 2. $300 Trailing Average of the Proportion of Respondents Voting Yes