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Disparities in empirical welfare measures: the effects of time and information

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Disparities in empirical welfare measures:

The effects of time and information

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For the Major Program

To my wife, Sonia, and my parents, Roger and Marilyn,
for all their love and support.

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ABSTRACT

In a static setting, willingness to pay (WTP) for an increase in quantity or quality is simply equal to the compensating variation, a Hicksian welfare measure. Likewise, willingness to accept compensation in exchange (WTA) for a decrease in quantity or quality is equal to the equivalent variation. However, in a dynamic setting characterized by uncertainty, limited delay or reversal, and the potential for learning, these stated preference measures may also contain option values. Zhao and Kling (*Economics Letters*, 2001) use real options theory to explain the relationship between learning, irreversibility, and value formulation in a dynamic setting. In this dissertation, I discuss the design and results of two empirical tests of whether stated preference value measures are affected by dynamic aspects of the market environment, and whether those effects, if they exist, are consistent with Zhao and Kling's predictions.

The first test incorporates the dynamic nature of the value formulation process into a contingent valuation study designed to measure the value local residents place on a north-central Iowa lake. My results show that WTP 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 were those facing a now-or-never decision. These results suggest that welfare analysts should take care to accurately represent the potential for future learning.

The second test also deals with the effects of learning and irreversibility on stated preference measures, but this time in an experimental economic setting. I test whether part of the disparity observed between WTA and WTP in the experimental economic literature can be explained by the presence of real options. To do this, I have performed a series of experimental treatments designed to analyze the effect subjects' perceptions regarding the relative difficulty of reversal and delay have on their valuation of a private good. While I find some evidence that subjects do take into account dynamic considerations, I cannot show that WTA and WTP are affected in a manner consistent with Zhao and Kling's theory.

(*JEL*: D60, Q26, C42, C91)

CHAPTER 1

INTRODUCTION

Hicksian welfare theory forms the foundation of modern welfare analysis. Though simple and undeniably elegant, this theory is also static. Using it to perform empirical welfare analysis in a dynamic environment, therefore, ignores key aspects of the value formulation process, and can result in either over- or underestimation of welfare change. If we are to have any confidence in our ability to perform reliable benefit-cost analysis, it is crucial that we better understand the factors affecting value formulation in a dynamic setting.

Hicksian theory's most basic components, compensating and equivalent variation, are used extensively in empirical demand studies, stated preference surveys, and experimental laboratory settings. The popularity of these measures follows from their equivalence, in a static setting, with what agents are willing to pay or accept in compensation for changes in price or quality. However, in an explicitly dynamic setting characterized by uncertainty, potential future learning, and limited reversibility or delay, the equivalence between stated preference measures and their underlying Hicksian variations breaks down. Although static Hicksian theory has little to say about how the potential arrival of new information and the ability to reverse or delay a transaction might affect stated values, recent work by Zhao and Kling (2001, 2002) systematically investigates the impact these dynamic issues have on the formation of willingness to pay (WTP) and willingness to accept (WTA).

Zhao and Kling show that if a potential buyer is uncertain about the actual value of the good she is interested in purchasing, there is an option value associated with delaying the transaction if more information regarding the good's value can be gained by waiting. Therefore, in order to commit to purchase today and forgo future learning opportunities, the agent must be compensated by being offered a lower price than the one she would have been willing to pay were future learning not an option. On the other hand, if the agent is uncertain about the future market value of the good, there is an option value associated with purchasing the good today, as this may allow her to sell the good for a profit in the future. Taking into account this potential for future profit, the agent would be willing to pay a higher price than would have been the case were future selling not an option. Zhao and Kling call the net effect of these two option values the commitment cost. This concept is parallel to the quasi option value developed by Arrow and Fisher (1974), and Henry (1974). In this dynamic setting, WTP and WTA are comprised not simply of the expected surplus from consuming the good, but also include a pair of opposing option values. Thus, depending on the situation, WTP for an improvement may either over- or understate compensating variation. The same is true for WTA and equivalent variation.

If the commitment cost is sufficiently large, Zhao and Kling's theory may provide insight into several critical issues related to welfare measurement. For example, the theory may be particularly important in gaining a better understanding of the use of stated preference techniques to gauge the value of nonmarket goods in a dynamic setting. While contingent markets for goods such as environmental quality are generally thought of as static, it is possible that there are dynamic elements present in these studies' willingness to pay estimates. Ignoring these dynamic elements may lead to misunderstanding and misstatement of value estimates. The commitment cost theory could help determine 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 has been undertaken concerning the effects key estimation choices have on environmental valuation (see, for example, Carson *et al.* 1997, 1998), the effects due to the dynamic formation of WTP values have not been studied.

Another area where a better understanding of dynamic value formation may prove useful is in interpreting the often-observed disparity between WTA and WTP. Economic laboratory experiments and CVM studies consistently find that individuals asked for their minimum willingness to accept compensation in order to give up a good report values several times higher than had they been asked for their maximum willingness to pay for the very same good (see Horowitz and McConnell 2000a for a comprehensive discussion of this literature). Previous theories attempting to explain this apparent anomaly have primarily treated the problem as static (*e.g.*, Tversky and Kahneman 1990, Hanemann 1991). Little work has been done where the disparity is considered in a dynamic context. Zhao and Kling (2001) show that, under certain dynamic conditions, the existence of commitment costs can cause WTA to exceed WTP, thus reconciling the observed disparity with neoclassical consumer theory. The authors cite several studies that offer "intriguing empirical support" for their theory, but note that none of these studies were specifically designed to test whether commitment costs contribute to WTA-WTP disparity.

My goal in this dissertation is, first, to test whether stated preference measures elicited in settings traditionally thought of as static actually contain significant dynamic components, and, second, to test if these dynamic components are sufficiently large to warrant a rethinking of the static methods that currently form the basis of empirical welfare measurement.

In Chapter 2, I present a review of the relevant literature. I begin by discussing the real options literature, which forms the basis of the commitment cost model. I also review the literature from two of the areas where a better understanding of the dynamic aspects of the decision problem could have the most meaningful implications. The first of these is the contingent valuation method, which is used extensively in nonmarket valuation. The second area of interest is the often-observed disparity between WTA and WTP.

In Chapter 3, I develop a theoretical model of WTA and WTP formation under dynamic conditions. I am able to formulate an explicit representation of the commitment cost. This allows for a better understanding of the factors that affect its magnitude, and thus makes it possible to test for the existence of commitment costs in contingent and experimental markets.

In Chapter 4, I develop an empirical specification of dynamic WTP derived directly from neoclassical consumer theory. I then use this to test whether the opportunity to delay the decision to "purchase" improved environmental quality significantly affects WTP in a CVM setting. My findings show that WTP is highly sensitive to the potential for future learning. Respondents faced with an explicitly static, now-or-never decision were willing to pay significantly more for improved water quality than those offered the opportunity to delay their purchasing decisions until more information became available.

In Chapter 5, I report the results of two economic experiments designed to test whether dynamic considerations affect WTP and WTA in a controlled laboratory setting, and whether this might explain the disparity observed in the experimental literature. I do this both by controlling subjects' information regarding the difficulty associated with reversing and delaying transactions outside of the experimental market, and by controlling the difficulty of reversal and delay within the experimental market itself. By comparing the values reported in these different experimental treatments with subjects' beliefs about the relative difficulty of delay and reversal, I find limited support for the idea that values formed in an experimental setting include dynamic components. However, I do not find evidence that suggests these dynamic components contribute significantly to the WTA-WTP disparity.

CHAPTER 2

A REVIEW OF THE RELEVANT LITERATURE

The commitment cost model can be thought of as an extension of the larger real options literature. As such, in Section 2.1 I provide background on the real options analysis that forms the basis of the theoretical commitment cost model I describe in Chapter 3. This is followed in Section 2.2 by a discussion of the contingent valuation method (CVM), which is the stated preference technique I use in Chapter 4 to test for the existence of dynamic component in willingness to pay. One of the more interesting results that follows from the commitment cost model is that, under certain circumstances, the often observed disparity between what an individual is willing to accept (WTA) in exchange for good and what she is willing to pay (WTP) for the same good can be explained within the context of neoclassical economic theory. In Chapter 5, I present the results of an experimental economic test of whether this in fact the case. Therefore, in Section 2.3 I discuss several theories that have been proposed in an effort to explain this apparent anomaly and the results from some of the relevant empirical literature.

2.1 THE REAL OPTIONS LITERATURE

The theory of commitment cost is an extension of the real options literature. The original concept of option value, as introduced by Weisbrod (1964), is today viewed essentially as a risk premium. Commitment cost, on the other hand, is more closely related to quasi-option value, which may exist even under risk neutral preferences.

In his 1962 work *Capitalism and Freedom*, Friedman draws a distinction between municipal parks, which serve as public goods, and national parks, which, in his view, do not. Based on this dichotomy, Friedman contends that if a national park such as Yellowstone cannot cover its costs through entry fees, it should be opened up to commercial development by the highest bidder. In response to this argument, Weisbrod points out that individuals who may never visit Yellowstone would be willing to pay to preserve the option of one day making the trip. This willingness to pay, now known as option value, would be impossible to capture through entry fees. Thus, Weisbrod concludes that it is likely in the interest of efficiency to maintain national parks even when their entry receipts do not cover their costs.

Hanemann (1989) divides the options literature that has followed from Weisbrod's original work into two categories. The first includes what is sometimes referred to as the Schmalensee-Bohm-Graham (SBG) option value. This option value follows directly from Weisbrod's early work and is, in essence, a risk premium. It represents the amount that a risk-averse agent would pay *ex ante* to be assured access to the good at some point in the future. While this value may be positive or negative depending on the nature of the agent's preferences, it can only be non-zero if the agent is risk averse. While the earliest formal work on this topic was performed by Cicchetti and Freeman (1971) and was refined and extended by Schmalensee (1972), and Bohm (1975) among others, Graham (1981) seems to have framed things most clearly. He developed what he calls the "WTP locus"—the set of *ex post* payment packages that hold *ex ante* utility constant. Graham shows that option price and expected consumer surplus are, in fact, just two different points along the WTP locus.

Hanemann's second category includes the quasi-option value developed by Arrow and Fisher (1974), and Henry (1974). As the name suggests, quasi-option value (QOV) bears some resemblance to the SBG option value in that both are measures of the value placed on future access to a resource in the face of uncertainty. However, QOV is more broad in that it can be non-zero even when agents are risk neutral. This is because QOV takes into account not only uncertainty but also the irreversibility of development and the resulting asymmetry of the development decision.[1] This asymmetry arises because the decision to preserve a resource in the current period can be reversed in the future by developing at that point. On the other hand, the decision to develop in the current period cannot be reversed in the future since the landscape has been irreparably altered. As Hanemann points out, QOV is the conditional value of perfect information—conditional, that is, on the resource being preserved today. An agent who takes these issues into account will pursue less development today than a naive agent. QOV can also be thought of as the shadow tax that induces the efficient level of development from a naive agent. Further theoretical work related to QOV has been done by Conrad (1980), Viscusi (1988), Hanemann (1989) and Usategui (1990), among others.

A number of empirical studies have attempted to measure option value. These studies focus mainly on the magnitude of the SBG option value relative to expected consumer surplus (for example, Brookshire, Eubanks, and Randall 1983; Smith, Desvousges, and Fisher 1983; Walsh, Loomis, and Gillman 1984; and Edwards 1988). While such studies have generally concluded that the SBG option value is positive, their findings on its magnitude relative to expected consumer surplus have varied widely. In contrast, little empirical work has been published on the magnitude of QOV relative to expected consumer surplus. An exception is the work on mining development by Greenley, Walsh, and Young (1981),

[1] Dixit and Pindyck's (1994) "option value" corresponds to what I refer to as "quasi-option value."

though their survey design and theoretical underpinnings have been criticized (see Brookshire, Eubanks, and Randall; Freeman 1984; Mitchell and Carson 1989; and Hanemann 1989).

2.2 The Contingent Valuation Method

An area where commitment cost theory is particularly relevant is environmental valuation. The contingent valuation method (CVM) enjoys widespread use within the environmental valuation literature, where it is generally accepted that there are certain types of nonmarket goods whose value can only be estimated using CVM or other similar stated preference techniques. However, CVM remains controversial among economists at large due to questions concerning the method's reliability. Chief among these is the concern that CVM estimates of WTP may overstate respondents' "true" valuation.

Originally developed by Davis (1963), Mitchell and Carson (1989) describe CVM as using survey questions to elicit respondents' preferences by estimating their willingness to pay for specified improvements in a nonmarket good. Respondents are typically presented with a survey instrument made up of three parts: (1) a detailed description of the good being valued and the hypothetical circumstances under which it will made available to them, (2) questions eliciting respondents' willingness to pay for the good, and (3) questions about the respondents' socioeconomic characteristics.

The importance of CVM is underscored by Executive orders 12044, 12291, and 12866 issued by Presidents Carter, Reagan, and Clinton, respectively. Each order requires federal agencies to consider both the costs and benefits of potential regulatory actions. But the importance of CVM was brought to the forefront by the *Exxon Valdez* oil spill along

Alaska's Prince William Sound in March 1989, which lead to the Oil Pollution Act of 1990 and the subsequent NOAA Panel report on the reliability of CVM as a means of assessing legal damages (Arrow *et al.* 1993).

In its report, the NOAA Panel details a number of guidelines that it believes are important to assuring the reliability of value estimates used to assess legal damages. Portney (1994) breaks these into seven distinct points: (1) personal interviews are preferable to phone interviews, which are preferable to mail surveys, (2) studies should elicit estimates of WTP even when WTA is the theoretically correct welfare measure, (3) valuation questions should not be open ended but should be posed as referenda, (4) the proposed program must be described in a way that is understandable and accurate, (5) respondents must be reminded of their budget constraints, (6) respondents must be informed of the existence of substitute goods, and (7) valuation questions should be followed up by a question ensuring that respondents understand the response they have just given.

CVM's primary appeal is its flexibility. This allows for the valuation of goods as varied as increased visibility (Rowe, d'Arge, and Brookshire 1980), mortality risk reduction (Krupnick *et al.* 2002), and the existence value of endangered species (Ekstrand and Loomis 1998). By creating a hypothetical market where no real market exists, CVM allows economists to estimate values (*e.g.*, nonuse, bequest, and option values) that would be difficult, if not impossible, to estimate using revealed preference techniques.

However, the flexibility afforded by CVM's hypothetical nature is often viewed as one of its principal drawbacks. Some economists suggest that the hypothetical nature of the questions and the lack of market discipline introduce what has come to be called "hypothetical bias" (Cummings *et al.* 1997). Hypothetical bias refers to respondents' tendency to be more generous when answering hypothetical willingness to pay questions than when the proposed payment is real.

Whether hypothetical bias does in fact pose a major problem is an empirical question. Carson *et al.* (1996) reexamine eighty-three studies where both CVM and revealed preference value estimates are reported. They show that CVM estimates are, on average, less than revealed preference estimates, which are generally considered to be less controversial. Likewise, Cummings and Taylor (1999) find that explicit warnings can eliminate hypothetical bias for a variety of public goods. In a similar study, List (2001) finds the same result among amateur sportscard traders (however, he finds that hypothetical bias persists among professional dealers).

2.3 The WTA-WTP Disparity Literature

Under certain circumstances, the commitment cost model may explain the frequently observed disparity between the minimum amount an agent is willing to accept in exchange for a good (WTA) and the maximum she is willing to pay (WTP) for it. Studies as early as that by Coombs, Bezembinder, and Goode in 1967 have consistently found that stated WTA is several times higher than WTP for the very same good, and the disparity between the two value measures appears to hold for many types of goods (see Horowitz and McConnell 2000a for a review of over 200 experiments dealing with WTA-WTP disparity). A number of explanations for this apparent anomaly have been put forward. These explanations can be put into two broad categories: behavioral arguments that borrow heavily from the psychology literature, and neoclassical arguments that attempt to explain the disparity by extending neoclassical utility theory.

Kahneman and Tversky (1979) were the first to suggest a behavioral approach. Their prospect theory represents an alternative to expected utility theory. Under prospect theory probabilities are assigned decision weights, and changes in welfare due to gains or losses are defined relative to an agent's initial endowment. In this way, the authors argue that an agent's preferences are reference dependent and that potential losses figure more prominently in the agent's mind than do potential gains. They later adapted this model to explain WTA-WTP disparity (Tversky and Kahneman 1991). Thaler (1980) also builds upon the prospect theory model. He points out that individual behavior is consistently at odds with the predictions of traditional economic theory, and goes on to use prospect theory to explain a number of "economic mental allusions," including the endowment effect.

The endowment effect has been the focus of dozens of empirical studies.[2] One particularly elegant test was performed by Knetsch (1989). An initial set of subjects was offered the choice between a coffee mug and a candy bar. The result was a fairly even split: 56% of subjects chose the mug, and the remainder chose the candy bar. In the later treatments, different subjects were endowed with either the mug or the candy bar and then were offered the option to trade for the other good. Given this choice, only 11% of subjects initially endowed with the mug and just 10% of those initially endowed with the candy bar were interested in the trade.

Loomes and Sugden (1982) develop a different framework that they claim is consistent with the predictions of prospect theory, but is also simpler and more intuitive. Their theory can best be understood by considering a simple example. Suppose an agent must

[2] See Thaler, Kahneman, and Knetsch (1992) for examples. Also see Brookshire and Coursey (1987) for comparisons of economic and psychological studies of the endowment effect.

consider two courses of action: a_1 and a_2. Further, suppose the future is characterized by two possible states of the world: S_1 that occurs with probability *p*, and S_2 that occurs with probability $(1-p)$. The consequence associated with action *i* in state *j* is denoted x_{ij}. The authors argue that given the agent chooses action a_i, utility depends not only on consequence x_{ij}, but also on x_{kj}, the consequence that would have been realized had the agent initially chosen action a_k. If consequence x_{ij} is preferred over x_{kj}, the agent rejoices and derives greater utility from x_{ij} than would have been the case had it simply been imposed upon her. Conversely, if consequence x_{kj} is preferred over x_{ij}, the agent experiences regret and derives less utility from x_{ij} than had it been imposed upon her. Regret aversion can be used to explain why an agent offered the opportunity to buy a good is willing to pay strictly less than that good's expected value, whereas had the same agent been initially endowed with the good, her willingness to accept compensation in exchange for it would be strictly more than its expected value.

Loomes, Starmer, and Sugden (1992) test the predictions of regret theory in an experimental setting, and are able to support only some of them. Namely, regret theory predicts violations of the assumptions of monotonicity (*i.e.*, that stochastically dominant prospects are preferred to those they dominate) and equivalence (*i.e.*, that if two lotteries can be represented by the same prospects, subjects should be indifferent between the two). While the authors are able to show that subjects' choices frequently violate monotonicity, they cannot show that subjects' choices violate equivalence.

While these behavioral theories are compelling, their findings are fundamentally at odds with standard, neoclassical consumer theory. In contrast, Heiner (1983), Hoehn and Randall (1987), Hanemann (1991), and Zhao and Kling (2001) provide explanations based firmly upon neoclassical theory. Heiner bases his argument on what he calls the "competence-difficulty gap." This gap refers to the difference between the cognitive wherewithal required to solve a decision problem and that actually possessed by the agent. While most economic analysis implicitly assumes the C-D gap is zero, Heiner suggests that agents are not always up to the optimization task. The existence of such a gap would introduce additional uncertainty into the problem, resulting in greater uncertainty surrounding the value of the good in question. This, in turn, results in an increase in reported WTA and a decrease in reported WTP.

Hoehn and Randall tell a similar story, developing what they call the "value formulation problem." They assert that the formulation of stated benefit measures is subject to two types of error: that due to imperfect information and that due to time constraints. Imperfect information arises when survey designers try to convey complex policy issues to a respondent. Misunderstanding or miscommunication of these issues leads to greater uncertainty regarding a good's value. Given perfect information, the authors define CV and EV as

$$\text{CV} = m - e(p,q^1,u^0) \text{ and } \text{EV} = e(p,q^0,u^1) - m, \tag{2.1}$$

where $e(\cdot)$ is the expenditure function, m is income, p is a vector of prices, q^0 and q^1 are the quantities of the public good before and after the implementation of some proposed policy, and u^0 and u^1 are the agent's utility before and after implementation. Imperfect information is characterized by introducing the uncertainty term D as follows:

$$\text{CV} = m - e(p,q^1,u^0;D) \text{ and } \text{EV} = e(p,q^0,u^1;D) - m. \tag{2.2}$$

This uncertainty raises the expenditure necessary to achieve u^0 in the CV case and u^1 in the EV case. The result, as in Heiner's model, is an increase in reported WTA and a decrease in reported WTP. Similarly, placing constraints on the time a respondent has to consider valuation questions cuts short her utility maximization process and leads to increased disparity between reported WTA and reported WTP.

Hanemann provides an explanation of the disparity based on a reinterpretation of Randall and Stoll's (1980) result. He suggests that, even in the face of small income effects, the difference between WTA and WTP resulting from a change in the quantity of a non-market good can still be large if that good has few substitutes. More specifically, the divergence between the reported benefit measures depends inversely upon the elasticity of substitution. Thus, for goods with few substitutes, Hanemann is able to reconcile the observed disparity with neoclassical consumer theory.

Empirical work by Shogren, Shin, Hayes, and Kliebenstein (1994, henceforth SSHK) lends support to Hanemann's theory. SSHK show that when subjects are repeatedly exposed to second-price sealed bid auctions for a private good with many substitutes (candy), WTA and WTP tend to converge. Though, when the authors use the same auction mechanism to value a private good with only poor substitutes (the subjects' own health), the disparity is persistent.

Although compelling, these results still fail to explain why other well-designed studies consistently find disparity between WTP and WTA for all types of goods. More recent studies such as those by Shogren and Hayes (1996) and Knetsch, Tang, and Thaler (2001, henceforth KTT) cast some doubt on SSHK's findings. Shogren and Hayes repeat the experiment originally performed by SSHK, but instead use the demand revealing Becker-DeGroot-Marschak (1964) auction mechanism with randomly determined market prices. Under this framework, the authors do not observe convergence of stated benefit measures for goods with many substitutes. KTT go on to suggest that the convergence found in SSHK's original experiments may be due in part to the auction mechanism used. KTT replicate the original experiments using both second- and ninth-price sealed bid auctions. While in the second-price case they find that repeated trials lead to convergence of WTA and WTP bids for goods with many substitutes, in the ninth-price treatment disparity actually increases. In a one-shot setting, both of these Vickrey (1961) auction mechanisms are theoretically demand revealing. KTT's results suggest that the auctions may lose their demand revealing property when repeated with market feedback.[3]

Horowitz and McConnell (2000b) cast further doubt on Hanemann's theory, making use of a reinterpretation of his work. Using a technique first suggested by Sugden (1999), the authors estimate the WTA/WTP ratio as a function of the income effect. Specifically, they use a first-order Taylor series approximation to write WTA as

$$WTA \approx WTP + WTA\frac{\partial WTP}{\partial m}, \tag{2.3}$$

where m represents income, implying

$$\frac{\partial WTP}{\partial m} \approx 1 - \frac{WTP}{WTA}. \tag{2.4}$$

Horowitz and McConnell point out that in order to explain the two-to-one WTA/WTP ratios commonly observed for private goods, the change in an agent's willingness to pay with respect to a change in income would have to be one half. Put loosely, given a $100 lump-

[3] See Kolstad and Guzman (1999) and Shogren *et al.* (2001a) for further discussion of this issue.

sum increase in income immediately prior to such an experiment, the consumer would be expected to allocate $50 of it toward the purchase of the good for sale. In this light, the ten-to-one ratios observed in contingent markets for public environmental goods seem even less plausible. The authors conclude that the "ratio of WTA to WTP is too high to be consistent with neoclassical preferences."

More recently, Zhao and Kling (2001) have suggested a real options analysis. They propose that, given uncertainty, irreversibility, and learning over time, the value of a good is affected not just by its intrinsic worth but also by an option value. That is, given that an agent is uncertain about the actual value of a good she wishes to buy or sell and that more information can be gained by waiting, delaying the transaction may be desirable. Therefore, in order to make the transaction now and forgo future learning opportunities, the agent must be compensated by being offered either a higher price if she is a seller or a lower price if she is a buyer. In other words, in the presence of uncertainty, irreversibility, and learning, WTA is higher and WTP is lower than would be the case if one or more of these conditions were not met. This explanation allows for the gap in reported benefit measures to persist for both private and public goods so long as an agent still stands to gain information by waiting. Further, commitment cost can explain WTA-WTP disparity for goods with many substitutes, even in the absence of endowment effects.

All of the empirical studies discussed in this section use experimental economics. While I will not attempt to survey that field here (see Roth 1995 for an excellent review), it is worth noting that, while still not accepted by all economists, experimental methods have been having an increasing impact on the larger economic literature. In their primer on the design of economic experiments, Friedman and Sunder (1994) concede that economics has traditionally been viewed as a non-experimental discipline such as meteorology or astronomy. Like these non-experimental disciplines, empirical work in economics has focused on observing phenomena that occur naturally in the marketplace. They note, however, that over recent decades there has been growing interest in testing economic theory in a controlled experimental environment. In his review of the experimental literature, Roth notes that since Thurstone's (1931) early work using experimental techniques to study the shape of indifference curves, the number of paper published in experimental economics has grown exponentially each decade. Holt's (1999) bibliography of the experimental literature cites 2000 publications and some 500 working papers in the field.

CHAPTER 3

THE COMMITMENT COST MODEL

In order to fully understand the concept of commitment cost and appreciate its policy implications, it is necessary to formalize the concept. In this chapter, I develop four models of commitment cost under different conditions. The model developed in Section 3.1 applies to non-durable goods and is useful in understanding the role agents' perceptions of the institutional structure of the market play in the formation of the option values that eventually determine the sign and magnitude of the commitment cost. This is the model that I will refer to in the experimental economic test of commitment cost presented in Chapter 5.

The model presented in Section 3.2 is similar to that in Section 3.1, though it extends the concept of commitment cost to the market for a durable good. The model presented in Section 3.3 imposes restrictions on the durable good model in a way that will allow me to test for the existence of commitment cost in a contingent market for environmental quality. The design and results of this test are presented in Chapter 4.

Finally, the model presented in Section 3.4 extends that from Section 3.3 by making it more consistent with the ecological realities of procrastination. Specifically, I allow the status quo level of environmental quality to deteriorate as the agent delays her decision about whether to pursue a proposed project to improve environmental quality, and I allow the cost of the proposed improvement to rise as the environment continues to decline.

3.1 Real Options and the Disparity Between Expected and Stated Values

Given that a potential buyer is uncertain about the actual value of a good she is interested in buying, that there are costs associated with either reversing or delaying the transaction, and that more information regarding the good's value can be attained by waiting, then there are option values associated with both delay and immediate action. Waiting may allow the potential buyer to avoid a transaction that would yield negative surplus. Therefore, in order to commit to the purchase now and forgo future learning opportunities, the agent must be compensated by being offered a lower price than the one she would have been willing to pay in the absence of future learning. However, there is also an option value associated with buying today, since that may allow the agent to sell the good for a profit at some future date. Thus, the agent's willingness to pay in a dynamic setting is not simply a function of the good's intrinsic value, but is also a function these options values.

A potential seller is in a similar situation. If there exists uncertainty about a good's value, if the agent perceives there to be costs associated with reversal or delay, and if she stands to gain more information by waiting, then, as before, there are option values associated with both selling immediately and delaying the selling decision. It may be in her best interest to delay the transaction until more information becomes available. In order to commit to the transaction today, she will demand greater compensation in exchange for the good than would have been the case in a static setting. Likewise, there is also an incentive to sell today as the good's future price may be lower than the price it commands today.

Kling, List, and Zhao (2001) develop a simple model incorporating the paired option values associated with any transaction made in a dynamic, uncertain setting. The first of these option values is associated with purchasing the good today. If an agent purchases a good in the current period, there is the potential that she will be able to sell it for a profit at some point in the future. This option value can be written as

$$OV_{buy}^{rev} = E\left(R - c_{buy}^{rev} - v \mid v < R - c_{buy}^{rev}\right), \tag{3.1}$$

where $v \sim [\underline{v}, \bar{v}]$ is the agent's valuation of the good, c_{buy}^{rev} is the perceived cost of selling later (*i.e.*, reversing the purchase), $R \sim [\underline{R}, \bar{R}]$ is the good's market price, and $E(\cdot)$ is the expectation over v and R. For simplicity, the authors assume the true values of v and R will be revealed in the second of two periods.

The second option value is associated with delaying the purchasing decision. If the agent does not purchase the good today, there is the chance that she will be able to purchase it in the future at a lower price. This option value can be written as

$$OV_{buy}^{del} = E\left(v - R - c_{buy}^{del} \mid v > R + c_{buy}^{del}\right), \tag{3.2}$$

where v and R are defined as before, and c_{buy}^{del} is the perceived cost of buying in the second period (*i.e.*, delaying the purchase).

Which of these option values is greater depends on the good's market price, the perceived costs of purchasing or selling the item in the future, and the agent's own valuation of the good. Kling *et al.* show that if a potential buyer perceives the cost of selling later c_{buy}^{rev} to be greater than the cost of buying later c_{buy}^{del}, OV_{buy}^{del} will be greater than OV_{buy}^{rev}, and *WTP* in the current period will be less than the good's expected value $E(v)$:

$$WTP = E(v) + OV_{buy}^{rev} - OV_{buy}^{del}. \tag{3.3}$$

A similar story can be told for the potential seller. If the seller believes that the cost of the buying later c_{sel}^{rev} will be greater than the cost of selling later c_{sel}^{del}, OV_{sel}^{del} will be greater than OV_{sel}^{rev}, and *WTA* in the current period will be greater than the good's expected value:

$$WTA = E(v) - OV_{sel}^{rev} + OV_{sel}^{del}, \tag{3.4}$$

where $OV_{sel}^{rev} = E\left(v - R - c_{sel}^{rev} \mid v > R + c_{sel}^{rev}\right)$ and $OV_{sel}^{del} = E\left(R - v - c_{sel}^{del} \mid v < R - c_{sel}^{del}\right)$.

Thus, the theory predicts that if, on average, both buyers and sellers *perceive* the cost associated with reversing a transaction to be greater than the cost associated with delaying it, the option value associated with delay will be greater than the option value associated with reversal, implying $WTP < E(v) < WTA$. This may seem counterintuitive since reversal for a buyer and delay for a seller both involve essentially the same transaction: selling the good in the future. However, the authors go on to point out that if only one of the two groups, buyers or sellers, believes that reversing is more difficult than delay, but the other group's beliefs are such that the relationship $OV_{wtp}^{del} + OV_{wta}^{del} > OV_{wtp}^{rev} + OV_{wta}^{rev}$ still holds, the model still predicts that *WTA* will be greater than *WTP*.

3.2 Commitment Cost in the Market for a Durable Good

In this section, I extend the previous section's analysis to the market for a durable good, the benefits from which can be enjoyed in both periods of a two-period model. This will be useful in Chapter 4 where I analyze the effects of delay and uncertainty on the valuation of environmental quality, a durable good. Similar to Zhao and Kling (2000), I begin by assuming the agent's utility function is time separable and defined over per-period income m_t and consumption of a durable good g_t. That is,

$$u(m_1, g_1) + \beta u(m_2, g_2), \tag{3.5}$$

where β is the discount factor. A single unit of the durable good G can be purchased in period one, period two, or not at all. If G is purchased in period one, it can be enjoyed in period two at no additional cost. For simplicity, I will 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 will be unaffected.[1] I also assume $m_1 = m_2 = m$, and I normalize the status quo level of durable good consumption to zero.

In this model, the agent is uncertain about the utility she would receive from G.[2] Her beliefs regarding G are represented by the distribution function $F_0(G)$ and the corresponding density $f_0(G)$ on $[\underline{G}, \bar{G}]$, where $\underline{G} > 0$.

In the absence of learning, the agent's decision is simply whether to buy in the current period or never to buy. While I assume the learning-constrained agent recognizes that benefits from purchasing G in the current period are also enjoyed in the future, I 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 willingness to pay wtp^{NL} is the critical price p^{NL} such that the she is indifferent between purchasing the durable good in the current period and never purchasing it. That is,

$$E_G\left(u\left(m - p^{NL}, G\right) + \beta u\left(m, G\right)\right) = (1+\beta)u\left(m, 0\right), \tag{3.6}$$

[1] Zhao and Kling (2002) show this assumption reduces the magnitude of the commitment cost.
[2] In the next section I will extend the model to the case where the agent is uncertain about the quality of g she would enjoy if she were to go ahead with the purchase.

where the *NL* superscript indicates no-learning.

If the agent can learn more about G in the second period, the problem becomes more interesting. I assume learning comes by way of a signal arriving in period two that provides the agent with more information about her value of G. I denote that signal as $s \in S \subset \mathbb{R}$, where S is the set of all possible signals. Conditional on the true value of G, the distribution of the signal 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: $f_{G|s}(G) = h_{s|G}(s) f_0(G) / h(s)$.

If the agent purchases G in the first period, she can sell it in the second after observing s by incurring a reversal cost c_{buy}^{rev}. Likewise, if the agent delays the purchasing decision, she can purchase G in period two but will incur a delay cost c_{buy}^{del}.

Let $V_{buy}^{rev}(p,s)$ be the agent's expected gain from purchasing G in the first period, but then selling in the second after observing s:

$$V_{buy}^{rev}(p,s) = \int \left(u(m + p - c_{buy}^{rev}, 0) - u(m,G) \right) dF_{G|s}(G). \tag{3.7}$$

Having observed s, the agent will exercise her option to sell in period two if and only if $V_{buy}^{rev}(p,s) > 0$. Let $S_{buy}^{rev} = \left\{ s \in S : V_{buy}^{rev}(p,s) > 0 \right\}$ be the set of signals that will induce the agent to sell in the second period. Further, let EU_1 denote the agent's expected utility if she purchases G in the current period:

$$\begin{aligned} EU_1 &= E_G u\left(m - p, G\right) + \beta \Pr(S_{buy}^{rev}) u\left(m + p - c_{buy}^{rev}, 0\right) \\ &\quad + \beta \left(1 - \Pr(S_{buy}^{rev})\right) E_G \left(u\left(m, G\right) \mid s \notin S_{buy}^{rev} \right), \end{aligned} \tag{3.8}$$

where p is the price of G, and $\Pr(S_{buy}^{rev})$ is the probability of observing a signal $s \in S_{buy}^{rev}$.

By delaying the purchasing decision, the agent retains the option to purchase in the second period. Let $V_{buy}^{del}(p,s)$ be the agent's expected gain from purchasing G after observing s:

$$V_{buy}^{del}(p,s) = \int \left(u_2(m - p - c_{buy}^{del}, G) - u_2(m, G_0) \right) dF_{G|s}(G). \tag{3.9}$$

Having observed s, the agent will exercise her option to purchase G if and only if $V_{buy}^{del}(p,s) > 0$. Let $S_{buy}^{del} = \left\{ s \in S : V_{buy}^{del}(p,s) > 0 \right\}$ be the set of signals that will induce the agent to purchase G in the second period. Further, let EU_2 represent the agent's expected utility from delaying the purchasing decision:

$$EU_2 = u_1(m,0) + \beta \Pr(S_{buy}^{del}) E_G \left(u_2(m - p, G) \mid s \in S_{buy}^{del} \right) + \beta \left(1 - \Pr(S_{buy}^{del}) \right) u_2(m,0). \tag{3.10}$$

The learning agent's willingness to pay wtp^L is the critical price p^L at which she is indifferent between purchasing in the first period and delaying the purchasing decision until period two. p^L can be solved for implicitly by equating formulas (3.8) and (3.10).

Zhao and Kling (2001, 2002) define the commitment cost CC as the difference between wtp^{NL} and wtp^L. The sign of CC is ambiguous when the agent is presented with both reversal and delay options. However, in the next section I show that strict irreversibility implies that CC is positive.

The potential seller's problem is very similar. Her expected utility from selling in period one is

$$EU_1 = u(m+p,0) + \beta \Pr(S_{sel}^{rev}) E_G\left(u\left(m-p-c_{sel}^{rev},G\right) \mid s \in S_{sel}^{rev}\right) + \beta\left(1-\Pr(S_{sel}^{rev})\right)u(m,0), \tag{3.11}$$

where c_{sel}^{rev} is the seller's perceived cost of reversing the transactions. Her expected utility from delaying the selling the selling decision until period two is

$$EU_2 = E_G u(m,G) + \beta \Pr(S_{sel}^{del}) u\left(m+p-c_{sel}^{del},0\right) + \beta\left(1-\Pr(S_{sel}^{del})\right) E_G\left(u(m,G) \mid s \notin S_{sel}^{del}\right), \tag{3.12}$$

where c_{sel}^{del} is the perceived cost of selling in the second period, and $\Pr(S_{sel}^{rev})$ is analogous to $\Pr(S_{buy}^{del})$. As was the case with the potential buyer, wta^{NL} is defined as the critical price that leaves the potential seller indifferent between selling today and never selling, while wta^{L} leaves her indifferent between selling today and delaying the selling decision until more information becomes available. The seller's *CC* is defined as $wta^{NL} - wta^{L}$. Again, *CC* is sign ambiguous when both delay and reversal opportunities are available.

3.3 Commitment Cost in the Context of Contingent Valuation

In the next chapter, I will use contingent valuation techniques to test for the existence of commitment cost in a hypothetical market for improved water quality. In order to do this, certain modifications have to be made to the model presented in Section 3.2. Primary among these is that complete irreversibility is implicit in the CVM survey's referendum format. Respondents are presented with a proposal to improve environmental quality and are then asked to vote on referendum that would both implement the proposed improvement and impose higher taxes. If the ballot measure passes, the government will raise taxes and go ahead with mitigation efforts. While the resulting environmental improvements could later be undone, the money spent on mitigation can never be recouped. In the context of the model presented in Section 3.2, this is the same as assuming $c_{buy}^{rev} > \bar{G}$.

The referendum format does, however, allow for delay. Some respondents in the study I will discuss in Chapter 4 were explicitly informed of their opportunity to delay the "purchasing" decision. They were told that, should the initial referendum fail to pass, the government would continue to study factors affecting water quality and would give area residents another chance to vote on an identical referendum once more information was available. In this context, there is the potential that $c_{buy}^{del} < \bar{v}$. Other respondents were informed that there would be no opportunity to delay their decision. They were told that this would be the last such referendum, and that if it failed to pass there would be no further efforts to improve water quality. This is equivalent to assuming $c_{buy}^{del} > \bar{v}$.

In the remainder of this section, I develop a model of willingness to pay formation in the presence of uncertainty, irreversibility, and potential learning. I begin by considering an individual who must decide whether to purchase a higher level of environmental quality in either or none of two periods. Her utility function is time separable:

$$u(m_1, g_1) + \beta u(m_2, g_2), \tag{3.13}$$

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, the second period, or not at all. However, once the agent has purchased G, the decision is irreversible. If G is purchased in the first period, it can also be enjoyed in the second at no additional cost. In the context of the CVM study to be discussed in Chapter 4, G might be achieved through a package of government-sponsored mitigation efforts such as dredging the lake, establishing buffer strips, and retiring agricultural land around the lake in order to reduce nutrient inflow. As in Section 3.2, I assume away income smoothing.

The agent is uncertain about the value of G resulting from the proposed policy. This may be due, for instance, to her uncertainty regarding the degree to which water quality would be improved if the proposed policies were implemented. Her beliefs regarding G and the signal s are defined as in the previous section, with the exception that here I am assuming $\underline{G} > G_0$.

Let EU_1 denote the agent's expected utility from purchasing G in period one:

$$EU_1 = E_G\left(u\left(m_1 - p, G\right) + \beta u\left(m_2, G\right)\right), \tag{3.14}$$

where p is the price of implementing the new environmental policy and $E_G(\cdot)$ represents expectation over G. Notice that (3.14) differs from (3.11) in that reversal is no longer an option. Let $V_{buy}^{del}(p,s)$ be the agent's expected gain from purchasing G after observing s:

$$V_{buy}^{del}(p,s) = E_G\left(u(m_2 - p, G) - u(m_2, G_0) \mid s\right). \tag{3.15}$$

Observing s, she will buy G if and only if $V_{buy}^{del}(p,s) > 0$. Let the set of signals that will induce the agent to purchase G be defined as $S_{buy}^{del}(p) = \left\{s \in S : V_{buy}^{del}(p,s) > 0\right\}$. Then the agent's expected utility if she delays the purchasing decision is

$$EU_2 = u\left(m_1, G_0\right) + \beta \Pr(S_{buy}^{del}) E_G\left(u\left(m_2 - p, G\right) \mid s \in S_{buy}^{del}\right) + \beta\left(1 - \Pr(S_{buy}^{del})\right) u\left(m_2, G_0\right). \tag{3.16}$$

To obtain closed form solutions, I assume

$$u(m_t, g_t) = \alpha \frac{m_t^\rho}{\rho} + (1-\alpha)\frac{g_t^{\ \rho}}{\rho}, \quad t = 1, 2. \tag{3.17}$$

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 $\rho \leq 1$ relates to the agent's elasticity of substitution (the elasticity is $\sigma = 1/(1-\rho)$). One of the benefits of the CES utility function is that the linear, Cobb-Douglass, and Leontief utility functions are special cases corresponding to $\rho = 1$, 0, and $-\infty$, respectively. I also assume that $m_1 = m_2 = m$. Given these assumptions, (3.14) becomes

$$EU_1 = \alpha \frac{(m-p)^\rho}{\rho} + (1-\alpha)\frac{E_G G^\rho}{\rho} + \beta\left(\alpha \frac{m^\rho}{\rho} + (1-\alpha)\frac{E_G G^\rho}{\rho}\right), \tag{3.18}$$

and (3.16) becomes

$$\begin{aligned} EU_2 = {} & \alpha \frac{m^\rho}{\rho} + (1-\alpha)\frac{G_0^\rho}{\rho} + \beta \Pr(S_{buy}^{del})\left(\alpha \frac{m^\rho}{\rho} + (1-\alpha)\frac{E_G\left(G^\rho \mid s \in S_{buy}^{del}\right)}{\rho}\right) \\ & + \beta\left(1 - \Pr(S_{buy}^{del})\right)\left(\alpha \frac{m^\rho}{\rho} + (1-\alpha)\frac{G_0^\rho}{\rho}\right). \end{aligned} \tag{3.19}$$

Taking into account uncertainty, irreversibility, and the opportunity for learning, the agent's decision in period one is whether to buy now or to delay the decision until period two when more information will be available. In this dynamic framework, Zhao and Kling (2001, 2002) show that in the presence of learning the rational agent's maximum willingness to pay wtp^L is the critical price p^L that leaves her indifferent between committing to *G* in period one and delaying her decision until period two. Here, the *L* superscript represents learning.

Equating EU_1 and EU_2 and solving for p^L, I find

$$wtp^L \equiv p^L = m - \left(m^\rho - \frac{A}{\left(1 - \beta \Pr(S_{buy}^{del})\right)} \right)^{\frac{1}{\rho}}, \tag{3.20}$$

where

$$A = (1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^\rho) - G_0^\rho\right) - \beta \Pr(S_{buy}^{del})\frac{1-\alpha}{\alpha}\left(E_G(G^\rho \mid s \in S_{buy}^{del}) - G_0^\rho\right). \tag{3.21}$$

In the absence of learning, the agent sees her decision as being whether to buy in the current period or never to buy. Thus, the learning-constrained agent's 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. That is,

$$\begin{aligned} &\alpha \frac{(m - p^{NL})^\rho}{\rho} + (1-\alpha)\frac{E_G G^\rho}{\rho} + \beta\left(\alpha \frac{m^\rho}{\rho} + (1-\alpha)\frac{E_G G^\rho}{\rho} \right) \\ &\qquad = (1+\beta)\left(\alpha \frac{m^\rho}{\rho} + (1-\alpha)\frac{G_0^\rho}{\rho} \right), \end{aligned} \tag{3.22}$$

or

$$wtp^{NL} \equiv p^{NL} = m - \left(m^\rho - (1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^\rho) - G_0^\rho\right) \right)^{\frac{1}{\rho}}, \tag{3.23}$$

where the *NL* superscript represents no-learning. Note that wtp^{NL} is a static measure—no consideration of future options is incorporated into its formation. I can now write the *CC* as the following closed-form expression:

$$\begin{aligned} CC &= wtp^{NL} - wtp^L \\ &= \left(m^\rho - \frac{A}{\left(1 - \beta \Pr(S_{buy}^{del})\right)} \right)^{\frac{1}{\rho}} - \left(m^\rho - (1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^\rho) - G_0^\rho\right) \right)^{\frac{1}{\rho}}. \end{aligned} \tag{3.24}$$

CC will be nonnegative when

$$(1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^\rho)-G_0^\rho\right)\geq\frac{A}{\left(1-\beta\Pr(S_{buy}^{del})\right)}. \tag{3.25}$$

Rearranging and simplifying, I can write the above inequality as

$$E_G(G^\rho \mid s\in S_{buy}^{del})-G_0^\rho\geq(1+\beta)\left(E_G(G^\rho)-G_0^\rho\right). \tag{3.26}$$

This relationship is always satisfied because the expected utility from delaying the purchasing decision will be at least as great as the expected utility from never purchasing. At the critical price p^L, this implies

$$\begin{aligned}&\left(\alpha\frac{m^\rho}{\rho}+(1-\alpha)\frac{G_0^\rho}{\rho}\right)+\beta\Pr(S_{del})\left(\alpha\frac{(m-p^L)^\rho}{\rho}+(1-\alpha)\frac{E_G\left(G^\rho\mid s\in S_{buy}^{del}\right)}{\rho}\right)\\&+\beta\left(1-\Pr(S_{buy}^{del})\right)\left(\alpha\frac{m^\rho}{\rho}+(1-\alpha)\frac{G_0^\rho}{\rho}\right)\geq(1+\beta)\left(\alpha\frac{m^\rho}{\rho}+(1-\alpha)\frac{G_0^\rho}{\rho}\right).\end{aligned} \tag{3.27}$$

After substituting in p^L from equation (3.20), the above inequality reduces to condition (3.26), thus proving $CC\geq 0$. CC will be strictly positive if $\Pr(S_{buy}^{del})>0$ and $E_G\left(G^\rho\mid s\in S_{del}\right)>E_G\left(G^\rho\right)>G_0^\rho$.

3.4 Commitment Cost When Environmental Quality Deteriorates Over Time

In this section, I extend the model from Section 3.3 in two ways: (1) status quo environmental quality G_0 is allowed to deteriorate over time, and (2) the price associated with attaining G increases as G_0 falls. The model in Section 3.3 can, of course, be viewed as a special case of this more general model.

Expected utility from purchasing G in period one is unaffected by continued deterioration, and thus EU_1 is the same as expression (3.14) from the previous section. Let G_0 be the status quo level of environmental quality in period one, and let the period-two status quo level be defined as λG_0, where $\lambda \in [0,1]$ is a constant associated with the degree of environmental deterioration that occurs during the delay period. Further, let p be the cost of mitigation if it is undertaken in period one, and let $p + \varphi(\lambda)$ be the cost of mitigation if it is instead undertaken in period two, where $\varphi(1) \geq 0$ and $d\varphi/d\lambda \leq 0$. That is, as the status quo level of environmental quality deteriorates over time, the cost of the proposed improvement increases. Finally, let $V(p,s)$ be the agent's expected surplus from delaying the purchase until after observing s. That is,

$$V(p,s) = E_G\left(u(m-p-\varphi,G) - u(m,\lambda G_0) \mid s\right). \tag{3.28}$$

If the agent waits until the second period and observes s, she will vote in favor of the proposed improvement if and only if $V(p,s) > 0$. Let EU_2 denote the agent's expected utility if she delays the purchasing decision. This can be written as

$$\begin{aligned} EU_2 &= u\left(m,G_0\right) + \beta \Pr(S_{buy}^{del}) E_G\left(u\left(m-p-\varphi,G\right) \mid s \in S_{del}\right) \\ &\quad + \beta\left(1-\Pr(S_{buy}^{del})\right) u\left(m,\lambda G_0\right), \end{aligned} \tag{3.29}$$

where $S_{buy}^{del}(p) = \{s \in S \mid V(p,s) > 0\}$ is the set of signals that will induce the agent to purchase G in period two.

In order to calculate a closed form expression for willingness to pay, I impose the following restriction on $U(\cdot)$:

$$u(m_t,g_t) = \alpha m_t + (1-\alpha)g_t, \ t = 1, 2. \tag{3.30}$$

This is the simple linear utility function, a special case of the CES utility function where $\rho = 1$.

As before, given the opportunity for learning, the agent's maximum willingness to pay wtp^L is the critical price p^L that leaves her indifferent between committing to G in period one and delaying her decision until period two. The agent's expected utility from delaying the decision must now be written to take into account declining status quo environmental quality:

$$\begin{aligned} EU_2 &= \alpha m + (1-\alpha)G_0 + \beta \Pr(S_{buy}^{del})\left(\alpha(m-p-\varphi) + (1-\alpha)E_G\left(G \mid s \in S_{buy}^{del}\right)\right) \\ &+ \beta\left(1 - \Pr(S_{buy}^{del})\right)\left(\alpha m + (1-\alpha)\lambda G_0\right), \end{aligned} \tag{3.31}$$

where S_{buy}^{del} is as defined before, and

$$V_{buy}^{del}(p,s) = \alpha(-p-\varphi) + (1-\alpha)\left(E_G(G \mid s) - \lambda G_0\right). \tag{3.32}$$

Equating EU_1 and EU_2 yields

$$wtp^L \equiv p^L = \frac{A}{1 - \beta \Pr(S_{buy}^{del})}, \tag{3.33}$$

where

$$\begin{aligned} A &= \frac{1-\alpha}{\alpha}\left[-\left(1 + \beta\left(1 - \Pr(S_{buy}^{del})\right)\lambda\right)G_0 + (1+\beta)E_G(G) - \beta \Pr(S_{buy}^{del})E_G\left(G \mid s \in S_{buy}^{del}\right)\right] \\ &+ \beta \Pr(S_{buy}^{del})\varphi. \end{aligned} \tag{3.34}$$

Given my assumptions on G_0 and G, I know p^L is positive. This is because $\alpha, \beta, \Pr(S_{buy}^{del}) \in [0,1]$, and

$$E_G(G) = \Pr(S_{buy}^{del})E_G\left(G \mid s \in S_{buy}^{del}\right) + \left(1 - \Pr(S_{buy}^{del})\right)E_G\left(G \mid s \notin S_{buy}^{del}\right). \tag{3.35}$$

It can also be shown that $\partial p^L/\partial\lambda < 0$, implying that the greater the environmental deterioration without mitigation, the more the agent is willing to pay for mitigation in period one.

In the no-learning case, the agent's 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. This can be written as

$$wtp^{NL} \equiv p^{NL} = \frac{(1-\alpha)}{\alpha}\big((1+\beta)E_G(G)-(1+\beta\lambda)G_0\big). \tag{3.36}$$

Given my assumptions on G_0 and G, it is easy to show that p^{NL} is positive and that $\partial p^{NL}/\partial\lambda < 0$.

The commitment cost is defined as the difference between wtp^{NL} and wtp^L. Thus, I can write CC as the following closed-form expression:

$$CC = \frac{(1-\alpha)}{\alpha}\big((1+\beta)E_G(G)-(1+\beta\lambda)G_0\big) - \frac{A}{1-\beta\Pr(S_{buy}^{del})}, \tag{3.37}$$

where A is defined as in equation (3.34). As was the case in Section 3.3, CC is nonnegative since the expected utility from delaying the purchasing decision must be at least as great as the expected utility from simply never purchasing. To see this, recognize that CC will be nonnegative if and only if

$$E_G\left(G \mid s \in S_{buy}^{del}\right) - \lambda G_0 - \frac{\alpha}{1-\alpha}\varphi \geq (1+\beta)E_G(G) - (1+\beta\lambda)G_0. \tag{3.38}$$

This is analogous to condition (3.26) in Section 3.3, and it can be shown to hold by comparing the expected utility of learners and non-learners at the critical price p^L. Once again, CC is strictly positive as long as $\Pr(S_{buy}^{del}) > 0$ and $E_G\left(G \mid s \in S_{buy}^{del}\right) > E_G(G) > G_0$.

The impact of λ on willingness to pay and commitment cost can be seen in Figure 3.1. In this figure, the light lines represent expected utilities given no environmental deterioration between periods one and two (*i.e.*, $\lambda = 1$), while the heavy lines represent expected utilities given a higher level of deterioration (*i.e.*, $\lambda < 1$). Since the expected utility of not purchasing in the period one decrease with status quo environmental quality, willingness to pay in both the learning and no-learning cases is higher when facing greater deterioration.

The effect of deterioration on commitment cost, however, is less definite. As shown in Figure 3.1, the commitment cost decreases as λ decreases, though the figure could also have been drawn with ***CC*** greater than *CC*. The sign of $\partial CC/\partial\lambda$ ultimately depends on how the probability of pursuing the environmental improvement in the period two $\Pr(S_{buy}^{del})$ is affected by λ.

The intuition behind this can be seen in Figure 3.2. The commitment cost *CC* is the difference between two willingness to pay measures. In the no-learning case, willingness to pay is the critical price wtp^{NL} that leaves the agent indifferent between purchasing in period one and never purchasing. In the learning case, willingness to pay is the critical price wtp^{L} that leaves the agent indifferent between purchasing in period one and delaying the purchasing decision until period two. In period two, the learning agent will purchase the improved quality with probability $\Pr(S_{buy}^{del})$ and will settle for the status quo with probability $\left(1-\Pr(S_{buy}^{del})\right)$. Thus, the only thing differentiating the no-learning and learning problems is that in the learning case there is some positive probability that the agent will pursue mitiga-

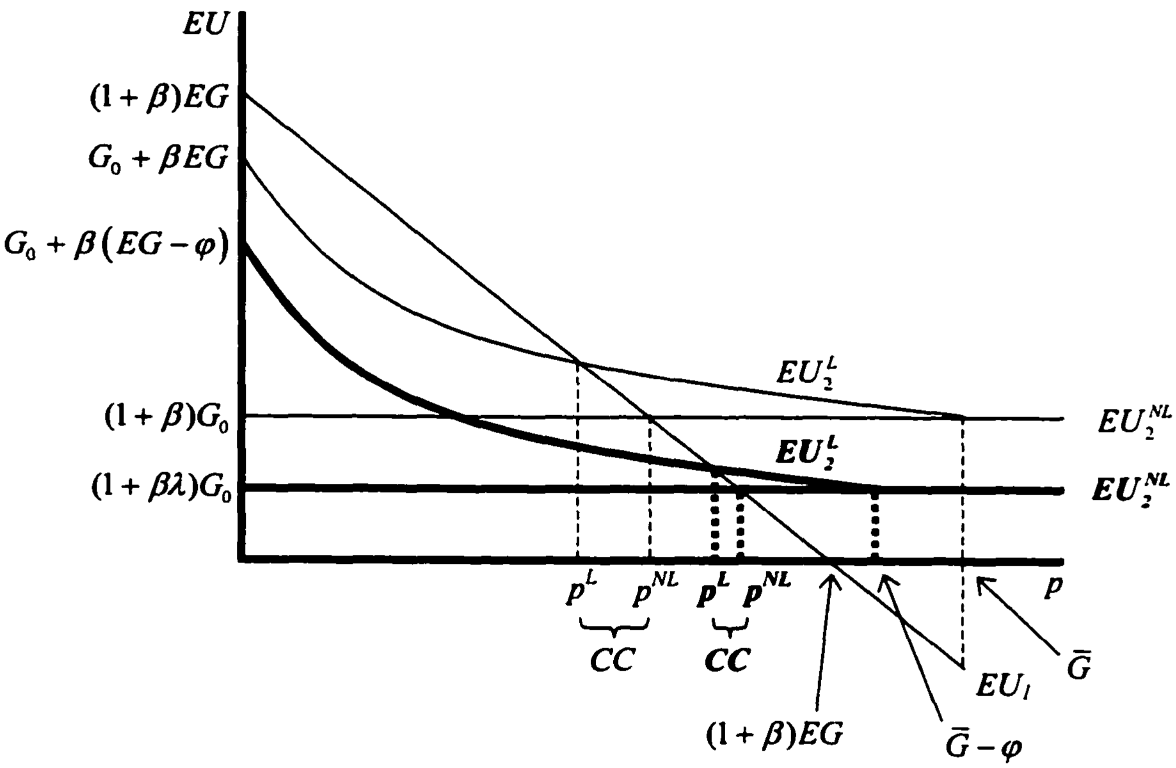

Figure 3.1 Commitment Cost in the Presence of Environmental Deterioration ($\alpha = 1/2$)

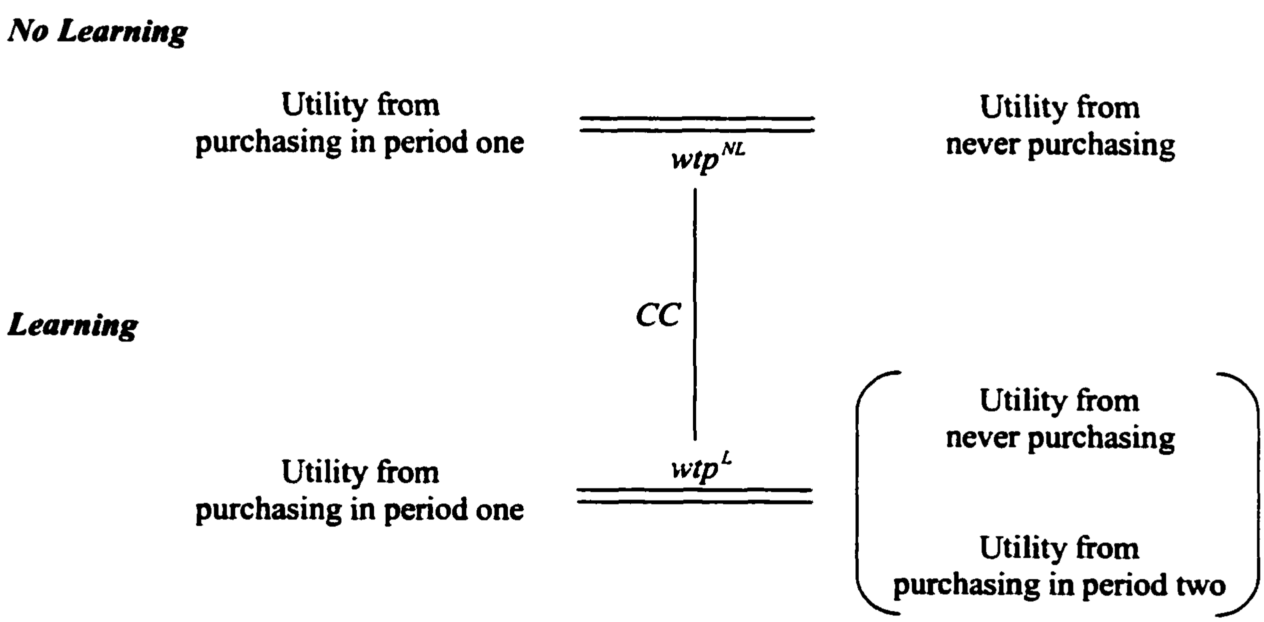

Figure 3.2 The Intuition Behind Commitment Cost

tion in the second period. As that probability approaches zero, the difference between the two problems diminishes, and CC approaches zero. Therefore, if $\Pr(S_{buy}^{del})$ decreases as the status quo level of environmental quality decreases (*i.e.*, as λ decreases), then $\partial CC/\partial\lambda > 0$. Alternatively, if $\Pr(S_{buy}^{del})$ increases as the status quo level of environmental quality decreases, then $\partial CC/\partial\lambda < 0$.

CHAPTER 4

THE DYNAMIC FORMATION OF WTP IN A CONTINGENT VALUATION SETTING

The maximum amount a consumer is willing to pay (WTP) 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 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

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

value can be gained by waiting. Therefore, in order to commit to the 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 this compensation as the commitment cost. 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]

Also related is the quasi-option value concept developed by Arrow and Fisher (1974) and Henry (1974). Option value, in this context, takes into consideration that, faced with uncertainty and asymmetric irreversibility, there exists an incentive to delay development until more information becomes available. An agent who considers this irreversibility and uncertainty will pursue less development in the current period than a naive agent. Hanemann (1989) notes that the option value is the conditional value of perfect information, conditional, that is, on the resource being preserved today.[3]

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, therefore, collect relevant information prior to committing to a purchase decision. That is, the willingness to pay for a good *today* will decline when there are additional opportunities to purchase the good or a close substitute in the future. In this case, today's WTP is not comprised simply of the expected surplus from

[2] For counter results, see Boyle, Reiling, and Phillips (1990) and Loomis, Gonzalez-Caban, and Gregory (1994).
[3] See also Conrad (1980), Viscusi (1988), and Usategui (1990).

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.

The purpose of this chapter 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, I 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 willingness to pay, 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.[4] 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 willingness to pay, confirming the predictions of the theory.

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[4] The Iowa Department of Natural Resources provided the funding for this study.

This chapter is organized as follows. Section 4.1 describes the design of the stated preference instrument and the empirical test. Section 4.2 presents the key findings and test results. Concluding remarks follow in Section 4.3.

4.1 Design of the Empirical Test

Section 3.3 develops the theoretical model that I will use in this chapter. In that section, I define commitment cost (CC) as the difference between no-learning willingness to pay

$$wtp^{NL} \equiv p^{NL} = m - \left(m^{\rho} - (1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^{\rho}) - G_0^{\rho}\right)\right)^{\frac{1}{\rho}}, \tag{4.1}$$

and willingness to pay in a dynamic setting characterized by uncertainty, irreversibility, and potential learning

$$wtp^{L} \equiv p^{L} = m - \left(m^{\rho} - \frac{A}{\left(1 - \beta \Pr(S_{P1})\right)}\right)^{\frac{1}{\rho}}, \tag{4.2}$$

where A is defined as

$$A = (1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^{\rho}) - G_0^{\rho}\right) - \beta \Pr(S_{P1})\frac{1-\alpha}{\alpha}\left(E_G(G^{\rho} \mid s \in S_{P1}) - G_0^{\rho}\right). \tag{4.3}$$

Thus, CC can be written as the closed-form expression

$$CC = wtp^{NL} - wtp^{L} = \left(m^{\rho} - \frac{A}{\left(1 - \beta \Pr(S_{P1})\right)}\right)^{\frac{1}{\rho}} - \left(m^{\rho} - (1+\beta)\frac{1-\alpha}{\alpha}\left(E_G(G^{\rho}) - G_0^{\rho}\right)\right)^{\frac{1}{\rho}}. \tag{4.4}$$

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

$$WTP_i = wtp_i^{NL} - CC_i + \varepsilon_i, \tag{4.5}$$

where wtp_i^{NL} is no-learning willingness to pay as defined in (4.1), ε_i is a mean-zero error term, and CC_i captures respondent i's commitment cost. CC_i will be positive if WTP is formed dynamically, and will be zero otherwise.

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

$$CC_i = D_i^{Delay}\left(\gamma^{Delay} + \gamma^{HiVar} D_i^{HiVar}\right), \tag{4.6}$$

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 respondent i votes "yes" ($Y_i = 1$) on a referendum to improve environmental quality is

$$\begin{aligned} \Pr(Y_i = 1) &= \Pr(WTP_i \geq T_i) \\ &= \Pr\left(wtp_i^N - CC_i + \tau\varepsilon_i \geq T_i\right) \\ &= 1 - \Pr\left(\varepsilon_i \leq \frac{T_i - wtp_i^N + CC_i}{\tau}\right), \end{aligned} \tag{4.7}$$

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 following logistic expression for the probability of a "yes":

$$\Pr(Y_i = 1) = \left(1 + \exp\left(\frac{T_i - wtp_i^N + CC_i}{\tau}\right)\right)^{-1}. \tag{4.8}$$

The corresponding log likelihood function is

$$\begin{aligned}\ln L = &\sum_i -Y_i \ln\left(1 + \exp\left(\frac{T_i - wtp_i^N + CC_i}{\tau}\right)\right) \\ &+ \sum_i (1 - Y_i)\left[\left(\frac{T_i - wtp_i^N + CC_i}{\tau}\right) - \ln\left(1 + \exp\left(\frac{T_i - wtp_i^N + CC_i}{\tau}\right)\right)\right].\end{aligned} \tag{4.9}$$

Estimates of the parameters from expression (4.9) can be readily obtained from maximum likelihood estimation. An estimate of respondent i's willingness to pay, $W\hat{T}P_i$, can be calculated as follows:

$$W\hat{T}P_i = w\hat{t}p_i^N - \widehat{CC}_i. \tag{4.10}$$

A survey instrument was designed to value various plans for improving the water quality at Clear Lake in northern 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 referendum-format CVM question designed to elicit respondents' willingness to pay in order to achieve the conditions described. Hoehn and Randall (1987) show that the referendum mechanism is demand revealing so long as respondent i believes that all respondents face the same policy price, and that the referendum will pass if the majority votes in favor of the proposed project. Strictly speaking, truth telling is a voter's weakly dominant strategy when voting is costless. Carson, Groves, and Machina (2000) argue that responses to such stated preference questions will contain relevant economic information so long as the respondent perceives there to be some positive chance that her response will influence policy, and so long as she cares about the outcome of that policy. A copy of the survey instrument can be found in Appendix A.

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 900 households in the cities of Clear Lake and Ventura, Iowa, both of which are located on Clear Lake. This sample was drawn from the white pages by Survey Sampling, Inc., a Connecticut-based market research firm. Of these 900 surveys, 132 were eventually returned as undeliverable. 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%.

A summary of the respondents' socioeconomic characteristics can be found in Table 4.1. Compared to the most recent county-level census data, survey respondents, on average, were significantly more likely to be college educated, to be older, to be male, to be homeowners, and to live in a larger household. Respondents' average income was not significantly different from the county average. While no county-level data is available for year-round residency, it is likely that seasonal residents were underrepresented in the sample since many do not receive mail at their Clear Lake address.

Table 4.1 Characteristics of Survey Respondents (n = 357)

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	—

Six 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 B. 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 *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 $p (payable in five $p/5 installments over a five year period)?

Version 3 differed from Version 2 only in that respondents were told that, should the initial referendum fail, five years would pass before they would be given a second chance to vote.

Survey Versions 4, 5, and 6 were analogous to 1, 2, and 3 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).[5] The color diagram used to depict this higher level of uncertainty appears in Appendix C.

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[5] Due to 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.

Using these data, I test for the presence of a dynamic element in the formation of the WTP values by testing whether *CC* in (4.5) is significantly different from zero. I further test two of the theory's comparative static predictions. First, that *CC* is only positive in the presence of future learning (*i.e.*, $\gamma^{Delay} > 0$). Second, that *CC* increases when the agent is more uncertain (faces higher variance) about the level of *G* after the proposed improvement (*i.e.*, $\gamma^{HiVar} > 0$).

4.2 Empirical Findings

A total of 357 respondents provided completed surveys. Of these, forty-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, I treat such answers as protest responses and exclude them from the following analysis. While I view this as the cleanest approach, results including the protest responses are qualitatively unchanged from those presented here.

I have also excluded respondents who were offered the opportunity to vote again in one year if the hypothetical referendum failed to pass. A typographical error in the first mailing of survey Version 5 left the CVM question ambiguous. While the error was corrected by the second mailing, it is impossible to know how the intitial error affected respondents' valuations. I have, however, also estimated the model throwing out only the sixty-one responses to the first mailing of Version 5 and including the responses from the second mailing. The results are not qualatatively different from those with the one-year wait excluded. Interestingly, there is no significant difference in estimated willingness to pay between respondents offered one- and five-year waits. I tested this by estimating willingness to pay for the environmental improvement using only the data from respondents offered the opportunity for delay. I also included a dummy variable distinguishing respondents offered a one-year wait from those offered a five years. The coeffiecient associated with this dummy variable was not significanlty different from zero ($t = 0.267$). This suggests that the benefit associated with an additional four years of learning are offset by the cost associated with delaying the proposed improvements another four years.

Table 4.2 presents the results of the logistic regression described in Section 4.1. To form the wtp^{NL} equation for estimation, the discount factor β was set to 0.758. This corresponds to a riskless rate of return of 5.70%, which is equal to the return on a five-year Treasury note issued in November 2000, the month the survey was initially mailed. Qualitative results were unaffected by the choice of β. In order to confine α to the unit interval, I set $\alpha = e^x/(1+e^x)$ and estimate x. Likewise, to restrict ρ to the $(-\infty,1]$ interval, I set $\rho = -e^y + 1$ and estimate y. 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.

The results in the second column of Table 4.2 correspond to the basic CES model. To investigate the robustness of the results, I also estimate a random parameters specification that allows α and ρ to vary with income, ignoring the interval restriction in the case of α.

Table 4.2 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%

[a] Asymptotic t ratio in parentheses.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.

More specifically, α_i is estimated as $\alpha_{Intercept} + \alpha_{Income} m_i$ and ρ_i is estimated as $-\exp(\rho_{Intercept} + \rho_{Income} m_i) + 1$.[6]

As seen in Table 4.2, the estimate of τ is positive and highly significant in both models, indicating the demand curve for improved environmental quality is downward

[6] A third model was estimated allowing α, ρ, γ^{Delay} and γ^{HiVar} to vary with income. The results are not reported here because the restriction $\gamma^{Delay}_{Income} = \gamma^{HiVar}_{Income} = 0$ could not be rejected at conventional significance levels ($\chi^2 = 0.58$ [2]).

sloping. As expected, the estimate for α reported in the second column is very close to one, indicating that the overall weight on water quality is small. 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% confidence interval of (0.929, 0.985), which was calculated using a bootstrapping technique. Specifically, 1000 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 4.2. For each of these draws, I calculated a sample average for $\hat{\alpha}$. The reported confidence interval was generated by ranking these 1000 $\hat{\alpha}$ estimates and deleting the highest and lowest twenty-five.[7]

The estimate of ρ reported in the second column of Table 4.2 suggest that while there is some degree of substitutability between money and environmental quality, the two are not perfect substitutes.[8] As is discussed in Section 4.1, ρ is related to the elasticity of substitution in that $\sigma = 1/(1-\rho)$. The value of ρ reported in column two corresponds to $\sigma = 1.38$. The average estimated value for ρ from the second model is 0.410 with an associated 95% 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

[7] In the heterogeneous case, α was not constrained to the unit interval as it was in the basic case. While confining α to the unit interval in the heterogeneous case does not qualitatively affect the results, it does result in much wider confidence intervals for the WTP estimates. For this reason, I have opted to estimate α simply as a linear function of income.

[8] One of the appealing features of the CES functional 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.

was calculated by bootstrapping. The estimate for ρ_{Income} is negative and highly significant, implying that respondents with higher income are more willing to substitute money for environmental quality. The average estimate of ρ from the third column of Table 4.2 corresponds to $\sigma = 1.69$.

I 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. A chi-squared test rejects the null hypothesis that the γ coefficients jointly equal zero at the 0.03 level in the basic case and at the 0.07 level in the heterogeneous case ($\chi^2 = 6.77$ [2] and $\chi^2 = 5.31$ [2], respectively). Using the same bootstrapping technique discussed earlier to generate 1000 estimates of mean CC_i, 99% of the realizations were greater than zero in the basic case, as were 97% 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 for learning) yields positive commitment costs is also confirmed by the data, as the γ^{Delay} coefficient is highly significant.

However, the lack of significance of the γ^{HiVar} parameter does not support the comparative static prediction that commitment costs are positively correlated with the degree of uncertainty respondents face. 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 noted earlier in a footnote, the mean water quality characteristics are not the precisely identical across the two uncertainty levels (recall that while water clarity was varied across treatments using a mean-preserving change of spreads, other measures of water quality could not be varied similarly and still be consistent with the underlying limnology). Thus, respondents may have viewed the increased uncertainty as being offset by increased mean water quality levels.

Table 4.3 presents estimates of mean WTP conditional on both the opportunity for learning and the level of uncertainty. Again, for the sake of comparison, I include the results of both regressions.

These results indicate that reported willingness to pay for changes in environmental quality can have a large option value component. As a percentage of the no-learning WTP, the commitment costs range from 25% to 57%. 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.

Reading earlier drafts of this chapter, some economists suggested that fewer respondents voting "yes" when offered the chance to delay their decision may simply be due to their putting off the taxes associated with the proposed improvement as long as possible. My

Table 4.3 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	475	1136	683	476	1159
	(467, 2277)[a]	(34, 1047)	(948, 3079)	(338, 1652)	(-10, 1151)	(836, 2404)
Low Variance	494	663	1157	532	639	1171
	(259, 2110)	(179, 1401)	(985, 3259)	(173, 1470)	(22, 2104)	(831, 2678)
High Variance	833	282	1115	834	313	1147
	(502, 2908)	(-257, 948)	(929, 3235)	(389, 2463)	(-313, 1317)	(793, 2693)

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

results, then, would not be consistent with the existence of commitment costs, so much as with respondents discounting the future. This, however, overlooks the fact that the plan not only imposes higher taxes, but also provides area residents with improved environmental quality. And since delaying the tax increase necessarily delays the realization of the water quality improvements, the simple discounting argument seems less appropriate. Further, recall that some respondents were offered the potential of a one-year delay, while others were offered a five-year delay. The discounting argument would predict that those offered a five-year wait would be even less likely to vote yes since they can delay the tax increase five times as long. This was not the case. As I discussed earlier in this section, WTP estimates from the one- and five-year groups are not significantly different.

4.3 Policy Implications and Conclusions

These results have important implications for the design of stated preference surveys. If uncertainty, irreversibility, and the potential for learning are inherent to a policy under consideration, then commitment cost is relevant to the eventual policy decision, and stated preference questions should be written to reflect this. My analysis suggests that it is especially important that the survey instrument accurately convey the potential for delaying the decision, as this can have important consequences for the magnitude of WTP.

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 stated WTP 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, 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 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.

On the other hand, suppose 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 to use in a benefit assessment regarding a decision on the project today would include a discount for the lost opportunities for delay. 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.

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

Many applied welfare analyses require the estimate of the value of an environmental service or improvement, regardless of the decision framework. For example, policymakers may simply be interested in knowing the welfare effect of having a better water quality in a local lake, even though they have no plan to take action now or in the future. In this case, the relevant value measure wtp^{NL} does not include commitment costs. However, survey questions in CVM studies are generally framed as hypothetical *decisions*, and commitment costs may arise if respondents think that there is the potential for delaying that decision. It is important, then, that the survey be designed to minimize or eliminate commitment costs, for example, by informing respondents that that the survey represents their only chance to make their preferences known.

In this chapter, I 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 and uncertainty, I collected data from Clear Lake-area residents regarding their valuation of a proposed project to improve water quality in Clear Lake. My findings show that respondents' willingness to pay is indeed sensitive to the potential for future learning. This is consistent with the dynamic formation of WTP values and suggests that CVM practitioners must take care to accurately represent the potential for future learning.

CHAPTER 5

THE DYNAMIC FORMATION OF WTP AND WTA IN AN EXPERIMENTAL SETTING

Traditional, neoclassical consumer theory predicts that willingness to pay for a good (WTP) and willingness to accept compensation in exchange for that same good (WTA) should differ by only a small margin, if at all. In particular, Hicksian theory (1943) shows that, in a static setting, a consumer's willingness to pay for a price decrease or quality increase is equal to the compensating variation, while willingness to accept compensation in exchange for that same price decrease or quality increase is equal to the equivalent variation (see Figures 5.1 and 5.2). Willig (1976) further develops this argument, showing that for price changes, compensating and equivalent variations should only differ substantially when income effects are very large or when the budget share of the good in question is large. Randall and Stoll (1980) extend Willig's result to quantity changes.

However, these theoretical analyses fail to explain the results of more than 200 economic laboratory experiments and contingent valuation (CVM) studies that have consistently found that people require much greater compensation in exchange for a good than they are willing to pay to receive it. Examples of empirical studies that find a stark difference between WTA and WTP include Kahneman, Knetsch, and Thaler's (1990) experimental work using simple private goods (*e.g.*, coffee mugs, chocolate bars), and Brookshire and Coursey's (1987) CVM study estimating the value of trees in a Colorado park. In their exhaustive survey of the empirical literature, Horowitz and McConnell (2000a) find that, on average, the ratio of WTA to WTP for private goods is nearly three to one, and that the same ratio for public goods is more than ten to one. Looking at the empirical evidence, it seems clear that a

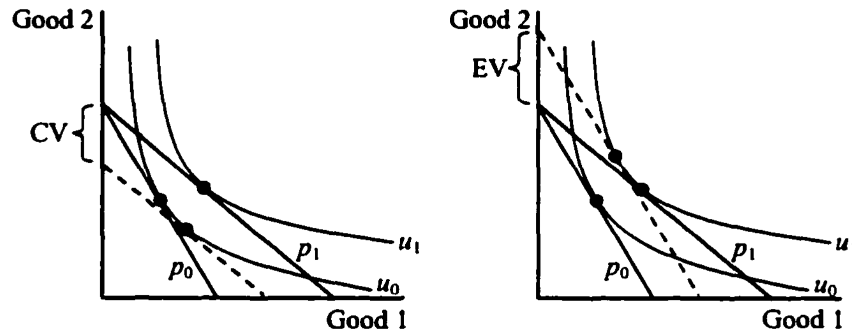


Figure 5.1 Compensating and Equivalent Variations for a Price Decrease

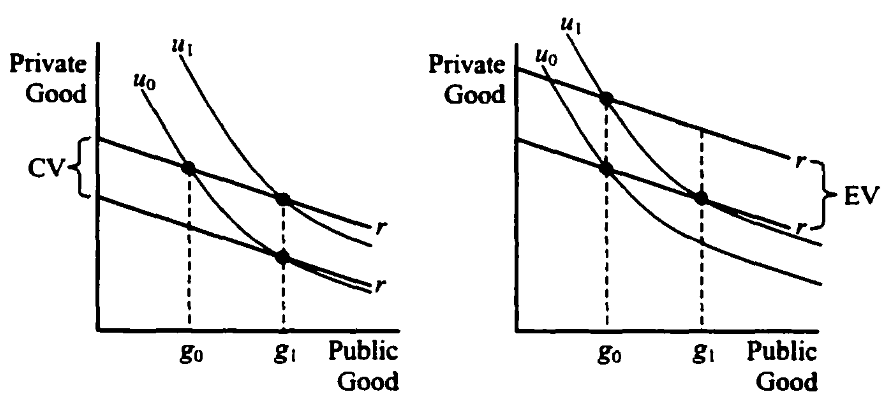


Figure 5.2 Compensating and Equivalent Variations for a Quality Increase

disparity exists between WTA and WTP and that that disparity is robust across many types of goods.

A number of theories have been advanced attempting to explain this apparent anomaly. These theories generally fall into one of two broad categories: behavioral arguments borrowing from the psychology literature, and neoclassical arguments attempting to explain the disparity by extending neoclassical utility theory. The behavioral category includes Tversky and Kahneman's (1991) endowment effect theory, which follows from their work on prospect theory (Kahneman and Tversky 1979). Also in this category is Loomes and Sugden's (1982) theory of regret aversion.

Neoclassical arguments include Heiner (1983) and Hoehn and Randall's (1987) work on value uncertainty, Hanemann's (1991) model based on the substitution effect, and, most recently, Zhao and Kling's (2001, 2002) commitment cost model.[1] Zhao and Kling use real options theory to analyze the effect of potential future learning on WTP and WTA in the presence of uncertainty and limited reversibility or delay.

In this chapter, I lay out the design and results of a pair of experimental economic tests of the commitment cost theory. In the first of these experiments, my aim is test whether subjects' perceptions about the difficulty of delay and reversal affect WTA and WTP in a manner consistent with the commitment cost theory, whether this can explain the disparity observed in the experimental literature, and whether providing subjects with information about the structure of the market affects their valuations. Subjects in this experiment bid to either buy or sell a private good in two auction rounds. After each of these rounds, subjects completed a survey intended to gauge their perceptions regarding the difficulty of selling and buying the good outside of the experimental market. In two of the four experimental treatments, subjects received information about the outside market structure before the second round of bidding. The results of this first experiment suggest that subjects' perceptions do in fact affect their bids, at least in the case of potential buyers. However, providing subjects with relevant information about the relative difficulty of delaying a transaction or reversing outside of the experiment does not significantly affect their bids.

In the second experiment, my goal is test whether manipulating the difficulty of delay and reversal affects subjects' WTA and WTP in a way that is consistent with the predictions of the commitment cost model. The second experiment is similar to the first, but, depending

[1] A more thorough discussion of all of these theories can be found in Chapter 2.

the treatment they were assigned to, subjects were given the chance to either reverse or delay a transaction within the experimental setting. The results of this test do not support the predictions of the commitment cost model.

This chapter is organized as follows. Sections 5.1 and 5.2 lay out the design and empirical results of Experiment 1. Likewise, Sections 5.3 and 5.4 lay out the design and empirical results of Experiment 2. Conclusions are reserved for Section 5.5.

5.1 The Design of Experiment 1

As I show in Section 3.1, the commitment cost model predicts that if the value formulation process is dynamic, and if agents, whether they be buyers or sellers, perceive the difficulty of reversing a transaction to be greater than the difficulty of delaying it, stated WTA will be greater than stated WTP even if agents are risk neutral. Therefore, in order for the dynamic nature of the value formulation process to drive WTA-WTP disparity, it is necessary (1) that the perceived relative difficulties of reversal and delay affect agents' valuations in a manner consistent with Zhao and Kling's model, and (2) that both buyers and sellers, on average, perceive reversal to be relatively more difficult than delay.

Kling, List, and Zhao (2001, henceforth KLZ) report the results of an experimental sportscard auction intended to test these two points. Attendees of a sportscard convention were either endowed with or given the chance to examine a sportscard with a market value of roughly $12. The attendees were then offered the chance to place a bid to either sell or buy the card, depending on whether or not they had initially been endowed with it. After submitting their bids, attendees completed a survey designed to obtain information about their perceptions regarding the difficulty of selling the card in another venue and of purchasing the card outside of the experimental auction. The authors found that for both amateur traders and professional dealers, perceptions of these delay and reversal difficulties had a significant effect on bid magnitude, and that that effect was consistent with the predictions of the commitment cost model. However, among attendees who did not intend to keep the card if they left the auction with it, the null hypothesis that both potential buyers and sellers had the same beliefs about the relative difficulty of buying versus selling outside of the experimental auction could not be rejected at conventional significance levels ($\chi^2 = 0.25$ [2]). In other words, buyers and sellers did not both perceive reversal to be more difficult than delay.

While KLZ's findings are suggestive, further empirical work is necessary to fully understand the dynamic formation of WTA and WTP. It should be kept in mind that the WTA-WTP disparity literature has been much studied in experimental auctions conducted in a controlled laboratory setting (*e.g.*, Kahneman, Knetsch, and Thaler 1990; Shogren *et al.* 1994; Knetsch, Tang, and Thaler 2001). It would, therefore, be useful to test the predictions of Zhao and Kling's theory in that same setting. If commitment costs are a component of the WTA-WTP disparity generally, their presence should be detectable in controlled experiments as well as in the field.

This first experiment is intended to help bridge the gap between the commitment cost theory and the larger WTA-WTP disparity literature. In this section, I describe the design of an experiment intended to test whether commitment costs, if they exists in a lab setting, are the proper sign and of sufficient size that they can explain at least part of the WTA-WTP disparity observed in studies such as Kahneman, Knetsch, and Thaler's (henceforth KKT). The design of my study is similar to KLZ's in that potential buyers (sellers) submit a bid indicating their maximum willingness to pay (minimum willingness to accept compensation in exchange) for a good, and then complete a survey designed to obtain information about their perceptions regarding the difficulty of selling and buying the good outside the experimental market. However, my study differs from KLZ's in that I conduct a second auction round after having given some of the subjects information about the structure of the outside market.

The design of my study is also similar to KKT's. All subjects in a treatment were assigned the role of either buyer or seller, and given the chance to buy or sell a private good in a series of auctions. Where my design differs from KKT's is that subjects were asked to complete a survey similar to the one used in KLZ. This allows me to test whether subjects consider dynamic aspects of the market when formulating their valuation of a good. In particular, I test whether subjects' perceptions about the relative difficulty of reversal versus delay affect their valuation. By comparing subjects' bids with what they report as their perceived difficulties of delay and reversal, I can test whether subjects form their values in a way that is consistent with the commitment cost model.

I also test whether providing subjects with information about the structure of the outside market affects their valuation of the good. The commitment cost predicts that if buyers and sellers have different perceptions about the relative difficulties of reversal and delay, this will lead to a gap between WTA and WTP. Therefore, if information provided to buyers and sellers brings each group's perceptions more in line with the other's, this should decrease that gap. In order to test whether this is actually the case, I compare both groups' perceptions before and after they were provided with information about the true potential for reversal and delay.

The experiment consisted of four treatments—two WTP and two WTA. In the WTP Control treatment, all subjects were assigned the role of potential buyers. The subjects first participated in a practice auction for a dollar bill. This was followed by two potentially binding auction rounds for a coffee mug, each followed by a survey eliciting subjects' perceptions regarding the difficulty of buying and selling the good outside the experiment. The WTP Information treatment differed only in that subjects were presented with information about the outside market for mugs between the first and second auction rounds for the mug. In particular, they were told where the mugs were purchased and what that store's policy was on returns and exchanges. WTA Control and Information treatments were similar to the WTP treatments, except each subject was endowed with a dollar bill and a coffee mug, and then offered the opportunity to sell them.

The commitment cost model predicts that if the value formulation process is dynamic, subjects' valuations will be affected by their perceptions of the difficulty of both buying and selling the good in the future. More specifically, subjects who believe that selling outside the experiment is more difficult than buying will submit bids that are, on average, lower than subjects who believe buying outside the experiment is relatively difficult. Further, insomuch as the information provided in the Information treatments brings subjects' perceptions in line with one another's, this should cause their valuations to converge.

Subjects for this study were recruited from Principles of Economics classes at Iowa State University during the spring semester of 2002. Thirty students participated in each of the four experimental treatments, for a total of 120 subjects. While the four treatments were conducted on four different days, subjects were recruited such that the class they were recruited from would not meet between treatments. This was done to reduce the possibility of students who participated in early treatments sharing information with classmates who would participate in later treatments. Each subject was paid $15 for participating. A summary of subjects' socioeconomic characteristics can be found in Table 5.1. The numbers for income and age seem reasonable considering the population from which the subjects were drawn. Women, however, are significantly underrepresented compared to the university's enrollment (44.5% women). The male dominance of the sample may be due to the population the subjects were drawn from. It is also worth noting that age, gender, and income did not vary significantly across the WTA and WTP treatments.

Each experimental treatment had six steps. (1) Subjects were read an introduction to the experiment and an explanation of the random nth-price auction mechanism. (2) Subjects submitted bids in a non-binding auction for a dollar bill. (3) The monitor explained that the next two auction rounds would be for an Iowa State University-logo coffee mug and that only one of the two rounds would be binding. (4) Subjects inspected the mug; submitted bids indicating their WTP or WTA, depending on the treatment; and completed a perceptions survey. In the WTA and WTP Information treatments, subjects were then given information about the difficulty of buying and selling the mug outside of the experiment. (5) Subjects submitted a second bid indicating either their WTP or WTA, and completed a second perceptions survey. (6) The binding round and random nth price were determined and announced, and any transactions agreed to were carried out. Appendix E contains the actual instructions given to subjects in the WTP Information treatment. These instructions and the instructions used in Experiment 2 borrow their description of the auction mechanism from Shogren *et al.* (2001b) and their follow-up quiz format from Rousu *et al.* (2002).

Table 5.1 Characteristics of Subjects in Experiment 1

	All Treatments ($n = 120$)		WTP Treatments ($n = 60$)		WTA Treatments ($n = 60$)	
	Mean (Std Dev)	Median	Mean (Std Dev)	Median	Mean (Std Dev)	Median
Age	20.3 (9.33)	19.0	19.8 (3.10)	19.0	20.8 (12.7)	19.0
Female	0.33 (0.47)	0.00	0.28 (0.45)	0.00	0.38 (0.49)	0.00
Income	5423 (5574)	4000	6091 (6418)	4500	4778 (4578)	3500

During the first step, subjects read along as the monitor read the experiment's instructions aloud. These instructions contained both a brief introduction to the experiment, as well as a detailed description of the workings of the random nth-price auction. The monitor also went over an example auction on the blackboard and administered a short quiz to test subjects' understanding of the auction mechanism.

The second step was a non-binding practice auction for a dollar bill. This auction was intended to further familiarize subjects with the auction mechanism. Depending on whether subjects in a given round had been assigned the role of buyers or sellers, they bid to buy or sell a dollar bill. Bids were collected and ranked on the blackboard. A cut-off bid was randomly determined and announced along with the cut-off price. Subjects were then informed that, had this been a real round, anyone who submitted a bid above (below) the cut-off price would buy (sell) a dollar bill.

During step three, the monitor informed subjects that the following two auction rounds would be for Iowa State University-logo coffee mugs, but that only one of the two rounds would be binding, and that the binding round would be determined by a coin flip after both rounds had been completed. This was done to eliminate demand-curve effects.

In step four, subjects were given the chance to inspect the mugs being auctioned off and to submit a bid indicating their maximum willingness to pay (minimum willingness to accept compensation in exchange for) for such a mug. After submitting their bids, subjects completed a survey designed to collect data on their age, gender, and income, as well as on their perceptions of the retail price of the mugs up for auction, and the relative difficulty of selling or buying the mugs outside of the experiment. Upon completion, the monitor collected these surveys.

Subjects in the Information treatment were then provided with information about the institutional structure of the market for mugs outside of the experiment. That information was as follows:

> Before we proceed to Object Round Two, I want to take a moment to inform you that the coffee mugs used in today's experiment were purchased at the University Book Store. These mugs can be returned to the bookstore for store credit, but they cannot be exchanged for a cash refund. This is because you will not be given a University Book Store sales receipt.

Subjects in the Control treatments received no such information.

During step five, subjects submitted a second bid indicating their maximum willingness to pay (minimum willingness to accept compensation in exchange) for the mug. After submitting these bids, they completed a second survey similar to the first, but excluding questions on age, gender, and income. These surveys were collected once all subjects had completed them.

In step six, the binding mug round was determined by flipping a coin. After announcing the result of the coin flip, the bids from that round were ranked on the blackboard. The cut-off bid was determined at random and was announced along with the cut-off price. Subjects were informed that if they had submitted a bid above (below) this cut-off price, they would purchase (sell) a mug at that price. Subjects were then paid $15 for their participation, and any transactions agreed to were carried out.

At this point, I should make special note of several aspects of the study's design. First, the coffee mugs used in the experiment were clearly marked with a University Book Store price tag. In different experiments, KKT auctioned off coffee mugs with and without price tags and found similar results in both cases (median WTA/WTP ratios of 2.5 and 3.5, respectively). I chose to leave the price tags on the mugs because of the bookstore's return policy. As that policy was explained to me, merchandise can be returned for a full cash refund if it still bears its price tag and is accompanied by a receipt. Items marked with a price tag but not accompanied by a receipt can be exchanged for in-store credit only. Items lacking both a price tag and a receipt cannot be exchanged or returned. Therefore, since I was interested in the effect of the perceived difficulty of selling the mug (*i.e.*, returning it to the bookstore), it seemed most convenient to choose the middle level (price tag, no receipt).

In order to solicit subjects' valuations, I used a variation of the random nth-price auction mechanism developed by Shogren *et al.* (2001b). This mechanism can be thought of as a hybrid of the popular Vickrey (1961) and Becker-DeGroot-Marshak (1964) auction mechanisms, drawing desirable elements from both. These auctions are widely used in the economic literature because, in contrast to the traditional first-price sealed-bid auction, both Vickrey and BDM auctions are theoretically demand revealing (in a one-shot setting).

Of these two auction mechanisms, the Vickrey auction has been more popular because it is relatively easy to explain and the market-clearing price is determined endogenously. However, there is some concern about the mechanism's ability to prompt off-margin bidders to reveal their true preferences (see Shogren *et al.* 2001b). While truth telling is weakly dominant for all bidders, those whose valuation is far below that of high-valuers will never be punished for insincere bidding.

The BDM auction offers a solution but introduces a new problem. By randomizing the number of winners, the BDM auction should incent off-margin bidders to bid sincerely. However, this is achieved by randomly selecting the market price from some predetermined distribution. Thus, the market price is no longer endogenously determined, and there need not necessarily be a positive number of winners or losers in any given auction round.

The random nth-price auction differs from the BDM in that while the market price, and thus the number of winners in any auction, is determined at random, the "distribution" the market price is chosen from is endogenized. Specifically, the market price is chosen at random from the bids submitted by market participants. In the buyer case, one of the bids submitted by potential buyers is chosen at random as the cut-off price. Anyone who submitted a bid higher than that price buys the good at the cut-off price. Anyone who submitted a bid at or below the cut-off price buys nothing. Thus, by separating what subjects bid from what they pay if they win the auction, the random nth-price auction mechanism preserves the demand-revealing properties of the Vickrey auction. Shogren *et al.* (2001b) show that the random nth-price auction does in fact outperform the Vickrey auction mechanism when it comes to motivating off-margin bidders to bid their true valuation in an auction for induced value tokens.[2]

[2] It can be argued that the random nth-price auction mechanism's endogenous determination of market price is actually a weakness. For example, an altruistic potential buyer might submit a zero bid in the hope that her bid would be chosen as the cut-off price, thus yielding the highest possible surplus for her fellow bidders.

Also worth noting was a potential problem observed after the first willingness to pay treatment (WTP Control). In this treatment, a dozen coffee mugs were displayed at the front of the room, and before bidding to buy the mugs, subjects were asked to come to the front of the room and inspect the mugs. Although the coffee mugs were clearly marked with their price ($5.95), when asked what they believed the mug could be purchased for outside of the experiment, seven of the thirty subjects gave answers that either over- or underestimated the true price of the mug by more than a dollar. Further, after controlling for subjects' perceptions about the relative difficulties of reversal and delay, there was an alarmingly high correlation between the outside price reported and the subjects' bids ($t = 1.67$). Taking these facts into consideration, I decided to pass the mugs around the room in the second WTP treatment. Subjects in that treatment were read the following paragraph as the mugs were passed around:

> The next two rounds will be conducted for the COFFEE MUG you have just been given. This coffee mug is *not* yours to keep, but you will be given the opportunity to buy it during the next two auction rounds. At this time, please take a few moments to carefully examine the mug to determine whether you wish to buy it in the rounds that are about to take place.

While mean WTP was higher in the second treatment, the impact was marginal ($t = 1.65$).

5.2 Empirical Results from Experiment 1

At first blush, the data are consistent with the large body of evidence suggesting that stated WTA for private goods is more than twice stated WTP. However, a more careful examination of the data shows that the perceived difficulty of selling later versus buying later has a significant negative effect on potential buyers' valuation of the coffee mug. In this section, I begin by comparing subjects' bids with their perceptions of the relative difficulties of delay and reversal. I then describe the results of a series of simple regressions designed to test more precisely the effects these perceptions have on WTP and WTA.

Table 5.2 presents the summary statistics from all three auction rounds, first for all treatments, then for WTP and WTA treatments separately. It is worth noting that while the ratio of both mean and median WTA to WTP are close to one for a dollar bill, there is a large disparity between WTA and WTP in both of the coffee mug auction rounds (t = 0.98, 7.25, and 6.78, respectively).

Table 5.3 reports subjects' valuations conditional on their reported perceptions of the relative difficulty of reversal versus delay. As predicted by the commitment cost theory, buyers who perceived reversal (*i.e.*, selling the good outside of the experiment) to be more difficult than delay (*i.e.*, buying the good outside of the experiment) submitted bids significantly lower than buyers who perceived reversal to be easier than delay ($2.26 versus $3.86, $t = 2.15$).

The theory also predicts that the mean bid for sellers who perceive reversal (buying later) to be more difficult than delay (selling later) will be higher than that for sellers who perceive delay to be relatively more difficult. While this is the case ($5.83 versus $4.83), the difference between the two means is not significant at conventional levels ($t = 0.82$). This lack of statistical significance may be due, in part, to the fact that only three out of the sixty potential sellers perceived buying later to be more difficult than selling. In Sections 5.3 and 5.4, I discuss an experiment where subjects are given the opportunity to delay or reverse their

Table 5.2 Mean Bids from Experiment 1

All Treatments

	Mean	Median	Standard Deviation	Observations
Dollar Bill	1.00	1.00	0.34	120
Coffee Mug (Round 1)	3.63	3.88	2.19	120
Coffee Mug (Round 2)	3.53	4.00	2.25	120

WTP Treatments

	Mean	Median	Standard Deviation	Observations
Dollar Bill	0.97	0.99	0.42	60
Coffee Mug (Round 1)	2.42	2.00	1.75	60
Coffee Mug (Round 2)	2.35	2.00	1.96	60

WTA Treatments

	Mean	Median	Standard Deviation	Observations
Dollar Bill	1.03	1.00	0.22	60
Coffee Mug (Round 1)	4.84	5.00	1.90	60
Coffee Mug (Round 2)	4.72	4.88	1.87	60

transactions within the experimental setting, thus allowing me to control the relative difficulty of buying and selling later.

Table 5.3 The Effects of Perceived Differences in Relative Reversal and Delay Difficulty

	WTP		WTA	
Perceived Relative Difficulty	Mean Bid	Observations	Mean Bid	Observations
Reversal Difficulty > Delay Difficulty	2.26 (1.72)[a]	43	5.83 (0.29)	3
Reversal Difficulty = Delay Difficulty	2.26 (1.76)	11	4.61 (1.33)	12
Reversal Difficulty < Delay Difficulty	3.86 (1.58)	6	4.83 (2.08)	45

[a] Numbers in parentheses are standard errors.

Table 5.3a The Effects of Perceived Differences in Relative Difficulties for Keepers

	WTP		WTA	
Perceived Relative Difficulty	Mean Bid	Observations	Mean Bid	Observations
Reversal Difficulty > Delay Difficulty	2.48 (1.79)[a]	34	6.00 (0.00)	2
Reversal Difficulty = Delay Difficulty	2.38 (1.80)	10	4.73 (1.48)	8
Reversal Difficulty < Delay Difficulty	4.72 (1.03)	3	5.48 (1.70)	31

[a] Numbers in parentheses are standard errors.

Table 5.3b The Effects of Perceived Differences in Relative Difficulties for Non-Keepers

	WTP		WTA	
Perceived Relative Difficulty	Mean Bid	Observations	Mean Bid	Observations
Reversal Difficulty > Delay Difficulty	1.42 (1.12)[a]	9	5.50 (—)	1
Reversal Difficulty = Delay Difficulty	1.05 (—)	1	4.38 (1.11)	4
Reversal Difficulty < Delay Difficulty	3.00 (1.73)	3	3.40 (2.18)[†]	14

[a] Numbers in parentheses are standard errors.

Commitment cost theory further predicts that mean WTP will be less than mean WTA among buyers and sellers who believe that reversal is relatively more difficult than delay. This is strongly supported by the data ($2.26 versus $5.83, $t = 3.56$).

Finally, the theory predicts that the mean bid submitted by potential sellers who perceive delay (selling later) to be relatively difficult will, on average, be less than that submitted by potential buyers who believe delay (buying later) is relatively difficult. This was not the case ($4.83 versus $3.86), but the difference between the two averages is not statistically significant ($t = -1.10$). This last test is particularly interesting, since this prediction is one of the elements that sets commitment cost apart from the endowment effect. The endowment effect predicts that WTA will be greater than WTP for all agents who do not simply think of the good as a means of exchange. The commitment cost model, on the other hand, predicts that WTP will actually exceed WTA if both buyers and sellers perceive delay to be more difficult than reversal. Given that the two means are not significantly different, I can make no definitive statement about which theory better describes the data.

Table 5.3a presents figures similar to those in Table 5.3, but for the subgroup of subjects who indicated they intended to keep the mug if they left the experiment with it. Likewise, Table 5.3b presents figures for the subgroup that indicated they intended to return or exchange the mug. The results in both tables are qualitatively similar to those in Table 5.3. This is also of interest when comparing the endowment effect and commitment cost models, since the endowment effect would predict no disparity between WTA and WTP for goods thought of as means of exchange (for example, the dollar bill used in the practice round). The fact that a significant disparity still existed among the 27% of subjects who intended to return the mug strongly suggests that the endowment effect alone cannot explain the WTA/WTP ratio of 2.11 observed among the subgroup of non-keepers.

Table 5.4 is similar to Table 5.3, but parses the data more finely. In order to make pair wise comparisons between this table's cells, it is necessary to first make a strong assumption. Namely, that absolute difficulty scores are comparable across subjects. This assumes, for example, that a sell difficulty score of *m* reported by agents *i* means the same think as a similar score reported by agent *j*. This is to be contrasted with results reported in Table 5.3, which only rely on comparison of relative difficulty.

Given this assumption, the commitment cost model predicts that potential buyers and sellers who report the same absolute scores for the difficulties of selling and buying later should also report similar valuations. For example, the model would predict that the mean bid of the eight potential sellers who reported a sell-difficulty score of 2 and a buy-difficulty score of 1 should not be significantly different from the mean bid of the four potential buyers who reported the same absolute scores. This, in fact, is not the case. Of the nine cells in Table 5.4 where such comparisons can meaningfully be made, in only three of them are mean WTA and mean WTP not significantly different.

The commitment cost theory further predicts that WTA will exceed WTP when both buyers and sellers perceive the difficulty of reversal to be greater than the difficulty of delay. This can be interpreted as meaning that the WTA values in cells above the diagonal should be greater than the WTP values in corresponding cells below the diagonal (*e.g.*, comparing bids submitted by sellers who reported a sell-difficulty score of 1 and a buy-difficulty score of 2 with bids submitted by buyers who reported a sell-difficulty score of 2 and a buy-

Table 5.4 The Effects of Perceived Differences in Relative Reversal and Delay Difficulty

		Difficulty of Buying Later (WTP Delay Difficulty, WTA Reversal Difficulty)				
		1	2	3	4	5
Difficulty of Selling Later (WTP Reversal Difficulty, WTA Delay Difficulty)	1	**2.31 (5)[a]** 4.74 (6)	— 6.00 (1)	4.63 (2) —	— —	— —
	2	1.19 (4) 5.36 (8)	**1.28 (2)** **4.78 (5)**	4.00 (1) —	5.90 (1) 6.00 (1)	— —
	3	3.23 (9) 5.51 (12)	2.86 (7) 4.14 (6)	**2.69 (4)** —	2.00 (2) —	— —
	4	2.09 (11) 4.15 (11)	3.75 (2) 6.00 (2)	2.18 (2) 6.75 (1)	— **3.00 (1)**	— 5.50 (1)
	5	6.80 (6) 4.25 (3)	— 5.95 (1)	1.75 (2) —	— —	— —

[a] The top number in each cell is mean WTP, the bottom number is mean WTA, and the numbers in parentheses are the number of observations.

difficulty score of 1). This comparison can only be made for two pairs of cells in Table 5.4, and it only holds true for one of them.

Finally, the theory predicts WTP will exceed WTA when both buyers and sellers perceive the difficulty of delay to be greater than the difficulty of reversal. This can be interpreted as meaning that the WTA values in cells below the diagonal should be less than the WTP values in corresponding cells above the diagonal. This comparison can be made for four pairs of cells, but in no case does it hold. While these comparisons do not reflect favorably on the commitment cost model's predictions, they are likely less reliable than the relative comparisons reported in Table 5.3.

To further assess the results, I have also performed regressions to estimate both WTP and WTA as functions of whether subjects intend to keep the good should they leave the experiment with it, and their perceptions of the relative difficulty of delay and reversal. The following six specifications were considered, and the results from this analysis are reported in Table 5.5.

[1] $WTP_i = \beta_0 + \beta_{Keep} Keep_i$,

[2] $WTP_i = \beta_0 + \beta_{Relative} Relative_i$,

[3] $WTP_i = \beta_0 + \beta_{Keep} Keep_i + \beta_{Relative} Relative_i$,

[4] $WTA_i = \beta_0 + \beta_{Keep} Keep_i$,

[5] $WTA_i = \beta_0 + \beta_{Relative} Relative_i$,

[6] $WTA_i = \beta_0 + \beta_{Keep} Keep_i + \beta_{Relative} Relative_i$.

Here, the coefficient β_{Keep} is associated with the variable $Keep_i$, a dummy variable that equals one for agents who report that they plan to keep the mug should they leave the experiment with it. The results from specifications [1], [3], [4], and [6] all strongly support the idea that keepers place higher value on the mugs than do non-keepers, as the coefficient β_{Keep} is significantly greater than zero in all four cases. This, however, is somewhat difficult to interpret. Is the value a subject puts on an item a function of whether she intends to keep that item, or is her decision about whether to keep the item dependent on the value she puts on it?

Table 5.5 Regression Results from the First Round of Bidding

	WTP			WTA		
	[1]	[2]	[3]	[4]	[5]	[6]
Constant	1.76***	2.91***	2.19***	3.72***	5.01***	3.92***
	(3.67)[a]	(7.56)	(4.54)	(9.24)	(13.6)	(8.40)
Keep	0.84	—	0.98*	1.64***	—	1.66***
	(1.54)		(1.89)	(3.38)		(3.41)
Relative	—	-0.34**	-0.37***	—	-0.47	-0.58
		(-2.48)	(-2.72)		(-0.62)	(-0.85)

[a] Numbers in parentheses are *t* statistics.
* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.

The coefficient $\beta_{Relative}$ is associated with the variable $Relative_i \in [-1,1]$, which is defined as the difference between subject *i*'s perceived difficulty of selling later and her perceived difficulty of buying later. That is,

$$Relative_i = \frac{1}{4}\left(SellDifficulty_i - BuyDifficulty_i\right), \tag{5.1}$$

where both $SellDifficulty_i$ and $BuyDifficulty_i$ are self-reported measures ranging from 1 (very easy) to 5 (almost impossible). If subject *i* reports that she believes that selling outside the experiment would be almost impossible, but that buying would be very easy, then $Relative_i = 1$. On the other hand, if she reports that she believes that selling outside would be very easy, but that buying would be almost impossible, then $Relative_i = -1$. A $Relative_i$ value of 0 would imply that she perceived buying and selling to be equally difficult. The estimates of $\beta_{Relative}$ reported in columns [2] and [3] of Table 5.5 are significantly less than zero. This suggests that potential buyers who believe selling later (reversal) will be more difficulty than buying later (delay) tend to bid significantly less than buyers who believe selling later will be relatively easy. This is consistent with the predictions of the commitment cost theory. The theory also predicts that potential sellers who believe selling later (delay) will be relatively more difficulty than buying later (reversal) will tend to bid significantly less than those who believe buying will be more difficult. This relationship, however, is not borne out by the data. While the estimates of $\beta_{Relative}$ reported in columns [5] and [6] of Table 5.5 are negative, they are not statistically significantly so.

As described in Section 5.2, subjects in the WTA and WTP Information treatments were presented with information about the structure of the outside market between the first and second auction rounds for coffee mugs. The commitment cost theory predicts that if subjects are provided with information that changes their perceptions about the relative difficulty of reversal versus delay, this should in turn affect their stated valuations.

Table 5.6 presents descriptive statistics from the second coffee mug auction. Table 5.7 presents the relative perceptions after the second mug auction round for subjects in both the Control and Information treatments. The results are stark. A chi-squared test of independence fails to reject the null hypothesis that there is no difference between subjects' reported relative perceptions of difficulty in the WTP and WTA Control treatments (χ^2 = 0.35 [2]). Likewise, the test fails to reject the null comparing perception between the two Information treatments (χ^2 = 0.39 [2]). However, when comparing reported relative perceptions across the Control and Information treatments, I can reject the null hypothesis at the 0.0001 level in both the WTP and WTA cases (χ^2 = 23.74 [2] and 24.91 [2], respectively).

Table 5.6 Mean Bids from the Second Round of Bidding

	WTP		WTA	
	Control	Information	Control	Information
Mean	2.03	2.66	4.66	4.78
Median	2.00	2.26	4.08	5.00
Standard Deviation	1.71	2.16	1.68	2.08
Observations	30	30	30	30

Table 5.7 Second-Round Relative Perceptions in the Control and Information Treatments

	WTP		WTA	
Perceived Relative Difficulty	Control	Information	Control	Information
Selling Difficulty > Buying Difficulty	28	10	27	8
Selling Difficulty = Buying Difficulty	1	17	2	18
Selling Difficulty < Buying Difficulty	1	3	1	4

Table 5.8 Second-Round Mean Bids in the Control and Information Treatments

	WTP			WTA		
Perceived Relative Difficulty	Control	Info.	*t* statistic	Control	Info.	*t* statistic
Selling Difficulty > Buying Difficulty	2.11 (1.73)[a]	1.74 (2.12)	0.55	4.79 (1.68)	5.39 (2.28)	-0.82
Selling Difficulty = Buying Difficulty	0.02 (—)	2.76 (1.87)	-1.42	3.65 (1.62)	4.52 (2.08)	-0.57
Selling Difficulty < Buying Difficulty	2.00 (—)	5.17 (2.36)	-1.16	2.95 (—)	4.78 (1.92)	-0.85

[a] Numbers in parentheses are standard errors.

Clearly, the information subjects were provided with in the Information treatments had a highly significant effect on their perceptions of the relative difficulty of reversal versus delay.

However, while subjects' perceptions were affected by this information, their valuations were not. Table 5.8 reports mean bids for the same sub-groups reported in Table 5.7. In no case is the mean bid from the Control treatment significantly different than that from the Information treatment (t statistics range from −1.42 to 0.55). So, while information significantly affected perceptions, this did not translate into the effect on stated valuations predicted by the commitment cost theory.

To further test whether information has any significant impact on subjects' valuations, I have performed regressions to estimate the change in both WTP and WTA from the first round of bidding to the second a function of whether subjects intend to keep the good should they leave the experiment with it, and how their perceptions of the relative difficulty of delay and reversal changed. The following six specifications were considered, and the results from this analysis are reported in Table 5.9.

$$[7] \quad \Delta WTP_i = \beta_0 + \beta_{Control} Control_i ,$$

$$[8] \quad \Delta WTP_i = \beta_0 + \beta_{\Delta Relative} \Delta Relative_i$$

$$[9] \quad \Delta WTP_i = \beta_0 + \beta_{Control} Control_i + \beta_{\Delta Relative} \Delta Relative_i ,$$

$$[10] \quad \Delta WTA_i = \beta_0 + \beta_{Control} Control_i ,$$

$$[11] \quad \Delta WTA_i = \beta_0 + \beta_{\Delta Relative} \Delta Relative_i$$

$$[12] \quad \Delta WTA_i = \beta_0 + \beta_{Control} Control_i + \beta_{\Delta Relative} \Delta Relative_i ,$$

where $Control_i$ is a dummy variable that equals one if subject i was in a Control treatment, and $\Delta Relative_i$ is defined as the difference between the $Relative_i$ figure calculated from first

Table 5.9 Regression Results from the Second Round of Bidding

	ΔWTP			ΔWTA		
	[7]	[8]	[9]	[10]	[11]	[12]
Constant	0.12	0.07	0.13	-.0033	0.04	-0.34
	(0.60)	(0.46)	(0.73)	(-0.01)	(0.15)	(-1.00)
Control	-0.11	—	-0.11	-0.24	—	0.66
	(-0.37)		(0.31)	(0.53)		(1.35)
Change in	—	0.01	-0.05	—	0.90	1.40*
Perceptions		(-0.01)	(-0.09)		(1.24)	(1.70)

[a] Numbers in parentheses are t statistics.
* Significant at the 0.10 level.

survey and that calculated from the second survey. The results of these regressions are reported in Table 5.9. In none of the four regressions is the coefficient $\beta_{Control}$ significantly different from zero. Thus, the data do not suggest that information regarding the structure of the outside market has any significant effect on valuation of the mug. The coefficient $\beta_{\Delta Relative}$ from regression [12] is positive and marginally significant, suggesting that valuation increased among potential sellers who decided after the first round that selling later was relatively easier or that buying later was relatively more difficult.

5.3 The Design of Experiment 2

The lack of a statistically significant relationship between perceptions and WTA bids in Experiment 1 may be due, in part, to the small portion of potential sellers who perceived buying later to be more difficult than selling (three out of sixty). Therefore, in this section I lay out the design of an experiment where subjects are given the ability to either delay or reverse transactions within the controlled environment of the experiment.

This test consisted of four experimental treatments—two WTP and two WTA—where subjects were given the chance to either buy or sell a box of cookies. The design differs appreciably from that of Experiment 1 in that subjects in this experiment were told that after the market price had been announced and transactions had been completed, they would be given a sample of the cookie and, depending on the treatment, given the chance to either buy a box from or sell their box back to the monitor at the randomly-selected market price. This allows me to test whether subjects consider the market's dynamic aspects when formulating their valuation of a good. Commitment cost theory predicts that potential buyers offered the opportunity for delay (but not reversal) will, on average, bid less than buyers offered the opportunity of reversal (but not delay). Likewise, potential sellers offered the opportunity for delay (but not reversal) will, on average, bid more than sellers offered the opportunity of reversal (but not delay). By manipulating subjects' ability to delay or reverse their transactions I am able to test whether the theory's predictions hold.

In the WTP Buy Later treatment, subjects were given a sample of the cookie after the completion of the binding auction round. Those subjects who had not purchased a box in the auction were then offered the chance to buy one at the (by then known) market price. The WTP Sell Later treatment differed only in that after tasting the cookie, subjects who had bought a box in the auction round were given a chance to sell it back to the monitor. WTA Buy Later and Sell Later treatments were similar, except that subjects were initially endowed with a dollar bill and a box of cookies, then offered the chance the sell them.

The commitment cost model predicts that if the value formulation process is dynamic, subjects' valuations will be affected by the relative difficulty of buying and selling the good in the future. More to the point, model predicts that subjects in a treatment where selling later is more difficult than buying later will submit bids that are, on average, lower than the bids submitted by subjects in a treatment where buying is relatively more difficult.

The four treatments were conducted over the course of one day in order to minimize discussion among potential subjects outside of the experiment. Subjects for this study were recruited from Principles of Economics courses at Iowa State University during the spring semester of 2002. Further, subjects for Experiment 2 were recruited from different Principles sections than were the subjects for Experiment 1. In other words, no student was invited to participate in both Experiments 1 and 2. Between twenty-seven and thirty students participated in each of the four experimental treatments, for a total of 114 subjects. Each subject was paid $10 for participating. A summary of subjects' socioeconomic characteristics can be found in Table 5.10. These numbers seem reasonable considering the population from which the subjects were drawn. Age, gender, and income do not vary significantly across the WTA and WTP treatments, nor do age and income differ across the two experiments. Experiment 2 differs from Experiment 1 in that women are not significantly underrepresented.

Each of the four experimental treatments had six steps. (1) Subjects were read an introduction to the experiment and an explanation of the BDM auction mechanism. (2) Subjects took part in a non-binding auction for a dollar bill. (3) The monitor explained that the next auction would be for a box of *Petit Écolier* cookies, and that it would necessarily be binding. (4) Subjects inspected the box of cookies, submitted bids indicating either WTP or WTA, depending on the treatment, and completed a perceptions survey. (5) The predetermined, randomly selected market price was announced, and any transactions agreed to were carried out. (6) All subjects were given a sample cookie, and, depending on the treatment,

Table 5.10 Characteristics of Subjects in Experiment 2

	All Treatments ($n = 114$)		WTP Treatments ($n = 57$)		WTA Treatments ($n = 57$)	
	Mean (Std Dev)	Median	Mean (Std Dev)	Median	Mean (Std Dev)	Median
Age	19.7 (1.49)	19.0	19.8 (1.38)	19.0	19.5 (1.60)	19.0
Female	0.48 (0.50)	0.00	0.42 (0.50)	0.00	0.54 (0.50)	1.00
Income	6000 (7123)	4000	6491 (8287)	4000	5491 (5707)	4500

were given the chance to buy a box or sell their box back at the market price. Appendix F contains the actual instructions given to subjects in the WTA Sell Later treatment.

During the first step, subjects read along as the monitor read the experiment's instructions aloud. These instructions contained both a brief introduction to experiment, as well as a detailed description of the workings of the BDM auction. The monitor went over an example auction on the blackboard and administered a short quiz to test subjects' understanding of the auction format.

The second step was a non-binding practice auction for a dollar bill. This round was intended to further familiarize subjects with the auction mechanism. The monitor announced that the market price had been drawn from a continuous uniform distribution over the $[0,5]$ interval. Depending on whether subjects had been assigned the role of buyers or sellers, they submitted bids to either buy or sell a dollar bill. These bids were collected and ranked on the blackboard. The predetermined, randomly selected market price was announced, and subjects were informed that, had this been a real round, anyone who submitted a bid at or above (below) the market price would buy (sell) a dollar bill.

During step three, the monitor informed subjects that the following auction round would be for a box of cookies and that the auction would be binding. The monitor further explained that after the bids had been submitted and the market price announced, subjects would be given a sample cookie. In the WTA and WTP Sell Later treatments, the monitor explained that anyone in possession of a box of cookies after the auction would be offered the chance to sell it back to the monitor at the market price after tasting a sample. Likewise, in the WTA and WTP Buy Later treatments, the monitor explained that anyone *not* in possession of a box of cookies after the auction would be offered the chance to buy a box from the monitor at the market price after tasting a sample. The monitor also explained that these sorts of transactions would incur a "cost of waiting." This cost varied from individual to individual and could equal either 0¢ or 50¢.

In step four, subjects were given the chance to inspect the box of cookies being auctioned off, the monitor announced that the market price would be drawn from a continuous uniform distribution over the $[0,10]$ interval, and the subjects submitted bids indicating their maximum willingness to pay (minimum willingness to accept compensation) for such a box. After submitting their bids, subjects completed a survey designed to collect data on their age, gender, and income, as well as on their perceptions regarding the retail price of the cookies, and the relative difficulty of selling or buying the cookies outside of the experiment. Upon completion, the surveys were collected.

During step five, the predetermined, randomly selected market price was announced, and any transactions agreed to were carried out.

In step six, all subjects were given a sample cookie, and, depending on the treatment, were given the chance to either buy or sell a box at the market price.

At this point, I should make special note of several of the study's key aspects. In order to have better control over the difficulty of reversal and delay, I felt it was necessary to choose a good that would be difficult for subjects to purchase or sell outside of the experiment. The good I eventually chose was a 150g box of French-labeled *Petit Écolier* cookies purchased in France. This particular type of cookie cannot be purchased in the Ames area, and the market for selling the cookies outside the experiment is likely thin, if not completely nonexistent.

I chose to use the BDM auction mechanism instead of the random nth-price mechanism used in Experiment 1 due concerns about the demand-revealing nature of the random nth-price auction in this particular context. Had the nth-price auction been used, a subject may have had the incentive to misrepresent in the first period in the hope that her bid would be chosen as the market price for which she could buy or sell in the second period. Using the BDM auction eliminates this incentive, since the market price is determined at random.

Finally, the prices used in the practice and real auction rounds were drawn in advance at random using a pseudo-random number generator. The same numbers were used in all four treatments so that any effects the prices may have had on later behavior would be consistent across treatments. The price used in the practice rounds was $2.26, and the price used in the real rounds was $8.87.

5.4 Empirical Results 2

Table 5.11 presents the summary statistics from both auction rounds, first for the combined treatments, then for WTP and WTA treatments separately. The theory of commitment cost predicts that the mean bid submitted by potential sellers in the WTA Sell Later

Table 5.11 Mean Bids from Experiment 2

All Treatments

	Observations	Mean	Median	Standard Deviation
Dollar Bill	114	1.01	1.00	0.32
Cookies	114	2.59	2.05	1.97
Cookies (Sell Later)	57	2.40	2.00	1.97
Cookies (Buy Later)	57	2.78	2.65	1.97

WTP Treatments

	Observations	Mean	Median	Standard Deviation
Dollar Bill	57	1.01	0.99	0.47
Cookies	57	3.08	3.00	2.25
Cookies (Sell Later)	27	3.36	3.25	2.30
Cookies (Buy Later)	30	2.83	2.75	2.21

WTA Treatments

	Observations	Mean	Median	Standard Deviation
Dollar Bill	57	1.01	1.00	0.19
Cookies	57	2.12	2.00	1.53
Cookies (Sell Later)	30	1.56	1.63	1.12
Cookies (Buy Later)	27	2.73	2.50	1.70

treatment should be greater than the mean bid submitted by potential buyers in the WTP Buy Later treatment, because reversal is more difficult than delay in both treatments. This was not the case ($1.56 versus $2.83). In fact, mean WTA was significantly less than mean WTP ($t = -2.81$). This is in conflict with the predictions of both the commitment cost and endowment effect models.

Further, contrary to the predictions of the endowment effect, the commitment cost model predicts that when the difficulty of delay is greater than the difficulty of reversal, the mean bid of potential buyers should be greater than that of potential sellers. Thus, commitment cost would predict that the mean in the WTP Sell Later treatment should be greater than meant in the WTA Buy Later treatment. While this was the case ($3.36 versus $2.73), the difference was not statistically significant ($t = 1.14$).

The theory also predicts that among potential buyers, those who were offered the opportunity to delay purchasing will bid lower than those offered the opportunity to reverse their purchase should they win the auction. This was true ($2.83 versus $3.36), but, again, the difference was not statistically significant ($t = 0.89$).

Similarly, commitment cost predicts that among potential sellers, those offered the option of delaying the transaction will submit bids greater than will potential sellers given the option to reverse a sale should they win the auction. Not only was this not the case ($1.56 versus $2.73), but the mean bid in the WTA Sell Later treatment was significantly less than in the WTA Buy Later treatment ($t = -3.10$).

Further, while mean WTA equals mean WTP for a dollar bill, mean WTA is significantly less than mean WTP for the box of cookies ($2.12 versus $3.08, $t = -2.00$). This clearly runs contrary the predictions of the endowment effect model. It is worth noticing that all of the results that run contrary to the predictions of the commitment cost theory involve the WTA Potential Delay treatment.

In Table 5.12, subjects' valuations are broken down based on their reported perceptions of the relative difficulty of buying or selling the good outside the experiment. Commitment cost theory predicts that bids submitted by buyers who perceive reversal (*i.e.*, selling the good outside of the experiment) to be more difficult than delay (buying the good outside of the experiment) will, on average, be less than those submitted by sellers who also believe reversal (buying later) is more difficult than delay (selling later). This is not supported by the data (\$2.77 versus \$2.11, $t = -1.00$).

In line with the predictions of the theory, buyers who perceived the difficulty of reversal (selling later) to be greater than the difficulty of delay (buying later) submitted bids lower than buyers who perceived reversal to be easier than delay (\$2.77 versus \$3.44). This difference, however, was not statistically significant ($t = 0.97$).

The theory also predicts that the mean of the bids submitted by sellers who perceive reversal (buying later) to be more difficult than delay (selling later) will be greater than the mean of the bids submitted by sellers who perceive delay to be relatively more difficult. As can be seen in Table 5.12, this prediction is not supported by the data (\$2.11 versus \$2.39, $t = -0.41$).

Finally, the theory predicts that, in the absence of the endowment effect, sellers who perceive delay (selling later) to be relatively difficult will bid less, on average, than buyers who perceive delay (buying later) to be relatively difficult. This was in fact the case, and the difference in means is significant at the 0.10 level (\$2.39 versus \$3.44, $t = 1.90$).

Table 5.12 The Effects of Perceived Differences in Relative Reversal and Delay Difficulty

	WTP		WTA	
Perceived Relative Difficulty	Mean Bid	Observations	Mean Bid	Observations
Reversal Difficulty > Delay Difficulty	2.77 (2.33)[a]	31	2.11 (1.46)	15
Reversal Difficulty = Delay Difficulty	3.50 (2.59)	10	1.58 (1.27)	14
Reversal Difficulty < Delay Difficulty	3.44 (1.87)	15	2.39 (1.65)	28

[a] Numbers in parentheses are standard errors.

To further investigate the results, I have performed the following regressions to estimate WTP and WTA as functions of subjects' perceptions of the relative difficulty of delay versus reversal and whether they face a cost when reversing or delaying a transaction within the experiment:

[13] $WTP_i = \beta_0 + \beta_{Relative} Relative_i$,

[14] $WTP_i^{BL} = \beta_0 + \beta_{Cost} Cost_i + \beta_{Relative} Relative_i$,

[15] $WTP_i^{SL} = \beta_0 + \beta_{Cost} Cost_i + \beta_{Relative} Relative_i$,

[16] $WTA_i = \beta_0 + \beta_{Relative} Relative_i$,

[17] $WTA_i^{SL} = \beta_0 + \beta_{Cost} Cost_i + \beta_{Relative} Relative_i$,

[18] $WTA_i^{BL} = \beta_0 + \beta_{Cost} Cost_i + \beta_{Relative} Relative_i$,

where WTP_i represents bids from the combined WTP treatments, WTP_i^{BL} represents bids from the WTP Buy Later treatment, and WTP_i^{SL} represents bids from the WTP Potential Reversal treatment. Likewise, WTA_i represents bids from the combined WTA treatments,

WTA_i^{BL} represents bids from the WTA Buy Later treatment, and WTA_i^{SL} represents bids from the WTA Sell Later treatment. The results of these specifications are reported in Table 5.13.

As in Experiment 1, the variable $Relative_i \in [0,1]$ is defined as the ratio of subject i's perceived difficulty of selling later over her perceived difficulty of buying later. That is,

$$Relative_i = \frac{1}{4}\left(SellDifficulty_i - BuyDifficulty_i\right), \tag{5.2}$$

where both $SellDifficulty_i$ and $BuyDifficulty_i$ are self-reported measures ranging from 1 (very easy) to 5 (almost impossible). $Cost_i$ is a dummy variable that equals one for subjects facing a 50¢ cost of waiting, and zero for agents with no waiting cost.

The estimates of $\beta_{Relative}$ reported in Table 5.13 are not significantly different from zero. This does not support the theory that buyers (sellers) who perceive reversal to be relatively more difficult than delay will submit lower (higher) bids than will buyers (sellers) who perceive delay to be more difficult.

Likewise, the coefficient β_{Cost} is not significantly different from zero in any of the four regressions for which it was calculated. Thus, the results do not support the theory that imposing a cost on selling (buying) later will tend to decrease (increase) subjects' bids in the auction round.

I should note that the four treatments were performed at noon, 1:00 pm, 2:00 pm, and 3:00 pm. The WTA Sell Later treatment, in particular, was conducted at 1:00 pm. If some of the subjects in that treatment had just had lunch, it is possible that that could have negatively affected their valuation of food products, which may, in part, explain why the mean bid from the WTA Sell Later treatment is significantly less than those from the other three treatments.

Table 5.13 Regression Results

	WTP			WTA		
	[13]	[14]	[15]	[16]	[17]	[18]
Constant	3.27***	3.25***	4.00***	2.07***	1.83***	2.52***
	(10.2)[a]	(5.11)	(6.03)	(9.90)	(6.35)	(5.16)
Relative	-1.13	-1.36	-1.05	0.63	0.55	0.83
	(-1.53)	(-1.24)	(-0.99)	(1.02)	(0.86)	(0.80)
Cost	—	-0.42	-0.89	—	-0.60	0.28
		(-0.50)	(-0.99)		(-1.42)	(0.41)

[a] Numbers in parentheses are *t* statistics.
*** Significant at the 0.01 level.

5.5 Conclusions

In the absence of unusually large income effects, Hicksian utility theory predicts that WTP and WTA should differ by only a small margin (Willig; Randall and Stoll). However, this prediction is at odds with the preponderance of data from the fields of both environmental and experimental economics. While the observed disparity between WTA and WTP clearly poses a problem for those two fields, it also poses a problem for the larger economic profession, as it may indicate a flaw in the Hicksian approach that forms the basis of consumer theory. A number of theories have been proposed to explain the disparity, making use of both behavioral and neoclassical arguments. Most recently, Zhao and Kling have proposed an approach that takes into account the dynamic nature of the decision making process, and recognizes that there are option values associated both with going ahead with a transaction and with delaying it.

In this chapter, I have discussed two economic experiments designed to test whether subjects' valuations are affected by their perceptions of the market's dynamic aspects, and whether those effects, if they exist, contribute to WTA-WTP disparity. The results from the first experiment suggest that potential buyers do take into account dynamic considerations when formulating their stated willingness to pay for a private good. And while the same cannot be said for potential sellers, deviation of just one of the two value measures from the underlying Hicksian variations is enough to cause disparity between WTA and WTP. However, while commitment costs do seem to arise in an experimental setting, my results do not suggest that subjects' perceptions are such that these commitment costs can explain the WTA-WTP disparity observed in the experimental literature.

In the second experimental test, I offered subjects the opportunity for future learning while varying the cost of the reversal and delay options. By manipulating the relative difficulty of delay versus reversal between treatments, I hoped to gain better understanding of the role dynamic considerations play in the formation of stated value measures. The results, however, are difficult to interpret. In particular, the fact that mean WTA is significantly less than mean WTP suggests either a flaw in the experimental design or that offering subjects the potential for delay or reversal changes their value formulation process in a manner that is inconsistent with current theories. I feel that the most likely explanation is that the experimental market was too complicated. Subjects were bidding on an unfamiliar good in an unfamiliar auction, and were then offered the chance to either reverse or delay the transaction through unfamiliar means. Were the market somehow simplified, or were subjects to gain more market experience, it is possible the results would be more consistent with theory.

CHAPTER 6

CONCLUSIONS

In this dissertation, I have examined whether dynamic elements of the decision process affect value estimates in settings traditionally viewed as static. Further, I have tested whether the effects of those dynamic elements are consistent with Zhao and Kling's theory of commitment cost. My results suggest that willingness to pay estimates elicited using the contingent valuation method include a significant dynamic component. However, my results provide only limited evidence that WTP and WTA estimates elicited in an experimental setting include dynamic components.

In the CVM case, 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 were told they would have only one chance to respond to such a survey. The difference was stark. In some cases, dynamic WTP was less than half static WTP. Not only are differences of this magnitude highly significant, but they also have serious implications for the design of stated preference surveys. If welfare analysts do not take care to accurately represent the potential for future learning, they risk dramatically misstating willingness to pay. If uncertainty, irreversibility, and the potential for learning are inherent to the policy under consideration, then commitment cost is relevant to the eventual policy decision, and stated preference questions should be written to reflect the dynamic nature of the valuation problem. However, if the conditions necessary for the existence of commitment cost are not met, then it is equally important that survey respondents be informed that they are facing a static decision.

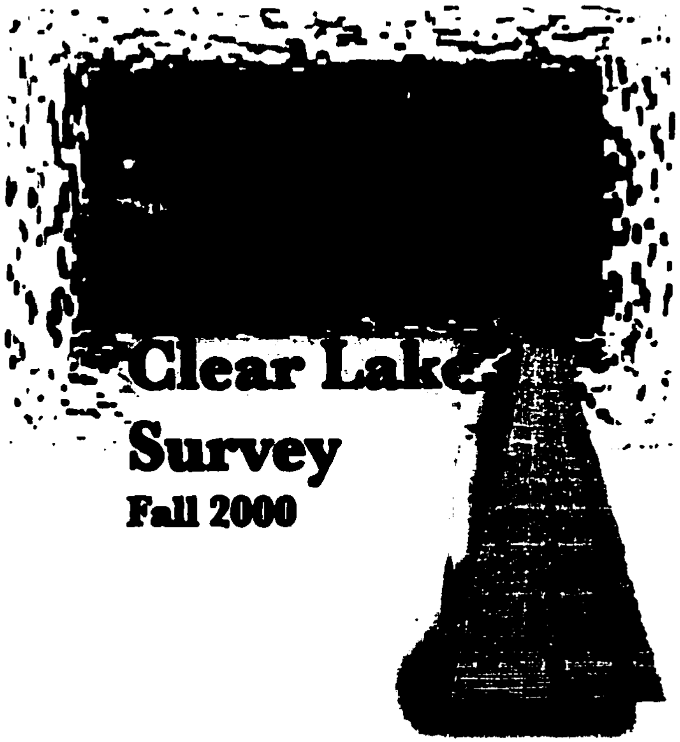
The recent efforts of the Friend's of Hallett's Quarry, and Ames-area interest group, offer an interesting example of the implications dynamic considerations can have on public policy. The group recognized that the 245-acre Hallett's Quarry site, a unique ecological and recreational resource, was facing imminent and irreversible commercial development, and that the City of Ames' option to purchase the site would soon expire. Under these circumstances, the decision of whether to preserve the area could not be delayed. Unless the static nature of the decision was made clear to area residents, their valuations may have erroneously included commitment costs. Therefore, in the weeks leading up to the November 6, 2001 bond-issue referendum that would determine whether the City could raise the funds needed to purchase the quarry, the interest group used a series of local newspaper advertisements and public forums to make it clear to Ames residents that the referendum represented their last chance to preserve the site before the City's option to purchase expired. A copy of one of those advertisements can be found in Appendix G. Note that it makes explicit reference to the static nature of the decision problem. The referendum went on to pass with an 86% majority.

The results of the economic experiments reported in Chapter 5 are less persuasive. While in the first of the two tests I find statistically significant evidence that subjects consider dynamic aspects when formulating WTP values, the same cannot be said for respondents formulating WTA values. Further, my results do not support the commitment cost theory's prediction that changes in subjects' perceptions regarding the relative difficulty of delay and reversal should affect their WTA or WTP values. While I show that providing subjects with information about the their ability to reverse or delay a transaction outside of the experiment has a significant effect on their beliefs about the relative difficulty of the two, this change in beliefs does not have a significant impact on reported WTP or WTA. Finally, in order for the theory to be able to reconcile the WTA-WTP disparity with neoclassical consumer theory, it is necessary that, on average, both buyers and sellers perceive the difficulty of reversal to be greater than the difficulty of delay. I do not find evidence that this is the case. Therefore, my results do not suggest that dynamic components in stated preference measures contribute to the WTA-WTP disparity.

The results from the second experimental test are more puzzling. By varying the relative difficulty of delay and reversal across treatments, I hoped to gain a better understanding of how a market's dynamic aspects affect the formation of stated preference measures. To do this, I offered subjects the opportunity for future learning and varied the cost of reversal and delay options. Not only are my results inconsistent with the predictions of the commitment cost model, they are also inconsistent with the predictions of the endowment effect. In particular, the fact that mean WTA was actually significantly *less* than mean WTP either suggests a flaw in the experimental design or that offering subjects the potential for delay or reversal changes their value formulation process in way that current theories cannot explain.

Experiment 2's curious results should not be allowed to overshadow the findings from Experiment 1. The most interesting of Experiment 1's results is that potential buyers' willingness to pay was significantly affected by their perceptions regarding the relative difficulty of outside reversal and delay. This has important implications for the design of experimental auctions for unfamiliar goods. Auctions conducted in an experimental setting are often the most convenient means for estimating consumers' willingness to pay for new products or product traits. For example, experimental auctions have been used to estimate consumers' valuation of new packaging techniques (Hoffman *et al.* 1993), irradiated meat

(Hayes *et al.* 1995), and food products containing genetically modified ingredients (Rousu *et al.* 2002). While experimental auctions are typically thought of as taking place in a static market, uncertainty and the potential for delay and subsequent future learning are inherent and inescapable aspects of such markets. My results suggest that, in such an environment, subjects' bids are likely to contain a significant dynamic component. If that is the case, researchers are not estimating expected value (which, presumably, is what they are after), but expected value minus an option value associated with delay and learning. The commitment cost model predicts that the effect of this option value could be lessened both by reducing subjects' uncertainty and by offering them the opportunity for reversal.



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IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

In order to make intelligent decisions concerning the future of Clear Lake, it is important to understand how the lake itself is used, as well as how this use would be affected by possible changes in the quality of the lake. The answers you give to the questions in this survey are very important in this process. Please try to answer each of the questions below. Finally, please keep in mind that, whenever we refer to Clear Lake, we are referring to the lake itself, not the town.

IN THIS SURVEY WE WILL ASK YOU SOME QUESTIONS ABOUT potential changes to the water quality of Clear Lake during the coming years. First, however, we will give you some information on the current condition of the lake. Please read this information carefully before answering the questions that follow.

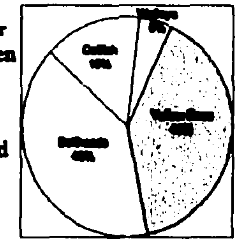
Clear Lake's Current Condition

The quality of a lake can be described in many ways. One measure of water quality is the clarity of the lake water. Water clarity is usually described in terms of how far down into the water an object is visible. The clarity of Clear Lake at the present time is about one-half to one foot. This means that objects are only visible down to about one foot under the surface of the water. The average water clarity of Clear Lake in 1953 was about ten feet.

Another measure of water quality is the amount of nutrients and other substances contained in the water. Water quality degradation can result from a number of sources, including runoff from the surrounding community containing fertilizers used for lawn care and from local agricultural sources. Currently these nutrients contribute to the occurrence of algae blooms in the lake, usually 10 to 12 times per year. Under some circumstances, these blooms can be a health concern, causing skin rashes and allergic reactions. In the past, concerns about bacteria present in Clear Lake have resulted in beach closings.

The overall quality of the water can have an impact on other conditions of the lake. Poor water quality results in an undesirable color and odor to the lake water. Currently, the color of Clear Lake varies between bright green and brown. The water has a mild odor that many describe as "fishy," with occasional periods of strong odor.

Finally, the quality of the water impacts the variety and quantity of fish in the lake. Currently, Clear Lake has a large quantity of walleye, but the largest percentages of the fish caught in the lake are fish that are considered somewhat less desirable. The chart indicates the type of fish that have been caught in the lake over the past year. While the rate at which fish are caught varies from year to year and from season to season, the typical catch rate has been 1 fish every 2 hours of fishing during the peak fishing months (May and June).



Experts believe that improved water quality would not significantly increase the number of fish in Clear Lake, but would increase the variety of fish species caught, including bass, perch, muskie, and pike.

Overall, the current condition of Clear Lake can be summarized in terms of

Water clarity	objects distinguishable 6 inches to 1 foot under water
Algae blooms	10 to 12 per year
Water color	bright green to brown
Water odor	mild odor, occasionally strong
Bacteria	possible short-term swim advisories
Fish	low diversity, good walleye

IN THE NEXT FEW QUESTIONS, WE WILL BE ASKING YOU how you would vote on a special ballot regarding the water quality of Clear Lake. While there is currently no such ballot being considered, we would like you to respond *as if* you were voting on the project and, in each case, as if it were the *only* project available. Please answer the questions in order and do not go back and revise your earlier answers.

When you think about your answer, it's important to keep in mind that people tend to be more generous when payments are hypothetical than when they are real. The idea is that it is very easy for people to say that they are in favor of improving the lake when they know no real money will ever change hands. However, if the proposed payments are real, people might be more inclined to think about their other options and how they would otherwise spend that money. So in answering the following questions, please keep in mind both the benefits from maintaining Clear Lake's water quality and the impact that passage of the referendum would have on your own pocketbook. In other words, please answer *as if* it were a real referendum.

Finally, the following questions ask you to consider making hypothetical payments. You might think of this payment as taking the form of higher state or local taxes. With this in mind, please answer the questions as carefully and honestly as possible.

Plan A

If nothing is done to improve the water quality of the lake it is likely to deteriorate over the next decade. Suppose that the deteriorated conditions at Clear Lake would be as follows:

Water clarity	objects distinguishable 1 inch to 5 inches under water
Algae blooms	constant
Water color	fluorescent green
Water odor	always strong
Bacteria	frequent swim advisories and/or beach closings
Fish	low diversity, mostly rough fish

Further, suppose the Iowa Department of Natural Resources (DNR) developed a program that would avoid this deterioration and instead maintain the current conditions of the lake.

1. Would you vote "yes" on a referendum that would *adopt* the proposed program (in which case water quality would not deteriorate as described under **Plan A**), but *cost* you $90 (paid over five years at $18 per year)?

- ❑ NO
- ❑ YES

2. To help us better understand your answers, please indicate the single most important reason for your response to the preceding question:

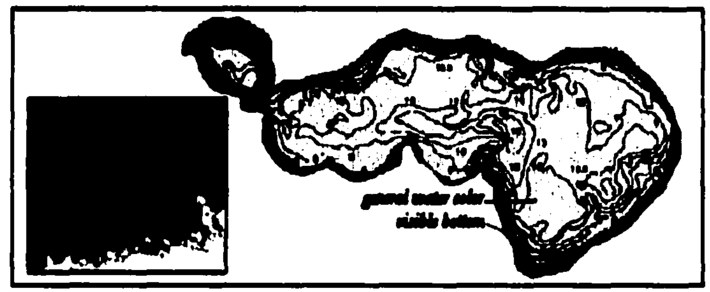
- ❑ The DNR program would not be a good use of my money.
- ❑ The DNR program would be a good use of my money.
- ❑ The plan is not realistic or is unclear.
- ❑ It is not appropriate to use a referendum like this one to determine water quality.
- ❑ I already contribute to environmental causes as much as I can afford.
- ❑ No one should have the right to damage the lake in the first place.
- ❑ I do not support tax increases under any circumstances.
- ❑ Other:__________________________

Plan B

Now suppose the DNR has developed a program that would actually improve the quality of Clear Lake. This program might include establishing protection strips along the edge of the lake to reduce runoff from the surrounding area or other structural changes to the lake.

These changes would avoid further deterioration to the lake and, in fact, improve the lake over the next five to ten years to the following conditions:

Water clarity	objects distinguishable 2 to 4 feet under water
Algae blooms	6 to 8 per year
Water color	green to brown
Water odor	occasional mild
Bacteria	occasional swim advisories
Fish	low diversity, good walleye



3. Would you vote "yes" on a referendum that would *adopt* the proposed program but *cost* you $810 (paid over five years at $162 per year)?

- ❑ NO
- ❑ YES

4. To help us better understand your answers, please indicate the single most important reason for your response to the preceding question:

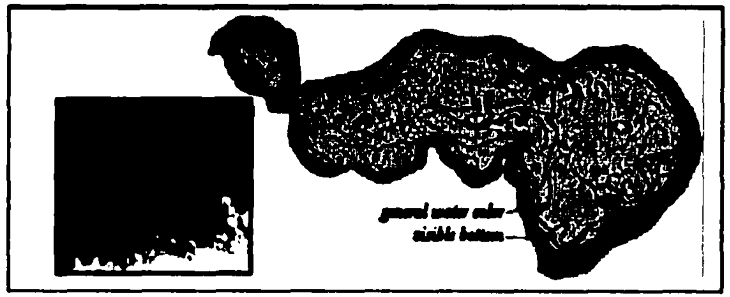
- ❑ The DNR program would not be a good use of my money.
- ❑ The DNR program would be a good use of my money.
- ❑ The plan is not realistic or is unclear.
- ❑ It is not appropriate to use a referendum like this one to determine water quality.
- ❑ I already contribute to environmental causes as much as I can afford.
- ❑ No one should have the right to damage the lake in the first place.
- ❑ I do not support tax increases under any circumstances.
- ❑ Other:____________________

Plan C

Now suppose that additional investments could be made such that conditions at Clear Lake would improve even further. These changes could include retiring some land from agricultural use, and programs to control nutrient runoff from urban and agricultural lands.

Suppose these changes would avoid further deterioration at the lake and, in fact, improve the lake over the next ten to twenty years to the following conditions:

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



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 this issue, and that if the following referendum fails to pass, there will be no future programs to improve water quality at Clear Lake.

5. Would you vote "yes" on a referendum that would *adopt* the proposed program but *cost* you $1410 (paid over five years at $282 per year)?

- ❑ NO
- ❑ YES

6. To help us better understand your answers, please indicate the single most important reason for your response to the preceding question:

- ❑ The DNR program would not be a good use of my money.
- ❑ The DNR program would be a good use of my money.
- ❑ The plan is not realistic or is unclear.
- ❑ It is not appropriate to use a referendum like this one to determine water quality.
- ❑ I already contribute to environmental causes as much as I can afford.
- ❑ No one should have the right to damage the lake in the first place.
- ❑ I do not support tax increases under any circumstances.
- ❑ Other:____________________________

IN THIS SECTION, WE WOULD LIKE TO ASK YOU ABOUT YOUR opinions regarding which lake characteristics are important to you and your views regarding some specific proposals to change Clear Lake.

7. Assume you have a total of 100 importance points to assign to the lake characteristics below. Please indicate the importance of each item by allocating your 100 points among the items on this list. To indicate one item is more important to you than another, you should allocate more points to it. You do not need to give points to all of the items, but remember that the total needs to equal 100.

Water clarity	
Hard, clean, sandy lake bottom in swimming areas	
Lack of water odor	
Diversity of wildlife seen at Clear Lake	
Diversity of fish species/habitat	
Quantity of fish caught	
Safety from bacteria contamination/health advisories	
Total	100

8. In order to improve water quality in the lake, changes in land use in the watershed may be needed. For example, it's likely that some land will need to be changed to low-impact use. If such changes occur, which of the following land uses do you favor? Please check all that apply.

	Strongly Support	Somewhat Support	Neutral	Somewhat Oppose	Strongly Oppose
Park lands	☐	☐	☐	☐	☐
Additional Conservation Reserve Program acreage	☐	☐	☐	☐	☐
Restored woodlands	☐	☐	☐	☐	☐
Restored prairie	☐	☐	☐	☐	☐
Restored wetlands	☐	☐	☐	☐	☐
Nature conservation area	☐	☐	☐	☐	☐
Constructed ponds	☐	☐	☐	☐	☐
Hunting reserves	☐	☐	☐	☐	☐
Restored riparian zones	☐	☐	☐	☐	☐
Perennial Agriculture	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

9. A number of projects have been suggested to accomplish improvements in the lake. How do you feel about the following possibilities?

	Strongly Support	Somewhat Support	Neutral	Somewhat Oppose	Strongly Oppose
Increased park lands and recreational areas	☐	☐	☐	☐	☐
Building of a nature center or environmental park	☐	☐	☐	☐	☐
Purchase of easements for building buffer strips	☐	☐	☐	☐	☐
Increased land idling	☐	☐	☐	☐	☐
Restoration of Ventura Marsh to improve nutrient retention	☐	☐	☐	☐	☐
Non-motor boat days	☐	☐	☐	☐	☐
Increased no-wake zones	☐	☐	☐	☐	☐
Limiting motor horse-power	☐	☐	☐	☐	☐
Lake friendly restrictions on residential development	☐	☐	☐	☐	☐
Repair of storm drains	☐	☐	☐	☐	☐

10. Thinking about the past year, while you were visiting Clear Lake, what percentage of your time did you spend:

Activity	Percentage
Fishing	_____%
Sailing	_____%
Recreational boating (water skiing, power boating, jet skiing, etc.)	_____%
Swimming/beach use	_____%
Nature appreciation/viewing	_____%
Snowmobiling and other winter recreation	_____%
Camping	_____%
Picnicking	_____%
Other_____________	_____%
	100%

INFORMATION ON YOU AND OTHER MEMBERS OF YOUR household will help us better understand how household characteristics affect an individual's use of and attitudes toward Clear Lake. It will also help us to determine how representative our sample is of the state of Iowa. All of your answers are strictly confidential. The information will only be used to report comparisons among groups of people. We will never identify individuals or households with their responses. Please be as complete as possible. Thank you.

11. Are you

❑ male ❑ female

12. What is your age?

❑ Under 18
❑ 18 - 25
❑ 26 - 34
❑ 35 - 49
❑ 50 - 59
❑ 60 - 75
❑ 76 +

13. What is the highest level of schooling that you have completed? (Please check only one)

❑ Eight years or less
❑ Some high school or less
❑ High school graduate
❑ Some college or trade/vocational school
❑ Two years of college or trade/vocational school
❑ College graduate
❑ Some graduate school
❑ Advanced degree

14. How many adults live in your household (over the age of 18)? _______

15. How many children live in your household (18 or under)?_______

To help us better understand how you value your leisure time, we would now like to ask you about your work choices.

16. If you are currently employed, how many hours a week do you typically work? _______

17. If you are currently employed, do you have the option of working additional hours to increase your total income?

❑ No
❑ Yes—if so, what would your hourly wage be?
$_______per hour

18. If you answered "no" to question 17, and you could have the option of working more or less hours, which would you prefer?

- ❑ Work more hours
- ❑ Work less hours

19. What was your total household income (before taxes) in 1999?

❑ Under $10,000	❑ $40,000-$49,999
❑ $10,000-$14,999	❑ $50,000-$59,999
❑ $15,000-$19,999	❑ $60,000-$74,999
❑ $20,000-$24,999	❑ $75,000-$99,999
❑ $25,000-$29,999	❑ $100,000-$124,999
❑ $30,000-$34,999	❑ $125,000-$149,999
❑ $35,000-$39,999	❑ Over $150,000

20. Do you own your home?

- ❑ No
- ❑ Yes

21. Are you a year-round resident?

- ❑ No
- ❑ Yes

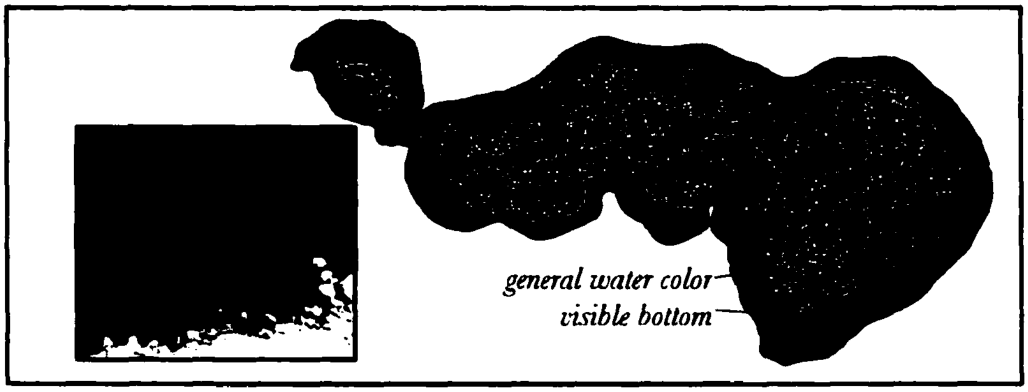
Please feel free to make any additional comments about your answers to these questions or about the survey itself. Thank you for your assistance with our Clear Lake Survey.

Comments: ____________________

APPENDIX B LOW VARIANCE GRAPHIC

Plan C

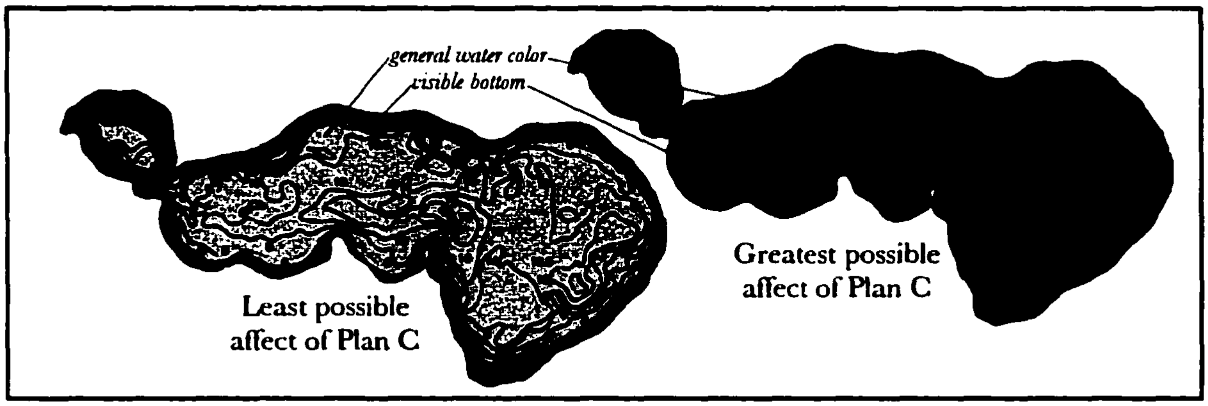
Water clarity	objects distinguishable 6 to 8 feet under water
Algae blooms	3 to 4 per year
Water color	green to blue
Water odor	occasional mild
Bacteria	infrequent swim advisories
Fish	high diversity



APPENDIX C 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 D The Relationship Between α and β

β Value	Estimate of α Basic Preferences	Estimate of α Heterogeneous Preferences
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

APPENDIX E INSTRUCTIONS FROM EXPERIMENT 1

General Instructions

Welcome and thank you for choosing to participate in this experiment. Today you will be taking part in a series of auctions. These auctions are being conducted as part of a research project funded by Iowa State University. For showing up to the experiment you have already earned $15. This show-up fee will be paid to you at the end of the experiment, though the amount will be adjusted to reflect any purchases that you make. Any items that are in your possession at the end of the experiment will be yours to keep.

Attached to the top of this page is a yellow piece of paper with a number on it. This is your ***Claim Check***. Each participant has a different number. We use claim checks to maintain anonymity. At the end of the experiment, you will need your claim check to collect your earnings. ***Please remove your claim check now and put it in a safe place.***

In the auction rounds to be conducted today, you will be given the chance to buy different items. In each case, you will be asked to indicate the maximum dollar amount you are willing to pay for these items.

It is important that you follow directions carefully. Do not turn pages or open envelopes until instructed to do so. You should not talk to or try to communicate with the other participants in the room. If you have a question, please raise your hand and the monitor will come to where you are seated.

Today we will be using what is known as a ***cut-off price auction***. Each auction round will have five steps:

Step 1 Examining the items

The monitor will describe the item being auctioned off during that round, and you will be given a chance to examine it.

Step 2 Submitting a bid

You submit a bid indicating the maximum price you would be willing to pay for one unit of the item being auctioned off. You will submit your bid by writing the amount on the bid form provided.

Step 3 The monitor ranks the bids from highest to lowest

Rank-ordered bids:	#1	$A.AA	highest bid
	#2	$B.BB	
	#3	$C.CC	
	#4	$X.YZ	
	#5	$D.DD	lowest bid

Step 4 Determining the cut-off price

The monitor determines the ***cut-off price*** by randomly selecting a ***cut-off bid***. There is an equal chance that the cut-off bid will be the 2nd, 3rd, 4th,..., or *n*th highest bid, where *n* is the number of different bids submitted in that round. In the above example there are five different bids, so it is equally likely that the cut-off bid will be the 2nd, 3rd, 4th, or 5th highest bid. The cut-off price is equal to the cut-off bid. For example, if the monitor randomly selected bid #4 as the cut-off bid, the cut-off price would be $X.YZ since that was the 4th highest bid submitted.

	#1	$A.AA	highest bid
	#2	$B.BB	
	#3	$C.CC	
Cut-off bid	**#4**	**$X.YZ**	
	#5	$D.DD	lowest bid

Step 5 Determining who wins the auction

Each person who bid *above* the cut-off price wins the auction and buys one unit of the item at the cut-off price. In our example, the three highest bidders (#1, #2, and #3) would each buy one unit and would each pay $X.YZ. Anyone who submitted a bid *at or below* the cut-off price would not buy anything. In our example, the two lowest bidders (#4 and #5) would not buy anything. Notice that there can be more than one winner in any auction round, but that the person who submits the cut-off bid does *not* win the auction.

A simple example will help to clarify things. Suppose ten people (Person A, Person B, Person C, ... , Person J) are bidding to buy some item (say, front row tickets to next season's Iowa-Iowa State football game). Their bids are as follows:

Person A—$24.50
Person B—$98.00
Person C—$250.00
Person D—$12.80
Person E—$50.00
Person F—$9.99
Person G—$67.00
Person H—$34.50
Person I—$1.42
Person J—$10.00

The monitor collects these bids and ranks them from highest to lowest:

Rank-ordered bids:	#1	Person C—$250.00	highest bid
	#2	Person B—$98.00	
	#3	Person G—$67.00	
	#4	Person E—$50.00	
	#5	Person H—$34.50	
	#6	Person A—$24.50	
	#7	Person D—$12.80	
	#8	Person J—$10.00	
	#9	Person F—$9.99	
	#10	Person I—$1.42	lowest bid

Since there were ten different bids submitted, the monitor randomly selects a number between 2 and 10 to determine the cut-off bid. Suppose the monitor selects the number 8. That means bid #8, the eighth highest, is the cut-off bid. Since bid #8 is $10.00, that becomes the cut-off price. Anyone who bid more than $10.00 buys a ticket for $10.00. Anyone who bid $10.00 or less does not buy anything. Notice that Person J does *not* buy a ticket.

In this type of auction it is always in your best interest to bid exactly what the item being auctioned off is worth to you. You do not want to bid more than what the item is worth to you because the cut-off price might turn out to be more than you are willing to pay. What is less obvious is that you do not gain by bidding less than the maximum you are willing to pay for the item. This is because the winners do not pay the amount that they bid, but instead pay the cut-off bid.

Claim Check Number _____

Short Quiz

Please complete the following quiz to make sure that you understand the auction format we will be using. When everyone has finished, the monitor will collect the quiz and explain the answers.

1) The winner of an auction purchases an item and will always have to pay what he or she bid.

    a) True

    b) False

2) If you have the third highest bid and the randomly selected cut-off bid is the eighth highest, you win the auction.

    a) True

    b) False

3) You might pay less than the amount you bid, but you will never pay more than your bid.

    a) True

    b) False

4) If the randomly selected cut-off bid is the eighth highest, how many people win the item?

    a) 6

    b) 7

    c) 8

    d) 9

5) It is in your best interest to bid the maximum amount you are truly willing to pay for the item being auctioned off.

    a) True

    b) False

Practice Round Instructions

In this round you will be given the chance to buy a DOLLAR BILL. This round is simply for practice. None of the transactions from this round will actually be carried out. It is simply intended to familiarize you with the auction procedure we will be using in the later rounds.

To illustrate how this round will work, suppose the cut-off price is 90¢. Were this a real round and you had submitted a bid of more than 90¢, you would buy a dollar bill for 90¢ and take it home with you at the end of the experiment, earning a profit of 10¢. If you had submitted a bid of 90¢ or less, you would not spend any money and you would not buy a dollar bill.

Again, this first round is only for practice. No money will actually change hands, and no one will actually buy a dollar bill.

In a moment, I will ask you to submit a bid indicating the maximum price you would be willing to pay for a dollar bill.

I will collect those bids, rank them from highest to lowest, and randomly select a cut-off bid in order to determine the cut-off price. Were this a real round, anyone who submitted a bid that was higher than the cut-off price would receive a dollar bill and would pay the cut-off price.

Notice the following two things: (1) Your bid can have no effect on the price you will pay if you win the auction. (2) It is in your best interest to bid your true value.

Object Round Instructions

The next two rounds will be conducted for the COFFEE MUG you have just been given. This coffee mug is *not* yours to keep, but you will be given the opportunity to buy it during the next two auction rounds. At this time, please take a few moments to carefully examine the mug to determine whether you wish to buy it in the rounds that are about to take place.

The auction for mugs will be repeated twice, but only the exchanges from one of the two rounds will actually be carried out. That is, you will write down your bid for one coffee mug, the monitor will collect everyone's bid forms, and then the auction will be repeated. When both rounds have been completed, the monitor will flip a coin to determine which round will be implemented, and the cut-off price for that round will be randomly selected. Only the transactions from that round will be carried out. Because you do not know which round will be chosen, it is in your best interest to bid your true value in both rounds.

For example, if the second of these two rounds is selected as the one to be carried out, the monitor would rank the bids from that round, randomly select the cut-off bid in order to determine the cut-off price. If your second-round bid was higher than that price, you would have to pay the cut-off price and you would receive a mug to take home. In this example, none of the trades from the first round for mugs would be carried out.

Object Round One

You do not own the COFFEE MUG in front of you, but you have the option of buying one to take home by paying money for it.

In a moment, I will ask you to submit a bid indicating the maximum dollar amount you would be willing to pay for a coffee mug.

I will collect these bids, and if this round is determined to be the one whose transactions are carried out, I will rank the bids from highest to lowest, and randomly select a cut-off bid in order to determine the cut-off price. Anyone who has submitted a bid higher than that price will pay the cut-off price and be given a mug to take home.

Notice the following two things: (1) Your bid can have no effect on the price you will pay if you win the auction. (2) It is in your best interest to bid your true value.

Claim Check Number _____

Survey

1) Gender: ❑ Female ❑ Male

2) Age: _______

3) What is your approximate yearly income from all sources, before taxes? $_______

4) What do you think would be the price of the ISU coffee mug if you were to buy one outside of this experiment?

   $_______

5) If you win the auction:

   A) What do you plan to do with the mug?
      ❑ Keep it
      ❑ Return or exchange it

   B) On the following scale of 1 to 5, how easy do you think it would be to return or exchange the mug? Please answer this question even if you plan to keep the mug.

      (very easy) 1 2 3 4 5 (almost impossible)

   C) Thinking about your bid in the previous round, if you were to try to return or exchange the mug, which of the following do you think is true? Again, please answer this question even if you plan to keep the mug.
      ❑ You could earn a profit
      ❑ You could break even
      ❑ You could take a loss

6) If you do *not* win the auction:

   A) On the following scale of 1 to 5, how easy do you think it would be to obtain the mug (or a close substitute) later?

      (very easy) 1 2 3 4 5 (almost impossible)

   B) If you were to purchase the mug (or a close substitute) later, which of the following do you think is true? The purchase price would be...
      ❑ more than your bid in the previous round
      ❑ about the same as your bid in the previous round
      ❑ less than your bid in the previous round

7) If you were to try to return a mug to the University Book Store, what, if anything, do you think you could exchange it for?
      ❑ Can't return
      ❑ Store credit
      ❑ Cash

Before we proceed to Object Round Two, I want to take a moment to inform you that the coffee mugs used in today's experiment were purchased at the University Book Store. These mugs can be returned to the bookstore for store credit, but they cannot be exchanged for a cash refund. This is because you will not be given a University Book Store sales receipt.

Object Round Two

You do not own the COFFEE MUG in front of you, but you have the option of buying one to take home by paying money for it.

In a moment, I will ask you to submit a bid indicating the maximum dollar amount you would be willing to pay for a coffee mug.

I will collect these bids, and if this round is determined to be the one whose transactions are carried out, I will rank the bids from highest to lowest, and randomly select a cut-off bid in order to determine the cut-off price. Anyone who has submitted a bid higher than the cut-off price will pay the cut-off price and be given a mug to take home.

Notice the following two things: (1) Your bid can have no effect on the price you will pay if you win the auction. (2) It is in your best interest to bid your true value.

Claim Check Number _____

Survey Two

1) What do you think would be the price of the ISU coffee mug if you were to buy one outside of this experiment?

   $_______

2) If you win the auction:

   A) What do you plan to do with the mug?
      - ❑ Keep it
      - ❑ Return or exchange it

   B) On the following scale of 1 to 5, how easy do you think it would be to return or exchange the mug? Please answer this question even if you plan to keep the mug.

      (very easy) 1 2 3 4 5 (almost impossible)

   C) Thinking about your bid in the previous round, if you were to try to return or exchange the mug, which of the following do you think is true? Again, please answer this question even if you plan to keep the mug.
      - ❑ You could earn a profit
      - ❑ You could break even
      - ❑ You could take a loss

3) If you do *not* win the auction:

   A) On the following scale of 1 to 5, how easy do you think it would be to obtain the mug (or a close substitute) later?

      (very easy) 1 2 3 4 5 (almost impossible)

   B) If you were to purchase the mug (or a close substitute) later, which of the following do you think is true? The purchase price would be…
      - ❑ more than your bid in the previous round
      - ❑ about the same as your bid in the previous round
      - ❑ less than your bid in the previous round

4) If you were to try to return a mug to the University Book Store, what, if anything, do you think you could exchange it for?
   - ❑ Can't return
   - ❑ Store credit
   - ❑ Cash

APPENDIX F INSTRUCTIONS FROM EXPERIMENT 2

General Instructions

Welcome and thank you for choosing to participate in this experiment. Today you will be taking part in a series of auctions. These auctions are being conducted as part of a research project funded by Iowa State University. For showing up to the experiment you have already earned $10. This show-up fee is yours to keep. Any items that are in your possession at the end of this experiment will also be yours to keep.

Attached to the top of this page is a yellow piece of paper with a number on it. This is your ***Claim Check***. Each participant has a different number. We use claim checks to maintain anonymity. ***Please remove your claim check now and put it in a safe place.***

In the auction rounds to be conducted today, you will be given different items and then offered the chance to sell them to the monitor. In each case, you will be asked to indicate the minimum price at which you are willing to sell these items.

It is important that you follow directions carefully. Do not turn pages or open envelopes until instructed to do so. You should not talk to or try to communicate with the other participants in the room. If you have a question, please raise your hand and one of the monitors will come to where you are seated.

Today we will be using what we will call a ***random price auction***. Each auction round will have four steps:

Step 1 Examining the item

The monitors will distribute the item being auctioned off during that round, and you will be given a chance to examine it.

Step 2 Submitting a bid

You submit a bid indicating the minimum price at which you would be willing to sell your item. You will submit your bid by writing that amount on the bid form provided.

Step 3 Announcing the market price

The ***market price*** has been determined at random using a computer. After the bids have been collected, the monitor will open a sealed envelope containing the market price, and will announce that price.

Step 4 Determining who wins the auction

Each person who submitted a bid *at or below* the market price wins the auction and sells their item at the market price. Anyone who submitted a bid *above* the market price does not sell anything. Notice that there can be more than one winner in any auction round.

A simple example will help to clarify things. Suppose ten people (Person A, Person B, Person C, ... , Person J) are bidding to sell some item that each of them already owns (say, front row tickets to next season's Iowa-Iowa State football game). Their bids are as follows:

Person A—$24.50
Person B—$98.00
Person C—$250.00
Person D—$12.80
Person E—$50.00
Person F—$1.42
Person G—$67.00
Person H—$34.50
Person I—$9.99
Person J—$10.00

After collecting the bids, the monitor announces the random market price (which has been determined in advance using a computer). Suppose, for example, that the market price turns out to be $52.80. Anyone who submitted a bid of $52.80 or less would sell their ticket for $52.80. Anyone who submitted a bid of more than $52.80 would not sell anything.

As you can see from the rank-ordered bids below, Persons I, F, J, D, A, H, and E all win the auction and sell their ticket for $52.80. Persons G, B, and C do not sell anything.

Rank-ordered bids:	Person I—$1.42	lowest bid
	Person F—$9.99	
	Person J—$10.00	
	Person D—$12.80	
	Person A—$24.50	
	Person H—$34.50	
	Person E—$50.00	
- - - - - - - -	- - - - - - - -	- - - - - - - -
	Person G—$67.00	
	Person B—$98.00	
	Person C—$250.00	highest bid

In this type of auction it is always in your best interest to bid exactly what the item being auctioned off is worth to you. You do not want to bid less than what the item is worth to you because the market price might turn out to be less than you are willing to accept in exchange for the item. What may not be so obvious is that you do not gain by bidding more than what the item is worth to you. This is because the winners are not paid the amount that they bid, but instead are paid the predetermined market price.

For example, think about Person E. Suppose the football ticket is truly worth $50.00 to Person E. In the example we have just discussed, Person E sells her ticket for $52.80, and in a sense earns a profit of $2.80. But what if instead of bidding her true value, she bid something more than that, say, $55.00? Then instead of selling her ticket for $52.80 and earning a profit, she does not sell anything.

Claim Check Number _____

Short Quiz

Please complete the following quiz to make sure that you understand the auction format we will be using. When everyone has finished, the monitors will collect the quiz and explain the answers.

1) The winner of an auction sells an item and will always be paid what he or she bid.

    a) True

    b) False

2) If the randomly determined market price turns out to be more than what you bid, you win the auction.

    a) True

    b) False

3) If you win the auction, you might be paid more than the amount you bid but you would never be paid less than your bid.

    a) True

    b) False

4) It is in your best interest to bid the minimum amount you are truly willing to accept in exchange for the item being auctioned off.

    a) True

    b) False

5) Suppose four people are bidding to sell some item. Their bids are $0.00, $5.00, $10.00, and $15.00. If the market price turns out to be $6.28, how many people win the auction?

    a) 1

    b) 2

    c) 3

    d) 4

Practice Round Instructions

In this round you will be given the chance to sell the DOLLAR BILL you have just been given. This is simply for practice. None of the transactions from this round will actually be carried out. It is simply intended to familiarize you with the auction procedure we will be using.

To illustrate how this round will work, suppose the market price is 90¢. Were this a real round and you had submitted a bid of 90¢ or less, you would sell your dollar bill for 90¢, suffering a loss of 10¢. If you had submitted a bid of more than 90¢, you would get to keep your dollar bill.

Now suppose the market price is $1.10. Were this a real round and you had submitted a bid of $1.10 or less, you would sell your dollar bill for $1.10, earning a profit of 10¢. If you had submitted a bid of more than $1.10, you would get to keep your dollar bill.

Again, this first round is only for practice. No money will actually change hands, and no one will actually sell their dollar bill.

In a moment, I will ask you to submit a bid indicating the minimum price at which you would be willing to sell the dollar bill you have been given.

The monitors will collect those bids, and I will then announce the predetermined market price. This price is somewhere between $0.00 and $5.00, and has been determined at random using a computer. Were this a real round, anyone who submitted a bid at or below the market price would sell their dollar bill and would be paid the market price.

Notice the following two things: (1) Your bid cannot affect the price you will be paid if you win the auction. (2) It is in your best interest to bid your true value.

Real Round Instructions

The next round will be conducted for the BOX OF COOKIES you have just been given. These cookies are yours to keep, but you will be given the opportunity to sell them during the next auction round. Please take a few moments to carefully examine the box of cookies to determine whether you wish to sell it in the auction that is about to take place.

To the best of our knowledge, this particular type of cookie is not available in the Ames area. The only chance you will have to sell or buy it will be during today's experiment.

After this auction, you will be given a small sample of the cookie. If you did not sell your box of cookies during the auction, you can return it to the monitor for a refund after having tasted a sample. The refund you will receive will be equal to the market price minus your ***cost of waiting***. You can find your cost of waiting on the brown form with the words "Cost of Waiting" in the upper left corner. This option will only be available to those who do ***not*** sell their box of cookies during the auction. Those who do sell their box of cookies will ***not*** be given the chance to buy a new one after having tasted a sample.

You now have and own a box of cookies. You also have the option of selling it and receiving money for it.

In a moment, I will ask you to submit a bid indicating the minimum price at which you would be willing to sell your box of cookies.

The monitors will collect those bids, and I will then announce the predetermined market price. This price is somewhere between $0.00 and $10.00, and has been determined at random using a computer. Anyone who has submitted a bid at or below the market price will sell their box of cookies and be paid the market price.

Notice the following two things: (1) Your bid cannot affect the price you will be paid if you win the auction. (2) It is in your best interest to bid your true value.

Claim Check Number _____

Survey

1) Gender: ❑ Female ❑ Male

2) Age: _______

3) What is your approximate yearly income from all sources, before taxes? $_______

4) What do you think would be the price of the box of cookies if you were to buy it outside of this experiment?

   $_______

5) If you sell your box of cookies in the auction:

   A) On the following scale of 1 to 5, how easy do you think it would be to obtain these cookies (or a close substitute) outside of this experiment?

      (very easy) 1 2 3 4 5 (almost impossible)

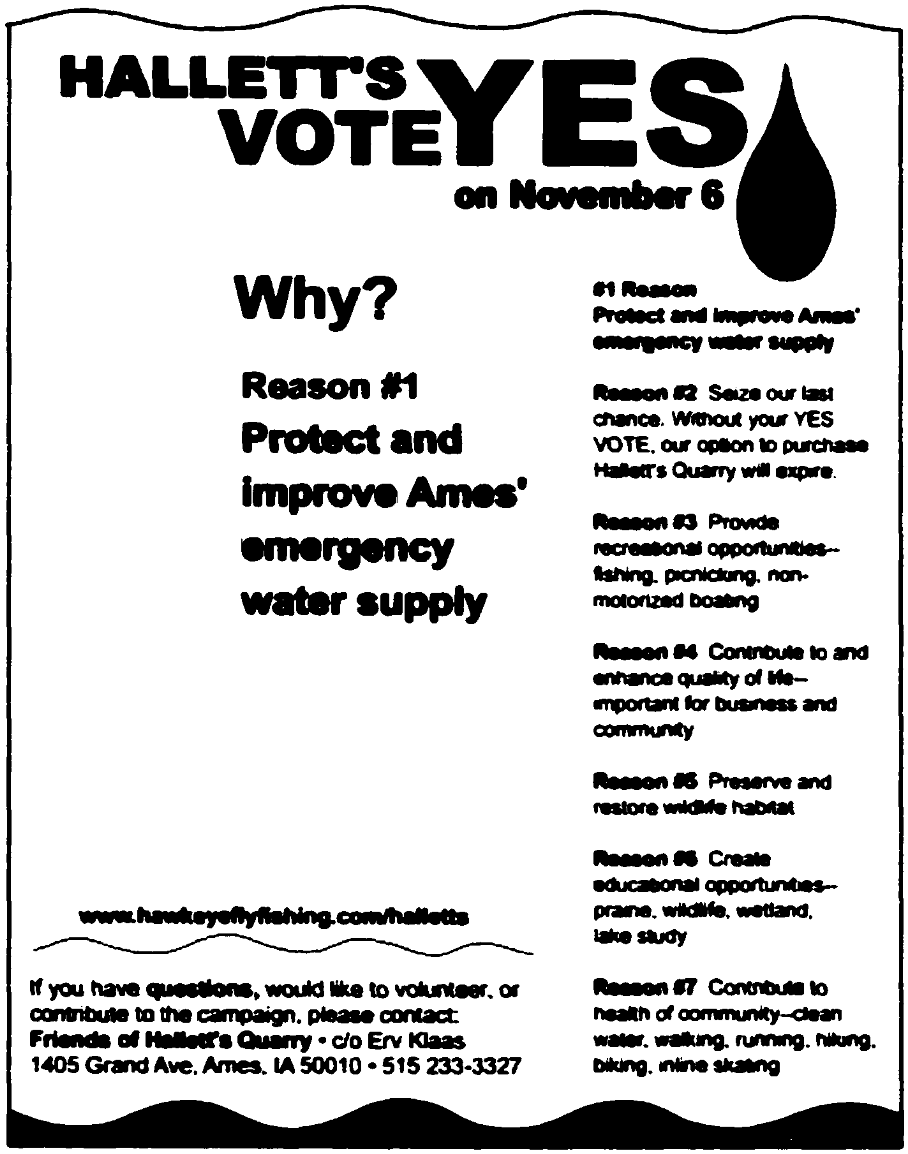
   B) If you were to purchase these cookies (or a close substitute) outside of this experiment, which of the following do you think is true? The purchase price would be...
      - ❑ more than your bid in the previous round
      - ❑ about the same as your bid in the previous round
      - ❑ less than your bid in the previous round

6) If you do *not* sell your box of cookies in the auction:

   A) On the following scale of 1 to 5, how easy do you think it would be to return or exchange the box of cookies outside of this experiment? Please answer this question even if you plan to keep the cookies.

      (very easy) 1 2 3 4 5 (almost impossible)

APPENDIX G HALLETT'S QUARRY NEWSPAPER ADVERTISEMENT



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