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An evaluation of statistical efficiency and bias trade-off involved with the use of follow-up questioning in the contingent valuation of environmental amenities

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An evaluation of statistical efficiency and bias trade-off involved with the use of follow-up questioning in the contingent valuation of environmental amenities

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DEDICATION

- dedicated to my parents and sister

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CHAPTER 1. INTRODUCTION

Policy makers are often required to evaluate prospective programs balancing the gains from improved environmental conditions and the cost of their implementation. Unfortunately, many environmental amenities are not traded in the market place and, thus, do not have a readily identified value or price. In order to assist policy makers in their decision making, researchers have developed methods to provide monetary measures of the value society places in changes to various non-marketed environmental resources. Broadly speaking, two approaches to non-market valuations exist: the Indirect and the Direct approaches. In the Indirect approach, market transactions or market data provide the necessary information required to infer the value individuals place in environmental resources; while with the Direct approach the individuals participate in a hypothetical market experiment and are asked to directly reveal their valuations. The Travel Cost Method (TCM) is the most common among the Indirect approaches.[1] Initially introduced by Harold Hotelling (1947), the TCM estimates the implicit price that visitors pay to visit a recreation

[1] See Bockstael, McConnell, and Strand (1991), Smith (1989), Cesario and Knetsch (1976), and Bowes, et al. (1980) for studies using TCM.

site. The implicit price includes the cost of travel to the site, opportunity costs of time, and other indirect trip related expenses. Using this implicit price and number of visits to the site researchers are then able to derive the demand function for the change in the environmental amenity. While the Indirect approach has been widely used in the past, much of the valuation literature has now shifted towards the Direct approaches in the recent years, specifically towards the Contingent Valuation Method (CVM). The CVM involves asking individuals, in survey or experimental settings, to reveal the value they place in an environmental amenity, or changes to specific attributes of that amenity, using contingent markets. The term contingent refers to the fact that the values revealed by the respondents are contingent upon the constructed market presented in the survey or experiment. Ciriacy-Wantrup (1947) is generally credited with its conception, though it was Davis (1963) who designed and implemented the first contingent valuation survey.[2]

The CVM has several advantages over such indirect valuation methods as the TCM.[3] First, direct approaches such as CVM create a hypothetical market for non-marketed goods where no real market exists, providing considerable flexibility in the goods or attributes to be evaluated. Second, the CVM can determine both use and nonuse values for environmental

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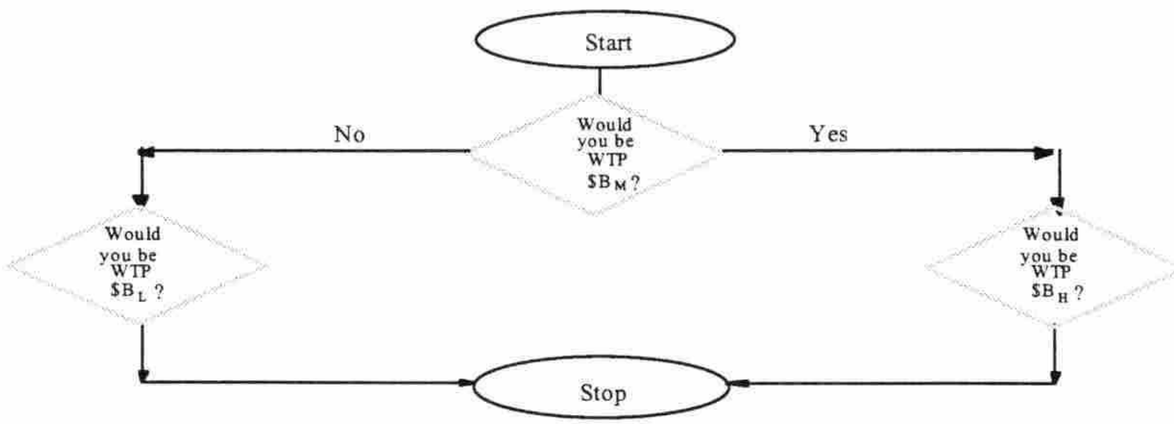
[2] Recent CVM studies have been conducted by Combs, et al. (1993), Duffied and Patterson (1991), Selp and Strand (1992), Hanemann, et al. (1991), Bishop and Heberlein (1990), Loomis, John B. (1990), and Cameron et al. (1987).

[3] However, some studies have shown that the estimated willingness-to-pay values of both the CVM and TCM are roughly comparable namelyKnetsch and Davis (1966), Desvousges et al. (1983), Seller et. al. (1985).

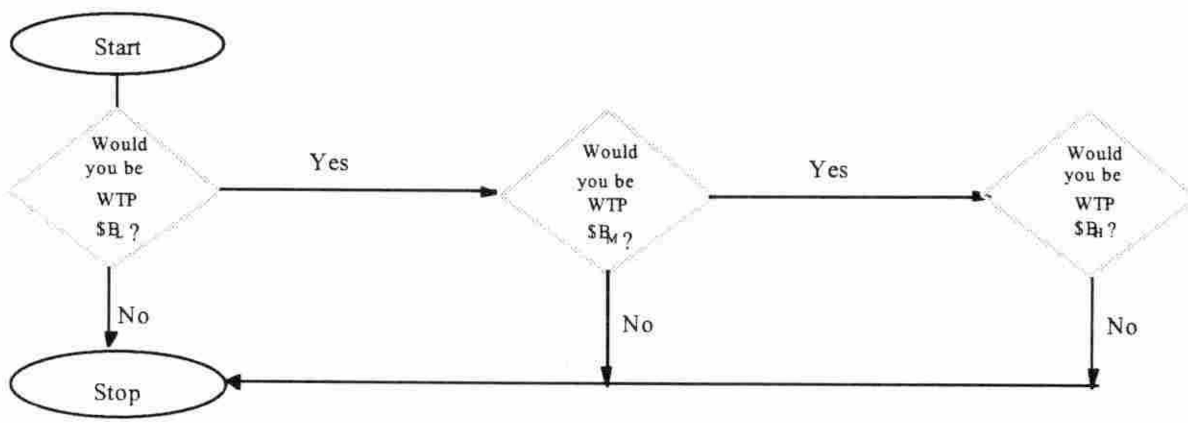
resources. Use values are based on current consumption, while passive values are dependent on future use or on the existence of the nonmarketed good. The TCM is limited by its nature to provide use values alone. On the other hand, CVM valuations are often criticized for their hypothetical nature and for potential biases engendered by the elicitation methods typically used. This thesis focuses on the latter issue in CVM valuations.

Among the elicitation methods used within Contingent Valuation, the continuous choice "open-ended" and discrete choice "closed-ended" approaches are most commonly used. The "open-ended" approach uses hypothetical questions that ask individuals what value they place in a specified change in an environmental amenity or the maximum amount they would be willing to pay to have it occur. In contrast, the "closed-ended" approach (sometimes called the "referendum approach") asks the individuals whether or not they would willing to pay or willing to accept a specified amount for a change in an environmental amenity. The advantage of the "closed-ended" method is that it is similar to the situation that most consumers face in normal market transactions, i.e. the respondent is not required to come up with a specific dollar value but is asked to accept or reject the "good" at a given price. The traditional "closed-ended" approach can be further classified into: (i) single-bounded approach; and (ii) follow-up approaches. In the traditional "single-bounded" approach, the respondent is asked only one dichotomous choice question. If the response is affirmative then the environmental amenity is valued equal or more than the threshold amount. The disadvantage of this method is that each individual's response reveals only limited information about the WTP, providing an upper bound (for a no) or a lower bound (for a yes) on the relevant welfare measure and hence requires considerably larger survey samples to precisely measure WTP. This disadvantage has led to the creation of the "follow-up" approach, in which the respondent may be asked either one follow-up question or a series of follow-up questions. The advantage of using "follow-up" questions is that it provides a lot more information for use in estimating the WTP values.

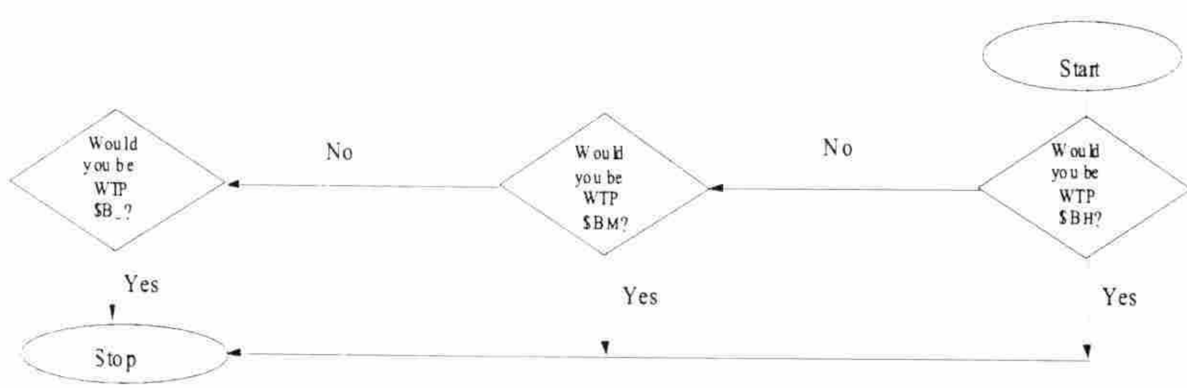
Figure 1.1 illustrates three variants on follow-up questioning, the (i) Double-Bounded approach; (ii) One way street up approach; and (iii) One way street down approach. Each of these variants allows the analyst to place the individual's true WTP in one of the following ranges: $[0, B_L]$, $[B_L, B_M]$, $[B_M, B_H]$, and $[B_H, +\infty]$. In the "double-bounded" approach, this is accomplished using two questions. The first question offers an intermediate first bid (B_M). If the respondent responds "yes" to the first bid then a second bid (B_H) is some amount greater than the first bid; if the respondent responds "no" to the first bid, the second bid (B_L) is lesser than the first bid. Thus, a "no" to the first question and a "yes" to the second question would place the individual's WTP in the $[B_L, B_M]$ range. First introduced by Hanemann et al. (1985); the double-bounded format has been shown theoretically and empirically to yield asymptotically more efficient estimates of the WTP distribution than the "single-bounded" approach (Hanemann et.al.,1991). These efficiency results assume that there is no impact on the response rate and that there are no biases induced from the follow-up questioning approach. The "one way street up" approach accomplishes the same task using an increasing



a) Double-Bounded Approach ($B_L<B_M<B_H$).



b) One way street up Approach ($B_L<B_M<B_H$).



c) One Way Street Down Approach ($B_L<B_M<B_H$).

Figure 1.1. Three variants of the follow-up questioning approach

series of WTP bid values. In the "one way street down" the respondent is asked a decreasing series of WTP bid values.

This thesis evaluates the efficiency of the "follow-up" approach over the "single-bounded" approach keeping in mind that the "follow-up" approach may give rise to the starting-point bias. Starting-point bias occurs when the respondents answers to the followup question are influenced by the first bid itself. In the early 1980's, CVM practitioners moved away from the iterative bidding elicitation techniques because of the concern that it led to starting-point bias problems. However it may be possible that the "closed-ended" technique in its follow-up form gives rise to a similar starting-point bias problem.

We use a contingent valuation experiment conducted at Storm Lake located in north-central Iowa to investigate the role of follow-up questioning in CVM analysis. Storm Lake is a 3097 acre natural lake in Buena Vista County, Iowa, used extensively for recreational activities in the region. This shallow bowl-shaped basin of Storm Lake is faced with deteriorating water quality primarily caused by sedimentation flowing from the surrounding town, local businesses, and agricultural production. The sedimentation flows have in turn impacted the lake's depth and clarity. CVM survey instruments were sent to 600 recreationists, asking whether they were willing to pay a given monetary amount for an improvement in the lake's water quality. A sample of 300 recreationists were asked "follow-up" questions; while the remaining sample of 300 recreationists were asked simple "single-bounded" WTP questions. The CVM study conducted as part of this thesis is used to meet two objectives: (i) to provide estimates of the recreationists willingness to pay for an improvement in the water quality at Storm Lake, and (ii) to investigate whether or not the "follow-up" approach produces biased WTP estimates given the potential starting point problem.

This thesis begins with a brief overview (Chapter 2) of both the empirical and theoretical Contingent Valuation literature; the various elicitation methods used in CVM, and the arguments for and against the use of follow-up questions in dichotomous choice CVM. This is followed by a description of the survey (Chapter 3) and examples of questions that are used to collect data required to estimate "single-bounded" and "follow-up" models. This chapter also describes the procedure used to come up with appropriate bid values. Chapter 4 provides summary statistics from the survey focusing on variables that will to be used in estimating the WTP for an improvement in Storm Lake's water quality. Chapter 5 is used to develop the theoretical model and the statistical framework for estimating the "single-bounded" and "follow-up" WTP estimation models. Chapter 6 presents the models estimated, the specific hypotheses to be tested and the following econometric results: (i) the aggregate WTP estimate of the entire sample, (ii) the WTP estimates for the "single-bounded", "double-bounded", "one-way street up", and "one way street down" formats, and (iii) the evaluation of bias in asking follow-up questions and using different formats. This chapter also compares and contrasts the results obtained and explores the trade-off between starting point bias and efficiency in the estimates of the WTP values. Finally conclusions and recommendations for future research is presented.

CHAPTER 2. LITERATURE REVIEW

The Contingent Valuation Method (CVM) has been used extensively in valuing non-marketed goods such as forests, wildlife, recreation, air, water and other resources which are not directly traded in the traditional market place. This chapter aims at serving as a compendium of the tremendous amount of research done using the CVM. The first section (2.1) of this chapter provides an overview of the CVM. Section 2.2 deals with the elicitation techniques available and various biases these techniques result in. Section 2.3 analyzes the "closed-ended" elicitation technique in particular, and the many studies done using this procedure.

2.1. Contingent Valuation Method in general

There are many non-marketed goods for which familiar market situations do not exist; i.e,. where people are able to alter their consumption of goods contingent upon price changes. This has led to the creation of the Contingent Valuation Method (CVM), which employs survey techniques to elicit valuations for hypothetical changes in some environmental amenity. Individual respondents are asked how much they would be willing-to-pay (WTP) for access to a resource or conversely, how much are they willing-to-accept (WTA) to be convinced to give up their access. The values revealed by the respondent are contingent upon the hypothetical or simulated market set-up, thereby, earning the name Contingent Valuation. The WTP or WTA dollar amounts provide information critical to policy makers in deciding whether a project involving these environmental amenities should be undertaken[4].

One of the earliest studies using CVM was conducted by Davis (1964), in which he interviewed hunters and recreationists in order to measure the benefits accruing from visiting a Maine backwoods area. Davis used the bidding game approach, in which the person interviewing increases or decreases the bids from an arbitrary chosen starting value until the respondent reveals his maximum willingness to pay. Many contingent valuation studies have been conducted since that time to test the validity and reliability of this method. One way of assessing the validity and performance of CV technique is to compare the results of the hypothetical CV markets with simulated market results in which these non-marketed goods are exchanged for actual money. The use of real money in these simulated markets is said to reduce both strategic and hypothetical biases that may exist in hypothetical markets. Strategic bias is said to exist if the respondent intentionally provides misleading WTP values to the interviewer. On the other hand, hypothetical bias stems from the inability of the respondent to accurately predict how they would value the non-marketed good.

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[4] A thorough evaluation and discussion on CVM is presented in Cummings et al. (1986), Mitchell et al. (1989), and Smith (1993).

The earliest studies comparing hypothetical and simulated market valuations is reported by Bishop-Heberlein (1979). Using a sample of hunters at Horicon marsh in Wisconsin, free seasonal goose hunting permits were valued. The idea behind this experiment was to see if the WTA amount elicited from hypothetical markets is in close proximity to the WTA amount in a simulated market. The sample was randomly divided into two groups. The first group was asked what specific amount they would accept to give up their permit. A second group faced the simulated market, and were asked to either return an actual check that was made out to them (refuse the offer) or to return the permit and keep the check (accept the offer). The dollar amounts in both groups ranged between $1 and $200. Results reported that the contingent values were $101, or 60 percent higher than the actual cash value of $63. This difference was statistically significant. This reflects a validity problem with WTA estimates. However, similar CV values for WTP appear to be a valid measure of monetary value of non-marketed goods when compared to a simulated market. Two other experiments to assess the validity of WTP were conducted at Sandhill in 1983 and 1984. See Bishop et al. (1988) for a detailed description of the two experiments. In neither of the two experiments was there a statistically significant difference between contingent WTP values and the simulated market WTP values[5].

[5] Further reinforcing evidence is provided in the field study looking at the WTP for strawberries and the actual payments for strawberries by Dickie, Fisher, and Gerking (1987). Other similar studies have been done by Bohm (1972), Bishop, Heberlein, and Kealy (1983).

The other way to access CV technique is to compare the contingent values with values determined by using other valuation techniques such as the travel cost and hedonic pricing methods. The general consensus on the different techniques is that they provide approximately similar results but one technique may be preferred over another depending on the study at hand. Knetsch and Davis (1965), for example compared WTP estimates resulting from an application of the CVM to estimates resulting from an application of TCM. The results show TCM and CVM estimates are fairly close to each other. Other comparison studies include Desvouges, Smith and McGivney (1983), Seller, Stoll, and Chavas (1985), all of which exhibited CVM values roughly comparable to those derived from TCM.

Until recently, evaluation of the CVM has generally focused on validity rather than reliability. Reliability is thought of as consistency in measurement, i.e,. the true value of the phenomenon being measured has not changed. Loomis (1989), conducted a reliability test to assess the stability of WTP values over time by again surveying the same general households and visitors nine months after their original survey. Test-retest correlations of WTP were found to be statistically significant and ranged from 0.422 for the general population sample to 0.782 for the visitor sample. Using a paired t-test, there was no statistical difference between an individual's first and second reported WTP values. It was reported that the WTP values were stable over the period of time surveyed.

2.2. Elicitation Techniques

The design of the CV survey is very important from the view of eliciting information about the respondents true willingness-to-pay for an improvement in a non-marketed good. There are many variations in how the elicitation questions can be framed. One of the earliest and most widely used elicitation technique is the *bidding game* format introduced by Davis (1964). In the bidding game, the interviewer asks the respondent whether he would be WTP a specified amount. If the respondent accepts the offer, the amount is increased to successively higher levels until a maximum WTP is obtained. Similarly, if the respondent rejects the offer, the amount is decreased successively until the respondent accepts the offer. This technique has been critiqued for leading to a "starting-point" bias problem. The "starting-point" bias exists when the initial bid, as stated by the interviewer, affects the final bid stated by the respondent. Ideally, the initial bid is merely a tool for initiating the bidding process and should not effect the final bid. Randall and Brookshire (1978) have indicated that the starting point bias may arise when the item being valued is poorly defined or is not clearly understood by the respondent. Many tests have been done to see if the iterative bidding game gives rise to starting point bias. Two studies that clearly provide evidence of starting point bias are those done by Rowe, d'Arge, and Brookshire (1980) and Brookshire et al. (1981). In the 1980 study on the value of visibility, it was found that an increase of $1 in the starting bid resulted in a $0.60 increase in the final bid. The 1981 study found starting point bias in one-sixth of their sample groups. Several other starting point bias studies have been done by Thayer (1981), Rowe et al. (1983), and Thompson and Roberts (1983).

In an effort to avoid the starting-point bias usually associated with the bidding game approach Randall, Ives, and Eastman, (1974), Boyle, Bishop, and Welsh, (1985), Mitchell and Carson (1981) proposed the *payment-card* technique as an alternative. Under this technique, the respondent is given a card which shows the amount spent by people for some familiar goods like national defense, education and national parks. There are other dollar values provided on the payment card from which the respondent selects the maximum he or she would be willing to pay for a change in the environmental amenity. Payments cards are vulnerable to biases associated with the range of dollar values stated. However studies done by Mitchell et al. (1981, 1987) reported no problem of biases.

Another technique is the *open-ended* format where the respondent is asked the maximum amount they are willing to pay to avoid an environmental damage or the minimum they would be willing to accept to receive compensation for an environmental damage. The earliest work done using the open-ended question format was conducted by Horvath (1974). This technique is suitable for mail surveys and eliminates the starting-point bias problem earlier faced in the iterative bidding technique. However, while the open-ended format has some good attributes, it is criticized on the grounds that it tends to produce an unacceptably large number of non-responses and protest zero responses to WTP questions (Desvouges, Smith, and McGivney (1983)). The primary reason for non-responses is the difficulty the respondent has in associating a dollar value for a commodity that previously had no market.

To circumvent this problem the *closed-ended* dichotomous choice technique is now frequently used. This technique was first developed by Bishop and Heberlein (1979, 1980). In the closed-ended technique the respondent is asked if he or she would accept or reject a hypothetical amount, either as a payment for giving up the non-marketed good or as a fee for it. The main distinction between the open-ended and the closed-ended techniques is in the manner in which the WTP question is asked. The open-ended WTP question asks "What is the maximum amount you are willing to pay for an improvement in the non-marketed good?"; while, the closed-ended WTP question asks " Would you be willing to pay $X for an improvement in the non-marketed good?"

There are significant advantages of using the discrete choice *closed-ended* technique over the continuous choice *open-ended* technique. The most important advantage is that the closed-ended technique generates a scenario most similar to the one faced by consumers in their daily market transaction, which in turn results in a lower item non-response. A hypothetical price is offered and the respondent is asked to either accept or reject the offer, relieving him of the burden of providing a specific dollar value. Another advantage of the closed-ended technique is that it reduces the incentive for strategic behavior. This issue is investigated by Loomis (1987).

While the closed-ended technique has some important advantages, the open-ended has the advantage of requiring first, fewer observations and, second the statistical procedures that are easier to implement and less expensive than the closed-ended estimation procedures. There is great interest in the literature on continuous choice open-ended versus discrete choice closed-ended techniques and whether they provide different WTP results. Seller et al. (1985) showed that the discrete approach gives higher estimates of mean WTP. However, Kealy et al. (1988) shows that there is no difference in the mean WTP estimates using both approaches. A study done by Loomis (1990) showed that the apparent advantages of closed-ended technique over the open-ended technique in terms of reduced burden on the respondent can be achieved without any apparent loss in the reliability of the WTP estimates.

2.3. Types of Closed-Ended questions

The closed-ended CV approach pioneered by Bishop and Heberlein is also known as the take-it-or-leave-it approach or *single-bounded* approach. This approach, the respondent is asked only one discrete choice dichotomous question. The dollar amount asked is treated as a single threshold. If the respondent answers "yes", then the good is valued more than the threshold amount, otherwise the good is valued less than the threshold amount. The disadvantage of this approach is that, though easier on the respondent it provides very little information about the individual's willingness-to-pay. To overcome this disadvantage the *follow-up* approach was introduced, in which the respondent is asked either one or a series of follow-up questions. The follow-up approach increases the information available from each respondent. In contrast to single-bounded technique, it places WTP within narrower intervals instead of indicating its position above or below a specified value.

The conventional approach to asking follow-up questions is called the *double-bounded* approach. In the double-bounded approach, the respondent is presented with two bids. The second bid value is contingent upon the response to the first bid. If the respondent says "yes" to the first bid, then the second bid is some amount greater than the first bid; if the respondent says "no" to the first bid, then the second bid is some amount lesser than the first bid. This iteration is done only once. The double-bounded approach was first introduced by Hanemann et al. (1985,1991) have shown theoretically and empirically that the double-bounded approach is asymptotically more efficient than the single-bounded approach. These efficiency results assume that there is no impact on the response rate and that there are no biases induced from the follow-up questioning itself. *One way street up* and the *one way street down* are two other approaches of asking follow-up questions; in which each respondent is asked a series of discrete choice questions. The "one way street up" WTP amounts are incremented at each follow-up question; in this case if the respondent accepts the first bid the second bid is increased. This process continues until the respondent rejects a bid. In the "one way street down" questions, the WTP amounts are decreased at each follow-up question. This process continues until the respondent accepts a bid. See Figure 2.1 to visually understand the different ways of asking WTP questions in Contingent Valuation.

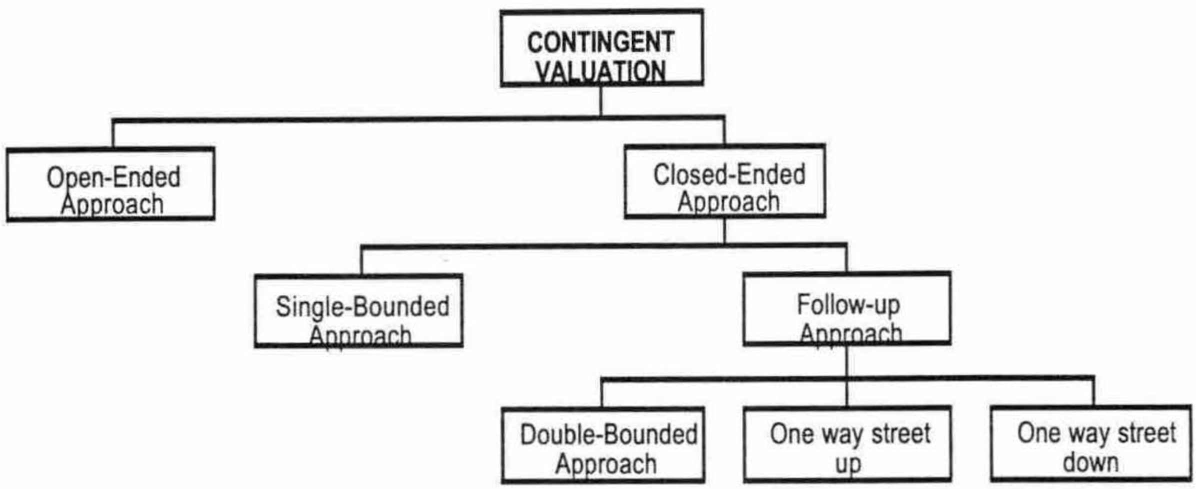

Figure 2.1 Main break-down of the ways of asking CVM questions

The double-bounded approach (Hanemann et al.; 1991) was employed in a CVM study to determine the WTP for wetlands in the San Joaquin Valley; it was shown that the "double-bounded" approach is asymptotically more efficient than the "single-bounded" approach. Both models were estimated using the maximum likelihood approach. The estimated variance of the slope is smaller by a factor of about 10 in the "double-bounded" model compared to the "single-bounded" model; the variance of the intercept is smaller by a factor of 3, and the variance-covariance term is smaller by a factor of 6. This results in much higher t-statistics for the double-bounded model. The WTP values for the single-bounded model ranged from \$214-\$336; whereas, the double-bounded model estimates have tighter confidence intervals ranging from \$152-\$308 for the five different wetland programs analyzed. Thus, using the double-bounded approach substantially improves the statistical efficiency provided by the data.

This thesis adopts both the "single-bounded" and "follow-up" approaches. The study done in this paper evaluates the efficiency of the "follow-up" approach over the "single-bounded" approach keeping in mind the starting-point bias and a higher lower response rate.

CHAPTER 3. SURVEY DESIGN AND SAMPLE POPULATION

This project is part of an interdisciplinary project funded by the Leopold Center for Sustainable Agriculture. The research team focus was on the management of riparian (streamside) areas in agriculture lands in an effort to ameliorate nonpoint source water pollution in two Iowan watersheds: Bear Creek and Storm Lake. The socio-economic assessment (SEA) at Storm Lake, part of the integrated study, is presented in this paper. The SEA objectives are to assess the perceived sources of the pollutants entering Storm Lake, to determine the current uses of Storm Lake by the recreationists and their socio-demographic characteristics, and to measure their willingness-to-pay (WTP) for different levels of improvement to the lake's water quality. This information will help identify the best management practices for the land around the water body and ways to reduce the occurrence of sedimentation.

In this chapter we provide information about the relevant design features of the survey instrument. It also focuses on the valuation problems that contingent markets create and how the survey was designed to circumvent these problems. Section 3.1 provides an overview of the lake's current condition and its essential usage. Section 3.2 explains the procedures adopted to obtain the sample population and the response rate achieved. Section 3.3 provides a detailed description of the four sections of the survey instrument. Section 3.4 describes the design of the bid vectors for both the "single-bounded" and "follow-up" survey instruments.

3.1. Current water quality at Storm Lake

Storm Lake is a 3,097 acre natural lake in Buena Vista County in north-central Iowa. The main problem that Storm Lake faces today is deteriorating water quality, primarily due to sedimentation. Sedimentation occurs when soil, dirt, and other matter flow into the lake from neighboring industries, developments, and town wastes. The impaired water quality can further be explained in terms of deteriorating lake depth, muck at the lake bottom, and water clarity. In terms of depth, a 1972 depth survey of the lake, conducted by the Iowa Conservation Commission showed the lake to average 8.5 feet in depth. Recent surveys show the lake to be about 6 inches shallower than in 1972, with an average of 8 feet in the center of the lake. The muck at the lake bottom is roughly 15 inches thick, and is significantly thicker in the deeper sections of the lake. The dirt running into the lake from nearby towns together with the water current stirring-up the lake bottom has resulted in reduced water clarity. On a typical day, one can distinguish an object only 1 foot under water (or less).

The use of the lake by recreationists is an important concern from the point of view of allocating funds efficiently for general environmental enhancement. Storm Lake is used by recreationists for fishing, recreational boating, camping, nature appreciation, and other activities. However the main emphasis is on recreational boating and fishing. In 1992, over 38,000 anglers visited Storm Lake, spending approximately 107,000 hours fishing. The typical catch rate has been 1 fish for every 3 hours of fishing during the peak fishing months. Table 3.1 indicates the percentage break-down of the type of fish caught over the past 3 years.

Table 3.1. Percentage break-down of type of fish caught over the last 3 years

Type of Fish	% of Total fish caught
Walleye	27%
Channel Catfish	20%
White Bass	18%
Crappie	12%
Others	23%

3.2. Determining the sampled population

In the summer of 1993, we visited Storm Lake 18 times for a duration of 8 hours on each visit. These trips were equally divided into weekends and weekdays. People interviewed from two of these 18 visits were excluded from our population because the first visit was only a couple of hours and the second visit occured during a special event going on at the lake. The survey period was divided into two eight hour workdays, denoted by "A" and "B". The "A" day covered 6 A.M. to 2 P.M. and the "B" day covered 2 P.M. to 10 P.M. Table 3.2 provides the break-down of the types of visits.

The purpose of these visits was to gather a sample that represented the entire population that visited Storm Lake. In an effort to catch everyone visiting the lake, we interviewed recreationists not only at the main marinas but also around the lake where recreationists were involved in activities like nature appreciation, camping, and shore fishing. During these brief interviews, each person was asked to provide their name and address so that a more extensive survey instrument could be mailed to them in November of 1993. We made 1100 contacts and obtained 1091 names and addresses (a 90% response rate).

Table 3.2. Break-down of type of visits

Time Period	Weekdays trips	Weekends trips
6 A.M. - 2 P.M.	4	4
2 P.M. - 10 P.M.	4	4

In November of 1993, we began mailing surveys to a group of 600 recreationists randomly selected from the population of 1091 recreationists. A $4 incentive was promised to the individuals who completed the survey. This incentive compensated the respondent for the time spent responding to the survey and also helped to improve the response rate. Also, follow-up correspondences were mailed to individuals who did not respond to the survey instruments mailed earlier. The follow-up mailing included: (i) a postcard reminder sent two weeks after the initial mailing; (ii) a second mailing of the survey instrument four weeks after the initial mailing; and (iii) a third mailing of the survey instrument two months after the initial mailing. We received a total of 491 completed survey instruments, for a response rate of 81.8%. This matches with the NOAA (1993) guidelines on the issue of minimum non-response rates. According to the NOAA report, a non-response rate below 20% is said to be an indication of a high quality survey. See Table 3.3 for the response rates at each stage of mailing.

Table 3.3. Response rate after initial mailing and follow-up mailing

After initial mailing	41.1%
After postcard reminder	18.4%
After second mailing	15.8%
After third mailing	6.5%
Total Response Rate	81.8%

3.3 Survey Design

The survey instrument was designed to obtain information about how the recreationists use Storm Lake, the value they place on the improved water quality at the lake, and their socio-demographic characteristics. The survey instrument has four sections. The *first* section provides information on the recreationists' pattern of use of the lake, the average number of visits to the lake over the past five years, and the number of visits to lakes located close to Storm lake that can be used as substitutes. The *second* section asks the respondents to rate the alternative sources of water pollution and also to assess the current condition of the lake. The *third* section gives an overview of the lake's present condition and asks respondents to evaluate potential changes to the lake in the future. The possible changes in the lake are described in three plans. Plan "A" asks the respondent if they are willing to pay to avoid changes in the water quality and maintain Storm Lake's current water quality. Plan "B" asks the respondents if they are WTP to improve the lake's water quality. Plan "C" asks the respondents if they are WTP the specified amount if the efforts to protect the lake could only postpone this deterioration, instead of maintaining or improving the current water quality at the lake.

A distinctive feature of this survey is that the four attribute levels of the lake, i.e. catch rate of fish per hour, the average lake depth, the muck at the bottom of the lake and the water clarity are varied among all respondents in plans "B" and "C". Also the WTP amounts provided are systematically varied among respondents, with each set of 25 respondents getting the same bid sequence. Since plans "B" and "C" have too many variations in the attribute levels, it is beyond the scope of this paper to estimate the WTP for these two plans. Instead, we concentrate primarily on the data set obtained from plan "A".

The *fourth* and the last section asks respondents to provide socio-demographic information about their household. The variables in this section allows us to determine characteristics like sex, age, household size, household income and education of the surveyed sample.

3.4. Design of Bid Matrix (Willingness-To-Pay Bids)

It is intuitively clear that a bad design of a bid vector may lead to inefficient estimates of the descriptive measures of WTP. The mean bid values for each format used in this survey were designed to mimic the mean WTP values obtained from surveys sent to local residents at Storm Lake. In addition, the survey was randomly divided between those receiving "follow-up" surveys and "single-bounded" surveys. The "follow-up" surveys were further broken down into: (i) One-way street up, (ii) One-way street down, and (iii) Double-Bounded formats. Half the recreationists received "follow-up" WTP questions, the other half received "single-Bounded" WTP questions. Within the follow-up surveys sent, one-third were randomly designated to each of the three formats. Table 3.4 provides a brief break-down of the number of recreationists that received a particular kind of survey instrument.

Table 3.4. Number of recreationists that received each type of survey

Type of WTP questions		**Number of surveys**
1. Follow-up:	Format UP: One-way street up	100
	Format DOWN: One-way street	100
	Format DB: Double-Bounded	100
2. Single-Bounded :	Format S	300

Within each format, 4 different sequences of the WTP values were randomly assigned to respondents. Therefore, 100 respondents within each format had an equal chance of being asked any one of the four sequences of WTP questions. Table 3.5 displays the bid matrix for formats UP, DOWN, DB (i.e.maintaining water quality) for the "follow-up" type of survey. The values in the columns (A1, A2, A3), represent the three bids for plan A. Each of the four bid sequences for a format is further presented by a superscript 1, 2, 3, and 4; for example, format $UP=UP_1+UP_2+UP_3+UP_4$. The total in the bid matrix represents the number of respondents that were sent a particular bid sequence.

The corresponding WTP bid values asked to the 300 respondents that received only "single-bounded" type of surveys is presented in Table 3.6. Since, by definition only one WTP bid value was asked to the respondents in each of the formats; the first bid for each of the sequences presented in the Table 3.5 was the selected value for these types of surveys. The bid value asked in sequence S_1 is the same as the first bid value asked in sequence UP_1. Therefore Table 3.6 is identical to Table 3.5 if the latter did not contain vectors A2 and A3.

Table 3.5. Bid Matrix for "follow-up" type of survey

Sequence	A1	A2	A3	B_L	B_M	B_H	Total
UP_1	50	125	250	50	125	250	25
UP_2	75	150	275	75	150	275	25
UP_3		175	325	100	175	325	25
UP_4	125	225	475	125	225	475	25
$DOWN_1$	250	125	50	50	125	250	25
$DOWN_2$	275	150	75	75	150	275	25
$DOWN_3$	325	175	100	100	175	325	25
$DOWN_4$	475	225	125	125	225	475	25
DB_1	125	50	250	50	125	250	25
DB_2	150	75	275	75	150	275	25
DB_3	175	100	325	100	175	325	25
DB_4	225	125	475	125	225	475	24

Table 3.6. Bid Matrix for "Single-Bounded" format

Sequence	A1	Total
S_1	50	25
S_2	75	25
S_3	100	25
S_4	125	25
S_5	250	25
S_6	275	25
S_7	325	25
S_8	475	25
S_9	125	25
S_{10}	150	25
S_{11}	175	25
S_{12}	225	24

CHAPTER 4. CHARACTERISTICS OF THE SAMPLED POPULATION

This chapter provides descriptive information about the sampled population's socio-demographic characteristics such as gender, age, educational level, income level, number of summer and winter visits to Storm Lake, and use of the lake by the type of activity among others. The information sought in this study aids in identifying best management practices for the lake and also identifying the activities recreationists most frequently use at the lake that may need attention in general environmental enhancement. It also provides an insight into the variables included in the WTP models estimated in chapter 6.

The tables presented in this chapter are primarily devoted to the proportions of those recreationists that responded to the survey that possess a given characteristic. Although the overall response to the survey instrument is 81.8 percent, the term "item-response rate" mentioned frequently in the explanatory text indicates the number of respondents that responded to a particular question at hand.

4.1. Socio-Demographic Characteristics

We begin with the socio-demographic characteristics of the survey population. Table 4.1 presents the percentage of male and female respondents. There is a larger proportion of males (88.9%) than females in the survey sample, which was expected as more of the male population is classically known to participate in activities such as boating and fishing. As indicated in Table 4.2, the population has been divided into four age groups, those under 26, between 26-45, between 45-59 and age 60 or more. Almost half (48%) the respondents are in the age group 26-45 years, mainly middle-aged individuals.

The education level of the sample population is presented in Table 4.3. Of the 487 people that responded to this item approximately 40 percent are high school graduates and about 42 percent have attended some college or technical school of which 17.5 percent are graduates. Only 4.3 percent have an advanced degree.

Table 4.1. Sex distribution of recreationists visiting Storm Lake, Iowa, in percent, 1993

Gender	Frequency	Percentage
Male	423	88.9%
Female	53	11.1%
Total	476	100%

Item Response Rate=96.94%

Table 4.2. Age distribution of recreationists visiting Storm Lake, Iowa, in percent, 1993

Age	Frequency	Percentage
Under 26	24	5.0%
26 - 45 yrs	233	48.0%
45 - 59 yrs	111	22.9%
60 and over	117	24.1%
Total	485	100%

Item Response Rate=98.77%

Table 4.3. Education of recreationists visiting Storm Lake, Iowa , 1993

Education Group	Frequency	Percentage
Eight years or Less	23	4.7%
Some High School	25	5.1%
High School Graduate	194	39.9%
Some College or Technical Degree	120	24.6%
College or Technical School Graduate	85	17.5%
Some Graduate School	19	3.9%
Advanced Degree	21	4.3%
Total	487	100%

Item Response Rate=99.18%

The income distribution of the recreationists is an important characteristic because one might expect a direct relationship between the estimates of the WTP and the respondent's income. A breakdown of respondents' incomes is provided in Table 4.4. The Income is well distributed though as one may expect it is slightly skewed. 85.6 percent of the respondents fell in the income range of $10,000 - $59,999. The estimated average annual income of the sample is $36,290, representing a fairly affluent population.

Table 4.5 reports about three-fourths of the respondents were employed full-time, part-time or self-employed. Of those persons employed about three in four were full-time employed, and almost one in five were self-employed. Homemakers amounted to only 2.3 percent of the sample. This low percentage is in part a reflection of the fact that the female population in our sample is low. About 20 percent of respondents were retired.

Table 4.4. Gross Income of recreationists visiting Storm Lake, Iowa, in percent, 1993

Income Group	Frequency	Percentage
$0 - $9,999	22	4.8%
$10,000 - $19,999	68	14.7%
$20,000 - $29,999	117	25.3%
$30,000 - $39,999	92	19.9%
$40,000 - $49,999	78	16.8%
$50,000 - $59,999	41	8.9%
$60,000 - $69,999	20	4.3%
$70,000 - $79,999	9	1.9%
$80,000 - $99,999	7	1.5%
$100,000 - above	9	1.9%
Total	463	100%

Item Response Rate=94.29%

Table 4.5. Employment status of recreationists visiting Storm Lake, Iowa, 1993

Employment Status	Frequency	Percentage
Employed Full-time	258	53.6%
Employed Part-time	15	3.1%
Self-Employed	73	15.2%
Full-time Homemaker	11	2.3%
Temporarily Unemployed	7	1.5%
Not Seeking Employment	9	1.9%
Retired, Not Employed	94	19.5%
Retired, Employed Part-time	14	2.9%
Total	481	100%

Table 4.6 presents the percentage of respondents in each of the household type categories. Slightly more than half of those surveyed reported to be in the category of couple with children, while couples without children accounted for 33 percent of the respondents. The average number of occupants in a household is 3.08. The distribution of the number of occupants in a household is given in Table 4.7. The significant age-groups are 5-12 years, 22-39 years and 40-59 years. When the respondents were asked whether they own or rent a house (Table 4.8), nearly four-fifths (83.6%) responded that they did. In addition, approximately 70 percent of the sampled population also own their own boat. However, only 1.9 percent of respondents own lakeshore property at Storm Lake with an average of 90.6.

Table 4.6. Percentage of recreationists in each of the household categories, 1993

Household Category	Frequency	Percentage
Single individual living alone	35	7.3%
Single head of household with children	11	2.3%
Couple without children	158	33.2%
Couple with children	255	53.6%
Multiple occupants	17	3.6%
Total	476	100%

Table 4.7. Average number of occupants in the household by age group, Storm Lake, 1993

Age Group	Average
Less than 5 years	0.181
5 - 12 years	0.461
13 - 17 years	0.364
18 - 21 years	0.166
22 - 39 years	0.715
40 - 59 years	0.775
60 - 64 years	0.157
More than 64 years	0.269
Total	3.088

Table 4.8. Percentage of recreationists that rent or own a house or a boat

Own/Rent	Frequency	Percentage	Item Response
Own a house	396	83.4%	96.74%
Own a boat	342	71.1%	97.96%
Own Lakeshore	9	1.9%	60.05%

4.2. Lake usage

In the survey instrument, recreational activities were classified as Shore fishing (SF), Boat fishing (BF), Ice fishing (IF), Recreational boating (RB), Swimming (S), Nature appreciation (NA), Camping (C), and Others (O). Figure 4.1 presents the percentage of recreationists that reported using the lake in one or more of these activities. Of the respondents, 72.7 percent reported using the lake for boat fishing, 62 percent reported using the lake for shore fishing, and 40 percent reported using the lake for recreational boating.

Survey respondents were also asked the partition their time by at Storm Lake by type of activity. Figure 4.2 presents the average percentage of time spent in any of the above mentioned activities. Fishing and boating were dominant. About 40 percent of their time was spent boat fishing, 20 percent shore-fishing, and 16.7 percent recreational boating. Ice fishing and nature appreciation were significantly lower in usage.

Table 4.9 indicates that the average number of summer day visits during the most recent year was 21 days, while the average number of winter day visits was approx. 8 days. In attempting to assess the importance of Storm Lake relative to the neighboring lakes, rivers and outlets; recreationists were asked to report the average number of trips made to nine specified other water bodies. Survey results (Table 4.10) show that on an average 8.58 trips were made to other inland rivers, 6.16 trips to lake Okoboji and 4.37 trips to Black Hawk lake; all significantly fewer than the visits to Storm Lake. Other lakes including Clear Lake, Lake Red Rock, and the Mississippi river reported less than 0.6 trips per year.

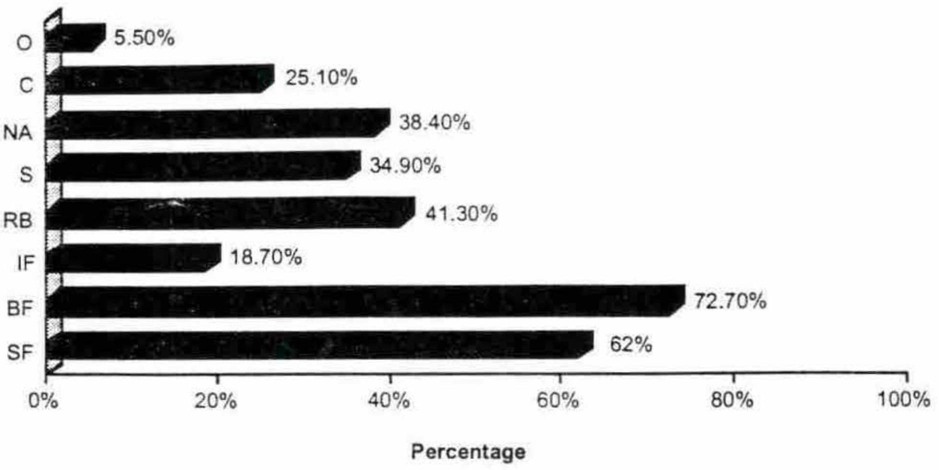

Figure 4.1. Percentage of recreationists that use the Lake by type of activity

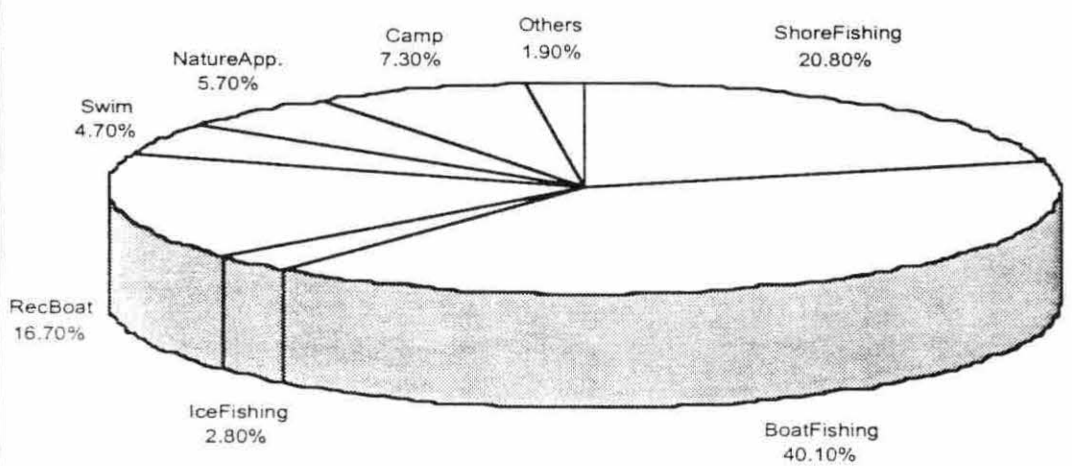

Figure 4.2. Percentage of time engaged by a recreationist in a particular type of activity

Table 4.9. Average number of summer and winter visits to Storm Lake over the last 5 yrs

Visits	Average	Maximum
Summer Day Visits (May - Sept.)	21.6	250
Summer Overnight Visits (May - Sept.)	4.92	360
Winter Day Visits (Oct. - April)	7.69	150
Winter Overnight Visits (Oct. - April)	0.50	16

Table 4.10. Average number of day trips to neighboring lakes, rivers and outlets

Location	Average day trips	Standard Error
Lake Okoboji	6.16	27.71
Black Hawk Lake	4.37	15.81
Twin Lake	2.59	9.23
Clear Lake	0.59	1.73
Spirit Lake	3.97	10.97
Saylorville Lake	1.61	8.28
Lake Red Rock	0.24	0.82
Mississippi River	0.47	1.25
Missouri River	3.04	8.65
Other Inland River	8.58	14.03
Out of State Lakes & Rivers	3.74	6.15

4.3. Lake and water quality attitudes

Section 2 of the survey instrument comprised of three subjective questions. The first question asked the respondents to rate the sources of water pollution in how they believed it affected the water quality of Storm Lake. The ratings are categorized as 1=Not Important, 2=Slightly Important, 3=Important and 4=Very Important. As indicated in Figure 4.3, farm-chemical runoff, illegal dumping, municipal sewage and other pollution sources all had ratings between Important and Very Important. Farm-chemical runoffs is rated as the most important source of water pollution, with an average rating of 3.68.

The second question asked respondents to provide a percentage break-up of where they thought the sediments flowing into Storm Lake come from. Respondents perceive that nearly 45 percent of the sediment flowing is due to agriculture (Figure 4.4) , 24.7 percent is due to storm sewers/street run-off and 18.3% is due to industry.

In the third and final question, (Figure 4.5) respondents are asked to rate the current condition of the lake as Very Poor, Poor, Satisfactory, Good and Excellent. Roughly 40 percent of the respondents are satisfied with the lake's condition, while 34 percent felt the condition is poor, and only 2.2 percent found the condition of the lake excellent.

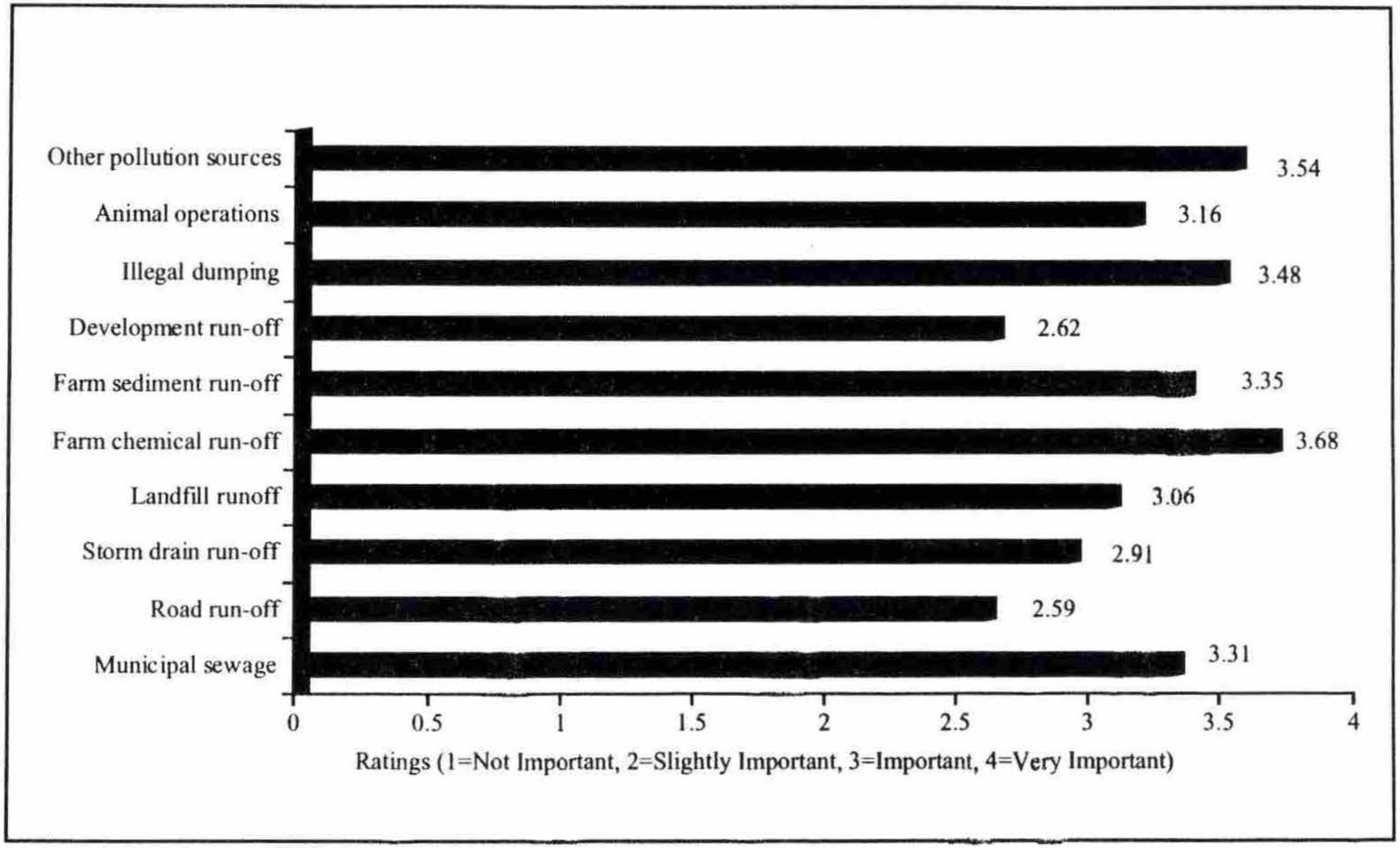

Figure 4.3. Average ratings of the sources of pollution at Storm Lake, Iowa, 1993

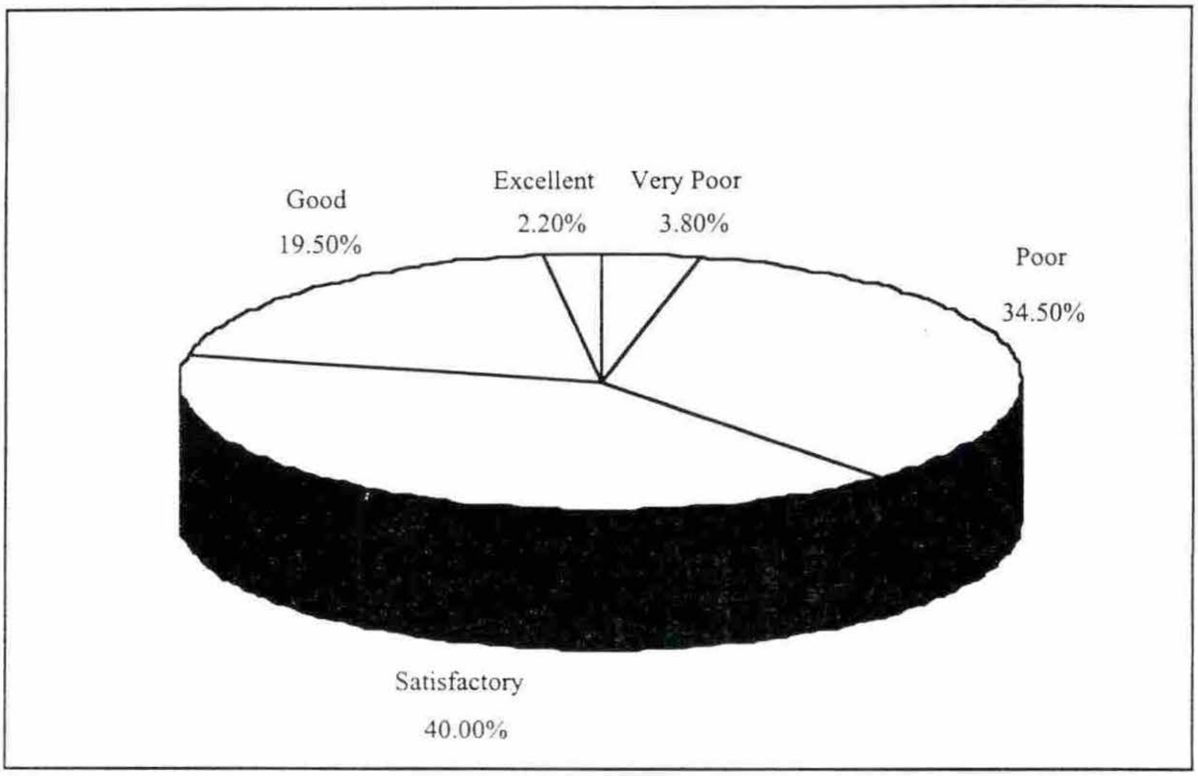

Figure 4.4. Percentage ratings of the current condition of Storm Lake, Iowa,1993

4.4. WTP Distributions

Figure 4.5 compares the distribution of the "single-bounded" format with the "double-bounded" format. As one would expect there is a higher percentage of "yes" reponses for the "single-bounded" format. Figure 4.6 compares the "single-bounded" format distribution with the "follow-up" distribution. Again, it is seen that the "single-bounded" has a higher percentage of "yes" responses. Figure 4.7, 4.8, and 4.9 compares the "single-bounded" distribution with only the 1st, 2nd, 3rd WTP questions asked in the "follow-up" approach respectively. It is clear that using the 1st questions of the "follow-up" approach and the "single-bounded" approach are very similar implying no bias in the 1st question WTP estimates across formats. However, the second and the third question shows a clear difference in the two approaches indicating a possibility of a bias in the WTP estimates across formats. Figure 4.10, 4.11, and 4.12 provide the WTP distribution for the three different follow-up approaches. In the "one way street up" format the highest "yes" responses are in the range of \$75-\$100. In the "one way street down" approach, the highest "yes" responses are in the range of \$100-\$125 and it also peaks at \$325, indicating some kind of a bias; while in the "double-bounded" approach it is in the range of \$100-\$175. Notice that all the distributions drop at the tails where the WTP bids are high.

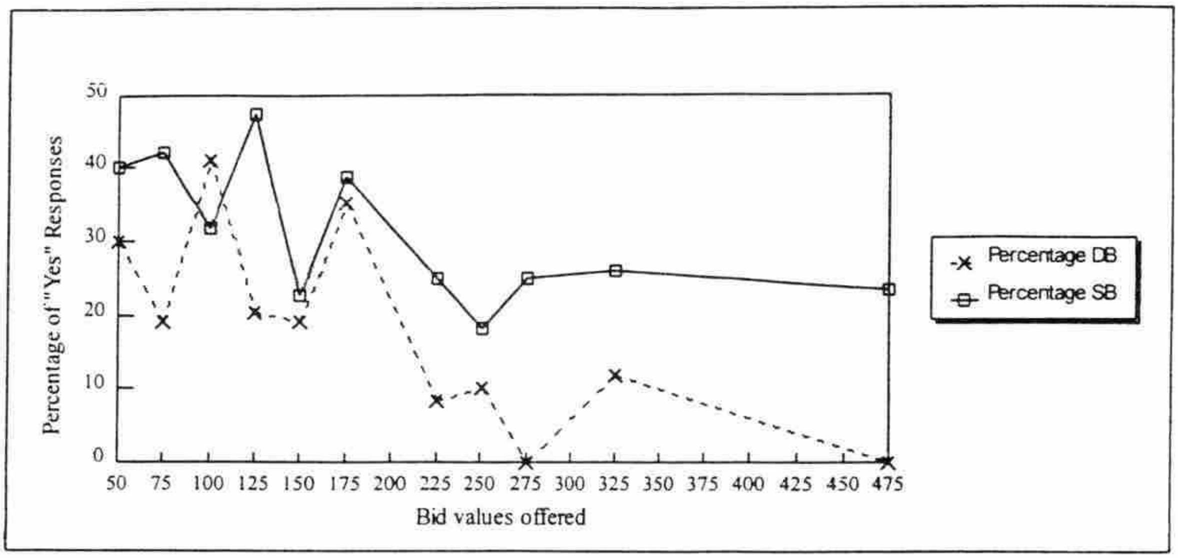

Figure 4.5. Comparison of the Single-Bounded format with the Double-Bounded format

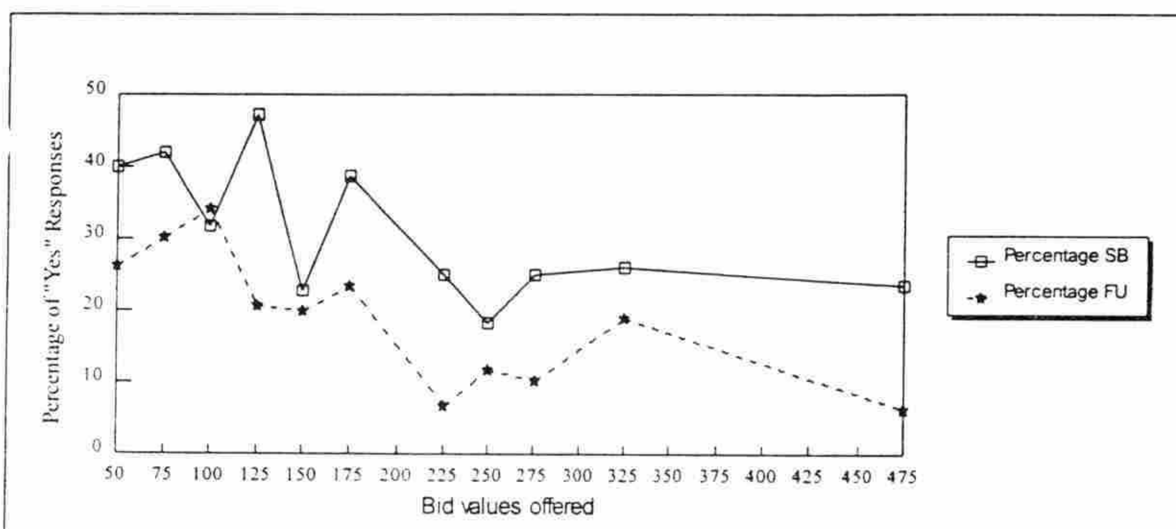

Figure 4.6. Comparison of the Single-Bounded format with the Follow-up format

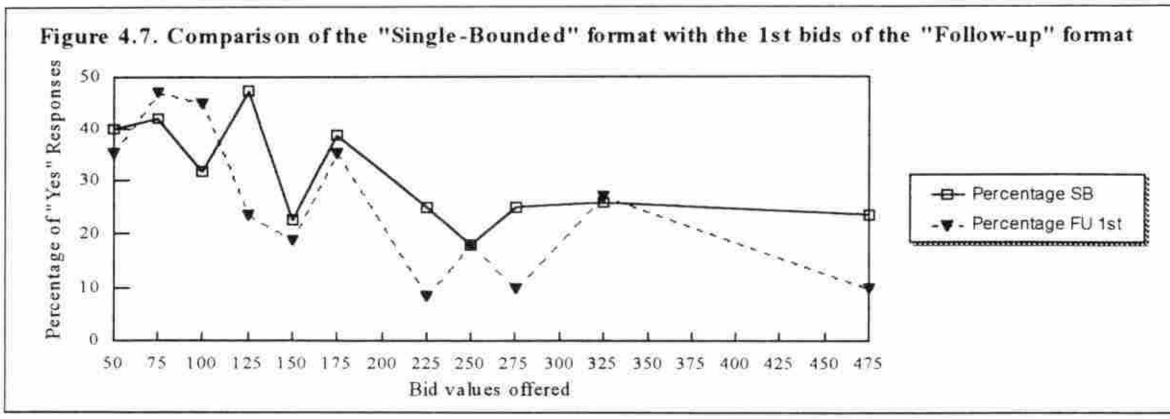

Figure 4.7. Comparison of the Single-Bounded with the 1st bids of the Follow-up format

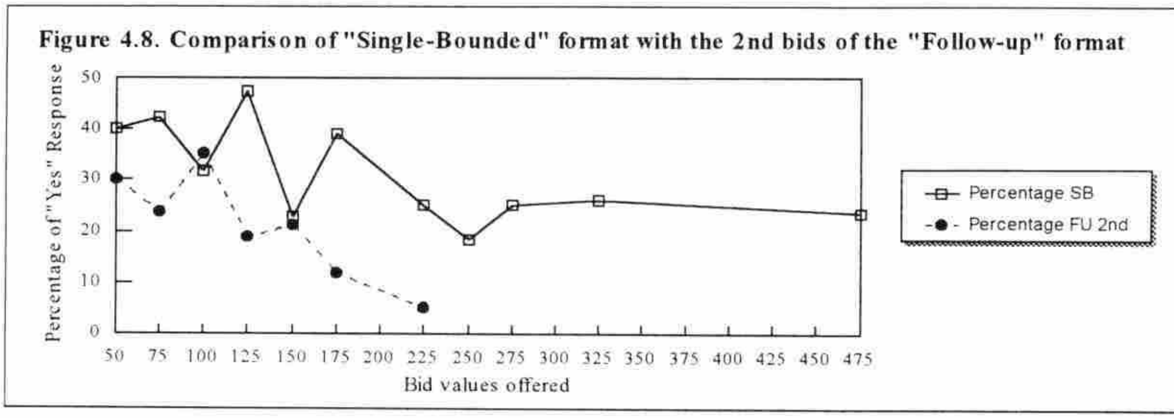

Figure 4.8. Comparison of the Single-bounded with the 2nd bids of the Follow-up format

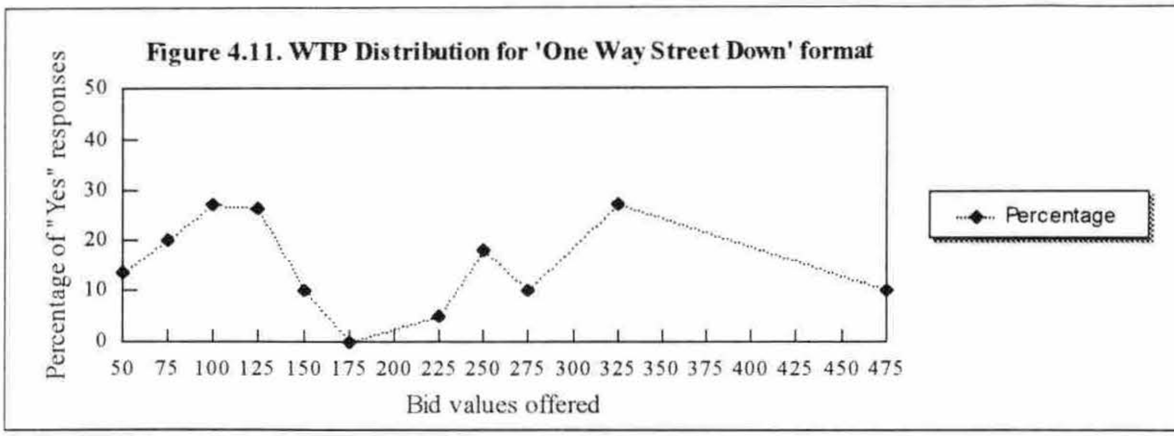

Figure 4.11. WTP Distribution for the "One-Way Street Down" format

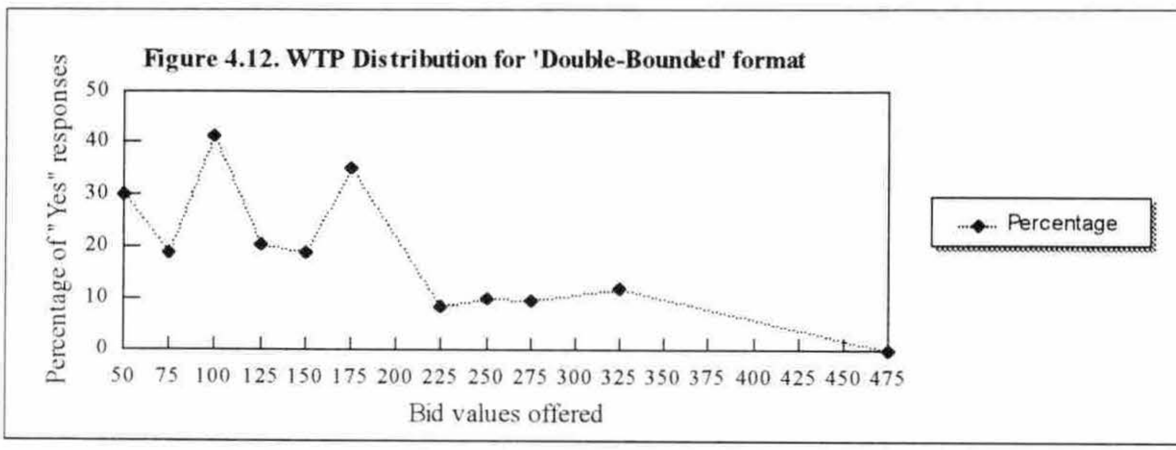

Figure 4.12. WTP Distribution for the "Double-Bounded" format

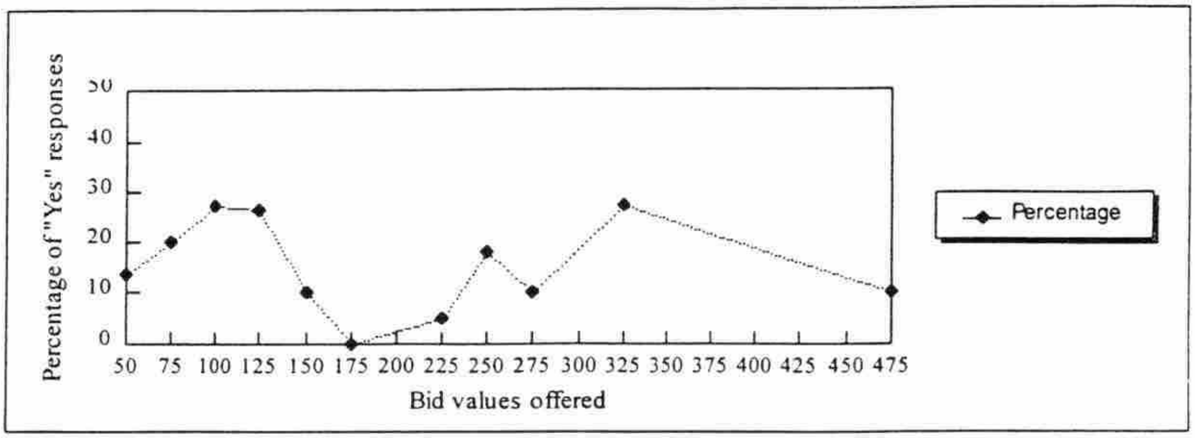

Figure 4.11. WTP Distribution for the "One-Way Street Down" format

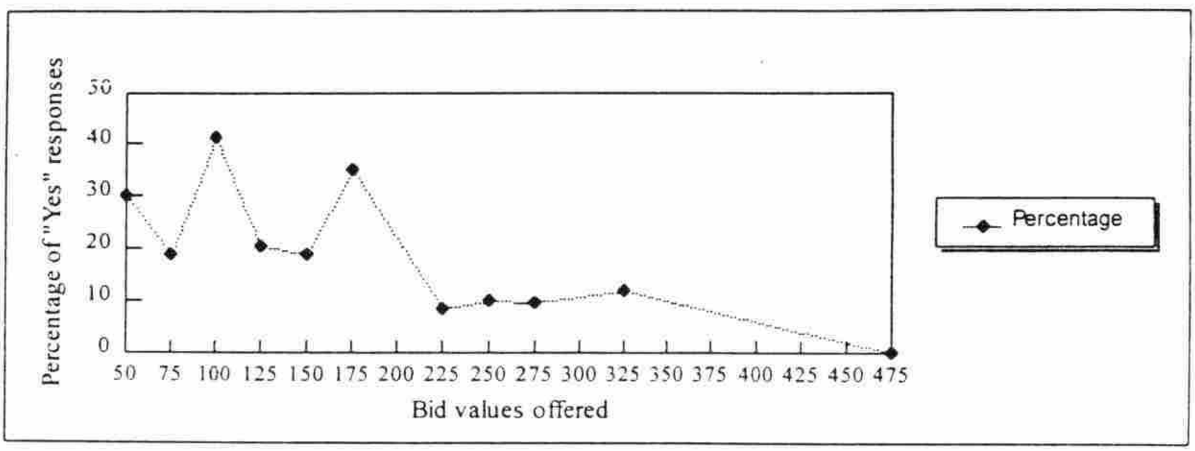

Figure 4.12. WTP Distribution for the "Double-Bounded" format

CHAPTER 5. COMPETING THEORETICAL MODELS FOR ANALYZING CLOSED-ENDED DATA

"Closed-ended" CVM questionnaires, such as the one used at Storm Lake, yield dichotomous choice data to estimate the economic values of non-marketed goods. In this chapter, we review the theoretical models for deriving estimates of the value of non-marketed goods from such data. Section 5.1 discusses Hanemann's (1984) random utility model[6], while Section 5.2 focuses on Cameron's alternative bid function approach. The latter provides the basis for the empirical work in Chapter 6. The model developed by Cameron is for referendum data with logistic errors. Section 5.2, provides maximum likelihood specifications for the "single-bounded", "double-bounded", "one-way street up", and "one way street down" formats.

[6] Since the utility maximization approach to discrete-choice modeling was established primarily by McFadden (1976), it is called "McFadden's random utility model".

5.1. Hanemann's Random Utility model specification

The first discrete contingent valuation model was proposed by Bishop and Heberlein (1979). Their main contribution was in the way they asked the elicitation questions; i.e. using closed-ended yes or no questions. A simple logit model was then used to analyze individual's willingness-to-accept (WTA) compensation for goose hunting permits. However, the procedure employed by Bishop and Heberlein for deriving estimates of the value of the permit was later criticized for not being strictly compatible with the utility theory. An alternate procedure, implicitly recognizes the utility-maximizing choice underlying the individuals' responses, was introduced by Hanemann (1984). The model derived by Hanemann is a logit model that is compatible with the assumption that the experimental responses are the outcome of a utility maximizing choice. He assumes that utility is given by $u = (h, y; s)$, where y denotes income and h is a dummy variable takes the value of 1 if the individual has access to the non-marketed good and 0 if not. The vector s denotes unobservable attributes of the consumer and is treated as stochastic. Thus, $u = (0, y; s)$ and $u = (1, y; s)$ are random variables with some parametric probability distribution. Equivalently, the utility function can be written as:

(1) $u(h,\ y;\ s) = v(h,\ y;\ s) + \varepsilon_i$ $\qquad h = 0,\ 1.$

where and ε_0 and ε_1 are i.i.d random variables with zero mean.

When offered an amount A to give up access to the non-marketed good, the probability that the respondent will be willing to sell is given by:

$$(2)\ \Pr\{u(0,\ y+A;\ s) \geq u(1,y;s)\} = \Pr\{v(0,y+A;s)+\varepsilon_0 \geq v(1,y;s)+\varepsilon_1\}$$
$$= \Pr\{(\varepsilon_1-\varepsilon_0) < v(0,y+A;s)-v(1,y;s)\}$$
$$= \Pr(\eta \leq \Delta v)$$

where $\eta \equiv (\varepsilon_1 - \varepsilon_0)$ and η is assumed to be a standard logistic random variable and

$\Delta v \equiv v(0, y+A; s) - v(1, y; s)$

In the logit model adopted by Bishop and Heberlein, the c.d.f. is defined as:

$$(3)\ F_n(\Delta v) = (1+\varepsilon^{-\Delta v})^{-1}$$

Hanemann proposed two simple functional forms for v:

$$(4)\ v(h,y;s) = \alpha_h + \beta y \qquad \beta > 0,\ h = 0,\ 1.$$
$$\Delta \text{v} = \alpha_0 + \beta(y+A) - (\alpha_1 + \beta y) = (\alpha_0 - \alpha_1) + \beta A$$

and

$$(5)\ v(h,y;s) = \alpha_h + \beta \log y \qquad \beta > 0,\ h = 0,\ 1.$$

$$\Delta v = \alpha_0 + \beta \log(y+A) - (\alpha_1 + \beta \log y)$$
$$\approx (\alpha_0 - \alpha_1) + \beta \log(y + A/y)$$
$$\approx (\alpha_0 - \alpha_1) + \beta A/y$$

These Δv's (utility differences) have simple linear-in-parameter forms which make them suitable for estimation using Δv as the logit index expression. The money value of the permit (C) is computed intuitively by equating $u(0, y+C; s) = u(1, y; s)$. For the functional forms (4) and (5), Hanemann shows that the corresponding mean value of C in the population is given respectively by:

$E[C] = \alpha / \beta$

$E[C] = y\exp(\alpha / \beta)\pi / \beta(\sin \pi / \beta)^{-1} - y$

The main limitation of this model is that within conventional logit packages Δv is assumed to be linear-in-parameters; unfortunately simple utility functions can result in complicated demand functions.

5.2. The Bid function approach

5.2.1. Single-Bounded Model Specification with logistic errors

The bid function approach of Cameron's begins by assuming that:

(6) $\mathrm{WTP}_i = \beta' \mathbf{x}_1 + \varepsilon_i$

where WTP_i is the individual i's true WTP for a resource or a change in the quality of the resource. It is an unobserved dependent variable. Instead we observe the binary indicator variable D_{yi}, where $D_{yi} = 1$, if an individual is willing to pay at least the specified bid value B_i or $D_{yi} = 0$ if otherwise. The vector $\mathbf{x}_1$ represents an array of explanatory variables or observable attributes of the resource or the individual.

Let B_i be the bid value that each individual is confronted with; resulting in a yes/no response. If the individual responds "yes" this implies $WTP_i \geq B_i$; while "no" implies $WTP_i < B_i$. The error term ε_i is assumed to be distributed according to a logistic distribution with mean 0 and standard deviation b. The probability of "yes" and "no" responses can then be given by:

$$(7)\ \pi_{yi} \equiv \Pr(D_{yi} = 1) = \Pr\{\varepsilon_i \geq (B_i - \beta'\mathbf{x}_1)\}$$

$$= \Pr\{\varepsilon_i / \kappa \geq (B_i - \beta'\mathbf{x}_1)/\kappa\}$$

$$= \Pr\{\psi \geq (B_i - \beta'\mathbf{x}_1)/\kappa\}$$

$$= 1 - G(B_i,\ \theta)$$

$$(8)\ \pi_{ni} \equiv \Pr(D_{yi} = 0) = \Pr\{\psi < (B_i - \beta'\mathbf{x}_1)/\kappa\} = G(B_i,\ \theta)$$

where $\kappa = b\sqrt{3/\pi}$, $\theta \equiv \{\beta,\ \kappa\}$ is the vector of unknown parameters, ψ denotes the standard logistic random variable with mean 0 and standard deviation $b = \pi / \sqrt{3}$, and $G(B_i,\theta) \equiv \Pr\{\psi < [(B_i - \beta'\mathbf{x}_1)/k]\}$ is the cdf for ψ. The formulae for the c.d.f. $G(B_i,\ \theta)$ with a logistic distribution is :

$$(9)\ G(B_i,\theta) = \exp(z)/[1 + \exp(z)]$$

$$= \exp[(B_i - \beta'\mathbf{x}_1)/\kappa]/\{1 + \exp[(B_i - \beta'\mathbf{x}_1)/\kappa]\}$$

For a given sample of n observations, the joint density function for the data, can be reinterpreted as a likelihood function:

$$(10) Likelihood = \prod_{i=1}^{n} \pi_{yi}^{D_{yi}} \pi_{ni}^{D_{ni}}$$

where $D_{ni} = (1 - D_{yi})$.

$$(11)\ \log(L) = D_{yi} \log \pi_{yi} + D_{ni} \log \pi_{ni}$$

$$= D_{yi} \log[1 - G(B_i,\theta)] + D_{ni} \log[G(B_i,\theta)]$$

$$= -D_{yi} \log\{1 + \exp[(B_i - \beta'\mathbf{x}_1)/\kappa]\}$$

$$+ D_{ni} \log\{\exp[(B_i - \beta'\mathbf{x}_1)/\kappa]/\{1 + \exp[(B_i - \beta'\mathbf{x}_1)/\kappa]\}$$

The presence of B_i allows κ to be identified, thereby allowing us to determine the β so that the true underlying fitted valuation can be determined.

5.2.2. Double Bounded Model Specification with logistic errors

The "double-bounded" model is slightly more complicated. While in the "single-bounded" there were only two possible outcomes (yes or no), the "double-bounded" offers four possible outcomes. The individual can answer "yes" to the two bids values, "no" to the two bid values, "yes" followed by a "no", "no" followed by a "yes". These possible outcomes are reported through dummy variables D_{yyi} , D_{nni}, D_{yni}, D_{nyi} . The dummy variable $D_{yyi} = 1$ corresponds to those respondents that answered "yes" to both the bids offered, similarly the dummy variable $D_{yni} = 1$ corresponds to a "yes" answer to the first bid followed by a "no" answer to the second bid. The likelihood's of these outcomes are respectively π_{yyi} , π_{nni}, π_{yni}, π_{nyi}, with:

$$(12)\ \pi_{yyi} = \Pr\{WTP_i \geq B_M \ and \ WTP_i \geq B_H\}$$
$$= \Pr\{WTP \geq B_H\}$$
$$= 1 - G(B_H, \theta)$$

$$(13)\ \pi_{nni} = \Pr\{WTP_i < B_M \ and \ WTP_i < B_L\}$$
$$= \Pr\{WTP_i < B_L\}$$
$$= G(B_L, \theta)$$

$$(14)\ \pi_{\mathrm{yni}} = \Pr\{WTP_i \geq B_M \ and\ WTP_i < B_H\}$$
$$= \Pr\{B_M \leq WTP_i < B_H\}$$
$$= G(B_H,\theta) - G(B_M,\theta)$$

$$(15)\ \pi_{\mathrm{nyi}} = \Pr\{WTP_i < B_M \ and\ WTP_i \geq B_L\}$$
$$= \Pr\{\mathrm{B_L} \leq WTP_i < B_M\}$$
$$= G(B_M,\ \theta) - G(B_L,\ \theta)$$

The likelihood function for the "double-bounded" can then be written as:

$$(16)\ Likelihood = \prod_{i=1}^{n} \pi_{\mathrm{yyi}}{}^{\mathrm{Dyyi}} \pi_{\mathrm{nni}}{}^{\mathrm{Dnni}} \pi_{yni}{}^{Dyni}\ \pi_{nyi}{}^{Dnyi}$$

Taking logs:

$$(17)\ \log(L) = D_{yyi} \log \pi_{yyi} + D_{nni} \log \pi_{nni} + D_{yni} \log \pi_{yni} + D_{nyi} \log \pi_{nyi}$$
$$= D_{yyi} \log\{1 - G(B_H,\theta)\} + D_{nni} \log\{G(B_L,\theta)\}$$
$$+ D_{yni} \log\{G(B_H,\theta) - G(B_M,\theta)\} + D_{nyi} \log\{G(B_M,\theta) - G(B_L,\theta)\}$$

5.2.3. One Way Street Up Model Specification with logistic errors

The "one-way street up" format has four possible outcomes. The individual can answer "yes" to all three bids $(D_{yyyi} = 1)$, or can answer "no" to all three bids $(D_{ni} = 1)$, or can answer a "yes" followed by a "no" $(D_{yni} = 1)$, or can answer a "yes" followed by a "yes" and then a "no" $(D_{yyni} = 1)$. The likelihoods of these outcomes are respectively π_{yyyi}, π_{yyni}, π_{yni}, π_{ni}, with:

$$(18)\ \pi_{yyyi} = \Pr\{WTP_i \geq B_L \ and\ WTP_i \geq B_M \text{ and } WTP_i \geq B_H\}$$
$$= 1 - \Pr\{WTP_i < B_H\}$$
$$= 1 - G(B_H, \theta)$$

$$(19)\ \pi_{yyni} = \Pr\{WTP_i \geq B_L \ and\ WTP_i \geq B_M \ and\ WTP_i < B_H\}$$
$$= \Pr\{B_M \leq WTP_i < B_H\}$$
$$= G(B_H, \theta) - G(B_M, \theta)$$

$$(20)\ \pi_{yni} = \Pr\{WTP_i \geq B_L \ and\ WTP_i < B_M\}$$
$$= \Pr\{B_L \leq WTP_i < B_M\}$$
$$= G(B_M, \theta) - G(B_L, \theta)$$

$$(21)\ \pi_{ni} = \Pr\{WTP < B_L\}$$
$$= G(B_L, \theta)$$

The likelihood function can be written as:

$$(22)\ Likelihood = \prod_{i=1}^{n} \pi_{yyyi}{}^{Dyyyi} \pi_{yyni}{}^{Dyyni} \pi_{yni}{}^{Dyni} \pi_{ni}{}^{Dni}$$

Taking logs yields:

$$(23)\ \log(L) = D_{yyyi} \log \pi_{yyyi} + D_{yyni} \log \pi_{yyni} + D_{yni} \log \pi_{yni} + D_{ni} \log \pi_{ni}$$
$$= D_{yyyi} \log\{1 - G(B_H, \theta)\} + D_{yyni} \log\{G(B_H, \theta) - G(B_M, \theta)\}$$
$$+ D_{yni} \log\{G(B_M, \theta) - G(B_L, \theta)\} + D_{ni} \log\{G(B_L, \theta)\}$$

5.2.4. One Way Street Down Model Specification with logistic errors

The one-way street down format has four possible outcomes. The individual can answer "yes" to the first bid $(D_{yi} = 1)$, or can answer "no" to the first (highest) bid and "yes" to the second (middle) bid $(D_{nyi} = 1)$, or can answer "no" to the first two bids offered and "yes" to the third bid $(D_{nnyi} = 1)$, or can answer "no" to all three bids $(D_{nnni} = 1)$. The likelihood's of these three outcomes are π_{yi}, π_{nyi}, π_{nnyi}, π_{nnni}, with:

$$(24)\ \pi_{yi} = \Pr\{WTP_i \geq B_L \text{ and } WTP_i \geq B_M \text{ and } WTP_i \geq B_H\}$$
$$= 1 - \Pr\{WTP_i < B_H\}$$
$$= 1 - G(B_H, \theta)$$

$$(25)\ \pi_{nyi} = \Pr\{WTP_i \geq B_L \text{ and } WTP_i \geq B_M \text{ and } WTP_i < B_H\}$$
$$= \Pr\{B_M \leq WTP_i < B_H\}$$
$$= G(B_H, \theta) - G(B_M, \theta)$$

$$(26)\ \pi_{nnyi} = \Pr\{WTP_I \geq B_L \text{ and } WTP_I < B_M\}$$
$$= \Pr\{B_L \leq WTP_i < B_M\}$$
$$= G(B_M, \theta) - G(B_L, \theta)$$

$$(27)\ \pi_{nnni} = \Pr\{WTP_i < B_L\}$$
$$= G(B_L, \theta)$$

The likelihood function can be written as:

$$(28)\ Likelihood = \prod_{i=1}^{n} \pi_{yi}^{\ Dyi} \pi_{nyi}^{\ D_{nyi}} \pi_{nnyi}^{\ Dnnyi} \pi_{nnni}^{\ D_{nnni}}$$

Taking logs yields:

$$(29)\ \log L = D_{yi} \log \pi_{yi} + D_{nyi} \log \pi_{nyi} + D_{nnyi} \log \pi_{nnyi} + D_{nnni} \log \pi_{nnni}$$
$$= D_{yi} \log\{1 - G(B_H, \theta)\} + D_{nyi} \log\{G(B_H, \theta) - G(B_M, \theta)\}$$
$$+ D_{nnyi} \log\{G(B_M, \theta) - G(B_L, \theta)\} + D_{nnni} \log\{G(B_L, \theta)\}$$

CHAPTER 6. EMPIRICAL RESULTS AND DISCUSSION

This chapter addresses the issue of whether the estimates of the median WTP are influenced by the follow-up questions asked or by the format category it falls under. The other part of this study is to evaluate the efficiency the different "follow-up" approaches have over the "single-bounded" approach. While many researchers have successfully shown the statistical efficiency of follow-up questioning, the main contribution of this paper is in assessing and testing for bias that may occur due to implementation of any of the three "follow-up" approaches.

The first section (6.1) provides the basic log-linear model used in this chapter to estimate median WTP based upon survey data using "single-bounded" (S), "double-bounded" (DB), "one-way street up" (UP), and "one-way street down" (DO) formats. This is followed with an augmented log-linear model which allows for explicit tests for different forms and sources of bias (i.e. whether it is a format bias or a follow-up bias). Eight specific hypotheses to be tested are then identified. Section 6.2 presents parameter estimates for the basic model and the augmented model using only individual responses to the 1st questions asked in the survey. We would generally expect the WTP estimates using the first question only not to be influenced by the format or the follow-up issue because a respondent's decision here is not only not to be influenced by the format or the follow-up issue because a respondent's decision here is not influenced by other bid values. The basic and augmented models are estimated to test this assumption. The third section (6.3) is very similar to the second section. It questions the same issue, except that now all the WTP survey responses are used. The primary reason for using all WTP questions is to see if the WTP estimates using follow-up responsespose a starting-point bias problem. Therefore, our main hypothesis is that while the answer to the first bid is not influenced by format type or the follow-up questions, the answer to the second and third bids may be influenced by it. Eight hypotheses are tested using the maximum likelihood ratio test. The fourth section (6.4) discusses and summarizes the conclusion which are drawn from this study.

6.1. Basic and Augmented log-linear models

The basic model employed in this study is of the double-log form:

(30) $\log WTP_i = \alpha + \beta(\log Y_i - \overline{\log Y}) + \varepsilon_i$

where ε_i is distributed according to a logistic distribution with mean 0 and standard deviation b (or an alternative parameter $\kappa = b\sqrt{3}/\pi$). This model is estimated for four sub-groups of the sample, i.e. single-bounded, double-bounded, one-way street up, one-way street down. It also estimates a common model by estimating the four sub-groups together. We use the maximum likelihood estimation procedures that are outlined in chapter 5.

To study the effects that format and follow-up may have on the estimates of the median WTP, we expand the basic model (30) by introducing dummy variables for each format. This is refered to as the augmented or unrestricted model. Let, $D_{FU} = 1$, if the respondent received a "DB" or "UP" or "DOWN" format survey (=0 otherwise). Let $D_{UP} = 1$, if the respondent received a "UP" format survey (=0 otherwise). Let, $D_{DO} = 1$, if the respondent received a "DOWN" format survey (=0 otherwise). The augmented double log-linear model is as follows:

$$(31)\ \log(WTP) = (\alpha + \gamma_{FU} * D_{FU} + \gamma_{UP} * D_{UP} + \gamma_{DO} * D_{DO})$$
$$+ (\beta + \delta_{FU} * D_{FU} + \delta_{UP} * D_{UP} + \delta_{DO} * D_{DO})(\log Y_i - \overline{\log Y}) + \varepsilon_i \rightarrow \textit{Unrestricted}$$

where ε_i has a logistic distribution with dispersion coefficient

$\kappa = (\kappa_1 + \tau_{FU} * D_{FU} + \tau_{UP} * D_{UP} + \tau_{DO} * D_{DO})$

The parameters $\gamma_i, \delta_i, \tau_i$ measure the marginal effect "follow-up" questions and format type have on the intercept, slope, and dispersion of the error term. The parameters $\gamma_{FU}, \gamma_{UP}, \gamma_{DO}$ provides the follow-up and format effect on the intercept, $\delta_{FU}, \delta_{UP}, \delta_{DO}$ analyzes the follow-up and format effects on the slope (income effect), and $\tau_{FU}, \tau_{UP}, \tau_{DO}$ analyzes the follow-up and format effects on the dispersion.

Using the functional form in equation (31), the estimates of median WTP for the "single-bounded", "double-bounded", "one-way street up", "one-way street down" questioning formats are respectively:

$$(WTP) = \exp\{\alpha + \beta(\log Y_i - \overline{\log Y})\} \quad \rightarrow \textit{Single - Bounded}$$

$$(WTP) = \exp\{(\alpha + \gamma_{FU}) + (\beta + \delta_{FU})(\log Y_i - \overline{\log Y})\} \quad \rightarrow \textit{Double - Bounded}$$

$$(WTP) = \exp\{(\alpha + \gamma_{FU} + \gamma_{UP}) + (\beta + \delta_{FU} + \delta_{UP})(\log Y_i - \overline{\log Y})\} \quad \rightarrow \textit{One - way street up}$$

$$(WTP) = \exp\{(\alpha + \gamma_{FU} + \gamma_{DO}) + (\beta + \delta_{FU} + \delta_{DO})(\log Y_i - \overline{\log Y})\} \quad \rightarrow \textit{One - way street down}$$

Following are the eight hypotheses tested:

FORMAT EFFECTS:

(i) Effects of formats on the intercept

$H_{10} : \gamma_{UP} = \gamma_{DO} = 0$

H_{1A} : atleast one inequality

(ii) Effects of format on the slope

$H_{20} : \delta_{UP} = \delta_{DO} = 0$

H_{2A} : atleast one inequality

(iii) Effects of format on the dispersion

$H_{30} : \tau_{UP} = \tau_{DO} = 0$

H_{3A} : atleast one inequality

(iv) Effects of format on the intercept, slope, and dispersion

$H_{40} : \gamma_{UP} = \gamma_{DO} = \delta_{UP} = \delta_{DO} = \tau_{UP} = \tau_{DO} = 0$

H_{4A} : atleast one inequality

FOLLOW-UP EFFECTS:

(v) Effects of follow-up on the intercept

$H_{50}: \gamma_{FU} = \gamma_{UP} = \gamma_{DO} = 0$

H_{5A} : atleast one inequality

(vi) Effects of follow-up on the slope (Income effect)

$H_{60}: \delta_{FU} = \delta_{UP} = \delta_{DO} = 0$

H_{6A} : atleast one inequality

(vii) Effects of follow-up on the dispersion

$H_{70}: \tau_{FU} = \tau_{UP} = \tau_{DO} = 0$

H_{7A} : atleast one inequality

(viii) Effects of follow-up and format on the intercept, slope, and dispersion

$H_{80}: \gamma_{FU} = \gamma_{UP} = \gamma_{DO} = \delta_{FU} = \delta_{UP} = \delta_{DO} = \tau_{FU} = \tau_{UP} = \tau_{DO} = 0$

H_{8A} : atleast one inequality

Hypotheses one to four test for format effects and hypotheses five to eight test for follow-up as well as format effects. While the format effects pin down the exact format that is significantly affecting the WTP estimates; the "follow-up" hypotheses determines whether "follow-up" format questions as a whole alters estimates of WTP. In order to test the null hypotheses that some of the parameters in our unrestricted model are equal to zero, we use the likelihood ratio test. To apply the test, suppose that $L(\beta_{UR})$ represents the maximum value of the log likelihood function when the restrictions do not apply, while $L(\beta_R)$ represents the maximum value when the restrictions does apply. Then it can be shown that for large sample sizes (asymptotically),

$$-2[L(\beta_R)-L(\beta_{UR})] \approx \chi^2_q$$

where q is the number of restrictions. If χ^2_q is greater than the critical value at 1% or 5% or 10% significance level, we can reject the null hypotheses that the parameters are zero (Pindyck and Rubinfeld, 1991).

6.2. Parameter estimates and hypotheses test results (Using 1st question only)

The basic model (30) results are presented in Table 6.1. Column 1, 2, 3, 4, and 5 report the estimates for the parameters (α, β, κ) for the joint (full-sample), "single-bounded" (SB), "double-bounded" (DB), "one-way street up" (UP), and "one-way street down" (DO) sub-groups using 1st question responses only. Standard errors are provided in brackets. The median WTP estimates are provided in Row 4.

The exponential of the α gives the estimate of the median WTP. In the 1st question basic model all but the "one way street-up" α's are different from zero at the 5 percent significance level. Also eyeballing the estimates of the median WTP for each format, there is not a substantial difference between the median WTP for the single-bounded ($36) and the double-bounded format ($45). However, the "one way street up" WTP estimate is close to zero, while the "one way street down" WTP estimate ($76) is over double the single-bounded estimate. These results suggest some difference in the median WTP estimates depending upon the different follow-up formats versus "single-bounded", though the individual WTP estimates are imprecisely measured.

Table 6.1. Estimated parameters of the individual and joint group, using 1st question only (Standard errors in parenthesis)

Parameter	Common Model	Single-Bounded	Double-Bounded	One-Way Street Up	One-Way Street Down
α	3.59***	3.60***	3.80**	-7.78	4.32**
	(0.44)	(0.72)	(1.58)	(254.92)	(1.97)
β	0.85**	1.00	1.45	19.21	-.285
	(0.35)	(0.61)	(1.83)	(404.13)	(0.47)
κ	1.62***	1.93**	0.72	27.7	0.95
	(0.46)	(0.89)	(0.84)	(579.35)	(1.29)
Median WTP	36.20**	36.46	44.54	0.418E-03	75.61
	(15.90)	(26.16)	(70.53)	(0.11)	(149.19)
Max Log-Likelihood	-265.74	-146.14	-30.80	-45.37	-35.74
n	458	239	73	70	76

*** Statistically significant at 1% level

** Statistically significant at 5% level

* Statistically significant at 10% level

The β in a log-linear model can be interpreted as the percentage change in WTP for a percent change in income. In the joint model, a one percent change in income results in almost a 1 percent (0.0085%) change in WTP. The β is significantly different from zero at the 5 percent significance level only for the joint model.

The κ estimates the dispersion of WTP in the target population. In the joint model as well as the "single-bounded" model, the estimated κ's are significantly different from zero at a 1 percent and 5 percent level of significance respectively.

Table 6.2 reports the parameter estimates for the augmented model described in equation (31). This reparameterization is useful to check if formats or follow-up questions contribute significantly alter the WTP estimates. The α estimate is significantly different from zero at the 1 percent level, while the κ_1 estimate is significant at the 5 percent level of significance. As we had expected this unrestricted model does not suggest any significant format or follow-up effects (i.e. none of the $\gamma_i, \delta_i, \tau_i$. are significant individually).

On running the restricted models to test the hypotheses 1-8, the maximum likelihood ratio tests (see Table 6.3) report that we reject the null hypotheses $H_{40}: \gamma_{UP} = \gamma_{DO} = \delta_{UP} = \delta_{DO} = \tau_{UP} = \tau_{DO} = 0$ at the 5 percent level of significance but not at the 1 percent level. This suggests that although individually $\gamma_i, \delta_i, \tau_i$ do not provide sufficient evidence for a format bias, jointly they do. Also, the hypotheses that tests for both format effect and follow-up $H_{80}: \gamma_{FU} = \gamma_{UP} = \gamma_{DO} = \delta_{FU} = \delta_{UP} = \delta_{DO} = \tau_{FU} = \tau_{UP} = \tau_{DO} = 0$ is significant at the 10 percent level of significance. Therefore these likelihood ratio tests do suggest that the WTP estimates using responses to the 1st questions only also have some format and follow-up bias.

Table 6.2. Parameter estimates of unrestricted model (Using 1st questions), n=458

Parameter	Estimate	Standard Error	t statistic
α	3.60***	0.72	5.01
γ_{FU}	0.20	1.74	0.11
γ_{DO}	0.53	2.54	0.21
γ_{UP}	-11.56	254.77	-0.04
β	1.00	0.61	1.64
δ_{FU}	0.45	1.94	0.23
δ_{DO}	-1.74	1.90	-0.91
δ_{UP}	17.75	403.99	0.04
κ_1	1.93**	0.89	2.17
τ_{FU}	-1.21	1.22	-0.99
τ_{DO}	0.23	1.55	0.15
τ_{UP}	26.97	579.05	0.05

$L(\beta_{UR})$ =-258.06

*** Statistically significant at 1% level
** Statistically significant at 5% level
* Statistically significant at 10% level

Table 6.3. Maximum Likelihood Ratio tests (Using 1st question only)

Log likelihood value	$-2[L(\beta_R)-L(\beta_{UR})]$	χ^2_q(1%LOS	χ^2_q(5%LOS	χ^2_q(10% LOS)
$L(\beta_{UR})$=-258.06	-	-	-	-
$L(\beta_{R1})$=-258.25	0.39	9.21	5.99	4.61
$L(\beta_{R2})$=-258.73	1.34	9.21	5.99	4.61
$L(\beta_{R3})$=-258.51	0.89	9.21	5.99	4.61
$L(\beta_{R4})$=-264.41	12.70	16.81	**12.59**	**10.64**
$L(\beta_{R5})$=-258.29	0.46	11.34	7.81	6.25
$L(\beta_{R6})$=-258.86	1.60	11.34	7.81	6.25
$L(\beta_{R7})$=-258.51	0.91	11.34	7.81	6.25
$L(\beta_{R8})$=-265.74	15.36	21.66	16.92	**14.68**

6.3. Parameter estimates and hypotheses test results (Using all questions)

Above we say that follow-up questions and format type does bias the results to some extent when using only 1st questions responses for estimation. The extent to which all the "follow-up" questions bias the WTP estimates is to be seen in this section. As earlier mentioned, we suspect some kind of starting-point bias in using all the information. The basic model (30) was estimated for the joint sample and the individual format sub-groups. Table 6.4 reports the results.

The α 's for all the models are different from zero at a 1 percent significance level. Estimates of the median WTP for the follow-up formats are almost double the "single-bounded" format estimates. This suggests some kind of bias in the estimates. However, it

Table 6.4. Estimated parameters of the individual and joint groups, using all questions (Standard errors in parenthesis)

Parameter	Common Model	Single-Bounded	Double-Bounded	One-Way Street Up	One-Way Street Down
α	4.18***	3.60***	4.22***	4.12***	4.11***
	(0.10)	(0.72)	(0.16)	(0.15)	(0.27)
β	0.49***	1.00	0.78***	0.39	-0.04
	(0.13)	(0.61)	(0.26)	(0.29)	(0.28)
κ	0.89***	1.93**	0.61***	0.61***	1.06***
	(0.08)	(0.89)	(0.11)	(0.13)	(0.21)
Median WTP	65.53***	36.46	67.76***	61.79***	60.97***
	(6.89)	(26.16)	(11.09)	(9.60)	(16.38)
Max Log-Likelihood	-396.105	-146.142	-76.82	-74.12	-86.799
n	458	239	73	70	76

*** Statistically significant at 1% level

** Statistically significant at 5% level

* Statistically significant at 10% level

should be noted that the stimate of the median WTP of the "single-bounded" ($36) format is not statistically significant.

The β in the joint model and the "double-bounded" model are different from zero at the 1 percent level of significance. In the joint model, a one percent change in income results in almost a 0.5 percent change in WTP.

The κ estimates in all the models is different from zero at atleast the 5 percent level of significance. The dispersion estimates using follow-up data are much lower than those using the "single-bounded" data.

The follow-up formats have lower standard errors for all the parameters and median WTP estimates when compared to the "single-bounded" results. This is consistent with the statistical efficiency of "follow-up" formats versus "single-bounded" format suggested by Hanemann et al (1991).

Table 6.5 reports the estimates of the parameters of the augmented model using all question responses. The α estimate is significantly different from zero at the 1 percent level, while the $\delta_{DO}, \kappa_1, \tau_{DO}$ estimates are significantly different at the 5 percent level. The significance of δ_{DO} and τ_{DO} does suggest some format or follow-up bias. Again running the restricted models to test the hypotheses 1-8, the maximum likelihood ratio tests (see Table 6.6) report that we fail to reject the following null hypotheses $H_{30}: \tau_{UP} = \tau_{DO} = 0$ at the 10 percent level, $H_{40}: \gamma_{UP} = \gamma_{DO} = \delta_{UP} = \delta_{DO} = \tau_{UP} = \tau_{DO} = 0$ at the 5 percent level,

$H_{70}: \tau_{FU} = \tau_{UP} = \tau_{DO} = 0$ at the 1 percent level of significance,and the hypothesis $H_{80}: \gamma_{FU} = \gamma_{UP} = \gamma_{DO} = \delta_{FU} = \delta_{UP} = \delta_{DO} = \tau_{FU} = \tau_{UP} = \tau_{DO} = 0$ at the 1 percent level of significance. Therefore again these likelihood ratio tests do report for format and follow-up effects in the first question asked.

Table 6.5. Parameter estimates of unrestricted model, n=458 (Using all questions)

Parameter	Estimate	Standard Error	t statistic
α	3.60***	0.72	5.01
γ_{FU}	0.62	0.73	0.84
γ_{DO}	-0.11	0.31	-0.34
γ_{UP}	-0.09	0.22	-0.41
β	1.00	0.61	1.64
δ_{FU}	-0.22	0.66	-0.34
δ_{DO}	-0.82**	0.39	-2.11
δ_{UP}	-0.38	0.39	-0.97
κ	1.93**	0.89	2.17
τ_{FU}	-1.32	0.90	-1.48
τ_{DO}	0.45*	0.24	1.90
τ_{UP}	-0.52E-03	0.17	-0.30E-02

$L(\beta_{UR})$ =-383.881

*** Statistically significant at 1% level
** Statistically significant at 5% level
* Statistically significant at 10% level

Table 6.6. Maximum Likelihood Ratio tests (Using all questions)

Log likelihood value	$-2[L(\beta_R)-L(\beta_{UR})$	χ^2_q(1%LOS)	χ^2_q(5%LOS)	χ^2_q(10%LOS)
$L(\beta_{UR})$=-383.88	-	-	-	-
$L(\beta_{R1})$=-383.98	0.19	9.21	5.99	4.61
$L(\beta_{R2})$=-385.59	3.43	9.21	5.99	4.61
$L(\beta_{R3})$=-386.86	5.96	9.21	5.99	**4.61**
$L(\beta_{R4})$=-390.29	12.83	16.81	**12.59**	**10.64**
$L(\beta_{R5})$=-384.58	1.41	11.34	7.81	6.25
$L(\beta_{R6})$=-385.94	4.13	11.34	7.81	6.25
$L(\beta_{R7})$=-391.52	15.27	**11.34**	**7.81**	**6.25**
$L(\beta_{R8})$=-396.10	24.45	**21.66**	**16.92**	**14.68**

6.4. Conclusions and future research

In this study we have tried to provide empirical evidence that using follow-up questions does bias the results to some extent. The hypotheses tests clearly show us that there is a format effect on the WTP estimates, and therefore researchers should be careful in choosing a particular questioning approach. However, while the follow-up approach does bias the WTP estimates, it also lowers the standard errors for all the parameters and median WTP estimates. The dispersion estimates using the follow-up data are much lower than those using the "single-bounded" approach. The "single-bounded" approach is recommended for projects that can afford to get a large sample and thereby overcome the main limitation this approach poses.

Although we were able to see that either the "one-way street up" or "one-way street down" formats is the main contributor to the bias. The "one-way street down" has the largest standard errors indicating imprecise results and a higher possibility of being the more faulty of the two approaches. However, it is yet to be proven statistically.

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