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THE VALUE OF REGIONAL WATER QUALITY IMPROVEMENTS

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The Value of Regional Water Quality Improvements

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Abstract

Four years ago, Magat, Huber, Viscusi, and Bell (2000) reported pretest results that introduced an iterative choice approach to valuing water quality improvements. This paper applies this approach to a nationally representative sample of over 1,000 respondents. We find that the method provides stable, policy relevant estimates of the amount people are willing to pay for improvements. Willingness to pay for a one percentage point improvement in water quality has a mean value of $23.17 with a median of $15, and appropriately increases with family income, age, education, and the likelihood of using lakes or rivers. In addition, the method passes an external scope test demonstrating that greater gains in the percent of water rated "good" increase the likelihood that the respondent will choose the alternative with better water quality. We tested the appropriateness of a national web-based panel of respondents and find that the Knowledge Networks sample does not fall prey to difficulties that could plague such panels. First, the sampled web-based panel matches United States demographics very well, and predictors of sample responsiveness, such as the likelihood to take a long time to respond to the survey, have minimal impact on the critical estimates of the value of good water. Second, the results are quite insensitive to doubly censored regression that accounts for the portion of respondents who indicated an unboundedly high or low estimate for the value of cleaner lakes and rivers. Finally, the stability of the benefit values is further demonstrated by the selection-corrected estimates that adjust for people invited to participate but who did not successfully complete the survey.

Keywords: water quality, environmental benefits, survey, contingent valuation

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The Value of Regional Water Quality Improvements

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1. Introduction

The economic benefit of water quality improvements is society's willingness to pay for increases in water quality. Early measures of water quality were derived from travel cost values of recreational benefits[1]. Subsequent benefit assessments, which remain in use in some policy applications, consist of analyzing the value of improvements in the water's ranking on a water quality ladder.[2] This unidimensional water quality index assumes that there is a hierarchy of quality levels in terms of whether the water is drinkable, swimmable, fishable, or boatable. Thus, water that is drinkable also meets acceptability criteria for all lower ranked uses. Unfortunately, this hierarchical characterization is problematic, as these categories of uses do not reflect our current scientific understanding of the empirical ordering of water quality. That is, if one examines the pattern of quality levels across states, there is almost no evidence of such a hierarchy.[3] The focus of the survey results reported here is on people's willingness to pay for water that is rated "good" based on an overall index, developed by the U.S. Environmental Protection Agency (EPA), that initially merges benefits with respect to fishing, swimming, and the quality of the aquatic environment. An additional survey component makes it possible to

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[1] See Berkman and Viscusi (1973).

[2] Mitchell and Carson (1989) and Carson and Mitchell (1993) provide benefit assessments using this approach, which was consistent with the previous scientific literature at that time. A different perspective is provided by Smith and Desvousges (1986).

[3] Examples of these differences using data from EPA's National Water Quality Inventory appear in Magat, Huber, Viscusi, and Bell (2000), pp. 10-11.

separate the component values.[4] The survey results reported here will focus on the overall water quality valuation component.[5]

This paper expands and tests the methodology developed by Magat, Huber, Viscusi, and Bell (2000), where water quality values are derived from hypothetical market choices. These values are based on simple choices between regions that differ on water quality and cost of living. A series of such choices yield bounds on the value of water quality improvements for each individual. The method has the advantage of generating estimates of the private value of improvements in water quality from a simple understandable task.

This paper discusses econometric stability of these estimates as well as some reliability and sampling questions that arise in this use of iterative choice to assess private values. The study is based on over 1,000 new surveys implemented through web-based interviewing. Generally, we find that water quality valuations follow expected economic patterns: factors such as income, education, and visits to lakes or rivers are appropriately related to the value of water quality. Further, a scope test indicates greater valuations for larger changes in water quality gains, increasing confidence in the metric quality of the results. We assess the reliability of this approach by testing for the stability of the results given different econometric assumptions, with particular focus on those responses for which the dollar value of water quality could only be bounded on one side.

A second important improvement in this study is the use of a national web-based panel rather than the recruitment to regional central sites or mall intercepts used in the Magat *et al.* (2000) study. The use of respondent panels for policy has emerged as a response to increasing difficulty and expense attached to recruiting probability-based random samples. It is

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[4] See Magat, Huber, Viscusi, and Bell (2000).
[5] The attributes of good water quality will be addressed in a separate survey to be administered by the authors in 2004.

fundamentally an empirical question whether a panel-based sampling approach will produce acceptable results. We find that the demographic characteristics of the final sample closely correspond to that of the target universe of U.S. adults. Additionally, we show that that the results are not affected by factors that might distinguish between those who take the survey against those who do not. Finally, a sample selection procedure adjusts the water quality valuations for the probability that a panel member will not take or successfully complete the survey. These estimates differed little from the unadjusted means, providing assurance that they are relatively independent of possible panel selection biases.

Section 2 describes the overall study design, the survey methodology and the iterative choice method for generating values for improvements in water quality. Section 3 explores the logical adequacy of the results, including an exploration of consistency tests for the responses as well as the variation of the valuation responses conditioned on demographics. Section 4 provides tests of survey and sample validity. The survey was internet-based, using the Knowledge Networks panel. We examine the extent to which attrition bias from the panel and other aspects of this survey mode influence the water quality values. As indicated in the concluding Section 5, the results are quite robust and meet a wide variety of tests for rationality and consistency.

2. Study Design

The survey used a computer-based methodology and was administered to a representative national sample.[6] The average respondent completed the survey in 25 minutes. The instrument initially acquainted the respondent with the meaning of regional differences in lake and river water rated of good quality and differences in annual cost of living. This introductory section

[6] While our survey uses an iterative choice format, it is related to contingent valuation surveys, though it uses a different survey approach. For discussions of contingent valuation, see among others Bishop and Heberlein (1990), Fischhoff and Furby (1998), and Mitchell and Carson (1989), and Schkade and Payne (1986).

establishes the cognitive groundwork for the respondents so that a choice between regions differing in these aspects can be reliably answered.

Introductory section in the survey

The key valuation task involves choices between regions differing in their levels of water quality and the annual cost of living. A critical part of the method involves introductory sections that encourage the respondent to think about these tradeoffs. This process begins with some very general questions to encourage the respondent to think about the value of freshwater bodies. It also elicits information on the frequency of visits to lakes and rivers as well as related activities, such as boating, fishing, or swimming. The primary reason for asking about usage is to encourage respondents to think about why they might value differences in water quality. However, it may also be the case that respondents reporting greater usage of lakes and rivers have higher valuations of improvements in the quality of those water bodies.

Immediately following the introduction to water usage, the survey explains the meaning of cost of living and elicits the respondent's level of concern with an annual increase in cost of living of $200. Respondents then respond to a question that tests comprehension involving a simple choice between two regions, identical except that one is more expensive. The few respondents who chose the more expensive location are provided a brief educational module before being asked to proceed.

Next, respondents are introduced to the criteria that define what it means for water quality to be "good." Consistent with definitions used by EPA's National Water Quality Inventory, the survey provides the following definition:

> The government rates water quality as either
> * Good, or
> * Not Good.

> Water quality is Good if the water in a lake or river is safe for all uses. Water quality is Not Good if a lake or river is polluted or unsafe to use.
>
> More specifically, water quality is Good if the lake or river
> * Is a safe place to swim,
> * Fish in it are safe to eat, and
> * Supports many plants, fish, and other aquatic life.
>
> Water quality is Not Good if the lake or river
> * Is an unsafe place to swim due to pollution,
> * Has fish that are unsafe to eat, or
> * Supports only a small number of plants, fish, and other aquatic life.

The survey then explicitly excludes drinking water from the valuation task.

Once familiar with the concepts of water quality and cost of living, these contexts are framed within context of a region, defined as “within a 2-hour drive or so of your home, in other words, within 100 miles.” A 100 mile radius is appropriate because it reflects a reasonable 2-hour drive for the recreational use of bodies of water, and about 80 percent of all recreational visits for lakes, rivers, and streams are within such a radius.[7] This text explanation of region contrasts with the method reported in Magat et al. (2000) where respondents viewed pictorial representations of the region size. However, our pretest interviews indicated that the 100-mile region radius could be well understood when described through the text used.

After they learned about water quality and the region, respondents received a warm-up choice. In this case they were asked to choose between two regions that differed in the percentage of water bodies with quality rated good. Respondents who preferred the region with a lower percent of lakes and rivers rated good received a brief interactive tutorial on the meaning of the benefit measure and the error in their response.

<u>Key Valuation Choice Task</u>

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[7] Data generated by the EPA NCEE Office for this study indicate that 77.9% of boating visits, 78.1% of fishing visits, and 76.9% of swimming recreational visits are within a 100 mile radius. Calculations were made by Jared Creason of NCEE using the 1996 National Survey on Recreation and Environment.

Once respondents learn about water quality, cost of living and their application to a region, they are ready for the iterative choice questions. This key valuation task is designed to elicit the respondent's tradeoff between water quality and cost of living in choices between different regions. These regions are "the same in all other ways, including the number of lakes and rivers near your home." As a final warm-up question respondents are asked to make a choice where one alternative dominated another on both cost of living and water quality. That is, they choose between two regions, where one region had more quality lakes and rivers and lower cost of living. Respondents who erred received a remedial tutorial that reviewed the nature of the choice being made.

The critical choice questions take the form shown in Figure 1. It is noteworthy that the task itself is not complex, which past evidence suggests should enhance the validity of the survey approach.[8] We will also present a series of rationality tests of the survey responses as validity checks of the methodology.

If a respondent was indifferent in the initial choice presented in Figure 1, then the iterative choice process is complete, yielding a cost of living willingness to pay value for the illustrated choice of (\$300-\$100) / (60%-40%) = \$10 per 1 percent improvement in water quality. A choice of either alternative led to successive choices that terminated either at indifference or a narrowly bounded value estimate. Specifically, if we let C_i be the cost of living in region i, i=1,2; and let G_i be the percent of water in region i rated good, then the value V of water quality benefits is given by

$$V = (C_2 - C_1) / (G_2 - G_1).$$

[8] DeShazo and Fermo (2002) show that complex choice sets can pose difficulties with respect to respondents' ability to process the choices and give consistent responses.

Figure 2 displays the logic of the iterative choice questions. The program iterates choices, each time degrading the desirable aspect of the last alternative chosen until the selection reverses. For example, a respondent preferring the lower cost region on the initial question in Figure 1 then considers the same pairwise choice, except the cost of living in that region is raised. Continued preference for the lower cost region leads to continued increases in the cost of living in the chosen region until the respondent faces a dominated choice in which the regions have the same cost of living but differ only in terms of water quality. Similarly, continued preference for the higher quality region leads to continued reductions in the water quality of the chosen region until the regions have the same water quality but differ only in cost of living. This series of questions permits a bounded estimate value of water quality improvements for all respondents except for those at the corners of the decision tree. For these corner respondents, we analyze their results in two ways. First, for those respondents who choose the non-dominated region, we estimate the value as twice the maximum observed dollar value for water improvements for those with very high and halved it for those with very low values of water quality. Second, we used more appropriate econometric treatment for those respondents based on censored regression methods, as described in Section 3.

As another check of rationality, for respondents who reach a corner boundary of the tree indicating zero value for money or good water, the survey brings this decision to the respondent's attention, offers a chance to reconsider, and then inquires regarding the reason for their choice. The analysis deals with the 6% who indicated that they would still choose the dominated alternative or had no preference by dropping them from the initial analysis and by treating as non-respondents in the Heckman adjustment for selection bias.

The survey also ends with a number of additional sections, such as a brief series of demographic questions and whether the respondent had difficulty understanding any part of the survey.

This process of elaborate training before the choice questions is one we have used a similar formulation in a wide variety of other environmental risk contexts. We have found that with sufficient grounding, the tradeoff against cost of living can be well understood.[9] We deliberately framed the choice as one between regions similar to but abstracted from the region where the person now lives. This abstraction is one that we believe contributes to the stability, validity and actionability of the results. In terms of stability, not having to focus on a particular body of water conditioned on the location of one's home discourages inferences about one's particular circumstance that may or may not apply to a particular change in the percent of good water quality in a region. In terms of validity, the survey focuses on a free market choice that has minimal social consequences—whether one buys in region A or B primarily influences one's own utility. These market choices contrast with referenda where one's vote can affect the welfare of others, confounding the results with an array of conflicting forces including altruism, confidence in the efficacy government action, willingness to impose costs on others, and attitudes about taxation to fund such referenda. Finally, the results are actionable in helping to establish a general social metric for policy decisions across regions. The projected dollar value for changes in water quality can be related to general citizen characteristics such as age, income and education. These values can be applied using census data to evaluate a broad range of options that affect the quality of water.

Experimental conditions

[9] The first of these many studies is Magat, Viscusi, and Huber (1988).

In order to test the robustness of the results to different versions of the questionnaire, randomly identified groups received alternative versions. These tests permit an assessment of the effects of anchoring and the initial range of the alternatives in the initial trade off.

Our study tests for anchoring influence by manipulating the presence of an external norm for water quality. Approximately half the respondents received information that the national average of water quality was rated 65% Good, whereas the other respondents received no national information. Being told the US 65% value may increase the sensitivity to water quality, since there is now an anchor that helps respondents value of the water percent amounts provided.

Second, the value of a given change in percent good may itself be affected by the range of percent good and dollars in the initial choice. For example, if the first choice is between a gain of 20% good in return for $400 in cost of living (e.g., $20 for one percentage point), then respondents may reasonably use that information to assume that, say, $15 is a good price to pay for one percentage point gain. By contrast, if the initial choice pits a 20% gain against $200, ($10 per one percentage point), then the $15 seems relatively high. This inference is understandable if one takes the Gricean (1975) assumption that the initial choices provided in such questionnaires are reasonable. To test the impact of the initial range we altered the initial range in cost of living to be either $200, $300 or $500, and the range of the gain in percent good to be either 20, 30 or 40 percentage points. This test is whether the initial choice is appropriately sensitive to ranges, as required for appropriate sensitivity to scope.

3. Valuation of Water Quality Improvements

In reporting our results we first give the mean and distribution of our unit water quality benefit measure, the dollar value of a one percentage point change in water quality. Then, to validate the results, we regress these valuation measures against respondent characteristics to demonstrate that the kinds of respondents expected to have higher or lower valuations indeed have them. To show that these results are meaningful for policy, we demonstrate that the initial choice is appropriately sensitive to scope. That is, the choice of the region with better water quality increases with its advantage in percent good, and goes down with its disadvantage in cost of living.

Overall Benefit Values

The benefit value measures how much of an increase in the annual cost of living respondents are willing to incur for each percentage point improvement of water rated good. For each respondent, this value V is calculated at the point of indifference between two regions or the average V where a finite bound can be estimated. The mean value of V for a 1 percent improvement in water quality is $23.17 per year, with a standard error of the mean of 0.79, based on 1,103 respondents.[10] The median water quality benefit value V is $15, which indicates that the benefit distribution is skewed with a large upper right tail. It is reassuring to note that these summary statistics correspond well to a mean of $22.40 and median of $12 reported by Magat et al. (2000).

There was a substantial variability in water quality values across people. Respondents at the 25th percentile registered a value of $6.25 per unit improvement in water quality, as compared to $15 at the median and $30 at the 75th percentile. The disparity between the valuation at the 10th percentile value of $1.92 and the 90th percentile value of $75 indicates substantial heterogeneity in the value respondents place on clean lakes, rivers, and streams.

Validity Tests

[10] Carson and Mitchell (1993) examined willingness to pay for national water quality and estimated that people would pay $242 in 1990 dollars (or $315 in 2003 dollars) annually to improve from a baseline of non-boatable to nationally swimmable.

Two validity tests provide evidence of the meaningfulness of the estimated water quality values. The first test requires that the individual estimates of water quality value differ across respondents in ways predicted by economic theory. The second validity assessment is an across person test requiring respondents to be sensitive to the scope of differences in cost of living and water quality provided.

Consider first the relationship between generated values and respondent characteristics. The Magat *et al.* (2000) survey found very weak relationships between valuations and demographic characteristics. The current results are far more substantial, perhaps due to a sample almost three times as large and because of better survey implementation. The dependent variable for analysis is the log of respondent's unit water quality benefit value, V. The log transformation is used because it has the effect of making the right-skewed distribution of V approximately normal.

Table 1 presents two sets of regression results for the log value of V, the unit value of water quality. The first column presents the OLS estimates, while the second column of results presents the censored Tobit regressions. Survey respondents consistently choose the low priced or high quality option eventually reach or the corner maxima or minima in the iterative choices shown in Figure 2. The censored regression in effect combines the information from the respondents who hit the upper or lower limits with conventional regression results for the bounded respondents. Thus, the censored regression coefficients makes the best prediction taking into account the fact that the survey truncates the distribution of possible responses at both the high and low end of the distribution of water quality values. The Tobit estimates in Table 1 are remarkably similar to the OLS estimates.

The statistically significant explanatory variables all have coefficients that one would expect. The coefficient of .17 for log income indicates that water quality is a normal good, with valuations increasing by 17% for a doubling in income. Individual education is likely to be a proxy for lifetime wealth. Better educated respondents exhibit a higher value for good water quality, controlling for current income levels and personal characteristics. Older respondents likewise indicate a higher valuation of water quality that is consistent with life cycle changes in wealth.

Two variables that should reflect whether a respondent is likely to have particularly strong preferences for good water quality are whether the respondent is a member of an environmental organization or has visited a lake or river in the last 12 months.[11] The coefficients of the environmental group membership and environmental activities variables were almost identical in magnitude, with each increasing the value of water quality by around 28%. The significant positive influence on benefit values of visits to lakes and rivers accords with previous research by Cameron and Englin (1997) showing that respondent experience with the good being valued raises the valuation amounts. After accounting for the influence of the environmental variables and demographic effect such as income and education, variables pertaining to region, race, and gender were not significant on an individual basis.

Whether the respondent was told the percentage of water in the country rated good did not have a statistically significant effect on valuations. The sub-sample that was given information pertaining to this possible anchor exhibited no difference in their valuation amounts. This result indicates that the respondents focused on the difference between the alternatives in the choice set, rather than on the presence of an external reference point.

[11] The particular environmental organizations listed in the survey for possible membership were the following: Environmental Defense Fund, Greenpeace, National Audabon Society, National Wildlife Federation, Nature Conservancy, Natural Resources Defense Council, and Sierra Club.

External Scope Tests

The second validity assessment is an external scope test. The scope test is important in establishing context that the estimates of V were a meaningful quantitative, valuation metric.[12] If respondents are willing to incur the same cost of living increase for a 20 percentage point change in water quality as a 40 percentage point change, then all one is measuring is a general attitude towards water quality over cost of living, such as "warm glow" effects. The test we report is across respondents, a stronger test than a within subject test.

This test is possible because we altered the initial range of water quality ranges and the cost of living across respondents. In particular, one of the alternatives in the initial choice was either 20, 30, or 40 percentage points in good water quality higher than the other, and the difference in cost of living was either $200, $300 or $400 per year.[13] To demonstrate appropriate sensitivity to the scope of the choice, respondents' initial choices should favor the region with higher water quality when its gain in water quality is greater. Similarly, respondents should favor the region with lower cost of living when its gain in living expense is greater. Table 2 displays a logistic regression predicting initial choice as a function of initial ranges and the demographic variables used to predict the final valuation amounts for the regressions in Table 1. The variables pertaining to each of the scope tests are significant and in the expected direction. Increasing the water quality difference or decreasing the cost of living difference makes one more likely to choose the alternative with higher water quality. Further, the characteristics that predict the initial choice for the regressions in Table 2 parallel those predicting the final tradeoff reflected in the regressions in Table 1, with choice of the high water quality option increasing

[12] For a detailed review of scope tests and the ability of contingent valuation studies to pass scope tests, see Smith and Osborne (1996).
[13] We also altered the average levels of water quality to see if response depended on these. Those analyses are available on a working paper: "Coping with the Contingency of Valuation: Range and Anchoring Effects in Choice Valuation Experiments," Huber, Viscusi and Bell (2004).

with age, income, education and the environmental preference variables such as visits to lakes and rivers or membership in environmental organizations.

4. Evaluation of the Panel Sample

Sample Characteristics

The sample used for the study came from the Knowledge Networks (Menlo Park, CA, www.knowledgenetworks.com) panel. Researchers on environmental benefits valuations have increased their use of internet panels, so that the performance of this survey approach has broad implications beyond our particular study.[14] The Knowledge Networks sample consists of a national sample of households recruited by random-digit dialing, who either have been provided internet access through their own computer or are given a WebTV console. The underlying Knowledge Networks sample has been selected to be broadly representative of the U.S. population.[15]

Table 3 compares the sample characteristics of those who completed the survey and with the 2001 U.S. adult population. The survey population closely mirrors the U.S. Census distribution. One might have hypothesized that people willing to be surveyed would be better educated, underrepresented at the extremes of income, and younger than the general population. However, there are no major discrepancies between the sample mix for our study and the population. While some differences are statistically significant, including the percentage of respondents age 64 and over and the representation of some income groups, these differences are not consequential. For example, 11 percent of the sample is age 64-74 compared to a national average 9 percent, and 21.1 percent of the sample have household income in the $50,000-

[14] Other researchers using the Knowledge Networks sample have included Krupnick et al. (2002), Berrens et al. (2004), and DeShazo and Cameron (2004).
[15] Ongoing research by Trudy Cameron and J.R. De Shazo has examined the representativeness of this sample and has developed a selection correction to account for differences from U.S. Census averages.

$74,999 range, as compared to the national average of 18.9 percent. Differences such as these are to be expected, both because of the stochastic nature of the sampling process as well as the fact that there is not an exact match up for the 2001 Census time period and the more recent sampling period. Overall, the sample tracks the U.S. population remarkably well.

<u>Sample Validity Tests</u>

Because the survey was administered via the internet using an existing panel of respondents, we undertook a series of validity tests specifically determining whether their panel membership influenced the valuation results. To the best of our knowledge, these are the first such tests to have been undertaken for this sampling methodology. We tested the panel influences of four variables on the regression analysis of the determinants of the value of water quality benefits. Table 4 reports these regression results in which these panel variables first are added to our earlier analysis shown in Table 1 and then are included without these variables.

The first variable is whether the respondent stopped the survey and then continued the survey at a later time. Conceivably, such respondents might be less engaged in the survey task. However, there was no significant effect of this variable on benefit values.

The second variable of interest is the time the respondent has been a member of the Knowledge Network panel. Length of time in the panel may affect attentiveness to surveys and potentially could be correlated with other personal characteristics that influence water quality valuations. The estimates in Table 4 fail to indicate any significant influence of this variable either.

Third, the number of days the respondent took to complete the survey after being offered the opportunity to participate could reflect a lack of interest in the survey topic or in taking surveys generally. Nevertheless, there is no significant effect of this variable on benefit valuations in either of the equations estimated in Table 4

The final survey methodology variable tested is whether the respondent subsequently quit the panel either immediately after the invitation for this survey or at any later time until May 2004, when data for this variable were collected. Such respondents could be less interested in taking surveys and might have different valuations. However, this variable was also not statistically significant in the water quality valuation equations.

Overall, there is no indication that any of these key aspects of the panel methodology bias the survey responses. In addition to the general match of our respondents to the U.S. population, we also examined whether these four variables reflecting the methodology had any influence on the probability that the respondent failed to pass the consistency test with respect to the benefit valuations. There were no significant effects of any of the Knowledge Networks panel variables so that there is no evidence that national performance of the survey task is importantly influenced by any of these variables.

Selection Effects

Although the sample is nationally representative and had a high overall response rate, it is useful to test for possible selection biases arising from panel members who were invited to participate but did not successfully complete the survey. Of 1,587 panel members invited to take the survey, 74% of respondents chose to participate. Of the 1,174 participants, three respondents did not complete the portion of the survey that elicits water quality value. Finally, 6% of participants completed the survey but were dropped because they chose the dominated alternative and continued with that choice even after being so informed. Therefore, 1,103 of 1,587 invitees consistently completed the water quality valuation portion of the survey. For the selection correction for bias, we used variables for which we had the values for non-respondents as well as survey respondents. This data is routinely collected by Knowledge Networks on its panel members. Thus, an additional advantage of such panels is that there is information available to analyze who chose not to take the survey after being offered the chance to do so.

To predict participation, we identified a number of variables that significantly affected survey completion. In particular, we found that being African American or Hispanic was negatively associated with completing the survey, as was household size. We also constructed two health-related stress dummy variables. The first stress variable was for individuals who reported that they had a high stress level. The high stress variable indicated respondents who reported more "stress, strain, or pressure" than usual "during the past few months." The second stress variable was for people who failed to respond to the stress information question. Each of these variables was negatively related to the probability of taking the survey but not significantly related to the water quality valuation amount V, thus achieving the appropriate identification.

Table 5 reports the selection equation and the selection-corrected regression of the log value of water quality. The threshold empirical issue is whether there are any statistically significant selection effects. As the chi-squared statistic reported at the bottom of Table 5 indicates, one cannot reject the hypothesis that there is no significant effect of sample selection on our empirical estimates. Thus, the empirical estimates are not biased in any statistically significant way by the self-selection of respondents in the Knowledge Networks sample who chose to complete the survey and did so successfully.

Given this absence of statistically significant selection effects, it is not surprising that the selection-corrected estimates closely parallel our earlier estimates. Water quality values increase with income levels, age, and education, as before. The race variable has become significant, but this effect may have been due in part to the omission of the environmental group membership and water recreation use variables from the equation, since they were not available for non-respondents.

Similar stability in the results is implied by an examination of the extent to which the estimates of the dollar value of water quality changes with the selection adjustment. Using the parameter estimates of the selection-corrected regression, we estimated the log value of a one percent improvement in water quality. The average log value then decreased by 4.5% and the antilog by 11.1% compared to corresponding estimates using parameters from the ordinary least squares regression. These differences are well within sample variability and thus are not statistically significant. More important, these results indicate that the estimates are not substantively different even after careful adjustment for sample selection.

5. Conclusions

The survey results presented here passed a variety of consistency tests and rationality checks. These tests included dominance tests as part of the iterative choice process and external scope tests across respondents. In addition, the internet-based methodology itself was tested with respect to a variety of potential sources of bias, such as sample attrition, and these panel characteristics had no significant effect on the results.

It is appropriate to speculate on why these results are much stronger than those reported in Magat et al. (1988). The earlier study produced similar aggregate values, but the covariates with water quality value were largely insignificant, and a scope test was not even attempted. The Magat et al (1988) study had less than half the number of respondents, but the main differences are methodological. In the current study, greater effort was placed on preparing the respondent to make the trade-off between water quality and cost of living. Three warm up questions involving dominated choices provided easy ways to understand the choice task, and for the relatively low percent of respondents who ‘failed’ those questions, provided a way to communicate the importance of their answers.

Working with a panel had several advantages. First, since our survey design involved the use of a computer-based sample, the Knowledge Networks panel yielded a more representative sample of survey participants than other survey methods such as those used by Magat et al. (2000) in which a group of subjects contacted by phone came to a central location to take the survey. Second, respondents in the panel are accustomed to taking surveys, so they are not confused by the process. Third, and most important, because there are data on those who declined to take the survey, it is possible to estimate the impact of that self-selection on our results. In this case, that self-selection had minimal effect on our estimates. However, that result strictly applies only to our focal question about the value of water quality. The real value of panels is that they contain the information that permits an assessment of the impact of respondent selection mechanism that will certainly be an even greater problem in the future.

The practical benefit of these results is that they provide unit water quality benefit values that can be matched to existing EPA measures of water quality to provide an assessment of benefits of water quality programs. Good water quality has a unit value of $23 per percentage point increase in water quality. This value is dependent on variables such as income, education, and personal use of lakes and rivers in the expected fashion. To value water quality improvements, one can use these values in conjunction with results that break down the benefits in terms of benefits for the components of water quality—fishing, swimming, and health of the aquatic environment— to gauge the economic benefit of an improvement project to the affected local population.

References

Berkman, Richard and W. Kip Viscusi. (1973). *Damming the West*. New York: Grossman Publishers.

Berrens, Robert P., Alok K. Bohara, Hank C. Jenkins-Smith, Carol L. Silva, and David L. Weimer. (2004). "Information and Effort in Contingent Valuation Surveys: Application to Global Climate Change Using National Internet Samples," *Journal of Environmental Economics and Management*, 47(2), 331-363.

Bishop, Richard C. and Michael P. Welsh. (1992). "Existence Values in Benefit-Cost Analysis and Damage Assessment," *Land Economics*, 68(4), 405-417.

Bishop, Richard C. and Thomas A. Heberlein. (1990). "The Contingent Valuation Method." In Rebecca L. Johnson and Gary V. Johnson (eds.), *Economic Valuation of Natural Resources: Issues, Theory, and Applications.* Social Behavior and Natural Resources Series. Boulder: Westview Press.

Cameron, Trudy, and Jeffrey Englin. (1997). "Respondent Experience and Contingent Valuation of Environmental Goods," *Journal of Environmental Economics and Management*, 33(3), 296-313.

Carson, Richard T. and Mitchell, Robert Cameron. (1993). "The Value of Clean Water: The Public's Willingness to Pay for Boatable, Fishable, and Swimmable Quality Water," *Water Resources Research*, 29(7), 2445-2454.

DeShazo, J.R., and German Fermo. (2002). "Designing Choice Sets for Stated Preference Methods: The Effects of Complexity on Choice Consistency," *Journal of Environmental Economics and Management*, 44(1), 123-143.

DeShazo, J.R., and Trudy Cameron. (2004). "Moving Beyond the Value of a Statistical Life: A New Theoretical and Empirical Analysis." Paper presented at 2004 AEA meetings.

Fischhoff, Baruch and Lita Furby. (1988). "Measuring Values: A Conceptual Framework for Interpreting Transactions with Special Reference to Contingent Valuation of Visibility," *Journal of Risk and Uncertainty*, 1(2), 147-184.

Grice, H.P. (1975) "Logic and Conversation" In PCole and J.P. Forgas (eds.) *Syntax and Semantics: 3. Speech Acts (*p. 41-58*),* New York, Academic Press.

Huber, Joel, W. Kip Viscusi, and Jason B. Bell. (2004). "Coping with the Contingency of Valuation: Range and Anchoring Effects in Choice Valuation Experiments," Working Paper, Fuqua School of Business, Duke University.

Kahneman, Daniel and Amos Tveski (1979) "Prospect Theory: An Analysis of Decision under Risk," *Econometrica, 47*, 263-291.

Krupnick, Alan, Anna Alberini, Maureen Cropper, Nathalie Simon, Bernie O'Brien, Ron Goeree, and Martin Heintzelman. (2002). "Age, Health and Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Survey of Ontario Residents," *Journal of Risk and Uncertainty*, 24(2), 161-186.

Magat, Wesley A., Joel Huber, W. Kip Viscusi, and Jason Bell. (2000). "An Iterative Choice Approach to Valuing Clean Lakes, Rivers and Streams." *Journal of Risk and Uncertainty*, 21:1, 7-43.

Magat, Wesley A., W. Kip Viscusi, and Joel Huber. (1988). "Paired Comparison and Contingent Valuation Approaches to Morbidity Risk Valuation," *Journal of Environmental Economics and Management*, 15, 395-411.

Mitchell, Robert Cameron and Richard T. Carson. (1989). *Using Surveys to Value Public Goods: The Contingent Valuation Method*. Washington: Resources for the Future.

Schkade, David A. and John W. Payne. (1993). "Where Do the Numbers Come from? How People Respond to Contingent Valuation Questions." In Jerry A. Hausman (ed.), *Contingent Valuation: A Critical Assessment*. New York: North-Holland, 271-293.

Smith, V. Kerry, and William H. Desvousges. (1986). *Measuring Water Quality Benefits*. Boston: Kluwer Academic Publishers.

Smith, V. Kerry, and Laura L. Osborne. (1996). "Do Contingent Valuation Estimates Pass a 'Scope' Test? A Meta-Analysis," *Journal of Environmental Economics and Management*, 31(3), 287-301.

United States Environmental Protection Agency. (1994). *National Water Quality Inventory, 1992 Report to Congress*, EPA 841-R-94-001.

Figure 1
Sample Private Water Quality Benefit Question

We would like to ask you some more questions like these. However, in these questions, one region will have a lower annual cost of living and the other will have higher water quality. **Remember that the national average for water quality is 65% Good.**			
	Region 1	Region 2	
Increase in Annual Cost Of Living	**$100** More Expensive	**$300** More Expensive	
Percent of Lake Acres and River Miles With Good Water Quality	**40%** Good Water Quality	**60%** Good Water Quality	
Which Region Would you Prefer?	Region 1 *	Region 2 *	No Preference *

Figure 2
Survey Decision Tree

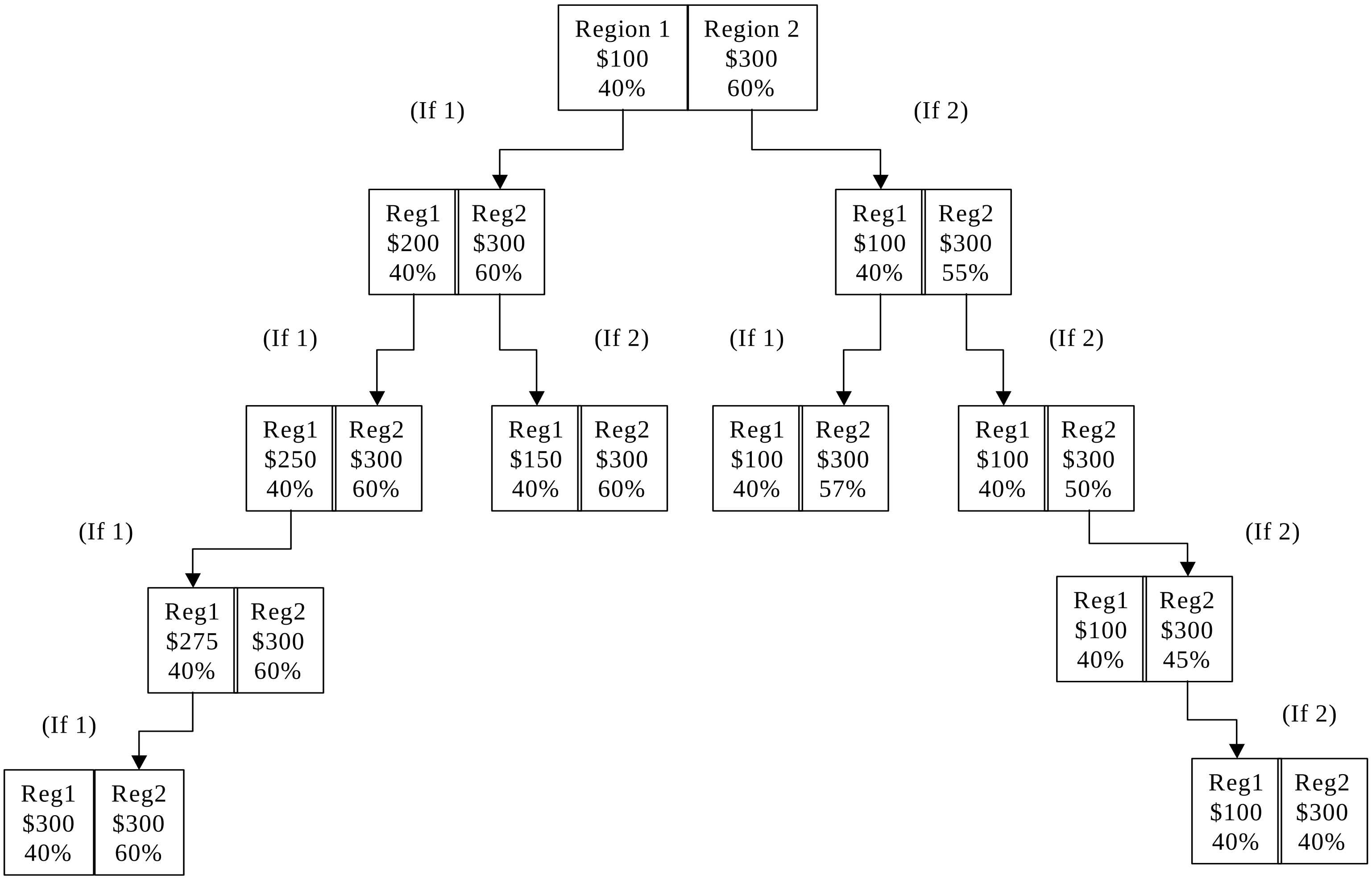

Table 1
Regression Estimates for Log of Unit Water Quality Benefit Value

	Log (Unit Value for Good Water Quality)			
	OLS		Censored	
Variable	Coefficient	Standard Error	Coefficient	Standard Error
Log (Income)	0.1668***	0.0480	0.1687***	0.0484
Years of education	0.0409***	0.0151	0.0423***	0.0153
Age	0.0115***	0.0023	0.0119***	0.0023
Environmental organization membership	0.2843	0.1734	0.3140*	0.1773
Visited a lake or river, last 12 months	0.2822***	0.0778	0.2839***	0.0784
Told national water quality	0.0966	0.0728	0.0955	0.0734
Race: Black	-0.1403	0.1109	-0.1404	0.1117
Race: Non-black, Non-white	-0.0661	0.1637	-0.0844	0.1642
Hispanic	0.1415	0.1223	0.1325	0.1232
Gender: Female	0.0166	0.0727	0.0169	0.0733
Household size	-0.0093	0.0291	-0.0099	0.0293
Region: Northeast	-0.0271	0.1126	-0.0333	0.1134
Region: South	-0.0765	0.0955	-0.0814	0.0962
Region: West	-0.0997	0.1096	-0.0980	0.1107
Intercept	-0.4646	0.5243	-0.5031	0.5282
Adjusted R^2	0.0614		0.0251	

Notes: * significant at the .10 level, ** significant at the .05 level, *** significant at the .01 level, all two-tailed tests.

Table 2
Scope Test: Demonstrating the Impact of
Water Quality and Cost of Living Range on Initial Choice

	Respondent Chose the Higher Water Quality Region in First Choice	
Variable	Coefficient	Standard Error
Logistic Regression		
Initial Cost of Living Range	-0.00161**	0.00072
Initial Water Quality Range	0.0180**	0.00751
Log (Income)	0.2904***	0.0847
Years of education	0.0620**	0.0269
Age	0.0196***	0.00404
Environmental organization membership	0.6427**	0.3420
Visited a lake or river, last 12 months	0.4445***	0.1357
Told national water quality	0.0642	0.1338
Race: Black	-0.0249	0.1933
Race: Non-black, Non-white	-0.1145	0.2846
Hispanic	0.2827	0.2154
Gender: Female	0.0574	0.1277
Household size	-0.0543	0.0508
Region: Northeast	0.0322	0.1999
Region: South	-0.1125	0.1679
Region: West	-0.1526	0.1927
Intercept	-4.6635***	0.9745
	c = 0.654	

Notes: * significant at the .10 level, ** significant at the .05 level, *** significant at the .01 level, all two-tailed tests.

Table 3
Comparison of Knowledge Networks Sample to the National Adult Population[1]

Demographic Variable	Survey Participants Percent	US Adult Population Percent
Employment Status (16 years or older)		
Employed	65.1	66.9
Age		
18-24	13.1	13.0
25-34	19.1	18.8
35-44	20.2	21.2
45-54	19.1	18.5
55-64	12.2	11.9
64-74	11.0*	8.6
75+	5.4*	7.9
Educational Attainment		
Less than HS	17.0	15.9
HS Diploma or higher	60.0	58.5
Bachelor or higher	23.0*	25.6
Race / Ethnicity		
White	81.5	82.3
Black/African-American	13.1	11.8
American Indian or Alaska Native	1.0	0.9
Asian/Pacific Islander	3.1*	4.1
Other	1.3	1.0
Race / Ethnicity of Household		
Hispanic	11.1	11.4
Gender		
Male	51.0	48.3
Female	49.0	51.7
Marital Status (2000)		
Married	61.4	59.5
Single (never married)	23.5	23.9
Divorced	9.0	9.8
Widowed	4.1*	6.8
Household Income (2000)		
Less than $15,000	13.2*	16.0
$15,000 to $24,999	11.3	13.4

$25,000 to $34,999	13.4	12.5
$35,000 to $49,999	18.9*	15.5
$50,000 to $74,999	21.1*	18.9
$75,000 or more	22.2	23.8

Statistical Abstract of the United States, 2002. 2001 adult population (18 years+), unless otherwise noted.
* The 95% Confidence Interval for survey participants does not include mean adult US population for this demographic variable.

Table 4
Validity Tests Based on Censored Regression of Log of Unit Water Quality Benefit Values

	Log (Unit Value for Good Water Quality)			
Variable	Coefficient	Standard Error	Coefficient	Standard Error
Log (Income)	0.1710***	0.0487	--	--
Years of education	0.0421***	0.0153	--	--
Age	0.0119***	0.0024	--	--
Environmental organization membership	0.3165*	0.1776	--	--
Visited a lake or river, last 12 months	0.2787***	0.0787	--	--
Told national water quality	0.0966	0.0736	--	--
Race: Black	-0.1362	0.1129	--	--
Race: Non-black, Non-white	-0.0876	0.1643	--	--
Hispanic	0.1326	0.1237	--	--
Gender: Female	0.0150	0.0734	--	--
Household size	-0.0086	0.0295	--	--
Region: Northeast	-0.0381	0.11406	--	--
Region: South	-0.0873	0.0971	--	--
Region: West	-0.1024	0.1119	--	--
Respondent stopped and continued survey later	-0.006	0.1467	0.0233	0.1517
Time as panel member, in months	-0.0021	0.0032	0.0023	0.0032
Days from invitation to completion	-0.0013	0.0023	-0.0039	0.0024
Has panel member quit panel	-0.0131	0.0789	-0.1006	0.0803
Intercept	-0.4561	0.5326	2.5538***	0.0950
Adjusted R^2	0.0254		0.0017	

Notes: * significant at the .10 level, ** significant at the .05 level, *** significant at the .01 level, all two-tailed tests.

Table 5
Log Unit Water Quality Value Regression Results Controlling for Selection Effects

Variable	Coefficient	Standard Error
Regression Model for Log of Value		
Log (Income)	0.1701***	0.0480
Years of education	0.0447***	0.0150
Age	0.0122***	0.0023
Race: Black	-0.2391**	0.1119
Race: Non-black, Non-white	-0.0919	0.1637
Hispanic	0.0446	0.1241
Gender: Female	0.0106	0.0727
Household size	-0.0195	0.0303
Region: Northeast	-0.0561	0.1124
Region: South	-0.1059	0.0951
Region: West	-0.1297	0.1094
Intercept	-0.3666	0.5243
Participation Equation		
High Stress level	-0.1929***	0.0749
Stress Data Unavailable	-1.4668***	0.1133
Race: Black	-0.2364**	0.0968
Hispanic	-0.3511***	0.1013
Household size	-0.1178***	0.0246
Intercept	1.2453***	0.0930

LR test of indep. eqns. (rho = 0): chi2(1) = 2.46 Prob > chi2 = 0.1164

Notes: * significant at the .10 level, ** significant at the .05 level, *** significant at the .01 level, all two-tailed tests.