Protest Adjustments in the Valuation of Watershed Restoration Using Payment Card Data

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When using a willingness-to-pay (WTP) format in contingent valuation (CV) to value watershed restoration, respondents may protest by questioning why they should pay to clean up a pollution problem that someone else created. Using a sample selection interval data model based on Bhat (1994) and Brox, Kumar, and Stollery (2003), we found that the decision to protest and WTP values were correlated. Protest sample selection bias resulted in a 300 percent overestimate of mean WTP per respondent. Using different ad hoc treatments of protesters, protest bias resulted in moderate effects (-10 percent to +14 percent) after controlling for sample selection bias.

Key Words: contingent valuation, protest bias, watershed restoration, sample selection, grouped Tobit

Despite decades of efforts, pollution of surface waters remains a serious problem in the United States. The U.S. Environmental Protection Agency estimates that 39 percent of rivers are polluted, mainly as a result of non-point pollution (U.S. EPA 2002). In order to address non-point pollution, federal and state governments have devoted substantial resources towards planning and management to restore damaged watersheds with Total Maximum Daily Load (TMDL) studies and implementation plans[1] (Houck 1999).

Valuing the restoration of damaged watersheds is an essential element of this effort in providing meaningful monetary benefit estimates for cost-benefit analysis. Monetary benefit estimates also provide additional motivation for implementation of restoration efforts by identifying restoration priorities among degraded water bodies based on people's preferences.

Contingent valuation (CV) is a commonly used method to assess total economic value, particularly passive use values (Carson, Flores, and Meade 2001). However, valuing watershed restoration creates potential problems for CV. Due to an existing pollution problem, there are usually current and/or former entities that can be identified as being responsible for causing this pollution. Attempting to place a monetary value on restoration is complicated by the general public's knowledge that others created the existing pollution problem. Under a willingness-to-pay (WTP) format, protest responses in the form of a zero response or a unit non-response may become prevalent among respondents due to the following fairness consideration: "Why should I pay to clean up a problem that someone else created?" This perception of unfairness creates a negative attitude towards paying for restoration (Jorgensen and Syme 2000).

There are several possible approaches to dealing with anticipated CV protest responses for watershed restoration. A willingness-to-accept (WTA) approach could be used in the CV question to value a restored condition relative to the current degraded condition. This approach to CV, however, results in large valuation differences com-

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[1] Acting under Clean Water Act authority, state governments develop TMDLs as written plans that specify the maximum amount of pollution that an impaired water body can receive and still meet water quality standards (U.S. EPA 2005).

pared to WTP approaches (Horowitz and McConnell 2002, Brookshire and Coursey 1987). Furthermore, WTA is not a recommended approach to CV (Arrow et al. 1993). Alternatively, a WTP approach could be used with a CV market scenario that describes water quality improvements in the abstract, devoid of a reference watershed. From our experience, these abstractions are less meaningful to respondents in answering a CV question. From a policy making perspective, abstract scenarios also provide less useful information for decision making as monetary values may be less applicable to any actual watershed restoration case.

The final approach is to utilize CV with an actual scenario involving pre-existing pollution levels in a degraded watershed, then to identify and adjust WTP estimates for restoration to account for protest "zero" responses. As noted in the literature, clean-up of existing pollution can generate high percentages (33 percent to 50 percent) of zero responses among respondents (Lindsey 1994, Jorgensen et al. 1999). The literature on CV protests has been dominated by identification of protesters in the data (Halstead, Luloff, and Stevens 1992, Lindsey 1994), respondent reaction to the format of CV questions (Morrison, Blamey, and Bennett 2000), and determination of the attitudes and beliefs that underlie protesting (Laughland, Musser, and Musser 1994, Jorgensen et al. 1999, Jorgensen and Syme 2000). Recently, Meyerhoff and Liebe (2006) have shown that protest attitudes and beliefs extend even to respondents who express positive WTP values. Jorgensen and Syme (2000) found common linkages among different reasons for protesting and concluded that the same negative attitudes toward paying existed across payment vehicles, payment regimes, and institutions presented in CV questions for all protesters. Morrison, Blamey, and Bennett (2000) found no difference in protest rates across payment vehicles.

The total economic value results obtained from a CV study can be dependent on how protest responses are utilized in the analysis (Desvousges, Smith, and Fisher 1987, Lindsey 1994). However, adjusting WTP for protest responses has been dominated by ad hoc procedures (see Halstead, Luloff, and Stevens 1992 and Jorgensen et al. 1999 for examples). Jorgensen et al. (1999) note that published CV studies are commonly vague about the criteria used to assess protesters. Some authors have argued that treatment of protest responses should depend on whether a CV study is being used to assess political referendum results or for valuation of a non-market good (Lindsey 1994, Epp and Delavan 2001).

When the objective of CV is valuation, the common practice is to eliminate protest responses (for example, see Carson and Mitchell 1993) or to provide no description of how protesters were incorporated (Taylor and Douglas 1999 and Brox, Kumar, and Stollery 2003 are examples). As described by Jorgensen and Syme (2000), censoring protests will mostly likely bias the sample relative to the general population.[2] Censoring also results in a loss of potentially useful information by introducing the possibility of self-selection bias (Halstead, Luloff, and Stevens 1992). Jorgensen and Syme (2000) question the justification for the censoring of any protest responses from the data set.

To avoid the biases presented by elimination, a number of studies have included protest responses using the Heckman two-step method (Desvousges, Smith, and Fisher 1987, Whitehead, Groothuis, and Blomquist 1993, Messonnier et al. 2000). Strazzera et al. (2003a) utilized a mixture model with sample selection that accounts for both true and protest zeroes in estimation. Strazzera et al. (2003b) recommended that analysts employ both the two-step method and a full information maximum likelihood (FIML) sample selection model. The FIML model incorporates protest responses into estimation via a two-equation system where respondents jointly decide on valuation and participation in the survey. Estimates from the FIML model are preferred if there is statistically significant correlation between error terms of both equations.

The objective of this research is to investigate the use of an FIML sample selection model with payment card data for incorporating protest responses into WTP estimation. This methodology is similar to the FIML utilized in Strazzera et al. (2003b) for a continuous dependent variable. However, we extend an FIML sample selection model developed by Bhat (1994) for imputing missing

[2] No bias exists when the censored protests are independent of the WTP question format, the distribution of legitimate zero responses, explanatory variables to the valuation process, and the WTP response (Jorgensen and Syme 2000).

values by applying it to interval data from payment cards. In our study, protesters are defined as respondents who state a zero WTP for watershed restoration, yet may possess a positive WTP when they refuse to contribute because they believe that either someone else should pay or that adequate funds can't be raised to restore the watershed. Using an FIML sample selection model, non-zero WTP values can be estimated for protesters based on their characteristics, attitudes, and/or knowledge and use of a water resource being similar to those respondents with a positive WTP. While subjective judgment is still required to identify protesters, this model allows WTP estimates to incorporate protest response data.

This method is applied to survey data collected on the degraded Cheat River watershed in West Virginia. We find sample selection bias to be of significant concern for valid WTP estimates among respondents with WTP greater than zero. Average protester WTP was positive but lower than the average among respondents with WTP greater than zero. Given these results, different ad hoc treatments of protest respondents would result in biased estimates—the direction of bias depending upon how protesters are treated in the analysis. Assigning protest respondents the sample's average WTP leads to an overestimate of welfare, while assigning them no value ($0) leads to an underestimate of welfare.

Model and Estimation Methodology

The demand-theoretic basis for CV has been well established (Freeman 2003). For watershed restoration, true WTP (W^*) can be defined in observable terms as

$$Y_0 - Y^*[p, E_1, v(p, E_0, Y_0)], \qquad (1)$$

where E_0 and E_1 represent degraded and restored conditions of the watershed, Y_0 is initial income, p is a price vector, and $Y^*[]$ is an expenditure function with an indirect utility function substituted for maximized utility (U^*). W^* will be positive unless the additional utility from improvements in E is zero or E does not appear in the individual's utility function (Brox, Kumar, and Stollery 2003).

We postulated the following relationship between W^* and stated WTP ($W^\#$):

$$W_i^\# = (W_i^*) \times R_i, \qquad (2)$$

where R_i is the propensity-to-reveal value by the ith respondent for watershed restoration. There are three possible circumstances when $W_i^\#$ is zero: (i) $W_i^* = 0$, (ii) $R_i = 0$, or (iii) $W_i^* = 0$ and $R_i = 0$. In order to decipher protesting behavior, we will confine model estimation to include only those respondents with $W_i^* > 0$. Thus, for responses of $W_i^\# = 0$, only respondents under circumstance (ii) are included in the model. Typically, R_i would range from zero for those respondents who chose to protest the CV question to one for participant (non-protest) responses.[3] Protest motivations can vary widely from ethical concerns to objections about the survey instrument. In the case of watershed restoration, we assumed that respondents make a decision whether or not to reveal their restoration value primarily based upon their evaluation of the fairness of paying to correct an existing pollution problem created by others (Jorgenson et al. 1999).

When presented with a CV question in a WTP format using a payment card approach, respondents' reactions based on equation (2) were modeled as a two-step decision making process following a procedure described by Brox, Kumar, and Stollery (2003). The first step is whether or not to reveal one's true value for restoration, W_i^*. When W_i^* is greater than zero, declaring a protest zero response to the CV question (i.e., $R_i = 0$) involves a decision to assign restoration responsibility to those who created the problem. If a respondent chooses to fully reveal her or his true value (i.e., $R_i = 1$), the second decision involves a determination of where one's true WTP is located within the payment card categories. To fully account for correlation between these two decisions, reduced-form simultaneous equations were created following Bhat (1994):

$$R_i^* = \beta_R' Z_i + \varepsilon_{Ri}, \qquad (3)$$

[3] When R_i is positive and less than one, respondents with $W^\# > 0$ have protest beliefs, as found by Meyerhoff and Liebe (2006). R_i can be greater than one when an individual replies with either hypothetical or strategic bias by inflating her or his W^* response. Conversely, R_i can be negative if the respondent believes clean watersheds constitute a "right" and she or he is allowed to express a willingness to accept payment for the degradation that has occurred.

where $R_i = 1$ if $R_i^* > 0$ and $R_i = 0$ if $R_i^* \leq 0$, and

$$(4) \qquad W_i^* = \beta_W^{'} X_i + \varepsilon_{Wi},$$

where $W_i = j$ if $a_j \leq W_i^* < a_{j+1}$.

R_i^* represents the unobserved continuous propensity-to-reveal variable explained by a vector of exogenous variables Z_i, and R_i is the observed actions of individuals responding ($R_i = 1$) or protesting ($R_i = 0$). Equation (3) is a sample selection between protesters and respondents with a WTP greater than zero. Respondents with $W_i^* = 0$ were excluded from model estimation.[4] W_i^* represents the unobserved, true WTP as determined by a vector of exogenous variables X_i.[5] Presented with a payment card, each ith respondent with a WTP greater than zero will choose among the j categories such that the response given (the a_j category) is at least as great as her or his W_i^* but strictly less than the a_{j+1} category. The error terms ε_{Ri} and ε_{Wi} were assumed to be random and jointly distributed for each individual i as bivariate normal with a cross-equation correlation coefficient of ρ. A positive ρ indicates that, conditional on X, respondents are more likely to reveal their WTP when W_i^* increases, while a negative ρ has the opposite implication (Strazzera et al. 2003b).

Based upon a likelihood function (shown in Appendix A) to derive the unknown coefficient vectors (β), estimated true WTP ($\hat{W}_i^*$) for respondents with a WTP greater than zero and protesters, respectively, can be written as

$$(5) \qquad \hat{W}_i^* \Big| (Z_i, X_i, R_i = 1, W_i = j) = \hat{\beta}_W^{'} X_i + \hat{\sigma}_W \frac{\begin{bmatrix} \varphi(k)\Phi(g) - \varphi(m)\Phi(h) \\ +\hat{\rho}\varphi(-\hat{\beta}_R^{'} Z_i)[\Phi(s) - \Phi(r)] \end{bmatrix}}{\begin{bmatrix} \Phi_2(\hat{\beta}_R^{'} Z_i, m, -\hat{\rho}) \\ -\Phi_2(\hat{\beta}_R^{'} Z_i, k, -\hat{\rho}) \end{bmatrix}}$$

$$(6) \qquad \hat{W}_i^* \Big| (Z_i, X_i, R_i = 0) = \hat{\beta}_W^{'} X_i - \hat{\rho}\hat{\sigma}_W \left(\frac{\varphi(\hat{\beta}_R^{'} Z_i)}{1 - \Phi(\hat{\beta}_R^{'} Z_i)} \right),$$

where φ is the normal probability density function, and Φ and Φ_2 are cumulative distribution functions of univariate and bivariate standard normal, respectively.[6] The variables g, h, k, m, r, and s are expressions of estimated parameters $\hat{\beta}$ and $\hat{\rho}$ as well as Z_i, X_i, a_j, and a_{j+1} (see Appendix A). Assuming a nonzero ρ, consistent estimates of W_i^* for each respondent [equation (5) for respondents with a WTP greater than zero and equation (6) for protesters] were generated using full information maximum likelihood estimation.

Study Area and Survey Description

The Cheat River watershed covers approximately 1,400 square miles in north-central West Virginia, flowing north through portions of Pocahontas, Randolph, Tucker, Preston, and Monongalia Counties (Figure 1). This watershed is faced with many water quality problems common to the Appalachia region. These problems include acid mine drainage (AMD), lack of aquatic life, trash, sewage, and sedimentation. In the northern part of the watershed (Preston and Monongalia Counties), most of the water quality concerns of low pH and elevated levels of iron, aluminum, and manganese are related to AMD impacts on the Cheat River and its tributaries. Fifty-four streams within the watershed plus the Cheat River have been listed on West Virginia's list of impaired waterways (303d list) due to AMD pollution.

Despite its water quality problems, the northern section of the Cheat River serves as a popular whitewater recreation area. In 1994, a large AMD spill from an underground mine resulted in severe degradation of the Muddy Creek tributary (Figure 1). This contamination episode ultimately led to the formation of the Friends of the Cheat (FOC) watershed association. FOC has been successful in attracting national attention to the Cheat River

[4] Respondents whose limited household income results in their $W_i^{\#}$ equaling zero could be included in model estimation; however, R_i and W_i^* would need to be re-defined in terms of an inadequacy of current income distribution to reveal one's true WTP for watershed restoration.

[5] Vectors Z and X may contain overlapping variables, but Z does not contain W_i^* in the reduced form (Brox, Kumar, and Stollery 2003).

[6] These equations are similar to Brox, Kumar, and Stollery (2003). Minor errors found in the formulas there have been corrected here.

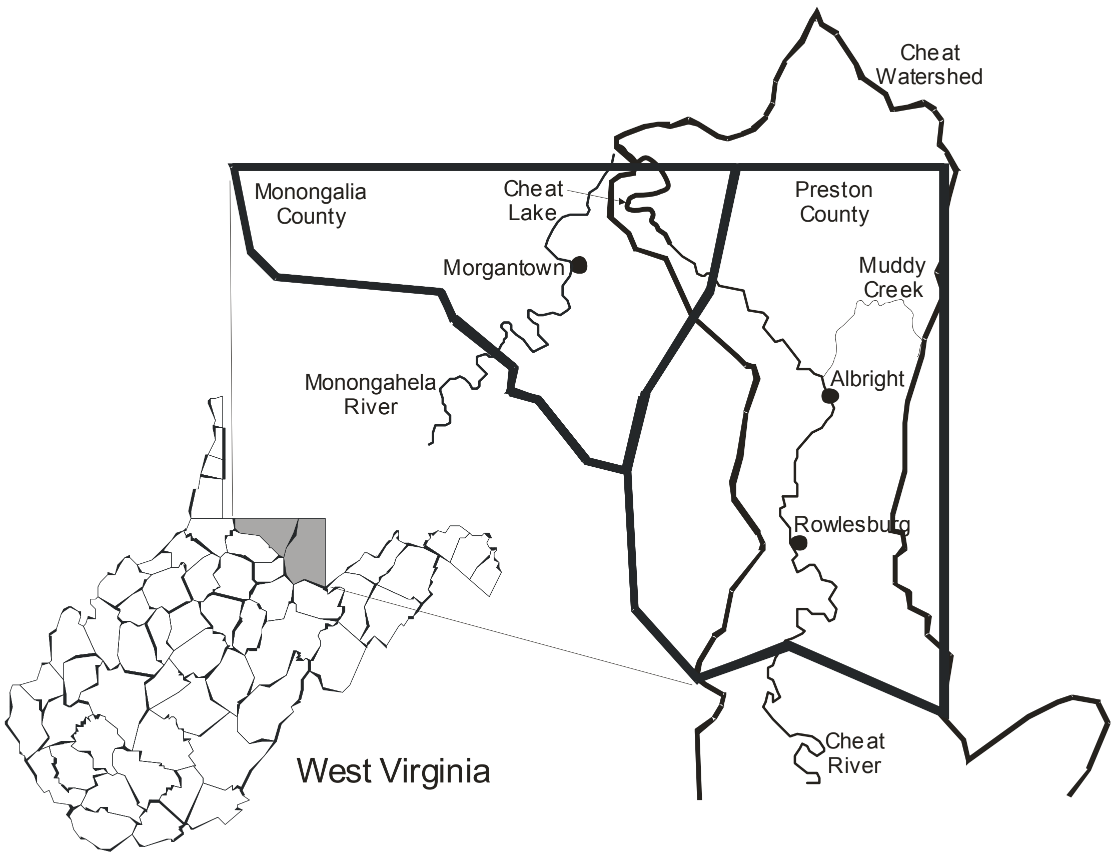

Figure 1. Location of Cheat River Watershed in West Virginia

and hundreds of thousands of dollars for reclamation projects. Yet, despite these efforts to clean up tributaries of the Cheat, much more financial resources are needed to treat all sources of AMD. While the costs of AMD treatment on the Cheat River watershed have been estimated (Ziemkiewicz 2000), the monetary benefits of restoring the Cheat River are largely unknown. Thus, a CV survey was developed to address this deficiency. The objectives of this survey were to (i) determine the attitudes and opinions of the public about restoring the water quality of the Cheat River watershed, and (ii) value its restoration based upon respondents' willingness to contribute financially towards AMD clean-up.

Survey development followed an earlier survey effort conducted on an adjacent watershed (Collins, Rosenberger, and Fletcher 2005). After several modifications were made to the survey instrument, it was pre-tested on about 35 individuals at two Preston County locations. The survey was conducted July through November 2004. A survey sample was derived from a list of 14,000 residential addresses within the most degraded portion of the watershed in Preston and Monongalia Counties. From these addresses, 2,000 randomly selected households were sent letters inviting them to participate in a survey either by mail or Internet. Those selecting to participate via the Internet were provided an access code and web address via e-mail, while participants who chose to respond by mail were sent a paper copy of the survey. Reminder postcards were sent a few weeks after the invitation letter. Budgetary limitations prevented additional mailings.

The survey instrument included questions about current participation in water-based outdoor recreation activities and perceptions of water pollution problems in West Virginia. Respondents were asked to indicate which environmental problems they considered most prevalent in the Cheat River watershed. Respondents were then presented with a hypothetical donation scenario where they were asked to provide financial support to ensure the watershed restoration (Appendix B). Those that responded with a "yes" to the financial support question were provided with a payment card list of dollar categories to select their maximum one-time donation.[7] These categories were based on a previous CV survey on the Cheat River (Rosenberger, Collins, and Svetlik 2005) and pre-test results. To add to the realism of a one-time donation, locally donated funds were described as being combined with federal and state funds to clean up the Cheat River over a five-year period of time. Follow-up questions were asked of "yes" respondents about how confident they were in their responses and their possible motivations for partial protest.

Respondents who chose not to financially support watershed restoration were asked a follow-up question about why they said "no". Implied zero responses were based on affirmative answers to the follow-up question of whether they either supported restoration but could not afford a donation, or supported watershed improvement but believed that AMD was not the problem. Protest respondents were designated from follow-up responses to the question of whether they either supported restoration but did not think sufficient funds could be raised, or supported restoration but believed that someone else should pay.

Because a TMDL-based trading plan was being developed in the Cheat River watershed at the time of this survey, the instrument inquired about opinions of a proposed pollutant trading program.[8] The final section of the survey contained socioeconomic questions. A copy of the survey is available from the authors upon request.

Methods

Variables derived from survey questions are defined in Table 1. To distinguish between survey respondents, previous research has utilized variables that measure socioeconomic characteristics, environmental values, knowledge of the resource, resource use by the respondent, and costs associated with resource use (Desvousges, Smith, and Fisher 1987, Halstead, Luloff, and Stevens 1992, Brox, Kumar, and Stollery 2003, Strazzera et al. 2003b). Numerous studies have examined factors that explain WTP for water quality improvements.[9] Based on previous research, explanatory variables in Z and X included the following: socioeconomic characteristics, knowledge about and use of the Cheat River, and attitudes about water quality. When estimating both the sample selection and WTP equations simultaneously, we dropped those variables that failed to generate asymptotic z values of at least 1.0.

Unknown β, σ, and ρ were estimated based on the likelihood function in Appendix A using a grouped Tobit model assuming a lognormal conditional distribution. All models were estimated using LIMDEP 8.0 (Greene 2002). As a basis of comparison, a single-equation model without the sample selection equation was estimated. In this model, only respondents with a WTP greater than zero were included, while implied zero and protest responses were excluded.[10] Individually fitted conditional mean WTP values were computed for each respondent using both the single-equation model and the two-equation model based on equation (5). Individually fitted conditional mean

[7] Boyle (2001) and Carson, Flores, and Meade (2001) note that incentive compatible problems exist with both payment card and donation formats. Since a respondent's optimal strategy is to contribute, these formats should result in an overestimate of true WTP. Thus, one might conclude that protests should not be a concern when using these formats.

[8] Pollution trading was described thus: "Those who currently discharge acid, minerals, or other pollutants into the Cheat River and its tributaries would be offered the opportunity of treating a greater amount of pollution discharges from abandoned mines in exchange for their ability to continue discharging at current permitted pollution levels rather than reducing pollution to meet discharge standards for degraded water bodies."

[9] Examples of water quality studies include Farber and Griner (2000), Bergstrom, Boyle, and Poe (2001), Brox, Kumar, and Stollery (2003), and Collins, Rosenberger, and Fletcher (2005).

[10] When protesters were included in the two-equation model, their coded WTP response did not change the estimation results (i.e., all protesters could be coded in any WTP category with the same results). The reason for this outcome is that the effect of protesters is measured in the sample selection equation. This effect is then a latent variable that is introduced into estimation of the grouped Tobit model. Assignment of any category value to protesters (through allocating them to a specific group) does not affect the grouped Tobit part since the protesters are not directly part of the observed WTP values. Therefore, regardless of an assigned amount, only their latent effect is brought forward from the sample selection equation.

Table 1. Variable Descriptions

Variable	Description	Descriptive Statistics		
	Socioeconomic Characteristics	Mean	Std. Error	N
AGE	Age of respondent (years)	51.605	0.788	281
EDUC	Education level of respondent (years of formal education)	15.062	0.146	288
INCOME	Household total annual income ($1000s)	69.797	3.187	288
	Knowledge and Use of the Cheat River			
ANGLERS	1 = fished in a lake, river or creek in past year, 0 = otherwise	0.464	0.029	296
BOATERS	1 = kayaked, canoed, or rafted rivers or creeks in past year, 0 = otherwise	0.186	0.023	296
HIGH	Number of eight Cheat River tributaries rated as high priority for acid mine drainage treatment by respondent	2.671	0.147	296
UPPER	1 = familiar with upper portion of the Cheat River, 0 = otherwise	0.356	0.028	296
USE	1 = recreationally used the Cheat River in the past year, 0 = otherwise	0.759	0.025	296
	Attitudes about Water Quality			
ACID	1 = perceived acid and minerals (sulfur water) pollution of rivers and streams in West Virginia to be very widespread, 0 = otherwise	0.388	0.028	296
CONCERN	1 = very concerned about aquatic habitat in the Cheat River being severely limited due to acid mine drainage, 0 = otherwise	0.682	0.027	296
TRADE-INDIFF	1 = indifferent toward pollution trading proposal, 0 = otherwise	0.058	0.014	296
TRADE-PRO	1 = agree with pollution trading proposal for the Cheat River watershed, 0 = otherwise	0.270	0.026	296
USEONLY	1 = respondent expressed use-only motivations for watershed restoration, 0 = otherwise	0.071	0.015	294

WTP values for protesters were recoverable using equation (6) from the two-equation model. For comparison purposes, average welfare measures were adjusted for implied zero responses and for when protest respondents were treated as zeros.

Results

Survey

Of the 2,000 letters sent out, 296 surveys were ultimately returned. Most respondents preferred completing the survey by mail (71 percent). Over half of respondents (55 percent) were from the Morgantown area of Monongalia County. The rest were spread out over the other eight zip codes in the lower Cheat River watershed.

The low response rate of 14.8 percent was attributed to only one mailing of the letter having been made. This response rate presented concerns about bias when applying survey data to the entire watershed population (see Cameron, Shaw, and Ragland 1999 for a description and method for addressing non-response bias). For example, the survey sample had more male respondents (58 percent vs. 50 percent), much higher education levels (51 percent vs. 19 percent with at least a college degree), were older (72 percent vs. 50 percent over the age of 45), and had higher household income (mean of about $70,000 vs. $43,500) compared to watershed residents from the 2000 Census. However, this data set was deemed to be adequate to analyze sample-only information of protesters versus non-protesters.[11]

Most respondents were familiar with the lower portion of the Cheat River (between Albright and Cheat Lake). Over half were familiar with the middle portion (Rowlesburg to Albright) and slightly

[11] There is little evidence in the literature that initial wave respondents are different from subsequent wave respondents. Wellman et al. (1980) found minimal differences in respondent attitudes and sociodemographic characteristics when initial and subsequent waves of responses were compared in a water-based outdoor recreation survey.

more than one-third with the upper portion (above Rowlesburg). Only 7 percent of respondents were not familiar with any portion of the Cheat River. Over 80 percent of the respondents felt that there are environmental problems in the Cheat River watershed. Most respondents perceived high levels of acid and minerals, unnatural colors of the water and rocks along the river, trash, and the lack of fish and aquatic life as common problems faced by the Cheat River. Less than one-third of respondents noted sewage or flooding problems.

Of the two options presented to respondents in the CV question (Appendix B), most respondents selected Option A (Figure 2). Among respondents who supported clean-up, the mean contribution level was $126, with the most common responses being $50 or $100 (Table 2).[12] Over 90 percent of Option A respondents indicated they were confident they would choose to donate at the same level if they were actually given the opportunity to improve the watershed. About 75 percent felt that they had been provided with enough information to decide whether they would financially support clean-up of the watershed.

Of the 37 percent of respondents who chose Option B, most supported watershed restoration but declined to make a financial contribution for a variety of reasons as listed in Figure 2. Option B responses were distributed towards implied zero (57 percent) versus protest zero (40 percent) responses. Of the protest zero responses, the majority cited the belief that someone else should pay for restoration (81 percent). The implied zero responses were dominated by income-limited respondents who cited an inability to afford restoration. A small percentage (6 percent) of survey respondents did not respond to the CV question.[13]

Survey respondents were very uncertain about pollution trading on the watershed. Many respondents (41 percent) indicated they were unsure and would need further information before they could decide whether or not they agreed or disagreed with pollution trading. Of those that expressed an opinion, more respondents agreed (27 percent) than disagreed (22 percent) with trading.

Estimation

Variable means were compared between sub-sample populations (Table 3). The main differences observed were that protesters were much more likely to express a use-only value for watershed restoration and were much less likely to perceive AMD as being very widespread in West Virginia streams and rivers as compared to the other two sub-samples. Respondents with a WTP greater than zero were more likely to be boaters or anglers and to have higher incomes than the protester or implied zero sub-samples. For many variables, the mean for protesters was between the means for the WTP > 0 and implied zero sub-samples (Table 3).[14]

The sample selection equation was dominated by variables reflecting attitudes about water quality (Table 4). The model included one socioeconomic characteristic (*EDUC*) and one knowledge variable (*HIGH*), with *HIGH* having a statistically significant coefficient. Respondents were more likely to be protesters when they believed the AMD problem was great (i.e., they rated more Cheat River tributaries as high priority treatment).

Attitudes about water quality included variables on perception of AMD problems statewide (*ACID*), respondent attitude about the Cheat River (*USEONLY*), indifference toward pollution trading (*TRADE-INDIFF*), and respondent concerns about aquatic life in the Cheat River (*CONCERN*). Three attitude variables (*USEONLY*, *CONCERN*, and *ACID*) had statistically significant coefficients in the sample selection equation (Table 4). Protesting was less likely when respondents both were very concerned about aquatic habitat and perceived AMD problems to be very widespread in West Virginia. Respondents were more likely to be protesters when they expressed use-only motivations for Cheat River restoration. Our results contrast with previous research in the sample selection equation, which found statistically significant

[12] The lowest bid in the payment card was $5 per year. This may have led respondents with $0 < WTP < $5 to not reveal their bid. However, bias introduced by the payment card design is likely trivial given the small percentage of respondents reporting low WTP values.

[13] Although some may be protesting, non-respondents to the CV question were excluded from the analysis because we had no indication that a non-response implied a positive WTP for watershed restoration.

[14] Probit models were run to explain differences between protesters and WTP > 0 respondents as well as implied $0 respondents. The results showed that protesters were predicted to be in the WTP > 0 category 87 percent of the time versus only 55 percent for implied $0 respondents. Thus, protesters had greater similarities to WTP > 0 respondents than to implied $0 respondents.

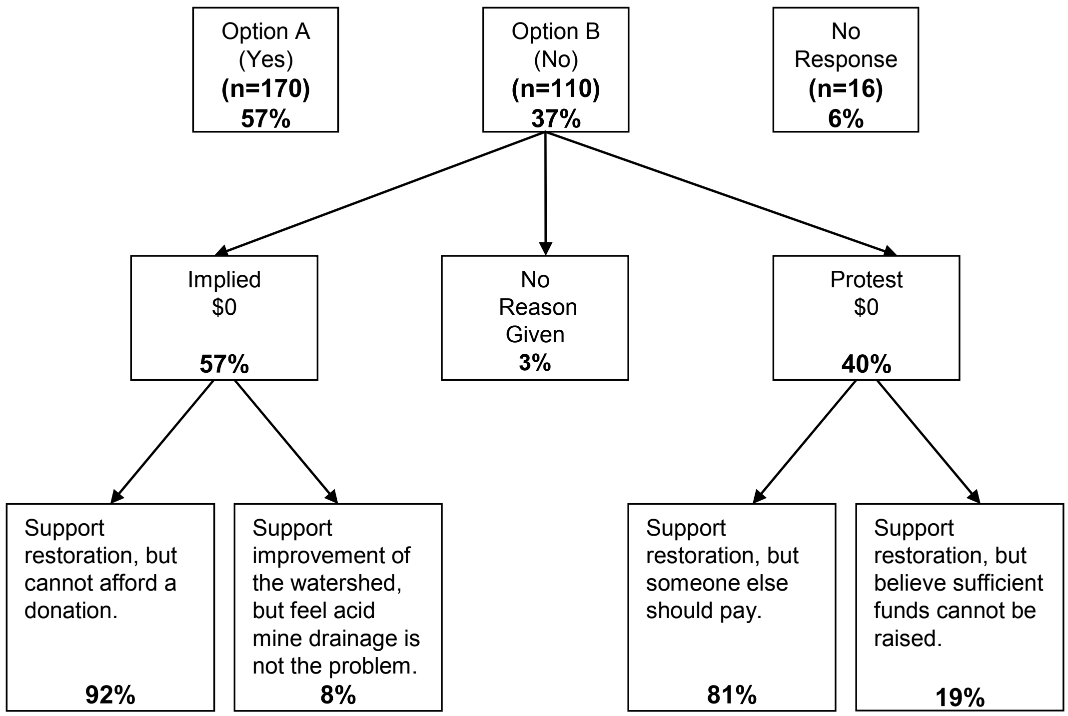

Figure 2. Distribution of Financial Contribution Responses for Restoration of the Cheat River Watershed

socioeconomic characteristics (Brox, Kumar, and Stollery 2003, Strazzera et al. 2003b) and no statistically significant water resource related variables (Brox, Kumar, and Stollery 2003).

The W_i^* grouped data model included socioeconomic characteristics (*AGE* and *INCOME*), respondent use of the Cheat River (*ANGLERS*, *BOATERS*, and *USE*), respondent knowledge of the Cheat River (*UPPER*), and respondent attitudes about water quality (*CONCERN* and *TRADE-PRO*). With the exception of *CONCERN*, coefficients were similar between the single- and two-equation models. *CONCERN* had a larger impact on WTP when the sample selection equation was included in estimation.

Higher WTP for restoration was related to the following respondent characteristics: being a recreational user of the Cheat River (particularly anglers and boaters), being very concerned about aquatic habitat in the Cheat River, being familiar with the relatively unpolluted upper portion of the watershed, and having higher levels of education and household income. Respondents who agreed with pollution trading on the watershed had lower WTPs for restoration than those who disagreed or were unsure. Our explanation for this result was that trading proponents may have viewed this proposal as reducing their burden to pay for restoration. Similar to Brox, Kumar, and Stollery (2003) and Strazzera et al. (2003b), correlation between

Table 2. Mean and Distribution of Maximum One-Time Donation Responses to AMD Clean-Up in the Cheat River Watershed

Contribution Range	Percentage of Responses (N = 171)
$5–$40	33%
$50–$150	50%
$200–$500	6%
$500–$1000	11%
Mean	$126

Table 3. Summary Statistics by Subsample

Variable	WTP > 0	Protesters	Implied $0
		Socioeconomic Characteristics	
AGE	50.829[a]	51.341	53.984
	(1.031)[b]	(1.697)	(1.754)
EDUC	15.506	14.909	13.873
	(0.186)	(0.353)	(0.296)
INCOME	76.929	63.010	56.864
	(4.334)	(7.675)	(6.286)
		Knowledge and Use of the Cheat River	
ANGLERS	0.512	0.386	0.381
	(0.038)	(0.074)	(0.062)
BOATERS	0.229	0.091	0.111
	(0.032)	(0.044)	(0.040)
HIGH	2.824	2.636	2.365
	(0.181)	(0.414)	(0.360)
UPPER	0.329	0.341	0.476
	(0.036)	(0.072)	(0.063)
USE	0.806	0.773	0.635
	(0.030)	(0.064)	(0.061)
		Attitudes about Water Quality	
ACID	0.424	0.273	0.413
	(0.038)	(0.068)	(0.062)
CONCERN	0.770	0.545	0.587
	(0.032)	(0.076)	(0.062)
TRADE-INDIFF	0.029	0.136	0.079
	(0.013)	(0.052)	(0.034)
TRADE-PRO	0.259	0.273	0.302
	(0.034)	(0.068)	(0.058)
USEONLY	0.053	0.182	0.063
	(0.017)	(0.059)	(0.031)
N	170	44	63

[a] Mean of variable.
[b] Standard error in parentheses.

error terms (ρ) was positive. Therefore, the higher a respondent's true WTP, the greater the likelihood that this respondent will express a positive WTP value and not be a protester.

Table 5 presents mean estimates and standard errors of $\hat{W}^*$ for a one-time donation to restore the Cheat River watershed using both the single- and two-equation models for participants, protesters, and the sample aggregate. In the comparisons noted below, the majority of the estimates were statistically different from each other using an overlapping 95 percent confidence interval approach. $\hat{W}^*$ was computed to be $97.61 per participant using the single-equation model. When sample selection correlation ($\rho > 0$) is accounted for, $\hat{W}^*$ declined by 75 percent from the single-equation estimate to $24.39 per participant using the two-equation model. Protester $\hat{W}^*$ was estimated to be $10.09 per protest respondent from the two-equation model, but was not recoverable from the single-equation model. Protester $\hat{W}^*$ was significantly greater than zero but 58 percent lower than participants' $\hat{W}^*$ from the two-equation model. Thus, protesters to this donation

Table 4. Final Estimated Single- and Two-Equation Models

	Single-Equation Model		Two-Equation Model	
			Sample Selection Equation	
Variable			Coefficient estimates	Std. error
Constant	---	---	-0.226	0.653
EDUC	---	---	0.059	0.042
HIGH	---	---	-0.069*	0.040
ACID	---	---	0.470**	0.223
CONCERN	---	---	0.463**	0.232
TRADE-INDIFF	---	---	-0.575	0.378
USEONLY	---	---	-0.994**	0.407
	WTP Grouped Data Equations			
Variable	Coefficient estimates	Std. error	Coefficient estimates	Std. error
Constant	-1.756*	1.067	-2.313**	1.138
Ln(*AGE*)	0.689***	0.261	0.734***	0.284
Ln(*INCOME*)	0.501***	0.097	0.501***	0.110
ANGLERS	0.301**	0.152	0.341**	0.156
BOATERS	0.386**	0.178	0.430**	0.200
UPPER	0.328**	0.159	0.273*	0.157
USE	0.449**	0.191	0.403**	0.201
CONCERN	0.467***	0.176	0.622***	0.210
TRADE-PRO	-0.315*	0.166	-0.358**	0.162
σ_w	0.927***	0.052	1.081***	0.097
ρ			0.860***	0.118
N	170		214	
Log likelihood	-423.820		-518.723	

Note: *, **, and *** equal *Z*-value significance greater or equal to the 0.10, 0.05, and 0.01 level, respectively.

format CV question had lower WTP values than respondents with WTP greater than zero, which facilitates their choice not to participate (i.e., protest) in the valuation question.

The sample aggregate $\hat{W}^*$ for the single-equation model was calculated by averaging participant $\hat{W}^*$ with non-participants (protesters and implied \$0). Thus, sample selection bias resulted in a 40 percent reduction in value to approximately \$60, which is a much larger bias than estimates derived by Brox, Kumar, and Stollery (2003) and Strazzera et al. (2003b). When the sample aggregate $\hat{W}^*$ from the two-equation model was computed by averaging participant and protester $\hat{W}^*$ along with all implied \$0, $\hat{W}^*$ declined 72 percent to \$16.57. The standard errors also declined 32 percent with the two-equation model, but not as dramatically as the mean $\hat{W}^*$.

Our results confirm non-zero values for protest respondents and direction of bias when $\rho > 0$. Treating the sample aggregate $\hat{W}^*$ from the two-equation model in Table 5 as the theoretically correct measure, when protesters were assigned the sample's average value, then the sample's aggregated mean WTP was \$19 per respondent, an overestimate of about 14 percent. Conversely, when protesters were assigned \$0 for their WTP, then the sample's aggregated mean WTP was \$15 per respondent. This is an underestimate of about 10 percent.

Table 5. Estimates of WTP Values from Grouped Data Models and Sample Aggregation

	n	Single-Equation Model [a]	Two-Equation Model [a]
Participants [b]	163	97.61	24.39
		(4.60)	(4.34)
Protesters [c]	44	----	10.09
			(0.90)
Sample Aggregate [d]	259	59.91	16.57
		(4.02)	(2.73)

[a] Mean (standard error) of the individually fitted conditional mean estimates of $\hat{W}_i^*$.
[b] $\hat{W}^*$ for participants estimated for the single-equation model from the individually fitted conditional mean WTPs [= exp($\beta_W' X_i$ + $\sigma^2/2$)] (Cameron and Huppert 1989), and for the two-equation model using equation (5).
[c] $\hat{W}^*$ for protesters in the two-equation model using equation (6).
[d] Sample aggregate's $\hat{W}^*$ consists of averaging 96 imputed $0 for non-participants with participants' $\hat{W}_i^*$ from the single-equation model to averaging 52 implied $0 with participants' $\hat{W}^*$ and protesters' $\hat{W}^*$ from the two-equation model.

Conclusions

The direction of bias in aggregate welfare measures depends on how protesters are treated in the analysis. Halstead, Luloff, and Stevens (1992) state that when protesters are ignored in aggregate welfare measures by removing them from the sample, then the implication is that protesters hold the sample's mean WTP. If protesters' true WTP for restoration (independent of the CV question context) is less than the sample mean (so that $\rho > 0$, as occurred in the Cheat River data), then the bias is upwards in the aggregate measure. If protesters are treated as zeros in the analysis and they have a positive WTP, then aggregate welfare measures are biased downwards. The small body of literature that estimates WTP values for protesters using a two-equation system typically has found a positive correlation between the residual errors in the two equations (Strazzera et al. 2003a is an exception). This trend indicates that protesters' values for non-market resources are non-zero, but that they also lie in the lower range of the distribution of WTP values expressed by respondents with a WTP greater than zero. Treating protester zeros as $0 leads to an understatement of their value, while using the sample mean overstates them.

Our results also show that the decision to protest and W_i^* were positively correlated ($\rho > 0$) so that the use of a single equation or restricted sample leads to biased and inconsistent overestimates. Sample selection bias was computed to be a 300 percent overestimate of WTP (participant $\hat{W}^*$ for the single-equation vs. two-equation model in Table 5). We interpret this result as an example of hypothetical bias where respondents who exceed the threshold to reveal their value for restoration ($R_i^* > 0$) tended to inflate their reported positive WTP. This 300 percent overestimate is lower than other estimates of hypothetical bias reported in the literature (Brown et al. 1996, Botelho and Pinto 2002), but slightly higher than the regression model results evaluated at the mean and median in a meta-analysis conducted by Murphy et al. (2005). However, when protesters were properly accounted for in the two-equation estimation, the adjustment for bias among the entire sample from $\rho > 0$ in equation (5) substantially lowers the overestimated WTP.

Expected bias increases with the proportion of protesters in a sample or the more contentious the valuation topic. As Meyerhoff and Liebe (2006) argue, being a protester is a matter of degree, with no clearly defined threshold between revealing WTP and stating a protest $0. They also contend that protest motivations or attitudes are held by protesters and participants alike. The interaction of actual WTP and strength of protest motivations determines whether someone will participate by revealing all or part of his or her WTP or protest by stating a $0 value. In both cases, some participants are understating their actual WTP, either as a protest "zero" or by underreporting their actual WTP. Based upon Meyerhoff and Liebe, one would expect to find $\rho < 0$ when protesters are included in a two-equation system. Given our results, additional research is needed to confirm whether partial protest respondents with WTP greater than zero understate (i.e., $0 < R_i < 1$) or overstate (i.e., $R_i > 1$) their W_i^* due to hypothetical bias. These results do confirm the Jorgensen et al. (1999) recommendation that all respondents be asked some type of follow-up question to determine partial protests.

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APPENDIX A: Likelihood Function and Variable Definitions

Likelihood function for estimation of coefficient vectors β_R and β_W is

$$L = \prod_{i=1}^{N}[1-\Phi(\beta_R^{'}Z_i)]^{1-R_i} \times \left[\prod_{j=1}^{J}(\Phi_2(\frac{a_{j+1}-\beta_W^{'}X_i}{\sigma_W}, \beta_R^{'}Z_i, -\rho) - \Phi_2(\frac{a_j-\beta_W^{'}X_i}{\sigma_W}, \beta_R^{'}Z_i, -\rho))^{M_{ij}}\right]^{R_i},$$

where M_{ij} is defined as a dummy variable such that $M_{ij}=1$ when $W_i = j$, and zero otherwise.

Variables g, h, k, m, r, and s in equations (5) and (6) are defined as

$$g = \frac{\hat{\beta}_R^{'}Z_i + k\hat{\rho}}{\sqrt{1-\hat{\rho}^2}}, \qquad h = \frac{\hat{\beta}_R^{'}Z_i + m\hat{\rho}}{\sqrt{1-\hat{\rho}^2}},$$

$$k = \frac{a_j - \hat{\beta}_W^{'}X_i}{\hat{\sigma}_W} \qquad m = \frac{a_{j+1} - \hat{\beta}_W^{'}X_i}{\hat{\sigma}_W},$$

$$r = \frac{k + \hat{\beta}_R^{'}Z_i\hat{\rho}}{\sqrt{1-\hat{\rho}^2}}, \qquad s = \frac{m + \hat{\beta}_R^{'}Z_i\hat{\rho}}{\sqrt{1-\hat{\rho}^2}}.$$

APPENDIX B: Contingent Valuation Questions in the Cheat River Survey

Support for clean-up question:

If offered the opportunity, would you be willing to provide financial support for full clean-up of the Cheat River watershed? Please select one of two options: Option 1 for full clean-up or Option 2 for no clean-up. Please check your choice on the last row of the table.

	Option A: Full Clean-Up	Option B: No Clean-Up
Clean-up plan	*Full clean-up:* Treatment of acid mine drainage from all stream tributaries of the Cheat River	*No clean-up:* The watershed has fish in only the upper portions of the Cheat River.
Clean-up improvements	The lower and middle portions of the Cheat River have warm water fish (bass) and all stream tributaries can support trout.	No improvement.
Please check one box	❒ Yes, provide financial support	❒ No

Financial support question for the "yes" respondents to full clean-up:

Currently, there is not enough government and private industry funding to treat all AMD from abandoned mine lands. You will be asked to place a value on clean-up through a one-time donation in support of Cheat River restoration. This donation is not an actual request. However, please select your choice as if you were actually being offered the opportunity to clean up the Cheat River. We realize that full clean-up of the Cheat River may not be available at the current time. Your choice is important in providing information to environmental regulators and public officials about how much local residents value cleaning up the Cheat River.

Please assume that an independent private foundation, called the Cheat Watershed Restoration Authority, would use your donation to treat AMD on streams and maintain these treatments. The goal of this authority is to raise the necessary $5 to $10 million to accomplish the clean-up. Assume that the Authority would be able to clean up the Cheat River within the next five years with locally donated funds plus federal and state dollars. All of those willing to donate would be provided with information about the progress of restoration within the Cheat River watershed.

What would be the maximum one-time donation that you would be willing to pay to fully clean up the Cheat River watershed from acid mine drainage pollution (Option 1 from the previous question)?

Please circle your maximum donation. For another response, please write in your maximum.

$5	$10	$15	$20	$30
$40	$50	$75	$100	$125
$150	$200	$300	$500	$1,000

Other (please specify) $_______