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Modeling Willingness to Pay for Land Conservation Easements: Treatment of Zero and Protest Bids and Application and Policy Implications

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This study compares an ordered probit model and a Tobit model with selection to take into account both true zero and protest zero bids while estimating the willingness to pay (WTP) for conservation easements in Macon County, NC. By comparing the two models, the ordered/unordered selection issue of the protest responses is analyzed to demonstrate how the treatment of protest responses can significantly influence WTP models. Both models consistently show that income and knowledge are positive and significant factors, while distance to poorer quality streams and duration of residency are negative and significant factors on WTP.

Key Words: censored dependent variable, conservation easement, protest bid, sample selection, WTP

JEL Classifications: C25, C42, Q56

A land conservation easement is a voluntary legal agreement between a landowner and the easement holder (e.g., government agency or private land trust) that places legal restrictions on development of the land (Bergstrom and Volinskiy). The existing literature has addressed public preferences for conservation easements in various natural areas using willingness to pay (WTP) analyses. Cooksey and Howard estimated WTP to protect forest benefits with conservation easements. Loomis et al. measured WTP for an increase in ecosystem services through higher water bills. Bergstrom and Volinskiy analyzed WTP for agricultural conservation easements in Georgia. Blaine, Lichtkoppler, and Stanbro assessed WTP for protecting green space and agricultural areas via conservation easement programs in Lake County, OH. All of these WTP analyses used contingent valuation method (CVM), a method frequently used to estimate WTP.

CVM is a survey-based economic technique for the valuation of nonmarket resources, typically environmental attributes and amenities. CVM was first applied by Davis to estimate the value hunters and tourists placed on a particular wilderness area. Work on CVM now typically makes up the largest single group of papers at major environmental

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economics conferences and in several of the leading journals in the field (Carson and Hanemann). One major issue facing CVM researchers is how to deal with differences between true zero bids and protest zeros. The true zero bids are true reflections of preferences, where zero is the reservation price for individuals who are indifferent to the increase in the provision of the public good (Strazzera et al. 2003a). The protest zeros are motivated by protest behavior aimed at some component of the survey design such as payment vehicle or ethical objections to personal payment for a public good (Bowker et al. 2003). In the case of controversial or unconventional policies or programs, the frequency of protest zero bids may be high.

Various approaches to dealing with protest zero bids have been used in the contingent valuation literature. Early studies simply discarded these observations from the sample (Halstead, Luloff, and Stevens; Mitchell and Carson 1989; Whitehead, Groothuis, and Blomquist). The removal of protest zero bids is rationalized by the fact that if a person bids zero on the grounds that she has an inherent right to the environmental good, it must be dropped from the sample when mean bids are calculated (Freeman). However, exclusion of protest responses from the sample may not be appropriate if these responses are nonrandom, which can induce a sample selectivity bias (e.g., Calia and Strazzera). Removal of protest responses may be valid if the protesters are not significantly different from the remainder of the sample (Strazzera et al. 2003b). Alternatively, Bowker et al. (2003), using Tobit (censored regression) (Tobin) and sample selection (Heckman) models, presented a series of estimates in a sensitivity analysis of various ways to treat protest zero bids. Cho, Newman, and Bowker estimated the WTP for conservation easements in Macon County, NC, using Tobit and sample selection models with and without protest zero bids. The separate estimation with and without protest zero bids yielded a wide range of WTP estimates along with potential selectivity bias in the exclusion of the protest responses.

Another approach is to model the individual protest decision by adopting a double-hurdle model (Dalmau-Matarrondona), which accommodates the possibility that zero responses to WTP could represent protest zeros and not simply be real zeros. Strazzera et al. (2003a,b) proposed a mixture model with sample selection to take into account the true zero values and the protest responses. Their mixture models correct for the selectivity bias caused by a considerable number of protest bids. They suggest a sequential procedure to balance the trade-off between the maximum-likelihood (ML) method and two-step estimators for sample selection models. They found the link between the signs of error correlation in the sample selection model and the direction of bias in the mean WTP discarding protest responses and concluded that the sample selection models can detect and correct selectivity bias caused by protest responses.

In this study, we apply two alternative approaches to modeling WTP with zero and protest bids: the ordered probit selection (OPS) model and Tobit with binary selection (TBS) model. The ordered probit is useful when survey responses are ordinal, as distinct from binary or numerical. In the multiple selections of the respondents' WTP answers, whereas the order of positive bids that are greater than true zero bids is clear, it is less clear where to situate the protest bids.[1] The revealed bids are zeros for the protest zero bids, but the respondent's true value is unknown because of the protest response. The respondents with protest zero bids may have three different underlying WTPs: (1) undetermined bids below true zero bids, (2) undetermined bids between true zero bids and positive bids, and (3) undetermined positive bids. By allowing the preference heterogeneity of the protest bids, the OPS design can be used

[1] Note that "protest bids" instead of "protest zero bids" is used in the selection of the model. We try to deviate from the convention that people with only zero bids could be protesting (Dalmau-Matarrondona; Strazzera et al. 2003a, 2003b). This assumption neglects the fact that positive bidders also can protest. Nonetheless, the assumption of only protest zero bids is trivial if the number of positive bids with protest response is insignificant. We did not have positive protest observations in our case.

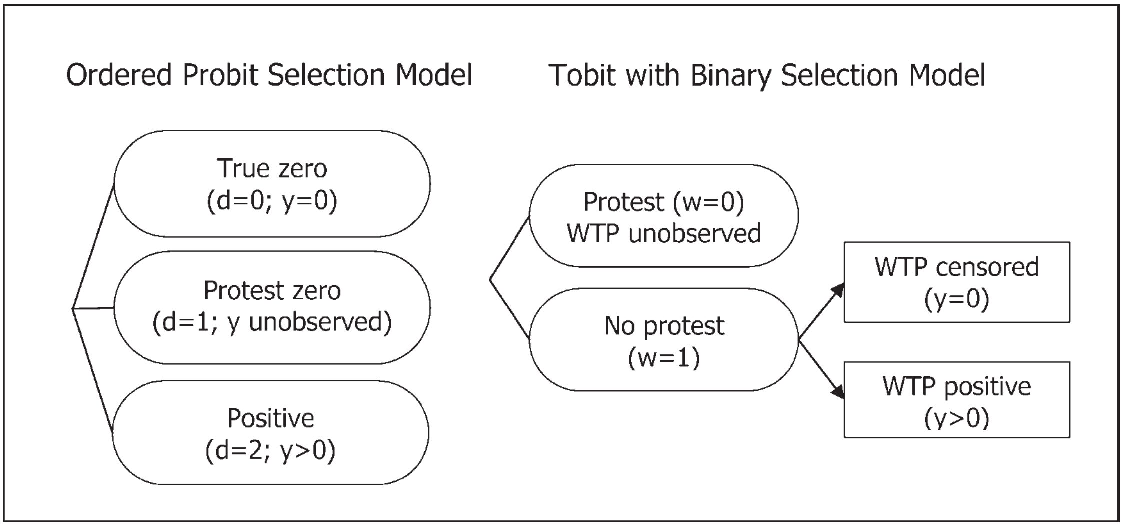

Figure 1. A Diagram to Illustrate the Ordered Probit Selection and Tobit with Binary Selection Models

to model all three premises of the protest zero bids.

Alternatively, a TBS model can be used. In this framework, the WTP answers can be classified into protest and not protest as a binary probit model. A binary sample selection rule is applied to accommodate protest zero bids, while a censored (Tobit) mechanism is used to accommodate true zero bids among nonprotesters. In this case, the respondents' decision is modeled as a joint process involving the choice to reveal and the choice to value. The choice to reveal part of the joint process is modeled in a binary sample selection, and a censored Tobit is used to model the choice to value the WTP, accommodating zero WTP under the assumption that the error terms are distributed as bivariate normal (see Figure 1 for a diagram that illustrates the two models).

The two models, OPS and TBS, used in this study better fit the WTP with zero and protest bids than the models used in previous studies for the following reasons. Both models in our study not only observe the presence of selectivity bias induced by protest responses, but they also correct for the selectivity bias. We develop sample likelihood functions for both models and estimate these models with the ML procedure, which is more efficient than a two-step procedure. We also calculate the marginal effects of exogenous variables, which facilitate interpretation of the effects of the exogenous variables. To our knowledge, this has not been done in the empirical literature. Next, we provide alternative treatments of zero and protest bids and compare the WTP models under the different treatments. The expected value of annual household WTP, aggregate annual county WTP, the annual area of conservation, and a 10 yr projected area of conservation are compared between the two models. By comparing results from the two models, the ordered/unordered selection issue of the protest responses can be analyzed to demonstrate how the treatment of protest responses can have a significant influence on the results of the WTP model.

Study Area

Rapid growth is occurring in many small towns and rural communities across America. Towns with clean air and water, little traffic, and a low crime rate near valuable natural amenities are attractive to retirees and second—home buyers. Macon County, NC, situated at the southern end of the Blue Ridge Mountains in western North Carolina, is one of these counties. During the 1990s, Macon

County's population grew from 20,178 to 29,811, an increase of nearly 50%. Over the same time period, the number of housing units increased 55% from 13,358 to 20,746. The higher increase of housing units relative to population growth reflects part-time residents and those who spend weekends in the mountains. In 2002, 45% of all new residences built in Macon County were second homes.

Whatever the cause of the influx, growth at this pace typically leads to a decline of environmental quality. According to a report by the North Carolina Division of Water Quality, water-quality monitoring revealed that four county streams (Crawford Branch, Mill Creek, Upper Cullasaja River, and Little Tennessee River near the Georgia state line) are partially impaired, i.e., diminished in quality. Although the report does not clearly identify sources of the impairments, it concludes that growth management is a key to maintaining good quality of water.

In response to the rapid growth, and concern over declining environmental quality, the Macon County government has attempted countywide land-use planning with little success thus far. The draft of the land-use plan proposed by the Macon County Board of Commissioners was dropped after residents protested. The issue of land-use management in the county remains controversial (Cho, Newman, and Bowker). The county government has been considering land-use planning alternatives such as high impact land use, flood damage prevention, voluntary farmland preservation, soil erosion and sedimentation control, and subdivision regulations. Regardless of the challenges that the county has faced with growth management, land conservation easements have been relatively successful as an alternative way of influencing sustainable development in the county. Conservation easements were introduced in the county when the Land Trust for the Little Tennessee was incorporated as a nonprofit entity in 1999.

Acquiring and managing a conservation easement involves costs on the part of the landowner and the easement holder. Although conservation easements have been relatively successful in the county, limited government support raises the need for more public support. Public and government support of the program is an important factor for the county's success with conservation easements in the future. Public and government support may be generated by either voluntary donations or public funds derived from property and/or sales tax receipts. Despite the need for public and government support, very little is known about the perceived value by the general public. Government and/or nonprofit organizations interested in conservation easements therefore need information on public preferences for conservation easements. In particular, acceptance by local homeowners and a measure of their net economic value or WTP for such programs are vital pieces of information for policy makers who would be charged with program implementation and allocation of resources for matching funds.

Survey Data

A self-administered, mail-back questionnaire was designed to characterize homeowners and their WTP for conservation easements. The questionnaire was designed based on a 2002 assessment report by the N.C. Division of Water Quality and interviews with land planners, the director of the Little Tennessee River Watershed Association, and ecologists who are familiar with the area. The questionnaire elicited information on household demographics, property characteristics, length of residency, WTP for land conservation easements, and knowledge of environmental issues relevant to the easements. The definitions and sample statistics of variables used in the models are reported in Table 1.

Respondents were first presented with a definition of a conservation easement. This was followed by information about the historical rate of land development in the county and the expected outcome of the proposed conservation easement program. Because an accurate portrayal of the expected outcome of payment and entrance into a Macon County conservation easement program was problematic, respondents were given a probable outcome based on a set of

Table 1. Variable Definitions and Sample Statistics

Variable	Definition	Mean	SD
Ordinal bid	2 = positive WTP (n = 182)	1.44	0.71
	1 = protest (n = 98)		
	0 = zero WTP (n = 41)		
WTP	Willingness to pay for conservation easements ($)	14.04	21.25
WTP > 0	Among those who support	24.76	23.05
Year	Duration of residency (yr)	20.31	18.77
Distance	Distance (from the respondent's house) to poorer quality streams (km)	6.77	5.25
Income	Household income ($1,000)	50.28	27.80
Knowledge	Knowledge about land development issues	0.15	
	0 = knowledge level "none" or "very little" or "some"		
	1 = knowledge level "a lot" or "detailed knowledge"		
Second home	Property used as a primary residence or second home	0.38	
	0 = primary home		
	1 = second home		
City	Property within city boundaries of Franklin or Highlands	0.88	
	0 = outside of the boundaries		
	1 = inside of the boundaries		

Note: Sample size is 321.

reasonable assumptions. Specifically, the respondents were informed that "By establishing a fund that could be used to purchase conservation easements from willing landowners, Macon County plans to conserve lands. After establishment of the fund, the rate of loss on resource land is expected to slow down to half of the current rate because the county will be able to offer an incentive for voluntary conservation. If every household were to pay $20 annually into the fund, this would allow the purchase of approximately 300 acres of easements per year at current prices." The set of assumptions provided to the respondents was established as if the county aimed the rate of loss on resource land to slow down to half. The potential expected benefit, i.e., improvement of environmental and ecological amenity value, and cost, i.e., economic loss of property tax from the prevented development, by the conservation were not presented to the respondents.[2]

After being informed of the conservation easement scenario, respondents were asked about their knowledge level of the environmental issues regarding the land conservation in the area prior to reading the survey. Next, respondents were asked to indicate their WTP, using a modified payment card format. This format includes an array of different dollar amounts starting with zero wherein respondents are asked to circle the amount closest to their WTP or fill in an open-ended amount (Kramer, Mercer, and Sharma; Mitchell and Carson 1989, 1993).

The modified payment card format with open-ended question is used to accommodate the advantages and drawbacks of both formats. Among CVM practitioners, there is no consensus on the optimal bid format, although dichotomous choice questions dominate in the CV surveys of nonmarket goods and services (Arrow et al.). Some researchers prefer one of a number of dichotomous choice elicitation variants because they are thought to simplify the cognitive task faced by respondents while at the same time providing incentives for the truthful revelation of preferences (Arana and Leon; Arrow et al.; Bishop and Heberlein; Cameron and James; Cooper, Hanemann, and Signorello; Freeman; Hanemann; Mitchell

[2] The information about the potential expected benefit and cost would have been confusing. For instance, the benefit side would have involved estimating environmental and ecological values of the area, and the cost side would have involved predicting the sizes of houses built.

and Carson, 1989; Yoo and Yang). Others prefer open-ended formats because an increasing number of empirical studies have revealed that values obtained from dichotomous choice elicitation are significantly and substantially larger that those resulting from comparable open-ended questions (Botelho and Pinto; Desvousges et al.; McFadden). Nevertheless, open-ended questions have not been widely used because respondents find it hard to name an exact WTP amount (Yrjölä and Kola). Carson et al. suggested that environmental valuation using a continuous response format, such as the payment card method, is likely to be biased because the beliefs and strategic behavior of the respondents toward nonprivate goods may prevent revealing truthful preferences from an incentive perspective. However, the same can be said for dichotomous choice. In contrast, Reaves, Kramer, and Holmes showed that the payment card format exhibited desirable properties pertaining to item nonresponse and protest zero bids relative to dichotomous choice and open-ended questions.

Following standard practice for the contingent valuation method, individuals bidding zero WTP were asked if this was because they did not value the proposed conservation easements, or because they objected to the payment vehicle or some other aspect of the question (McFadden). The choice of answers included (a) I can't afford to pay more taxes; (b) I don't think additional taxes are the best way to fund the conservation easement projects; (c) I don't believe conservation easements will lead to the outcomes as claimed; (d) It just isn't worth it to me to pay anything to change the current rate of land development; and (e) I would like to see more development. The households answering (a), (d), or (e) were classified as true zero bidders who did not value the proposed conservations easements. Those who answered (b) were classified as protests because they objected to the payment vehicle. Also, those who answered (c) were classified as protesters because they objected to the conservation easement program itself.

It could be argued that those who answered (e), "I would like to see more development," actually have negative WTP because they might like development rather than conservation. Alternative approaches for modeling negative WTP exist (Clinch and Murphy; Haab and McConnell; Hanemann and Kanninen; Huhtala; Keith, Fawson, and Johnson; Kristrom; McMillan, Duff, and Elston). However, we had only three such responses and chose to treat them as true zero bidders.

The survey was mailed to 1,400 randomly chosen residents and homeowners in Macon County during the period of October–December 2003 following Dillman's Total Design Method (Dillman). A total of 385 surveys was returned due to vacancies and/or wrong addresses, while 321 recipients responded with usable answers, giving an effective response rate of 32%. While resources were not available to follow up on the 385 unsuccessful mailings, it is possible that this number could have been influenced by the large number of seasonal and second homes.

Our response rate was low relative to some previous studies that have estimated WTP for environmental goods. For example, Johnston et al. measured rural amenity values using survey data with a 58% overall response rate, and Breffle, Morey, and Lodder measured neighborhood WTP to preserve undeveloped urban land using survey data with a 63% overall response rate. Choe, Whittington, and Lauria measured the benefit of surface-water-quality improvement using survey data with a 65% overall response rate. Alternatively, in a study valuing green space and farmland preservation in Ohio, Blaine, Lichtkoppler, and Stanbro obtained a response rate of 44%, which included a large proportion of late respondents.

While the response rate was relatively low, the protest bid ratio was 31%, which is high among those reported in the CVM literature (e.g., less than 5% in Boyle, 18% in Strazzera et al. [2003b], 23% in Brouwer and Slangen). There may be correlation between low response rate and high protest ratio because the issues of conservation and land use are highly controversial in the area. In our sample, 36%

of primary homeowners and 22% of second-home owners were protesters. Census data indicate that 32% of the homes in Macon County are for seasonal, recreational, or occasional use, while 38% of our survey respondents are second-home owners. The higher protest rate and slightly lower response rate for primary homeowners suggest that primary homeowners have greater frequencies of protest zero bids and nonrespondents than second-home owners. This may, however, simply be an artifact of sample, as Bowker et al. (2003) obtained an 82% overall response rate together with a 32% protest rate when studying the highly charged issue of lethal versus nonlethal deer control at Hilton Head, SC.

Low response rates can compromise survey results if respondents are not representative of the target population (Arrow et al.; Desvousges et al.; Mitchell and Carson). Harrison and Lesley found that even inexpensive convenience samples could serve as good proxies for expensive surveys with high response rates if explanatory variables in the estimated valuation functions were calibrated to the population of interest. Our relatively low response rate suggests caution when using the dollar amounts derived herein. However, the response rate is unlikely to diminish the applicability of the analytical methods we present.

Econometric Approaches

We consider two alternative modeling approaches. In the first approach, reporting of WTP is subject to an ordered probit selection rule, and in the second approach, we use a binary probit selection rule to accommodate "protest" while accommodating (true) zero WTP with a censored (Tobit) mechanism.

Ordered Probit Selection Model

Respondents' WTP answers were classified as three alternative (ordinal) outcomes: true zero bids, protest zero bids, and positive bids. This particular order was based on the assumption that the protest bids are undetermined bids between true zero bids and positive bids. This response pattern is accommodated with an ordered probit mechanism for the ordinal bid variable (d)

$$d = j \text{ if } \xi_j < z'\alpha + u \le \xi_{j+1}, \quad j = 0,1,2, \tag{1}$$

where $j = 0$ for true zero bids, $j = 1$ for protest zero bids, $j = 2$ for positive bids, and u is a random error term. In this mechanism, each respondent's WTP answer is assumed to be in the ascending order of true zero bid, protest zero bid, and positive bid. A positive WTP outcome (y) is observed and modeled with a regression equation when $d = 2$:

$$\begin{array}{ll} \log y = x'\beta + v & \text{if } d = 2 \\ y = 0 & \text{if } d = 0 \text{ or } d = 1. \end{array} \tag{2}$$

In Equations (1) and (2), z and x are vectors of explanatory variables, α and β are conformable parameter vectors, and the ξ values are threshold parameters such that $\xi_0 = -\infty$, $\xi_1 = 0$, $\xi_3 = \infty$, and ξ_2 is estimable. The dependent variable (y) is logarithmically transformed to accommodate nonlinearity between y and the explanatory variables; such (variance-stabilizing) transformation can also ameliorate potential heteroscedasticity in the error variance. The error terms of the two equations are distributed as bivariate normal with zero means and a finite covariance matrix

$$\begin{bmatrix} u \\ v \end{bmatrix} \sim N\left(0, \begin{bmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{bmatrix}\right), \tag{3}$$

where σ is the standard deviation of u_2, and ρ is the correlation between u_1 and u_2. The assumption of unitary variance for u_1 is needed as d is observed only in categories. Note that the second line of Equation (2) could be replaced with another mechanism such that $y = 0$ if $d = 0$ and $y =$ unobserved if $d = 1$. Even though zero WTP is reported when $d = 1$, this WTP outcome is categorized as unobserved based on the protest response to the follow-up question for a zero answer. Such recategorization does not affect construction of the likelihood function.

Based on Equations (1), (2), and (3), the sample likelihood function for an independent sample is

$$L = \prod_{d=0}[1 - \Phi(z'\alpha)] \times \prod_{d=1}[\Phi(\xi_2 - z'\alpha) - \Phi(-z'\alpha)] \times \prod_{d=2} y^{-1}\sigma^{-1}\phi\left(\frac{\log y - x'\beta}{\sigma}\right) \times \Phi\left[\frac{-(\xi_2 - z'\alpha) + \rho(\log y - x'\beta)/\sigma}{(1-\rho^2)^{1/2}}\right], \quad (4)$$

where $\phi(.)$ and $\Phi(.)$ are the univariate standard normal probability density function (pdf) and cumulative distribution function (cdf), respectively. The three components of the likelihood function represent, respectively, the probabilities of a zero bid ($d = 0$), protest ($d = 1$), and the probability density of a positive bid ($d = 2$, $y > 0$). ML estimation can be carried out based on the likelihood function (Equation [4]). As in other sample selection models (e.g., Heckman), restricting the error correlation (ρ) to zero reduces the model to an independent model, for which estimation can be carried out by an ordinal probit based on the full sample and an OLS based on the truncated sample (conditional on positive bid, i.e., $d = 2$). Such separate estimation is possible because the two sets of parameters are separable under independence.

One issue related to ordered selection, Equation (1), is whether an unordered selection mechanism such as multinomial probit (or logit) might be appropriate. Because a multinomial probit selection model is more cumbersome, we take an empirical approach to this ordered versus unordered selection issue by recategorizing the outcomes for d, and we conclude that the OPS rule is appropriate (more details to follow).

The effects of explanatory variables can be derived by differentiating the following probabilities, conditional mean, and unconditional mean, respectively:

$$\Pr(d = j) = \Phi\left(\xi_{j+1} - z'\alpha\right) - \Phi\left(\xi_j - z'\alpha\right), \quad j = 0,1,2 \quad (5)$$

$$E(y|d = 2) = \exp\left(x'\beta + \sigma^2/2\right) \times \left\{\frac{1 - \Phi(\xi_2 - z'\alpha - \rho\sigma)}{1 - \Phi(\xi_2 - z'\alpha)}\right\}, \quad (6)$$

and

$$E(y) = \exp\left(x'\beta + \sigma^2/2\right) \times [1 - \Phi(\xi_2 - z'\alpha - \rho\sigma)]. \quad (7)$$

See Yen and Rosinski for derivation of the conditional mean (Equation [6]), and note that the unconditional mean in Equation (7) follows from Equations (5) and (6). The marginal effects of continuous explanatory variables are derived by differentiating Equations (5), (6), and (7) (analytic derivatives are available upon request). The marginal effects of each binary explanatory variable are calculated by differencing, that is, by simulating a finite change in the variable, from 0 to 1, other variables held constant at the sample means.

Tobit with Binary Sample Selection

Our second approach is to treat WTP (y) as a censored dependent variable subject to a binary sample selection rule to accommodate a protest outcome ($w = 0$). The model is characterized as

$$\begin{aligned} w &= 1 \quad \text{if } z'\alpha + u > 0 \\ &= 0 \quad \text{if } z'\alpha + u \leq 0 \end{aligned} \qquad w = 1 \quad (8)$$

and

$$\begin{aligned} y &= 0 && \text{if } z'\alpha + u > 0 \text{ and } x'\beta + v \leq 0 \\ &= x'\beta + v && \text{if } z'\alpha + u > 0 \text{ and } x'\beta + v > 0, \\ &= \text{unobserved} && \text{if } z'\alpha + u \leq 0, \end{aligned} \quad (9)$$

where the error terms are also distributed as bivariate normal as in Equation (3). In this model, WTP (y) can be zero (censored) or positive when protest does not occur ($w = 1$) and is treated as unobserved when protest occurs ($w = 0$). If we denote the standard bivariate normal cdf with correlation τ as ψ

$(\cdot,\cdot\,;\tau)$, then the sample likelihood function is

$$L = \prod_{w=0}[1-\Phi(z'\alpha)] \times \prod_{w=1,\,y=0}\Psi(z'\alpha,\ -x'\beta/\sigma;\ -\rho) \times \prod_{w=1,\,y>0}\frac{1}{\sigma}\phi\left(\frac{y-x'\beta}{\sigma}\right) \times \Phi\left(\frac{z'\alpha+\rho(y-x'\beta)/\sigma}{(1-\rho^2)^{1/2}}\right). \tag{10}$$

The three components of the likelihood function represent, respectively, the probability of protest ($w = 0$), no protest but censored ($w = 1$, $y = 0$), and the conditional density of WTP (y) conditional on no protest and no censoring ($w = 1$, $y \geq 0$). A number of probabilities, conditional mean, and unconditional mean of y are of interest. The marginal probability of not protesting, marginal probability of positive bid conditional on not protest, joint probability of not protesting and positive bid, and conditional mean of y (conditional on no protest and no censoring) are, respectively,

$$\Pr(w=1) = \Pr(u > -z'\alpha) = \Phi(z'\alpha), \tag{11}$$

$$\Pr(y>0|w=1) = \Pr(u > -z'\alpha,\ v > -x'\beta|u > -z'\alpha), = \Psi(z'\alpha,\ x'\beta/\sigma;\ \rho)/\Phi(z'\alpha) \tag{12}$$

$$\Pr(w=1,\ y>0) = \Pr(u > -z'\alpha,\ v > -x'\beta) = \Psi(z'\alpha,\ x'\beta/\sigma;\ \rho), \tag{13}$$

and

$$\begin{aligned} E(y|w=1,\ y>0) &= x'\beta + E(v|u > -z'\alpha,\ v > -x'\beta) \\ &= x'\beta + [\Psi(z'\alpha,\ x'\beta/\sigma;\ \rho)]^{-1}\sigma \\ &\quad \times \left\{\phi(x'\beta/\sigma)\Phi\left[(z\alpha-\rho x'\beta/\sigma)\big/(1-\rho^2)^{1/2}\right]\right. \\ &\quad \left.+\rho\phi(z'\alpha)\Phi\left[(x'\beta/\sigma-\rho z'\alpha)\big/(1-\rho^2)^{1/2}\right]\right\}. \end{aligned} \tag{14}$$

In Equation (14), the second equality follows from properties of the truncated bivariate normal distribution (Rosenbaum). The unconditional mean is the product of the probability from Equation (13) and the conditional mean (Equation [14]). Marginal effects of continuous and discrete explanatory variables are derived by differentiating and differencing the above expressions, as described previously for the OPS model.

Implementation of the Econometric Models to Willingness-to-Pay

ML estimation was carried out by programming the likelihood functions in Equation (4) and (15) for the OPS and TBS models, respectively, in Gauss. Asymptotic standard errors for parameter estimates were calculated from White's heteroscedasticity consistent covariance matrix. There are three issues pertaining to the choice of explanatory variables. One issue is related to multicollinearity. Multicollinearity is a concern because it can inflate the variance of parameter estimates, thereby limiting the accuracy of estimation. In preliminary analysis, the education variable was found to be highly correlated with income, with a correlation coefficient greater than 0.7. The education variable was excluded because it had a variance inflation factor (VIF) of 6.2 (Maddala). The VIFs of the explanatory variables that remain are all lower than 1.5, which is much lower than the commonly used threshold of 10.

Another specification issue relates to the potential endogeneity of the knowledge variable. The literature on technology adoption indicates that when people are interested in a topic, they are more likely to obtain information on it (Rogers). In other words, if they are interested in the environmental issue regarding land conservation, they are more likely to learn about the issue. This means that the knowledge variable is likely to be endogenous in the WTP equation. A major problem caused by the potential endogeneity of knowledge, if it is indeed endogenous, would be simultaneous-equation bias. Whereas the lack of usable instruments prevents a full investigation of the endogeneity issue, we take a parsimonious approach in investigating the potential simultaneous-equation biases in the empirical estimates by comparing the models with and without the knowledge variable (estimation results without the knowledge variable are available upon request). We find that exclusion of the knowledge variable from both the selection and regression equations did not produce any discernible differences in empirical results (maximum likelihood estimates and marginal effects). For instance, there is only one variable, i.e., second home, which has a slightly increased significance level in the regression equation of the TBS model without the knowledge variable. The signs and significance levels stay the same for the rest of parameter estimates. We conclude from this exploratory analysis that potential endogeneity of the knowledge variable does not cause an empirical difficulty.

The third specification issue relates to choice of explanatory variables for the selection equation and the regression equation in both models. Unlike the two-step estimation for which exclusion restrictions are often needed, parameters in both equations are fully identified in ML estimation because the nonlinear identification criteria are met even without exclusion restrictions due to the functional form and distributional assumptions for the system. However, to avoid overburdening the functional form for identification, and due to the very limited number of explanatory variables, we take an empirical approach to the identification issue. Specifically, the variables knowledge, second-home, and city were found to be insignificant in preliminary estimation of the ordinal probit equation (Equation [1]), so these variables were excluded from the selection equation in the OPS model. The exclusion of these variables was also supported by likelihood-ratio tests (LR = 0.05, df = 3, $p > 0.99$). Results for the model without exclusion restrictions, i.e., with all and identical regressors in the selection equation and level equation, suggested qualitatively similarly parameter estimates and marginal effects of explanatory variables. Likewise, exclusion of income, year, and knowledge from the binary probit selection equation for the TBS model was motivated by their statistical insignificance in preliminary estimation of the selection equation (Equation [8]) and was also supported by likelihood-ratio tests (LR = 2.75, df = 3, $p > 0.43$). The results of both OPS and TBS models without exclusion restrictions are available upon request.

It may be worth noting the expected signs of the marginal effects of the explanatory variables on WTP for the selection and regression equations. Income is expected to have positive effects because higher income relaxes the budget constraint. Proximity between the house of respondents and poorer quality streams is also expected to have positive effects because as the distance to poorer quality streams increases, the homeowner would have less to gain from conservation easements protecting streams. Negative effects of residency duration are anticipated because previous literature finds that newer residents of rural, urban-fringe communities place relatively higher values on amenities and conservation (Dubbink; Healy and Short; Johnston et al.). Knowledge about environmental issue has been found to explain WTP for environmental goods and services (e.g., Bowker et al., 2003; Cho, Newman, and Bowker; Choe, Whittington, and Lauria); it is therefore expected to have positive signs in both WTP equations. The effects of city dummy and second-home variables are unclear.

ML estimates of the OPS model with protest zero bids ordered between true zero and positive bids are presented in Table 2. The error correlation coefficient is significant at the 1% level, supporting the correction for sample selection in both models. Superiority of the model over the restricted (independent) version is also confirmed by a likelihood-ratio tests (LR = 7.16, df = 1, $p < 0.01$). Among the estimates for the selection equation, income has a positive effect on the probability of a positive WTP ($d = 2$), whereas distance to poorer quality streams and year have negative effects. As to the regression estimates for the WTP equation, self-assessed knowledge is found to increase the amount of WTP.

Results for the same OPS model using an alternative underlying assumption for the

Table 2. Maximum-Likelihood Estimates: Ordered Probit Selection Model

Variable	Ordered Probit Selection	WTP
Constant	1.059*** (0.195)	3.200*** (0.353)
Income	0.012*** (0.003)	0.003 (0.004)
Distance	−0.028*** (0.010)	−0.008 (0.019)
Year	−0.011*** (0.003)	0.003 (0.005)
Knowledge		0.552*** (0.158)
City		−0.055 (0.208)
Second home		0.107 (0.170)
σ		1.268*** (0.124)
ξ_2	1.085*** (0.097)	
ρ		−0.880*** (0.065)
Log likelihood	−1027.574	

Note: Asymptotic standard errors are in parentheses.
*** $P < 0.01$.

protest zero bids, undetermined bids below true zero bids, are shown in the Table A1 in the Appendix. Under this alternative assumption, the respondents' WTP answers were classified in ascending order of protest zero bids, true zero bids, and positive bids. The reordering of protest zero bids and true zero bids from the original order probit selection model in Equation (1) does not change the statistical significances and signs of the coefficients of the ML estimates. This indicates insignificance of the role of the order between true zero bids and protest zero bids in the estimates of the model. The same likelihood function where protest zero bids are positive bids collapses during the run of the estimates, implying model misspecification. The test of different order of protest zero bids implies that protest zero bids can be reasonably assumed to be below true zero bids or between true zero and positive bids; however, they are not likely positive bids.

To further quantify the effects of explanatory variables on the probabilities of ordinal outcomes (zero bids, protest bids, and positive bids) and WTP level, we calculated the marginal effects using Equations (5), (6), and (7). For statistical inference, standard errors for these marginal effects were also calculated by mathematical approximation (Rao, p. 388). Results are presented in Table 3. (Results for the alternative order of protest zero bids smaller than true zero bids are presented in Table A2.)

The marginal effects on probabilities suggest that income, distance to poorer quality streams, and duration of residency play significant roles (at the 1% level) in residents' WTP for the conservation easement. All else being equal, residents with the highest income category of \$90,000 on average are 15.0% and 22.5% less likely to choose zero WTP and protest, respectively, than residents with the lowest income category of \$15,000.[3] Residents with \$90,000 are 37.5% more likely to choose positive WTP than residents with \$15,000. A resident furthest from the poorer quality stream (28.4 km) is 14.0% and 16.8% more likely to choose zero WTP and protest, respectively, than a resident closest to the poorer quality stream (0.4 km). A resident closest to the poorer quality stream is 30.8% more likely to choose positive WTP than residents at the sample's upper limit of distance to poorer quality streams. A resident who has lived in the county for 10 yr is 2.0% more likely to choose zero WTP, and protest consistently, than a resident who most recently moved into the county. A resident who moved

[3] Given the difficulty typically associated with obtaining exact household income information from surveys, respondents were asked whether their incomes fell into any of three categories—less than \$30,000; between \$30,000 and \$60,000; and more than \$60,000; respectively. For the regression analyses, interval midpoints (\$15,000 and \$45,000) were used for the first two categories and \$90,000 was used for the final category.

in the county most recently is 4.0% more likely to choose positive WTP than a resident who has lived in the county for 10 yr.

Table 3 also presents the marginal effects of explanatory variables on WTP. For both conditional and unconditional values, WTP values are not significantly influenced by whether residents live within city boundaries or whether they are second-home or primary homeowners. Instead, higher income, proximity to poorer quality streams, and knowledge about land development issues contribute to higher WTP values, both conditional and unconditional on positive WTP and unconditional at the statistical level of 5%. Shorter duration of residency contributes to higher WTP for unconditional WTP, but it is not a significant factor for WTP conditional on WTP.

Household income has positive and significant marginal effects on the conditional and unconditional WTP, indicating that conservation easements are normal goods. A $1,000 increase in annual household income results in a $0.40 increase in average conditional WTP for the conservation easement program. The corresponding effect on unconditional WTP is $0.38. Households located further away from any of the four streams of poorer water quality are more likely to have lower WTP for conservation easements. A 1 km increase in the distance to one of the four streams of poorer water quality would result in a $0.97 decrease in the conditional WTP. The same increase in distance results in a $0.91 decrease in the unconditional WTP. Households with shorter duration of residency are more likely to have higher unconditional WTP. Conditional WTP does not appear to be influenced by duration of residency. Based on the unconditional WTP, the marginal WTP for a year increase in the duration of residency would result in a $0.25 decrease in the WTP.

Households with more knowledge about land development issues are more likely to have a greater WTP. The difference in marginal WTP associated with being in the higher knowledge group is quite large between WTP for unconditional value and the WTP conditional on positive WTP. More knowledge adds $22.18 to conditional WTP, while

Table 3. Marginal Effects of Explanatory Variables on Probabilities and WTP: Ordered Probit Selection Model

	Probabilities of Ordinal Outcomes			WTP	
Variable	Zero WTP	Protest	Positive WTP	Conditional on Positive WTP	Unconditional
			Continuous Explanatory Variables		
Income	−0.002*** (0.001)	−0.003*** (0.001)	0.005*** (0.001)	0.400*** (0.102)	0.384*** (0.076)
Distance	0.005*** (0.002)	0.006*** (0.002)	−0.011*** (0.004)	−0.971** (0.545)	−0.913*** (0.350)
Year	0.002*** (0.001)	0.002*** (0.001)	−0.004*** (0.001)	−0.192 (0.136)	−0.251*** (0.097)
			Binary Explanatory Variables		
Knowledge				22.177*** (7.679)	12.601*** (4.444)
City				−1.820 (7.056)	−1.034 (4.011)
Second home				3.529 (5.690)	2.005 (3.233)

Note: Asymptotic standard errors are in parentheses. The marginal effects of continuous and binary explanatory variables are derived by differentiation and differencing, respectively. See text for details.

* $P < 0.10$.

*** $P < 0.01$.

Table 4. Maximum-Likelihood Estimates: Tobit Model with Sample Selection

Variable	Binary Probit Selection: Not Protest	WTP
Constant	1.272*** (0.365)	9.191 (7.207)
Income		0.349*** (0.067)
Distance	−0.058*** (0.018)	−0.745* (0.392)
Year		−0.263*** (0.091)
Knowledge		17.552*** (4.035)
City	−0.585** (0.299)	−1.985 (5.140)
Second home	0.453*** (0.158)	1.451 (3.572)
σ		23.245*** (1.979)
ρ		−0.201** (0.087)
Log likelihood	−1048.537	

Note: Asymptotic standard errors are in parentheses.
* $P < 0.10$.
** $P < 0.05$.
*** $P < 0.01$.

the marginal effect of knowledge on the unconditional result is $12.60. This indicates that the increased WTP resulting from better knowledge for conditional on positive WTP is significantly greater than the increased WTP resulting from better knowledge for unconditional value. That is, those high-knowledge households that believe the CVM scenario will work, and thus will participate in the program, have considerably higher WTP values than the rest of households who have high knowledge but do not believe the CVM scenario.

ML estimates of the TBS model are presented in Table 4. The error correlation coefficient is significant at the 1% level, justifying the correction for sample selection. Among the estimates for the selection (not protest) equation, distance and city have negative effects on "not protest," while second home has positive effect. As to the regression estimates for the WTP equation, income and knowledge increase the amount of WTP, whereas duration of residency and distance to poorer quality streams decrease the WTP.

We calculated the marginal effects of each variable on the probability of not protest, positive WTP conditional on not protest, and not protest and positive WTP, as well as on the levels of WTP conditional and unconditional on positive WTP, based on Equations (16, 17). Results are presented in Table 5. All else being equal, residents with $90,000 income on average are 37.5% and 22.5% more likely to choose positive conditional on not protest and not protest and positive WTP, respectively, than residents with the $15,000 income. A resident very close to the poorer quality stream (0.4 km) is 56.0%, 33.6%, and 64.4% more likely to choose zero WTP, positive WTP conditional on not protest, and not protest and positive WTP, respectively, than a resident farther away from the poorer quality stream (28.4 km). Residents who have lived in the county 10 yr longer are 4% and 3% less likely to choose positive WTP conditional on not protest and joint of not protest and positive WTP, respectively. Residents with better knowledge are 19.5% and 13.7% more likely to choose positive WTP conditional on not protest and not protest and positive WTP, respectively. Residents outside of the city boundary are 17.4% and 16.5% more likely to respond not protest and not protest and positive WTP, respectively. The second-home owners are 15.1% and 13.7% more likely to respond not protest and not protest and positive WTP, respectively.

All else being equal, a $1,000 increase in annual household income resulted in a $0.19 increase in average conditional WTP for the conservation easement program. The corresponding effect on unconditional WTP was $0.18. A 1 km increase in the distance to one of the four streams of poorer water quality would result in a $0.48 decrease in the conditional WTP. The same increase in distance reduced the unconditional WTP by

Table 5. Marginal Effects of Explanatory Variables on Probabilities and WTP: Tobit Model with Sample Selection

	Probabilities			WTP	
Variable	Not Protest	Positive WTP Conditional on Not Protest	Joint of Not Protest and Positive WTP	Conditional on Positive WTP	Unconditional
			Continuous Explanatory Variables		
Income		0.005*** (0.001)	0.003*** (0.001)	0.186*** (0.036)	0.184*** (0.037)
Distance	−0.020*** (0.006)	−0.012** (0.006)	−0.023*** (0.006)	−0.476** (0.210)	−0.843*** (0.248)
Year		−0.004*** (0.001)	−0.003*** (0.001)	−0.140*** (0.047)	−0.139*** (0.048)
			Binary Explanatory Variables		
Knowledge		0.195*** (0.036)	0.137*** (0.026)	10.754*** (2.804)	10.150*** (2.527)
City	−0.174*** (0.073)	−0.042 (0.067)	−0.165** (0.077)	−1.808 (2.946)	−5.335 (3.660)
Second home	0.151*** (0.050)	0.034 (0.049)	0.137*** (0.052)	1.379 (1.957)	4.234* (2.273)

Note: Asymptotic standard errors are in parentheses. Equations (11), (12), (13), and (14) pertain the columns for "Not Protest," "Positive WTP Conditional on Not Protest," "Joint of Not Protest and Positive WTP," and "Conditional On Positive WTP," respectively. The "Unconditional" WTP is the product of the probability (Equation [13]) and the conditional mean (Equation [14]). The marginal effects of continuous and binary explanatory variables are derived by differentiation and differencing, respectively. See text for details.

* $P < 0.10$.

** $P < 0.05$.

*** $P < 0.01$.

\$0.84. The marginal WTP for a year increase in the duration of residency would result in a \$0.14 decrease in the both conditional and unconditional WTP values. More knowledge adds \$10.75 to conditional WTP, while the marginal effect of knowledge on the unconditional result is \$10.15.

At the sample mean of relevant explanatory variables, the expected value of annual household WTP is \$32.66 conditional on positive WTP and \$18.56 unconditional, according to the OPS model. Using the TBS model, the corresponding conditional and unconditional expected values are \$25.22 and \$13.31. We estimate aggregate annual county WTP across 20,746 households with the unconditional mean and across 11,763 households with the conditional mean, based upon the positive WTP response ratio of 56.7% (182 of 321 responses). For the OPS model, the values range from \$384,180 for the conditional mean to \$385,046 for the unconditional mean. For the TBS model, aggregate values range from \$296,663 for the conditional mean to \$276,129 for the unconditional mean. Based on the average conservation easement price of \$2,059 per acre for North Carolina under the Farmland Protection Program by U.S. Department of Agriculture through 2001, the county could expect to conserve 186 or 187 acres annually based on the OPS model and 134 or 144 acres based on the TBS model.

A 10 yr projection of land conserved, based on an assumption of a 5.5% increase in the number of households (average increase of 1990–2000), a 9.2% increase in conservation easement price (average increase of market value of farmland and building from 1987 to 1997), and 2.7% discount rate (average consumer price index of 1990–2000), ranges from 1,551 to 1,555 acres based on the OPS model and 1,115 to 1,198 acres based on the TBS model. This represents a decrease in the rate of farmland development at just over 50% and around 40%, respectively, compared to the 1987 to 1997 rate of 2,969 acres.[4]

[4] The farmland includes cultivated cropland, noncultivated cropland, pastureland, and rangeland.

Although the projections based on the two models are fairly close, it is useful to test which model is preferred statistically. Because the two models are nonnested, they may be compared with a nonnested model specification test. In particular, we let f and g be n-vectors containing the log-likelihoods of the OPS and TBS models, respectively, ι is an n-vector of ones, and we define $d = f - g$. Then, under the null hypothesis of no difference between the two models, Vuong's (Eq. [5.6]) statistic is $z = \iota' d/[d'd - (\iota' d)^2/n]^{1/2} \sim N(0, 1)$. The result ($z = 2.016$, $p < 0.044$ for a two-tailed test) suggests that the OPS model is preferable to the TBS model because the former is a better characterization of the data-generating process than the latter.

Conclusions and Policy Implications

This study compared the OPS and TBS models to take into account both true and protest zero bids in estimating the WTP for conservation easements in Macon County, NC. The differences of individual decisions for the true zero bids, protest zero bids, and positive bids were captured in the OPS model. Marginal effects of explanatory variables on the probabilities of "zero WTP," "protest," and "positive WTP," respectively, were also calculated. The TBS model accommodated protest bids while taking into account zero WTP with a censored mechanism. The marginal probabilities of not protest, positive WTP conditional on not protest, and joint probability of not protest and positive WTP, conditional mean, and unconditional mean were calculated. The marginal effects of both models provide valuable information because there is a distinction between the characteristics of the protest zero bids from the true zero bids and positive bids.

Both models consistently show that income and knowledge are positive and significant factors, whereas distance to poorer quality streams and duration of residency are negative and significant factors on WTP conditional and unconditional on positive WTP. The large marginal effect of better knowledge on WTP, relative to the effects of other factors (estimated to be as low as $10.15 and as high as $22.18), is an important finding for policy. Public trusts, nongovernmental organization, and state and local governments should be aware that conservation education and marketing programs that promote and raise the level of public knowledge about relevant environmental issues may be useful to increase public acceptance and financial support.

Education and marketing programs that enhance public knowledge of the environmental issues about conservation easements can be developed to improve household support for these programs significantly. The marginal improvement can be higher if the education and marketing programs are targeted to the households with lower probability of positive WTP (e.g., long-time settlers, households further away from poorer quality streams, households with lower income, primary homeowners, and homeowners within city boundaries).

In the application of an OPS model and the Tobit model with selection to estimations of the WTP for conservation easements, both models account for the presence of selectivity bias induced by zero and protest responses. By comparing the two models, the ordered/unordered selection issue of the protest responses was analyzed to demonstrate how the treatment of protest responses can have a significant influence on the results of the WTP model. We found that the difference in the WTP estimates was within a 30% range, and the higher values resulted from the OPS model. Even though the OPS model is preferable to the TBS model based on a statistical criterion, projections from the two models are fairly close. Further research might explore the differences between the models in assessing the WTP survey results so as to judge the accuracy and consistency of the estimates.

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Appendix

Table A1. Maximum-Likelihood Estimates: Ordered Probit Selection Model (with Alternative Order of Ordinal Outcomes)

Variable	Ordered Probit Selection	WTP
Constant	0.588*** (0.192)	3.072*** (0.353)
Income	0.008*** (0.003)	0.005 (0.004)
Distance	−0.035*** (0.012)	0.000 (0.020)
Year	−0.009*** (0.003)	0.002 (0.005)
Knowledge		0.539*** (0.154)
City		−0.062 (0.212)
Second home		0.116 (0.167)
σ		1.300*** (0.122)
ξ_2	0.366*** (0.054)	
ρ		−0.900*** (0.052)
Log likelihood	−1036.912	

Note: Asymptotic standard errors are in parentheses.
*** $P < 0.01$.

Table A2. Marginal Effects of Explanatory Variables on Probabilities and WTP: Ordered Probit Selection Model (with Alternative Order of Ordinal Outcomes)

	Probability of Ordinal Outcomes			WTP	
	Zero WTP	Protest	Positive WTP	Conditional on Positive WTP	Unconditional
Continuous Explanatory Variables					
Income	0.000** (0.000)	−0.003*** (0.001)	0.003*** (0.001)	0.365*** (0.098)	0.303*** (0.071)
Distance	0.002** (0.001)	0.012*** (0.004)	−0.014*** (0.005)	−0.915* (0.529)	−0.959*** (0.349)
Year	0.000** (0.000)	0.003*** (0.001)	−0.004*** (0.001)	−0.189 (0.129)	−0.223** (0.091)
Binary Explanatory Variables					
Knowledge				21.173*** (7.234)	12.097*** (4.210)
City				−2.034 (7.113)	−1.162 (4.066)
Second home				3.762 (5.518)	2.149 (3.154)

Note: Asymptotic standard errors in parentheses.
* $P < 0.10$.
** $P < 0.05$.
*** $P < 0.01$.