Journal of Agricultural and Resource Economics 31(2):301–317

Estimating Willingness to Pay Using a Polychotomous Choice Function: An Application to Pork Products with Environmental Attributes

Sean P. Hurley, Douglas J. Miller, and James B. Kliebenstein

Bid data from a Vickrey auction for pork chops with embedded environmental attributes were analyzed. It was found that approximately 62% of the participants had a positive WTP for the most "environmentally friendly" package of pork. Thirty percent of the participants had no WTP, and 8% had a negative WTP. A polychotomous choice model was used to accommodate data having an anchoring point within the distribution of the data. Standard variables found in the WTP literature coupled with this model were used to predict participants who were premium payers and non-premium payers using an estimated ordered probit equation.

Key words: anchoring points, environmental attributes, ordered probit, polychotomous choice functions, pork, Vickrey auction, willingness to pay

Introduction

Manure spills and odor from confined animal feeding operations (CAFOs) have increased the concerns surrounding livestock production. In recent years, large-scale hog operations have received heightened attention due to their potential impact on the neighboring environment. The three most commonly vocalized concerns have been odor, contamination of ground and surface water, and major catastrophic events such as lagoon spills (Honeyman, 1995, 1996; Letson and Gollehon, 1996). This recent attention has brought considerable scrutiny to the pork industry, which has been working to develop solutions for these issues.

Environmental issues pertaining to air and water quality from CAFOs can be addressed in one of two general ways: a governmental regulatory solution or a market-based solution. A regulatory solution would require that a federal, state, or local body enact regulations to curb the negative externalities coming from CAFOs. A critical concern with the regulatory approach is that it tends to be inefficient.

A potential market solution can be achieved if producers receive a premium for voluntarily internalizing the negative externalities from the production process and

---

Sean P. Hurley is assistant professor, Department of Agribusiness, California Polytechnic State University, San Luis Obispo; Douglas J. Miller is associate professor, Department of Economics, University of Missouri-Columbia; and James B. Kliebenstein is professor, Department of Economics, Iowa State University. The authors would like to thank two anonymous reviewers for their helpful comments. Junjie Wu, John Fox, Qingbin Wang, and John Brandt deserve special recognition for assisting in the coordination of the consumer experiments conducted at their respective universities. The authors also thank the Leopold Center for Sustainable Agriculture for its generous financial support of this research.

Review coordinated by DeeVon Bailey.

producing livestock in more "environmentally friendly" ways. However, for this market solution to be viable, there must be an identifiable set of consumers willing to pay a premium for pork products with environmental attributes. Moreover, this premium needs to be large enough to offset any additional costs of producing pork in more "environmentally friendly" ways. Finally, once these consumers are identified, marketing efforts must be focused toward that particular target audience.

Many studies have examined willingness to pay (WTP) for air and water quality, as well as other environmental amenities. For example, several studies have used contingent valuation surveys to estimate WTP for groundwater protection (Spencer, Swallow, and Miller, 1998; Boyle, Poe, and Bergstrom, 1994; Powell, Allee, and McClintock, 1994; Edwards, 1998; Sun, Bergstrom, and Dorfman, 1992; Caudill and Hoehn, 1992; Poe and Bishop, 1992; Jordan and Elnagheeb, 1993; Laughland et al., 1993) and open-space amenities (Beasley, Workman, and Williams, 1986; Bergstrom, Dillman, and Stoll, 1985; Ready, Berger, and Blomquist, 1997; Rosenberger and Walsh, 1997). Regarding environmental amenities specifically related to livestock, some work has been conducted to examine how air quality around livestock production facilities affects the neighboring property values (Palmquist, Roka, and Vukina, 1997; Abeles-Allison and Connor, 1990; Taff, Tiffany, and Weisberg, 1996).

In this paper, we analyze observed consumer WTP for pork products with embedded environmental attributes from information collected from a second-price sealed-bid auction. Participants in the study were simultaneously allowed to bid on 10 different packages of pork chops, each having differing environmental attributes. The participants were informed that the hogs were raised in production systems having distinctly different impacts on neighboring ground water, surface water, and air quality. Econometric techniques are utilized to investigate the relationship between WTP for embedded environmental attributes and the socioeconomic characteristics of the respondents. A two-stage econometric model developed using an ordered probit polychotomous choice function is employed to accommodate data that have anchoring points within the distribution of the data.[1]

This analysis contributes to the WTP literature in three unique, distinct ways. First, several previous studies have examined WTP for attributes of food products themselves (e.g., food safety, appearance, nutritional content), including studies of production practices that may affect the product attributes as well as the environment in the producing region (e.g., pesticide applications to fruit). However, very few studies have specifically evaluated WTP for food products produced under "environmentally friendly" conditions that do not directly affect the product attributes but may affect the environment surrounding the livestock production facilities. Thus, the WTP estimates presented here are more closely akin to those associated with values for open space in a non-neighboring region rather than values for the attributes of food directly consumed by the respondents (e.g., product appearance). Second, while much of the earlier research on WTP for environmental amenities (including all of the studies cited above) has employed contingent valuation and hedonic price methods, experimental economic methods were applied to elicit the WTP estimates in the current investigation. Third,

[1] An anchoring point for the purposes of this paper is defined as a point having probability greater than zero, i.e., a point α within a continuous distribution such that $\text{Prob}(x = \alpha) > 0$. Chien, Huang, and Shaw (2005) examine an issue of anchoring in relationship to starting point bias in dichotomous choice contingent valuation studies.

we adopt a two-stage estimation process, which uses a polychotomous choice function, to handle anchoring points within the distribution of the bids. To the authors' knowledge, this estimation technique has not been previously used to control for anchoring points within experimental data coming from auction experiments.

Study Design and Data

An auction was conducted using two-pound packages of uniformly cut, boneless, 1¼ inch pork loin chops, defined as coming from hogs raised in farm production systems with varying environmental attributes. The specific auction mechanism selected was a second-price sealed-bid auction segmented into five bidding rounds. List and Shogren (1999) examined many repeated trial auctions to see if these auctions create a bias in the values participants bid. They found that when bidders are provided with non-price information or are knowledgeable about the product prior to the auction, then price effects are dissipated in these types of auctions.

In the first three rounds of the auction, participants simultaneously bid only on the physical attributes of the product, having no other information except for bids from the previous rounds. In the fourth round, participants were informed of the specific environmental attributes associated with the respective products.[2] In the fifth round, the implications of the embedded environmental attributes were further explained and participants were allowed to bid a final time.

Many recent studies have been conducted to determine how releasing information in an auction affects participants' bidding behavior. For example, Fox, Hayes, and Shogren (2002) examined how favorable and unfavorable descriptions affect consumers' value for irradiated pork. Lusk et al. (2004) studied how information on the potential benefits of biotechnology affected consumers' value of genetically modified foods. Rousu et al. (2004) and Huffman et al. (2004) investigated how consumers use different sources of information when establishing their values for products. Similarly, the information released in our experiment is used to examine how environmental information affects consumers' valuations.

After the third round in the experiment, participants were informed that one package was a "typical package" while the other nine packages were from hogs produced with varying levels of environmental attributes pertaining to ground water, surface water, and odor reduction.[3] Hog production with reduced odor was presented at two levels: a low-level reduction of 30%–40%, and a high-level reduction of 80%–90%.[4] Reduced ground water and surface water impacts of the hog production system were also at two levels: a low level of reduction at 15%–25% and a high level of reduction at 40%–50%. Packages were provided with single attributes, double attributes, or all three embedded attributes. The double- and triple-attribute pork packages were all at the high-reduction levels.

Once all five rounds of the experiments were completed, one round and one product to be sold were randomly chosen to maintain the properties of the second-price auction.

[2] This fourth-round process provides a means to determine the impact of releasing environmental information on participants' bids.

[3] The attributes of the nine other packages used the typical package as a basis.

[4] The attribute of odor reduction was associated with the production facility and its relationship to air quality. It was not related to the aroma of the pork chop—i.e., the product attribute was not proposing pork chops with different odors.

Table 1. Number of Experiment Participants by Geographic Area

Experiment Area	Number of Participants	Experiment Area	Number of Participants
Ames, IA	49	Iowa Falls, IA	58
Manhattan, KS	60	Corvallis, OR	60
Raleigh, NC (#1, 6/28/97)	31	Raleigh, NC (#2, 6/27/98)	44
Burlington, VT	27	***Total All Areas:***	***329***

As noted by Fox et al. (1995), this method controls for wealth effects. List and Shogren (1999, p. 943) explain that this method also controls for "rapidly declining marginal valuation functions."[5]

Experiments were conducted in six different geographic areas of the United States. Table 1 gives the location and the number of participants at each site. There were three experiments at each location, where the goal was to have 20 participants for each experiment. To control for bias in package labeling, the corresponding package numbers were switched with the assigned environmental attribute for each of the three different experiments. Participants were selected randomly from local telephone directories, and each was paid $40 at the beginning of the experiment for their participation.

Methods Used to Model WTP Data

Many econometric methods have been used to analyze the relationship between WTP and socioeconomic characteristics. Menkhaus et al. (1992) and Melton et al. (1996) employed ordinary least squares (OLS), while Roosen et al. (1998) and Fox (1994) adopted more advanced models incorporating a two-stage analysis. Using Cragg's (1971) double-hurdle model, Roosen et al. (1998) investigated the relationship between WTP for apples with reduced pesticide use and socioeconomic characteristics. Fox (1994) used a Heckman (1976, 1979) two-stage procedure to evaluate WTP for milk with no trace of bovine somatotropin and socioeconomic characteristics.

There are two reasons Roosen et al. (1998) and Fox (1994) selected more advanced modeling techniques over OLS. The first is associated with their methods of data collection. In both studies, a censoring or limiting point at zero is induced for a segment of their participants. This is due to their experimental designs which endowed each participant with a good and then used an experiment to elicit the participant's willingness to pay to upgrade to a product having a different set of attributes.[6] The second reason they chose more advanced two-stage techniques is related to the nature of how consumers make decisions. Fox (p. 133) notes, "Even in the absence of selection

[5] Wealth effects may occur when participants change their bids because they won an earlier trial (Fox et al., 1995). Davis and Holt (1993) provide a discussion of wealth effects in experimental markets. Rousu (2005) demonstrates the perils that occur when participants can choose which good they purchase in a multi-unit auction. Specifically, when the participant is allowed to bid on multiple products, and then allowed to choose which product he or she will purchase, then it is no longer the weakly dominant strategy using a Vickrey auction mechanism to tell the truth. As pointed out by one reviewer, the use of the terminology "wealth effects" may be misleading, suggesting that selling more than one product should be considered a "demand curve effect." Since "wealth effect" is standard in the literature, this article maintains the nomenclature.

[6] According to results reported by Corrigan and Rousu (2006), providing an initial endowment changes the participants' bidding behavior in comparison to experiments in which participants are not endowed with a good initially. Their findings show that participants with the endowed good on average significantly increase their bids.

Table 2. Distribution of Willingness to Pay for the Most "Environmentally Friendly" Product: The Product with High Ground Water, Surface Water, and Odor Improvements

Premium Level (interval) per Package	Percent of Participants	Premium Level (interval) per Package	Percent of Participants
Below $0.00	7.6%	$1.00 to $1.49	13.1%
$0.00	30.4%	$1.50 to $1.99	7.0%
$0.01 to $0.49	9.7%	$2.00 to $2.49	8.2%
$0.50 to $0.99	12.8%	Over $2.50	11.2%

bias, the two-stage method facilitates an intuitively appealing decomposition of the bidding decision."

In contrast, the method selected for this study to collect WTP information elicits unbounded continuous values. In particular, the WTP measure was calculated from the change in bids from round 3 to round 4, which was not restricted to a lower or upper bound. Consequently, it would first appear that OLS estimation may be appropriate and advanced modeling techniques may not be necessary.

Table 2 provides the distribution of premiums for the most "environmentally friendly" product, as derived from the differences in bids from round 3 to round 4. Since bids could be higher in round 3 in comparison to round 4, the premiums can take a negative value. This occurred for over 7% of the participants in the study. [Parkhurst, Shogren, and Dickinson (2004) have shown that negative values can be elicited from second-price auctions.]

While having negative premiums in itself is an interesting finding, a more striking result is that approximately 30% of the bids are zero. This implies OLS is inappropriate for the analysis and could lead to bias results. While the method of data collection allowed for an unbounded distribution of premiums, the nature of the information given caused a discrete cluster point within the range of premiums.

Lee (1983) offers a way to model this type of data using a two-stage procedure similar to the Heckman (1976, 1979) and double-hurdle models. Lee's two-stage procedure incorporates an initial polychotomous choice function, e.g., multinomial probit, in the first stage to represent the discrete component of the dependent variables. In the second stage, standard OLS procedures can be used to estimate the continuous component of the dependent variables with the discrete variables factored out. One of the advantages of Lee's model is its ability to account for more than two choices in the selection process, whereas the double-hurdle model and the two-stage Heckman procedure cannot.

Ordered Probit Polychotomous Choice Selectivity Model

The model presented by Lee (1983) for handling dependent variables with mixed discrete and continuous variables was set up as a two-stage process. In the first stage, Lee used a multinomial logit to classify the different groups to take into account the anchoring points. In the second stage, Lee employed a corrected OLS model based on the multinomial logit estimated in the first stage to estimate the continuous portions of the data in the second stage.

While a multinomial logit selection criterion could be used (as Lee proposed), a better selection criteria would be an ordered probit due to the natural ordering of the informational effects from the experiment described above. Greene (2002) presents a two-stage model which incorporates an ordered probit selection criterion. In the first stage of model estimation, a generalized ordered probit is estimated for J different categories. This stage of the model can be written as follows:

$$z^* = \alpha'\mathbf{W} + u,$$

where

$$z = \begin{cases} 0 \text{ if } -\infty < z^* \leq 0, \\ 1 \text{ if } 0 < z^* \leq \mu_1, \\ 2 \text{ if } \mu_1 < z^* \leq \mu_2, \\ \vdots \\ J \text{ if } \mu_{J-1} < z^* < \infty. \end{cases}$$

The variable z is the observed counterpart to the unobserved z^*. The error term u is assumed to come from a standard normal distribution. The μ's are estimated along with the α coefficients.

In the second stage of model estimation, an adjusted OLS is estimated for each category used in the ordered probit. This OLS estimation for category j is:

$$y_j = \mathbf{b}_j'\mathbf{X}_j + \varepsilon_j,$$

where y_j is the observed data and $\mathbf{X}_j$ is the explanatory data, which includes a correction parameter λ_j when category j is chosen. Greene (2002) shows that the error term ε_j has the following mean and variance given category j is chosen:

$$\mathrm{E}[\varepsilon_j] = \mathrm{E}[\varepsilon \mid \text{category } j \text{ is chosen}] = \sigma\rho\lambda_j$$

and

$$\mathrm{Var}[\varepsilon_j] = \mathrm{Var}[\varepsilon \mid \text{category } j \text{ is chosen}] = \sigma^2(1 - \rho^2\delta_j).$$

The error term for category j (ε_j) is an error from a normally distributed vector of error terms $\varepsilon = (\varepsilon_1, \varepsilon_2, ..., \varepsilon_J)$, where σ is the standard deviation of ε, and ρ is the correlation between ε and u. The terms λ_j and δ_j are defined as:

$$\lambda_j = \frac{\phi(\mu_{j-1} - \alpha'\mathbf{W}) - \phi(\mu_j - \alpha'\mathbf{W})}{\Phi(\mu_j - \alpha'\mathbf{W}) - \Phi(\mu_{j-1} - \alpha'\mathbf{W})}$$

and

$$\delta_j = \frac{(\mu_{j-1} - \alpha'\mathbf{W})\phi(\mu_{j-1} - \alpha'\mathbf{W}) - (\mu_j - \alpha'\mathbf{W})\phi(\mu_j - \alpha'\mathbf{W})}{\Phi(\mu_j - \alpha'\mathbf{W}) - \Phi(\mu_{j-1} - \alpha'\mathbf{W})} - \lambda_j^2.$$

For category 1, μ_0 equals zero, and for category J, μ_J is set to positive infinity.

Two-Stage Estimation with an Ordered Probit Selection Rule

Information shocks pertaining to product attributes can have a natural self-selection aspect to them, as explained by Fox, Hayes, and Shogren (2002). When maximizing consumers are given new information on a product, they must decide how that new information impacts their purchase decision. They decide whether the information has a positive, neutral, or negative effect on the evaluation of the product.[7] In essence, the consumers can be viewed as self-selecting themselves into one of three groups. Once they have decided to which group they belong, they can reallocate their resources to maximize their utilities. Since this self-selection process has a natural ordering to it, an appropriate selection rule would be an ordered probit rule characterized by three choices—a negative premium, no premium, and a positive premium.

Let z equal the ex post categorical realization of whether the consumer's perception of the product was negatively affected, not affected, or positively affected. The ordered probit of the model can be written as:

$$z^* = \alpha'\mathbf{W} + u, \tag{1}$$

where:

$z = 0$ if $z^* < 0$ (i.e., participant's value is negatively affected by the information);
$z = 1$ if $0 \le z^* \le \mu_1$ (i.e., participant's value is not affected by the information);
$z = 2$ if $z^* > \mu_1$ (i.e., participant's value is positively affected by the information).

Equation (1) can be considered a latent utility function where z^* is the unobserved utility. The term z is the observed choice that is made by the consumer. It is assumed that $u \sim N(0,1)$. The term μ_1 is an unknown threshold parameter that is estimated with the explanatory values. The matrix $\mathbf{W}$ is a set of explanatory variables, and the vector α is the set of corresponding coefficients. The explanatory variables for the ordered probit model are assumed to be the same for each category.[8] The WTP equation is given by:

$$WTP_s = \beta_s'\mathbf{X}_s + \varepsilon_s, \tag{2}$$

where s represents one of the three categories chosen—positive premium payers, negative premium payers, or those unaffected. WTP_s is the willingness to pay of participants who fall into category s. The noise term ε_s has an expected mean of $\sigma\rho\lambda_s$ and a variance of $\sigma^2(1 - \rho^2\delta_s)$. The correlation between ε, which is a vector of error terms of all the categories taken together [i.e., $\varepsilon = (\varepsilon_1, \varepsilon_2, \varepsilon_3)$], and the error term u from the ordered probit model is ρ. The matrix of explanatory variables, $\mathbf{X}_s$, includes λ_s which is the estimated bias that occurs due to the self-selection process. The corresponding coefficient vector, β_s, is the vector of estimated coefficients.

---

[7] The authors thank a reviewer for pointing out an important debate regarding informational effects and how they should be viewed. One view is that when new information is provided to a consumer, information has one of three classifiable effects on the consumer—positive effect, no effect, or negative effect. Rousu et al. (2004) take a different stance and argue a consumer can be no worse off with new information. They show in their experiment that negative information on genetically modified foods has a public good value. Schlee (1996), on the other hand, has demonstrated a set of conditions where public information can have a negative effect on consumers, i.e., some consumers can be worse off with new information.

[8] This model is general enough to account for the explanatory variables being different for each category.

Table 3. Participant Bid Levels ($) by Environmental Attribute Information (all participants, N = 329)

Pork Chop Environmental Attributes (level of improvement over typical package)	Average Bid Level per Package: Round 3: No Information	Round 4: Environmental Attribute Added	Premium Bid: Absolute Change
Typical Package (no particular environmental attributes)	4.13	3.61	-0.52***
Odor 30%–40%	4.26	3.87	-0.39***
Odor 80%–90%	4.05	3.92	-0.13**
Ground Water 15%–25%	3.91	3.85	-0.06
Ground Water 40%–50%	4.03	3.94	-0.09
Surface Water 15%–25%	4.15	3.99	-0.16**
Surface Water 40%–50%	4.06	4.10	0.04
Odor 80%–90%/Ground Water 40%–50%	4.25	4.56	0.31***
Odor 80%–90%/Surface Water 40%–50%	4.17	4.58	0.41***
Odor 80%–90%/Ground Water 40%–50%/ Surface Water 40%–50%	4.19	5.13	0.94***

Note: Double and triple asterisks (*) denote a significant difference from zero at the 0.05 and 0.001 levels, respectively (Freund, 1992).

Empirical Results

Table 3 summarizes the changes in average bids from round 3 to round 4.[9] The difference between the average, high, and low bid in the no-information third round is $0.35. This reflects the difference in participant perception of the visual quality of the packages and does not represent a significant difference at the 5% level. For the entire group, the average bid increase for the two-pound package of pork loin chops with the highest level of embedded attributes was $0.94, while the bid for the typical package decreased by $0.52.[10]

The estimated model has two WTP equations with a trichotomous choice function to be estimated. The bias component from the self-selection process is estimated for each participant and then used as a regressor in the corresponding OLS estimation. Equation (2) is estimated for the positive premium payers.[11] The model for the group whose WTP was zero does not need to be estimated by the OLS procedure because this group model has been estimated using the ordered probit procedure.

The explanatory variables for both equations are a subset of the socioeconomic characteristics and derived variables collected from the experiment. The explanatory variables

[9] Information in round 3 only pertained to physical attributes, while round 4 had information regarding the environmental attributes.

[10] Bid changes were examined between each round. In general at the 5% level, bids significantly changed from round 1 to round 2, but did not significantly change from round 2 to round 3. This implies participants settled on a value of the physical attributes for each product within the first three rounds. The bids also did not change significantly from round 4 to round 5 with the new information released. The information released in round 5 was meant to clarify for the participant what the attributes in round 4 actually meant. This information did not have a significant effect on participants.

[11] Due to the small number of negative premium payers, this group will not be estimated.

Table 4. Description of Variables for Each Estimated Equation

Variable	Description
NOINHOUS	Number of people living in the household
PORKM	Number of times per month pork is consumed by participant
GENDER	1 if female; 0 otherwise
AGE	Age of the participant
*LOC*1	1 for experiments conducted in Ames, IA; 0 otherwise
*LOC*2	1 for experiments conducted in Manhattan, KS; 0 otherwise
*LOC*3	1 for experiments conducted in Raleigh, NC in 1997; 0 otherwise
*LOC*4	1 for experiments conducted in Burlington, VT; 0 otherwise
*LOC*5	1 for experiments conducted in Iowa Falls, IA; 0 otherwise
*LOC*6	1 for experiments conducted in Corvallis, OR; 0 otherwise
*LOC*7	1 for experiments conducted in Raleigh, NC in 1998; 0 otherwise
*INC*1	1 if household income is less than $10,000; 0 otherwise
*INC*2	1 if household income is between $10,000 and $20,000; 0 otherwise
*INC*3	1 if household income is between $20,000 and $30,000; 0 otherwise
*INC*4	1 if household income is between $30,000 and $40,000; 0 otherwise
*INC*5	1 if household income is between $40,000 and $50,000; 0 otherwise
*INC*6	1 if household income is between $50,000 and $60,000; 0 otherwise
*INC*7	1 if household income is between $60,000 and $70,000; 0 otherwise
*INC*8	1 if household income is between $70,000 and $80,000; 0 otherwise
*INC*9	1 if household income is between $80,000 and $90,000; 0 otherwise
*INC*10	1 if household income is over $90,000; 0 otherwise
*EDU*1	1 if highest level of education achieved was 8th grade
*EDU*2	1 if highest level of education achieved was 11th grade
*EDU*3	1 if highest level of education achieved was high school or G.E.D.
*EDU*4	1 if highest level of education achieved was some technical, trade, or business school
*EDU*5	1 if highest level of education achieved was some college, no degree
*EDU*6	1 if highest level of education achieved was a bachelor's degree
*EDU*7	1 if highest level of education achieved was some graduate work, no degree
*EDU*8	1 if highest level of education achieved was a master's degree
*EDU*9	1 if highest level of education achieved was a doctorate degree

related to socioeconomic characteristics are taken from the literature on WTP for attributes. Specifically, the papers by Roosen et al. (1998), Menkhaus et al. (1992), and Melton et al. (1996) are the major sources of the socioeconomic factors that enter equations (1) and (2). These explanatory variables, described in table 4, are participant's age, household income, participant's education, and participant's gender. Location of the experiment, pork consumption, and number of people living in the household are also included as variables.

The first equation estimated is the ordered probit equation. The explanatory variables used in these ordered probit equations are a constant term and all of the explanatory variables in table 4, excluding *EDU*1, *EDU*2, *INC*1, *INC*2, and *LOC*7.[12] In this case, the first two response categories under education and income and the location of the second

[12] Due to the extremely small number of participants falling into *EDU*1 and *INC*1, *EDU*2 and *INC*2 were also excluded to avoid collinearity between the constant term and the income and education categories.

experiment conducted in Raleigh are used as the bases of comparison for their respective categories. The findings reported by Roosen et al. (1998), Menkhaus et al. (1992), and Melton et al. (1996) are used to hypothesize most of the signs of the explanatory coefficients.

Since there is nothing in the literature which gives an a priori expectation as to the effect of location on WTP, a benefit hypothesis is investigated. Using this hypothesis, it is expected that locations closer to high concentrations of hog production will tend to have a higher benefit received from consuming pork with embedded environmental attributes, which should have a positive effect on the probability of being a premium payer.

Table 5 provides the estimation results for the ordered probit model. Three estimated parameters were significant at the 5% or 10% level. The constant term and the estimated threshold parameter were significant at the 5% level. *GENDER* was significant at the 10% level and had the expected positive sign.[13] This finding implies women generally have higher probabilities of being premium payers.

The variables for education all have positive signs, consistent with the a priori expectations.[14] These results support those found by Israel and Levinson (2004), implying an individual with at least a high school diploma has a higher probability of being a premium payer. While the sign was consistent with expectations, the coefficients were not statistically significant. These results were hypothesized to mirror the results of Israel and Levinson, where the magnitude of these coefficients would increase as education level increased. For the participants in our study, however, such was not the case. A participant with a bachelor's degree had the highest magnitude effect for being a premium payer, followed by a participant with a doctorate degree having the second highest probability. A person with some college was found to have the third highest probability. The group of participants with the lowest magnitude effect was comprised of individuals with some technical, trade, or business schooling.

Excluding income and location, the coefficients for age and the number of times pork is consumed in a month have consistent signs. Both of these variables had a negative effect on the probability of being a premium payer. Hence, a participant who was older had a lesser probability of being a premium payer. Also, the probability of a participant being a premium payer decreases as he/she consumes more pork in a month. The coefficient for number of persons in the household had an inconsistent insignificant sign.

Some of the income variables had positive signs as expected, while others were inconsistent with expectations. As observed from table 5, the variables for the income levels from \$30,000 to \$70,000 (*INC*4 to *INC*7) all have the expected positive coefficient. Variables for the income levels over \$70,000 have an inconsistent negative sign. The participants who fell in the income range of \$20,000 to \$30,000 (*INC*3) were also less likely to be premium payers compared to those reporting income of less than \$20,000.

All of the location variables have insignificant signs. Some of the variables have signs consistent with the benefits hypothesis proposed above, while others do not. Iowa Falls (*LOC*5) has the expected positive sign, while Burlington (*LOC*4) has the expected negative sign. Due to the insignificance of the location variables, the benefits hypothesis does not appear to explain how location affects WTP for environmental pork.

---

[13] Taking from the findings of Andreoni and Vesterlund (2001), women are hypothesized to have a higher probability of paying a premium.

[14] All of these education levels are being compared to the group of participants with less than a high school degree.

Table 5. Ordered Probit Estimates for the Ex Post Categorical Realization of Whether the Participant's Value Was Negatively Affected, Not Affected, or Positively Affected (*N* = 329)

Variable	Coefficient	Standard Error	Mean of Variable
Constant	1.2780**	0.6138	
NOINHOUS	0.0076	0.0485	2.6869
PORKM	-0.0113	0.0150	5.8290
GENDER	0.2443*	0.1502	0.5988
AGE	-0.0052	0.0049	47.7362
*LOC*1	0.0609	0.2763	0.1489
*LOC*2	0.2136	0.2716	0.1824
*LOC*3	-0.0079	0.2911	0.0942
*LOC*4	-0.2573	0.3030	0.0821
*LOC*5	0.0691	0.2764	0.1763
*LOC*6	0.1422	0.2660	0.1824
*INC*3	-0.2859	0.2620	0.1376
*INC*4	0.1669	0.2544	0.1865
*INC*5	0.0851	0.2614	0.1407
*INC*6	0.3906	0.3334	0.1040
*INC*7	0.0780	0.3180	0.0703
*INC*8	-0.2289	0.3309	0.0599
*INC*9	-0.0184	0.4273	0.0398
*INC*10	-0.1795	0.3265	0.0734
*EDU*3	0.2925	0.4754	0.1220
*EDU*4	0.0831	0.4792	0.0854
*EDU*5	0.3063	0.4439	0.2530
*EDU*6	0.3873	0.4668	0.2409
*EDU*7	0.1871	0.5056	0.0732
*EDU*8	0.2939	0.4694	0.1220
*EDU*9	0.3326	0.5416	0.0579
Threshold parameter for index:			
μ_1	1.1847**	0.1168	

Notes: Single and double asterisks (*) denote statistical significance at the 10% and 5% levels, respectively. A premium payer is a participant who increased his or her bid for the most "environmentally friendly" package from round 3 to round 4.

Table 6 reports the frequencies of actual and predicted outcomes for participant group placement from the estimated ordered probit equation. The columns show the predicted outcomes from the model, while the rows show the actual outcomes from the data. The major result is that the probit equation failed to predict which participants were negatively affected by the environmental information. The model also had difficulty predicting who was not affected by the environmental information.

The probit equation had a strong tendency to predict premium payers over the other groups. Of the 329 participants, the equation picked 311 premium payers. Of this group, 92 participants were not actually affected by the information, and 21 were negatively

Table 6. Frequencies of Actual and Predicted Outcomes from the Estimated Ordered Probit for Definition 1 of Willingness to Pay

	Predicted Outcome			
Actual Outcome	Negatively Affected	Not Affected	Positively Affected	**Total**
Negatively Affected	0	4	21	25
Not Affected	0	8	92	100
Positively Affected	0	6	198	204
Total	0	18	311	329

Note: A premium payer is a participant who had a higher bid for the most "environmentally friendly" package compared to the typical package within round 4.

affected (table 6). The fitted probit equation was not able to predict any negative premium payers correctly. Furthermore, the model had trouble predicting the participants who were not affected by the environmental information. This probit equation does not predict well the three different categories using the core variables derived from the WTP literature, suggesting there are important variables missing in the literature to explain the behavior of negative premium payers.

Table 7 presents the conditional OLS model predictions of the premium magnitude for those who were affected positively by the environmental information. Column [2] from the table shows the estimated standard errors without the heteroskedasticity correction, while column [3] reports the estimated standard errors corrected for heteroskedasticity. The explanatory variables used to predict the magnitude for this group are assumed to be the same as the variables used to predict which category each participant falls into. Means of the variables are given in column [4]. The predicted signs and magnitudes for this equation will be the same as the first-stage probit parameters. Also included with these explanatory variables is *LAMBDA*, which is an adjustment factor for the bias caused by the clustering of zeros.

As shown by table 7, the values for number in household, age, gender, and monthly pork consumption all have signs consistent with a priori expectations. Age has the expected negative coefficient and is significant at the 5% level. Both gender and monthly pork consumption are significant at the 10% level. Gender has the expected positive coefficient, while monthly pork consumption has a negative coefficient. Although the value of the coefficient for the number in household is not significant, it has the expected negative sign.

When examining the category of education, all but one of the coefficients are significant at either the 5% or 10% level. *EDU*4, the only education variable that is not significant, pertains to some technical, trade, or business schooling. The variable related to a bachelor's degree (*EDU*6) is significant at the 10% level, and the parameters for all of the other education levels are significant at the 5% level. The magnitudes of the education coefficients indicate that the higher education levels tend to have higher magnitudes over the lower education levels.

Similar to the probit equations above, the variables for income in the OLS model were not consistent with a priori expectations. Only two income levels have the expected positive sign: *INC*4, the income level associated with the range of $30,000 to $40,000,

Table 7. Second-Stage OLS Analysis of the Positive Premium Payers for Definition 1 of Willingness to Pay (N = 204)

Variable	[1] Coefficient	[2] Standard Error (uncorrected)	[3] Standard Error (corrected)	[4] Mean of Variable
Constant	-5.2814	6.1650	4.9218	
NOINHOUS	-0.0201	0.0924	0.0713	2.7598
PORKM	-0.0755*	0.0577	0.0458	5.6193
GENDER	1.6749*	1.1205	0.9156	0.6324
AGE	-0.0567**	0.0255	0.0230	46.8369
*LOC*1	0.5133	0.5235	0.5429	0.1471
*LOC*2	0.9499	1.0290	0.8407	0.1961
*LOC*3	-0.6417	0.4547	0.4226	0.0931
*LOC*4	-1.3752	1.3421	1.1100	0.0735
*LOC*5	0.6058	0.5299	0.5265	0.1716
*LOC*6	0.9225	0.7621	0.6748	0.1863
*INC*3	-2.5784**	1.4503	1.2601	0.1141
*INC*4	0.2129	0.8331	0.6922	0.2028
*INC*5	-0.3956	0.5728	0.4428	0.1484
*INC*6	1.2828	1.6751	1.4142	0.1285
*INC*7	-0.3034	0.6158	0.6836	0.0791
*INC*8	-2.2129**	1.1993	0.9553	0.0495
*INC*9	-0.7742	0.6465	0.6357	0.0396
*INC*10	-1.7473**	1.0130	0.8748	0.0644
*EDU*3	2.6061**	1.6032	1.2314	0.1225
*EDU*4	0.7413	0.8735	0.5234	0.0784
*EDU*5	2.5661**	1.6343	1.2564	0.2500
*EDU*6	2.8897*	1.9599	1.5745	0.2647
*EDU*7	3.5634**	1.2595	1.1795	0.0686
*EDU*8	2.8889**	1.6236	1.2557	0.1324
*EDU*9	2.9007**	1.7731	1.4013	0.0539
LAMBDA	10.9237*	8.2374	6.7337	0.5898

R^2	=	0.2041
Log Likelihood	=	-355.0125
Log Likelihood (restricted)	=	-378.2970

Notes: Single and double asterisks (*) denote statistical significance at the 10% and 5% levels, respectively. A premium payer is a participant who had a higher bid for the most "environmentally friendly" package compared to the typical package within round 4.

and *INC*6, associated with the range of $50,000 to $60,000. The remaining income variables are negative. Three income levels are significantly negative at the 5% level: *INC*3 ($20,000 to $30,000), *INC*8 ($70,000 to $80,000), and *INC*10 (the highest income category).

None of the location variables were found to be significant at either the 5% or 10% level. Among these, only two have the hypothesized sign. Burlington (*LOC*4) has the expected negative coefficient, while Iowa Falls (*LOC*5) has the expected positive coefficient. Manhattan (*LOC*2) and Corvallis (*LOC*6) have unexpected positive signs. Ames (*LOC*1) has a positive coefficient, and the first Raleigh experiment (*LOC*3) has a negative coefficient.

The bias adjustment coefficient *LAMBDA* shows the level of bias due to the zeros has a positive and significant effect at the 10% level. Thus, deleting the zeros and running OLS on the remaining observations would cause a serious bias to occur in the estimates on the coefficients. Using a likelihood-ratio test, the null hypothesis that all coefficients are zero for this model can be rejected at the 5% level of significance. The critical value for this test at the 5% level of significance is 38.89, while the calculated likelihood ratio from the model is 46.56. Hence, the variables in this model do have explanatory power.

Concluding Remarks

Bid data for pork chops with embedded environmental attributes were analyzed to determine which consumers would pay a premium and how much they would pay. It was found that approximately 62% of the participants had a positive WTP for the most "environmentally friendly" package of pork, which equated to an average WTP of $0.94 for a two-pound package of pork chops. Thirty percent of the participants had no WTP, and 8% had a negative WTP.

Due to the nature of the data, a two-stage model similar to Lee's (1983) model was used to handle the discrete mass point at zero, i.e., an anchoring point within a continuous distribution. Lee's model uses a two-stage procedure that incorporates an initial polychotomous choice function in the first stage to estimate the discrete dependent variables, and OLS procedures in the second stage to estimate the continuous dependent variables with the discrete variables factored out.

An advantage to using a two-stage model similar to Lee's (1983) is that participants can be classified as premium or non-premium payers in the first stage, and the magnitude of the premium can be predicted in the second stage. From a marketing point of view, an important task is to identify the target market—which in this case is premium payers—so marketing efforts can be focused on targeted consumers. Theoretically, this is accomplished in the first stage of Lee's model. This paper incorporated the standard variables used in the WTP literature, coupled with a two-stage econometric model, to predict participants who were premium payers and non-premium payers using an estimated ordered probit equation. This equation did not perform well in predicting the three different categories using the core variables found in the WTP literature. In fact, the only significant variables in the equation were gender and the constant term. This implies that the standard variables in the WTP literature are not sufficient to separate who was positively, negatively, and not affected by the environmental information released.

There is another advantage to using the model presented in this paper. Since this model can account for anchoring points within a distribution, economic experiments are no longer confined to truncating WTP values, i.e., researchers no longer have to design experiments which assume information impacts have no adverse effects. This model allows researchers more flexibility when initially designing their experiments. When negative premium payers are lumped together with zero premium payers, valuable information is lost to the researcher. The importance of the negative premium payers is that they represent a backlash to the information about the product being introduced. This is valuable information for marketers because these are the individuals who would most likely switch to a substitute product.

Following estimation of the ordered probit equation, OLS procedures were used to predict the magnitude of the positive premiums utilizing the standard WTP variables from the literature. In this context, the standard variables used in the literature did a better job of predicting. Gender, monthly pork consumption, and age had a significant impact on the premium. Many education coefficients had a significant effect on the premium—higher education levels tended to have higher premium effects. In contrast, variables for income tended not to have the expected impacts on premiums. Location variables were not found to have a significant effect on premiums, suggesting regional differences do not significantly affect premiums. The bias adjustment coefficient *LAMBDA* showed that the level of bias due to the zeros had a significant and positive effect. Hence, the bias from the anchoring point of zero is an important consideration which needed to be factored into the OLS estimation procedure.

[*Received September 2005; final revision received June 2006.*]

References

Abeles-Allison, M., and L. J. Connor. "An Analysis of Local Benefits and Costs of Michigan Hog Operations Experiencing Environmental Conflicts." Agr. Econ. Rep. No. 536, Dept. of Agr. Econ., Michigan State University, East Lansing, June 1990. [26pp.]

Andreoni, J., and L. Vesterlund. "Which Is the Fair Sex? Gender Differences in Altruism." *Quart. J. Econ.* 116,1(February 2001):293–312.

Beasley, S., W. Workman, and N. Williams. "Estimating Amenity Values of Urban Fringe Farmland: A Contingent Valuation Approach: Note." *Growth and Change* 17,4(October 1986):70–78.

Bergstrom, J., B. Dillman, and J. Stoll. "Public Environmental Amenity Benefits of Public Land: The Case of Prime Agricultural Land." *S. J. Agr. Econ.* 17,1(July 1985):139–149.

Boyle, K. J., G. L. Poe, and J. Bergstrom. "What Do We Know About Groundwater Values? Preliminary Implications from a Meta-Analysis of Contingent-Valuation Studies." *Amer. J. Agr. Econ.* 76,5(December 1994):1055–1061.

Caudill, J. D., and J. P. Hoehn. "The Economic Valuation of Groundwater Pollution Policies: The Role of Subjective Risk Perceptions." Staff Pap. No. 92-11, Dept. of Agr. Econ., Michigan State University, 1992.

Chien, Y., C. J. Huang, and D. Shaw. "A General Model of Starting Point Bias in Double-Bounded Dichotomous Contingent Valuation Surveys." *J. Environ. Econ. and Mgmt.* 50,2(2005):362–377.

Corrigan, J. R., and M. C. Rousu. "The Effects of Initial Endowments in Experimental Auctions." *Amer. J. Agr. Econ.* 88,2(May 2006):448–457.

Cragg, J. G. "Some Statistical Models for Limited Dependent Variables with Application to Demand for Durable Goods." *Econometrica* 39,5(September 1971):829–844.

Davis, D. D., and C. A. Holt. *Experimental Economics.* Princeton, NJ: Princeton University Press, 1993.

Edwards, S. F. "Option Prices for Groundwater Protection." *J. Environ. Econ. and Mgmt.* 15,4(December 1998):475–487.

Fox, J. A. "Essays in the Measurement of Consumer Preferences in Experimental Auction Markets." Unpub. Ph.D. diss., Dept. of Econ., Iowa State University, Ames, 1994.

Fox, J. A., B. L. Buhr, J. F. Shogren, J. B. Kliebenstein, and D. J. Hayes. "A Comparison of Preferences for Pork Sandwiches Produced from Animals With and Without Somatotropin Administration." *J. Animal Sci.* 73(1995):1048–1054.

Fox, J. A., D. J. Hayes, and J. F. Shogren. "Consumer Preferences for Food Irradiation: How Favorable and Unfavorable Descriptions Affect Preferences for Irradiated Pork in Experimental Auctions." *J. Risk and Uncertainty* 24,1(January 2002):75–95.

Freund, J. E. *Mathematical Statistics*, 5th ed. Englewood Cliffs, NJ: Prentice-Hall, 1992.

Greene, W. H. *LIMDEP Version 7.0 User's Manual.* Bellport, NY: Econometric Software, Inc., 2002.

Heckman, J. J. "The Common Structure of Statistical Models of Truncation, Sample Selection, and Limited Dependent Variables and a Simple Estimator for Such Models." *Annals of Econ. and Social Measurement* 5,4(1976):475–492.

———. "Sample Selection Bias as a Specification Error." *Econometrica* 47,1(January 1979):153–161.

Honeyman, M. S. "Västgötmodellen: Sweden's Sustainable Alternative for Swine Production." *Amer. J. Alternative Agr.* 10(November 1995):129–132.

———. "Sustainability Issues of U.S. Swine Production." *J. Animal Sci.* 74(1996):1410–1417.

Huffman, W. E., M. C. Rousu, J. F. Shogren, and A. Tegene. "Who Do Consumers Trust for Information? The Case of Genetically Modified Foods." *Amer. J. Agr. Econ.* 86,5(December 2004):1222–1229.

Israel, D., and A. Levinson. "Willingness to Pay for Environmental Quality: Testable Empirical Implications of the Growth and Environment Literature." *Contributions to Economic Analysis and Policy* 3,1(1st Quarter 2004):1–29.

Jordan, J. L., and A. H. Elnagheeb. "Willingness to Pay for Improvements in Drinking Water Quality." *Water Resour. Res.* 29,2(February 1993):237–245.

Laughland, A. S., L. M. Musser, W. N. Musser, and J. S. Shortle. "The Opportunity Cost of Time and Averting Expenditures for Safe Drinking Water." *Water Resour. Bull.* 29(1993):219–229.

Lee, L.-F. "Generalized Econometric Models with Selectivity." *Econometrica* 51,2(March 1983):507–512.

Letson, D., and N. Gollehon. "Confined Animal Production and the Manure Problem." *Choices* (3rd Quarter 1996):18–24.

List, J. A., and J. F. Shogren. "Price Information and Bidding Behavior in Repeated Second-Price Auctions." *Amer. J. Agr. Econ.* 81,4(November 1999):942–949.

Lusk, J. L., L. O. House, C. Valli, S. R. Jaeger, M. Moore, J. L. Morrow, and W. B. Traill. "Effect of Information About Benefits of Biotechnology on Consumer Acceptance of Genetically Modified Food: Evidence from Experimental Auctions in the United States, England, and France." *Euro. Rev. Agr. Econ.* 31,2(June 2004):179–204.

Melton, B. E., W. E. Huffman, J. F. Shogren, and J. A. Fox. "Consumer Preferences for Fresh Food Items with Multiple Quality Attributes: Evidence from an Experimental Auction of Pork Chops." *Amer. J. Agr. Econ.* 78,4(November 1996):916–923.

Menkhaus, D. J., G. W. Borden, G. D. Whipple, E. Hoffman, and R. A. Field. "An Empirical Application of Laboratory Experimental Auctions in Marketing Research." *J. Agr. and Resour. Econ.* 17,1(July 1992):44–55.

Palmquist, R. B., F. M. Roka, and T. Vukina. "Hog Operations, Environmental Effects, and Residential Property Values." *Land Econ.* 73,1(February 1997):114–124.

Parkhurst, G. M., J. F. Shogren, and D. L. Dickinson. "Negative Values in Vickrey Auctions." *Amer. J. Agr. Econ.* 86,1(February 2004):222–235.

Poe, G. L., and R. C. Bishop. "Measuring the Benefits of Groundwater Protection from Agricultural Contamination: Results from a Two-State Contingent Valuation Study." Staff Pap. No. 341, Dept. of Agr. Econ., University of Wisconsin-Madison, 1992.

Powell, J. R., D. J. Allee, and C. McClintock. "Groundwater Protection Benefits and Local Community Planning: Impact of Contingent Valuation Information." *Amer. J. Agr. Econ.* 76,5(December 1994):1068–1075.

Ready, R., M. Berger, and G. Blomquist. "Measuring Amenity Benefits from Farmland: Hedonic Pricing vs. Contingent Valuation." *Growth and Change* 28,4(Fall 1997):348–458.

Roosen, J., J. A. Fox, D. A. Henessey, and A. Schreiber. "Consumers' Valuation of Insecticide Use Restrictions: An Application to Apples." *J. Agr. and Resour. Econ.* 23,2(December 1998):367–384.

Rosenberger, R., and R. Walsh. "Nonmarket Value of Western Valley Ranchland Using Contingent Valuation." *J. Agr. and Resour. Econ.* 22,2(December 1997):296–309.

Rousu, M. C. "European Consumers' Willingness to Pay for U.S. Beef in Experimental Auction Markets: Comment." *Amer. J. Agr. Econ.* 87,1(February 2005):255–257.

Rousu, M. C., W. E. Huffman, J. F. Shogren, and A. Tegene. "Estimating the Public Value of Conflicting Information: The Case of Genetically Modified Foods." *Land Econ.* 80,1(February 2004):125–135.

Schlee, E. E. "The Value of Information About Product Quality." *RAND J. Econ.* 27,4(Winter 1996): 803–815.

Spencer, M. A., S. K. Swallow, and C. J. Miller. "Valuing Water Quality Monitoring: A Contingent Valuation Experiment Involving Hypothetical and Real Payments." *Agr. and Resour. Econ. Rev.* 27,1(April 1998):28–42.

Sun, H., J. C. Bergstrom, and J. H. Dorfman. "Estimating the Benefits of Groundwater Contamination Control." *S. J. Agr. Econ.* 24,2(December 1992):63–71.

Taff, S. J., D. G. Tiffany, and S. Weisberg. "Measured Effects of Feedlots on Residential Property Values in Minnesota." Staff Pap. No. P96-12, Dept. of Appl. Econ., University of Minnesota, St. Paul, July 1996. [27 pp.]