Do Stated Preference Values Predict Revealed Behavior in "New" Markets for Ecosystem Services?

A Comparison of Experiments Addressing Establishing A Market for Farmland Ecosystem Services

Julie I. Santos, Emi Uchida, Christopher Anderson, and Stephen Swallow

Department of Environmental and Natural Resource Economics
University of Rhode Island

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Many ecosystem services enjoyed by local communities from farmland are public goods and are consequently under-provided. For instance, agricultural land may provide wildlife habitat, scenic views, and groundwater aquifer recharge. Because it is often prohibitively difficult to preclude non-payers from benefiting from the good, markets for ecosystem services often suffer from free-riding. For this reason, providing farmland ecosystem services is quite challenging. The typical remedy for under-provision of public goods involves government intervention, often in the form of levied taxes and subsidies. However, these measures may not result in the socially optimal level of provision because they act on a regional scale and may inadequately account for local characteristics. Market approaches aim to provide incentives for agricultural land owners to incorporate ecosystem services into their business plans as additional output for which monetary compensation may be received. Theoretically, constructing a market for ecosystem services would facilitate payment transfers from those who value the service most to those who can produce it by the least-cost method. However, constructing new markets for public goods is complicated by non-exclusivity and the resultant problem of free-ridership. This study describes the results of two experiments, a hypothetical choice experiment and a revealed preference experiment aimed at designing a market in which farmers and local beneficiaries of the ecosystem service contract for the provision of nesting bird habitat in Jamestown, Rhode Island. Specific attention is placed on the payment elicitation mechanism. The ultimate goal of this research is to address the manner in which choice experiments can be used to predict market behavior in order to facilitate contract design and market construction.

Designing an efficient market for ecosystem services requires truthful expression of beneficiaries' preferences. Several mechanisms for eliciting accurate expressions of willingness to pay have been proposed in the literature. The aim of different elicitation mechanisms is to minimize the incentives for individuals to free-ride on others' contributions. The unique aspect of the two experiments is that both field experiments utilized several types of elicitation mechanisms with provision points: a pivotal mechanism based on the Clarke tax, provision point with money back guarantee, and uniform price auctions. Since elicitation mechanisms were common to both studies, they provide a unique opportunity to compare the relative performance of each mechanism in achieving truthful revelation of willingness to pay.

The ecosystem service being offered in both experiments was habitat for grassland nesting birds called Bobolinks (*Dolichonyx oryivorus*). Hay harvesting on farms in Jamestown, Rhode Island destroys nests containing fledgling Bobolinks every spring, contributing to substantial mortality in the population (Sauer et al. 2004). The proposed market would establish a price that community members would pay farmers to delay hay harvest on different plots of land in order to mitigate the damage to the Bobolink fledgling cohort caused by this agricultural practice.

The first experiment was a hypothetical choice experiment wherein residents of the town of Jamestown were presented with several potential contracts designed to delay hay harvesting on plots of farmland in order to preserve nesting bird habitat. Subjects were assigned to different elicitation mechanisms and administered several questions in which they were asked to compare two farm-wildlife contracts with varying levels of attributes and determine whether they would pay the posted price for one, both or neither of the contracts. A conditional logit model was applied to the responses and it was determined that the type of elicitation mechanism imposed had an impact on valuation of the contracts (Uchida et al. 2007).

A well-documented drawback of stated preference methods is the presence of hypothetical bias. There is a substantial body of literature illustrating that hypothetical bias of stated choice experiments leads to over-estimation of WTP (Ethier et al. 2000). By comparing the two experiments, we find evidence supporting this finding.

The second experiment was a revealed-choice experiment whereby acceptable contracts were drawn up between the mediators and farmers in the same community of Jamestown, RI. Community members were solicited for payment toward provision of the contracts, again via the different types of elicitation mechanisms. In addition to the application of competing mechanisms, individuals were randomly assigned either open-ended or binary choice questions. This experimental market was open to the residents of Jamestown in early 2007 and again in early 2008. The markets successfully provided five of ten potential field contracts. Similarly, it was determined that elicitation mechanism had an impact on valuation estimates. By comparing the incentive-compatible mechanisms between the two experiments, we may, in theory, eliminate the effect of free-ridership and determine the effects of hypothetical bias on the prediction of willingness to pay in the market.

Another interesting facet of the combined studies is the ability to examine the robust anomaly of higher revelations due to the binary choice question format when compared to open-ended formats. Several studies cite the intriguing result that, on average, binary choice questions reveal higher willingness to pay values than open-ended questions. The revealed preference study described herein adds to the body of evidence in support of this tendency.

Two main research questions have emerged from the combined experiments. The first stems from the fact that, while the performance of different elicitation mechanisms at addressing free-ridership has been well tested in the lab, the issue of whether the mechanisms perform as expected in actual market settings has not been properly addressed. The unique advantage of the two experiments is that they apply nearly the same mechanisms to the valuation of a service in a "new" and unfamiliar market setting. The uniform price auction mechanism adversely impacts the valuation estimates in the market experiment but has highest valuation in the hypothetical choice experiment. This implies that, if stated preference methods are to be used to predict market behavior, design is an important consideration. For instance, according to the evidence presented here, one would expect predictions to suffer if the revealed preference experiment utilizes an elicitation mechanism that is different than the mechanism applied in the stated preference experiment, and not in the expected manner. While the pivotal mechanism, based on the Clarke Tax, would theoretically yield highest valuations, we find in both surveys that it does not outperform the provision point with proportional rebate mechanism. We explore this result further.

The second research question addresses the long-standing observation that binary choice questions often elicit higher payments than open-ended questions (Balistreri et al 2001). We compare estimates of willingness-to-pay from the SP choice experiment with both binary choice and open-ended questions in the RP experiment to determine whether there are consistent differences in WTP revelation. While there is no reason to believe that hypothetical bias differs between mechanisms, what does vary is incentive to free-ride. We compare the incentive-compatible mechanisms between the two studies in order to reveal the nature of hypothetical bias. Then we can use this information to address the issue of the discrete choice method.

Guided by the initial results from the two studies, individual-specific willingness-to-pay estimates were derived from the SP data via a random-parameter logit model. Several authors have cited the advantages, when deriving willingness-to-pay estimates from RP logit models, of specifying the model in WTP-space rather than the conventionally used utility-space specification. Many have found that this specification avoids setbacks in WTP estimation by the conventional specification and results in more reasonable estimates (Scarpa et al. 2007, Das et al. 2009, Train and Weeks 2005). These values were compared, by elicitation mechanism, with the values offered in the revealed preference experiment. In addition, the stated preference data was used to augment estimation of the RP equation in order to determine the extent to which willingness to pay estimates from SP experiments can be used to predict market behavior.

The paper proceeds as follows. Section 2 describes the ecosystem service under analysis. Sections 3 and 4 review the stated preference and revealed preference experiments. Section 4 describes the method used to construct the willingness-to-pay estimates. Section 5 presents the data. Section 6 describes the method used to combine the data. Section 7 presents results and section 8 provides a summary and conclusion.

Farmland Ecosystem Services for Jamestown, Rhode Island: The Bobolink

In order to facilitate the design of a local market for ecosystem services, it was important to choose an ecosystem service that could be easily quantified, implemented on a sufficiently short time line, and be relatively inexpensive. Consequently, habitat preservation in the form of protection for fledgling bird populations was chosen. To this end, the black and yellow Bobolink (*Dolichonyx oryivorus*) species was chosen. Bobolinks utilize hay fields in Jamestown as nesting habitat during the months of May and June. Hay harvesting and grazing activities during this period prove devastating to cohort success. Optimal harvest of hay in Jamestown occurs during mid-June. In order to protect the Bobolink cohort, “farm-wildlife” contracts were designed in an attempt to garner enough funds to cover the farmers' costs of delaying harvest until after July 4th. This would effectively incentivize farmers to incorporate farmland ecosystem services into their business plans.

Jamestown, Rhode Island is a small community of 4500 residents inhabiting 2800 households. There are 9 farms on the island, most of which produce grass-fed beef. There has in the past been evidence that the Jamestown community places a high valuation on its farms. In addition, its residents tend to have a keen sense of attachment to the community.

The Stated Preference Survey

The SP survey was designed as a multi-question choice experiment mailed to the residents of Jamestown from October to December of 2006. There were 5 questions comparing two potential contracts and a sixth question with one potential contract. The sixth response was not utilized in this analysis, but may be useful in determining predictive validity in the future. Each contract was described by the list of attributes outlined in Table 1. Respondents were asked whether they would choose contract A, contract B, both, or neither. A full description of the survey design and implementation can be found in Euchida et al. 2007.

We shall describe the three mechanisms that were common to both experiments. The pivotal mechanism is designed such that the respondent pays only if her bid is pivotal; that is, her contribution makes the difference between the good being provided and not. This mechanism was included because it has been demonstrated to be incentive-compatible in mitigating freeriding. The second mechanism, the proportional rebate mechanism, collects bids from all respondents and if more money than is needed is collected, returns the balance as a proportion of bid amount. The third mechanism, uniform price auction, is designed so that a uniform price is ultimately administered to all bidders whose willingness to pay exceeds a reserve price. That all participants ultimately pay the same price has two effects. First, it mirrors the "law of one price" aspect of conventional markets and, second, there is a notion of equity not present in the other mechanisms. That is, all participants ultimately have the same financial responsibility toward provision of the good.

Euchida et al. 2007 utilized a conditional logit model to explore the effects of the various elicitation mechanisms on the marginal utilities of the attributes of the contracts and the marginal utility of income. They found that elicitation mechanisms had the most significant effect on the marginal utility of income. The mechanisms were not found to jointly affect the marginal utility of the contract attributes. Base utility level was also not found to be affected by mechanisms. In addition, the authors computed marginal willingness-to-pay estimates and mean WTP for a contract with typical attributes and compared them by mechanism. They concluded that, for a typical farm-wildlife contract, the pivotal mechanism had the lowest estimated WTP.

The Revealed Preference Survey

The market experiment was conducted over a two year time period and issued to the same population on Jamestown, RI. (We shall focus on the results from the survey sent out during the first year, 2007, with ambitions to combine the stated and revealed preference data to test predictive validity on the 2008 data.) The researchers approached the farmers of Jamestown and successfully established contingent contracts on six of the hay fields in 2007. After substantial marketing efforts, the solicitation was mailed to all residents in March of that year. The households were randomly assigned to particular groups that were administered different elicitation mechanisms, parcel contracts, and solicitation formats (binary choice or open-ended). Sufficient funds were raised to compensate for the provision of the contracts on three of the six contingent contracts.

The researchers were primarily interested in determining the effects of the different elicitation methods on participation and payment in the market. They used a random effects probit model to analyze the participation decision and a panel-selection adjusted interval regression model to capture the determinants of the payments offered. Readers are referred to the authors for further details of the experiment.

The findings of primary importance to the research goals outlined in this paper are as follows. With regard to the solicitation format, discrete choice questions were found to result in nearly $25 higher offers regardless of mechanism. This supports common findings in contingent valuation studies (Boyle et al. 1996, Balistreri et al. 2003, Halvorsen and Saelensminde 1998, Cameron et al. 2002). In addition, they found that the pivotal mechanism does not elicit significantly different payments than the proportional rebate mechanism but that the uniform price auction elicited $19 less per respondent. Participants were not found to participate based on mechanism.

The mixed logit model and utility in WTP space

The first step in addressing our research goals was to derive individual-specific estimates of willingness-to-pay from the hypothetical choice experiment. It is our intention to use these estimates to compare responses from the binary choice format with the open-ended format. In addition, we aim to use the estimates to test the efficacy of the different mechanisms at predicting payment in the constructed market. We utilized a random parameter, or mixed, logit model to derive these estimates. RP logit models are often used to incorporate individual-specific heterogeneity over choice attributes. Carlsson et al. (2003) used random parameter logit to identify attributes that affect valuation of wetlands. Brownstone, Bunch, and Train (2000) estimate joint RP and SP models of alternative vehicle choice. Bhat and Sardesai (2006) modeled transportation mode choice using joint RP and SP methods. Greene et al. (2006) incorporate heterogeneity in the means of the random parameters in a model of commuter mode choice.

The model is formulated as follows. Suppose an individual i = 1…I faces a choice instance defined by c alternatives. Further assume the individual is presented with T such choice occasions. Utility is assumed separable in price so that the utility to individual i of choice c in choice occasion t follows random utility theory:

$$U_{ict} = -\alpha_i p_{ict} + \varphi'_i x_{ict} + \varepsilon_{ict} \qquad (1)$$

where the parameters alpha and omega may vary randomly in the population. For our purposes, this model specifies that the price coefficients are fixed but that most attribute coefficients vary randomly in the population such that $\varphi_i = \bar{\varphi} + \sigma\rho_i$ where $\bar{\varphi}$ is the vector of population means of the coefficients, σ is the standard deviation of the marginal distribution of φ, and ρ_i is a random term assumed to be distributed normal. ε_{ict} captures unobserved attributes that may affect utility and is assumed to be Gumbel-distributed with variance that is individual-specific and defined as $Var(\varepsilon_{ict}) = \lambda_i^2(\pi^2/6)$, where λ_i is the scale parameter for each individual. The scale parameter is the standard deviation of the unobserved utility. Dividing the utility equation by the scale parameter yields scale-free error variance:

$$U_{ict} = -(\alpha_i/\lambda_i)p_{ict} + (\varphi_i/\lambda_i)'x_{ict} + e_{ict} \qquad (2)$$

where now e_{ict} is type I extreme value with constant variance.

If the coefficient on the price attribute is specified to be random, then calculating willingness-to-pay requires dividing two distributions by each other. If the distribution of the price coefficient has mass close to or at zero, then this will lead to implausibly large estimates of willingness-to-pay. A normal distribution allows implausible positive cost coefficients and log-normals allow the cost coefficient to be arbitrarily close to zero which provides implausibly high estimates of WTP. Most studies avert this difficulty by specifying constant cost parameters. However, lately there has been interest in re-formulating the model in "willingness-to-pay" space rather than preference space. We outline the basic theory below.

A simple rearrangement of equation (2) redefines the specification in willingness-to-pay space. This allows the researcher to specify the distribution of WTP directly. If we define $\delta_i = (\alpha_i/\lambda_i)$ and $\kappa_i = (\varphi_i/\lambda_i)$, then equation (2) simplifies to

$$U_{ict} = -\delta_i p_{ict} + \kappa_i' x_{ict} + e_{ict} \qquad (3)$$

The implied willingness-to-pay for an attribute is $\omega_i = \kappa_i/\delta_i = \varphi_i/\alpha_i$. Using this information, we can once again formulate the utility function as:

$$U_{ict} = -\delta_i p_{ict} + (\delta_i\omega_i)' x_{ict} + e_{ict} \qquad (4)$$

This specification was originally proposed by Cameron (1988). Recently, Train and Weeks (2005) estimated a hierarchical Bayes specification of the model and Das, Anderson, and Swallow (2009) implemented a classical maximum-likelihood version. Most have found that while this alternative specification may or may not fit the data better, the resultant welfare measures are more tenable. Since the measurement of WTP from the mixed logit model is central to our analysis, we spent some time comparing the two approaches and shall present the results of this comparison.

Data

We focus on the 790 people who returned the SP surveys in 2007. Of those, 759 individuals received solicitations in the market experiment. 137 individuals returned the revealed preference survey with a response that they would make an offer. 78 responded that they would not make an offer, and 548 did not return the survey.

With regard to comparing mechanisms, there were 187 individuals who returned the SP survey and were issued the UPA treatment in both experiments. 48 returned surveys 25 made offers. There were 208 individuals in 2007 who were issued the PM in both years. 50 Returned a RP survey. Of those 50, 38 made offers. 206 individuals received the proportional rebate mechanism in both experiments. 61 returned the RP survey, 40 made offer, and 21 did not (Table 1).

Methods

From the individual-specific estimated willingness-to-pay values, we construct an indicator function as follows:

I_n = 1 if estimated willingness to pay is greater than discrete choice value or lower bound of open-ended scale
0 otherwise

We use the indicator function as an instrumental variable in the estimation of the panel-selection adjusted interval regression payment equation. We compare the results by mechanism paying specific attention to whether respondents had matching mechanisms in both studies or not and how this impacts the estimation. In addition, we examine the relationship between the discrete choice and open-ended responses.
More to follow…

Results

Specifying the random parameters in the RP logit model is one of the most complicated steps. A description of the variables used in the estimation can be found in table 2. The attributes of the contracts in the RP study are included for comparison (table 2a). Descriptive statistics for the SP variables are presented in table 3. The model presented here is specified in preference space. Results from the model specified in WTP space are forthcoming. The ultimate model specification presented here is the result of a specification search described by Revelt and Train (2000). The coefficient on highbobo was fixed because its standard deviation was insignificant in most specifications. All cost coefficients were similarly specified as fixed variables in order to facilitate calculation of willingness to pay estimates. Specifying fixed cost coefficients allows WTP for each attribute to have the same distribution as the coefficient of the attribute. This follows many prior studies' specification (Carlsson et al 2003, Sillano and Ortuzar 2005). This implies that the marginal utility of income is constant for all individuals (contingent upon treatment mechanism), an unfortunate feature of specifying the model this way. There are expected to be significant gains from re-specifying the model in WTP space so as to avoid this unfortunate restriction.

We included results from a conditional logit model for comparison (See table 4). The RP logit model performs significantly better than the conditional logit model. All population mean coefficients are significant as well as the standard deviations of the random parameters. The significant standard deviations implies the existence of heterogeneity in preferences among respondents. All coefficients have the expected sign. Marginal utilities are positive for all attributes of the contract except for cost. The alternative-specific constant that corresponds to accepting both contracts switches signs between the conditional logit model and the RP logit model, but the standard deviation of the variable is highly significant. All cost coefficients have the expected sign.

From these estimates, we calculate the estimated marginal willingness-to-pay based on the population mean (Table 5). We find these results to be consistent with previous research.

In a pooled model of all respondents regardless of elicitation method administered, the willingness-to-pay estimates from the RP logit model predicted behavior better in the discrete choice version of the revealed preference study than the open-ended version.

Overall, the WTP instrument predicted offers correctly 52% of the time, with 41% over-prediction rate. Of this sample of individuals who were administered the uniform price auction in both studies, the SP instrument predicted correctly 55% of the time, with 45% over-prediction rate. In the sample of individuals who were sent pivotal mechanism questions, 38% of the SP willingness to pays over-predicted actual market behavior.

Conclusion

Determining the relative performance of various elicitation mechanisms at predicting market behavior is of crucial importance with regard to designing new markets for ecosystem services. With market-based mechanisms for providing ecosystem services gaining in popularity, having true estimates of willingness to pay will help inform policy makers determine the scope and success of potential market-based policies.

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Table 1
Proportions of individuals who were administered identical mechanisms in both surveys

Mechanism	Returned Survey	Made Offer	Did not Make offer
Proportional Rebate	61/206	40	21
Uniform Price Auction	48/187	25	23
Pivotal Mechanism	50/208	38	12
Overall	215/763	137	78

Table 2

Attributes and Attribute Levels for Choice Experiment

Attribute	Description	Levels
Cost	Cost of Contract	\$10, \$20, \$35, \$45, \$60, \$75, \$85, \$105
Acres	Number of acres to be placed under contract upon which farmer will delay mowing and harvesting	10, 25, 40, 55
High Bobolink	Level of expected fledglings saved (correlated with acreage)	Low, high
Tour	Residents who pay into a particular contract may be invited to a bird walk led by expert birders.	Invited, Not Invited
View	Whether the proposed acreage is viewable from the road	View, No view
Restore	Number of acres to be restored to active hay fields, not restricted to delayed mowing/harvesting.	0, 10, 20, 30

Table 2a

Attributes and Attribute Levels for Revealed Preference Experiment

Attribute	Description	Levels
Size	Size of the field under contract	6.2, 10, 10.6, 11.4, 18
Number of territories	Number of Bobolink territories support by the field in 2006	1 through 4
View	Whether there is a view of the field from the road	None, Partial, Yes
Elicitation Mechanism	Pivotal Mechanism, Proportional Rebate, Uniform Price Auction	NA

Table 3

Descriptive statistics for attributes included in final model

Variable	Description	Mean	Std. Dev.	Min.	Max.
Cost		53.28	47.18	0	190
Acres		3.23	2.75	0	9.5
High Bobolink		0.38	0.49	0	1
Tour		0.35	1.28	-1	2
PM mechanism		0.20	0.40	0	1
VCM mechanism		0.10	0.30	0	1
PPPR mechanism		0.21	0.41	0	1
UPA mechanism		0.20	0.40	0	1

Table 4.

Mixed logit Results

VARIABLES	Conditional Logit	Random Parameter Logit Mean	Random Parameter Logit SD
cost	-0.0175***	-0.0278***	
	(0.00106)	(0.00171)	
costvcm	-0.00703***	-0.0118***	
	(0.00159)	(0.00279)	
costpppr	-0.00496***	-0.0112***	
	(0.00125)	(0.00235)	
costupa	-0.00699***	-0.0123***	
	(0.00127)	(0.00236)	
costpm	-0.00687***	-0.0118***	
	(0.00128)	(0.00231)	
highbobo	0.102***	0.148**	
	(0.0395)	(0.0582)	
asc_no	-0.569***	-0.775***	0.580***
	(0.0929)	(0.151)	(0.144)
asc_both	0.189**	-0.299*	1.410***
	(0.0933)	(0.154)	(0.103)
acres	0.0159***	0.0280***	0.0366***
	(0.00148)	(0.00271)	(0.00343)
restore	0.0229***	0.0386***	0.0391***
	(0.00221)	(0.00361)	(0.00686)
view	0.116***	0.184***	-0.366***
	(0.0231)	(0.0358)	(0.0846)
tour	0.105***	0.249***	0.671***
	(0.0248)	(0.0439)	(0.0603)
LL	-4502.2753	-3595.6011	
Observations	14972	14972	14972

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5.

Marginal willingness to pay for attributes, 90% confidence interval

Attribute	Conditional Logit	Random Parameter Logit using Krinsky Robb method
Acres	0.90 (0.7233-1.0811)	1.01 (0.8035-1.208)
Restored Acres	1.30 (1.0384-1.610)	1.39 (1.1226-1.6991)
High Bobolink	5.82 (1.1197-10.3471)	5.32 (0.9891-9.527)
View	6.63 (4.1165-9.4804)	6.63 (4.2095-9.3551)
Tour	6.00 (3.0845-8.8511)	8.97 (5.713-12.1578)