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Generating Revenues from WTP for Ecosystem Restoration: An Auction Experiment on Public Goods

Elizabeth C. Smith, Stephen K. Swallow
Department of Environmental and Resource Economics,
University of Rhode Island

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This draft reflects preliminary results to provide conference participants an introduction to the research.

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Abstract*: Research on public good auctions is intended to initiate development on new approaches to finance public goods, beyond government and philanthropic efforts. The researchers evaluate the potential to identify economic value for a subset of ecosystem services and markets that have the potential to provide for them. Empirical analysis focuses on public valuation for three specific types of ecosystem activities (bird habitat, sea grass restoration and shellfish restoration) in coastal Virginia. Data was collected using a field experiment employing an experimental auction approach with mechanisms to reduce free riding often seen in the experimental economics literature. These incentive mechanisms are applied to individual restoration activities and willingness to pay estimates are compared to a baseline choice experiment that employs an incentive compatible, majority vote mechanism and actual (not hypothetical) money payments. A conditional logit model, rooted in McFadden's choice theory, is used to examine the trade-offs between ecosystem restoration activities to estimate willingness to pay, while interval regressions are applied to individualized price auctions. Linear and non-linear models are estimated to check for validity and sensitivity to scope.*

Keywords*: experimental economics, valuation, public goods, ecosystem services*

Introduction

Increased demands on our ecosystems, due to development and population growth, are threatening many environmental goods and the amenities associated with well functioning ecosystems. While few to no markets exist for ecosystem services that provide public goods and are not traditional commodities, such as habitat services provided by healthy sea grass beds or water quality benefits associated with clam habitats, consumer preferences can provide insight to managers and policymakers on how to prioritize limited funding and make trade-offs between restoration priorities. This study explores ways to generate revenues for these goods via exploring individual willingness to pay for specific ecosystem restoration activities and auction methods by which such willingness to pay might be translated into revenues (for provision of ecosystem restoration).

Results and insights into such preferences and valuations are potentially useful for private enterprises looking to establish new markets, philanthropic organizations who regularly solicit voluntary contributions from the public, and policy makers looking to establish a better balance between the public value of environmental quality and the alternative uses of environmental resources.

Using mechanisms known to alleviate free riding, we explore how different rules impact individual willingness to pay for specific ecosystem restoration activities and methods by which

such willingness to pay might be translated into revenues. One set of incentives establishes an incentive-compatible choice, in which strategic incentives are consistent with truthfully revealing the full value (full willingness to pay) for the alternative that an individual prefers most. For example, in a choice among two alternative sets of restoration activities and required payments from the individual, a voting institution with majority rule is incentive compatible because each voter's best strategy is to vote for the alternative that he or she would most prefer to see implemented (Bagnoli and Lipman 1989; Swallow et al. 2008). An individualized pricing approach, grounded in marginal benefit theory, is then compared to an incentive compatible scenario. Integrating an individualized pricing mechanism into the public goods research agenda has the potential for generating more accurate estimates of individual and community willingness-to-pay for environmental restoration activities, including the ecosystem services well functioning ecosystems provide.

Our objective was to answer the following questions:

(1) Can (Lindahl's) individualized prices be established for local public goods?
(2) How might the individualized pricing approach perform relative to other institutions for public good provision?
(3) Do alternative incentive mechanisms have different impacts in reducing free-riding or cheap-riding behavior under this individualized pricing framework

Methodology

This preliminary report concerns a field experiment in economics. The field execution of this experiment involved approximately 85 residents of Virginia's Eastern Shore. Participants were provided with a budget constraint between $90 and $150. Any money not offered towards restoration activities could be designated as cash to be taken home by the participant. Participants made decisions involving local public goods (e.g., half-acre increments of ecosystem restoration for sea grass habitat, bird habitat and clams for water quality) and were informed of the ecosystem services that may result from additional ecosystem restoration associated with each activity. For instance, this information included the additional habitat and oxygen resulting from more sea grass restoration or the critical migratory sites and ecotourism opportunities resulting from bird habitat or the increased water clarity resulting from clam restoration (see Fig. 2 for example of ecosystem services outlined to participants).

IC Mechanism

In order to examine the preferences and willingness to pay of environmental restoration activities under an individualized pricing scenario, a baseline incentive compatible scenario is first constructed and examined. In these valuation experiments, individual participants were asked to make commitments, with real money, under rules of trade that align the individual's incentives so that their best strategy is to make choices consistent with the full value they place on the alternatives. Carlsson and Martinsson (2001) provide a precedent for using this type of choice experiment for actual provision of public goods.

For this task, participants were asked to make decisions between bundles of restoration activities in order to establish baseline values, via marginal substitution between ecosystem restoration activities. Using an efficient design approach, each participant received 8 pair-wise choices that contained four variables (birds, clams, sea grass and personal cost) with four possible levels; environmental goods ranged from 0-3 increments and the money variable had 4 levels of percentage possible for restoration, the remainder as cash returned to the individual. The pilot ran with a 50 person group, split into two groups of 25 at random. We identified these groups through a simple system of 1-25, 31-55 id numbers. Within each group, an individual could have a budget of $90 or $120, alternating with id #'s and each sub-group of $90 or $120, there were 4 levels of restoration percentage that could be possible. The two groups faced the same choice questions in reverse order, allowing for a test of the ordering effect. These choices involved real monetary allocations and real actions for ecosystem restoration.

The bundle of restoration that will be provided is modeled on a traditional voting institution, where majority decision determines the outcome. Thus, in a choice among two alternative sets of restoration activities and required payments from the individual, a voting institution with majority rule is incentive compatible because each voter's best strategy is to vote for the alternative that he or she would most prefer to see implemented (Bagnoli and Lipman 1989; Swallow et al. 2008).

The experiment conducted under task one asks participants to choose between two bundles (or alternatives) from a choice set. Each bundle is comprised of half-acre units of restoration activities (e.g. sea grass restoration, bird habitat restoration, clam restoration for water quality) and an amount of money the individual was asked to pay towards the implementation of that bundles' activities. Each participant is presented with 8 choice sets, following an orthogonal fractional factorial design (Addelman and Kempthorne 1961). By causing individuals to choose between pairs of bundles, this task elicits preferences that indicate individuals' preferred trade-offs between the restoration activities or attributes of different bundles and enables the researcher to estimate willingness-to-pay for restoration.

All 8 of the paired choice sets could be implemented through contracts with firms that restore ecosystems, so all choices could be "real." However, due to budget limitations, the research did inform respondents, after individuals answer all 8 questions, that only one question will be chosen, at random, for implementation; by this approach, data from all 8 questions can be treated as a real choice since participants know the outcome of any one question could affect real restoration. Such choice experiments are rooted in random utility modeling (Lancaster 1966; Hardie and Strand 1979). A conditional logit model, founded in McFadden's choice theory (1974), is used to examine the trade-offs between ecosystem restoration activities to estimate willingness to pay. Linear and non-linear models are estimated to check for validity and sensitivity to scope.

Individualized Pricing Mechanism

Additional information was collected for each restoration activity using an individualized price experimental auction. Lindahl first proposed a system for individualized pricing of public goods in 1919, based on an individuals' marginal cost being equal to the marginal benefit they receive from provision of the good (Nicholson 2005). The sum of all the marginal payments (offers)

establishes the Pareto optimal[1] level of the good provided (Samuelson 1954). Theoretically, Lindahl's approach can reach a Pareto optimal level of public good provision, if each individual were to reveal their full value (Groves and Ledyard 1977), yet it has been thought to be near impossible to produce offers sufficient to provide for the goods in actuality (Nicholson 2005). Using incentive mechanisms from the experimental economics literature discussed below, this research will test the feasibility of an individualized pricing system, motivated by Lindahls' marginal benefit theory.

Participants faced a series of questions about how much they would be willing to pay to support a given level of a restoration activity, incrementally. In other words, they were asked how much they would offer for a single unit of restoration activity, then for two units of the same activity and so on. In all cases, the participant was provided $100-$150 with which to make decisions. Any money not offered towards incremental restoration activities was designated as cash to be taken home. In this way, if a participant decided to offer, for example, $90 for a single unit of restoration, they would be able to take $10 home if this was the highest amount of restoration provided by the group.

Rules for provision drew on established methods in experimental economics, notably methods for threshold public goods that involve a provision point or target of funds that must be raised to enable provision of the good. Participants were instructed that incremental provision for each good would happen only if the group offered enough funds to pay for the restoration activity. If enough funds were offered to pay for a single unit, then the auctioneer determined if enough funds were available to pay for two units based on each participant's incremental decision, and so on. The actual levels of ecosystem restoration provided are based on aggregate willingness to pay reaching a pre-determined (but unknown to the participants) provision point, or cost of implementing the project. This aggregate determination is done for each infra-marginal unit of restoration, based on the rules of the incentive mechanism, and no level of restoration can be implemented if the aggregate offers did not reach the provision point. In this way we are simulating an auction-like experience where participants willingness to pay (offers) on a given level of restoration is matched with the amount they have to pay for any level of restoration.

Previous research in the experimental economics literature has shown that individuals will increase donations to a public good project if the payment rules reduce the incentives for individuals to 'free ride' (benefit without paying towards the cost of provision) on the contributions of others (Isaac et. al. 1989; Bagnoli and Lipman 1989; Davis and Holt 1993; Ledyard 1995; Holt 2007), Additionally, individuals have been shown to contribute more towards a project if there is a provision point and money back guarantee. Under these conditions, the public good is supplied only if a pre-specified amount of money (the provision point) is raised, and participants receive their money back if the market fails to raise that amount. (Bagnoli and McKee 1991; Marks and Croson 1998; Cadsby and Maynes 1999; Poe et al. 2002; Das 2007; Spencer et al. 2009)

Such that, a single unit decision earnings are based on the equation,

[1] A Pareto optimal level of provision is one where it is impossible for any individual to be made better off without making some individuals worse off.

$$E_i = \begin{cases} M & \text{if } \sum_{j=i}^{N} C_j \le PP \\ M - C_i + V_i + \dfrac{C_i}{\sum_{j=i}^{N} C_j}\left(-PP + \sum_{j=i}^{N} C_j\right) & \text{if } \sum_{j=i}^{N} C_j \ge PP \end{cases}$$ where,

E_i Participant i's earnings, dependent on whether or not the provision point was reached
M_i Participant i's budget (provided)
C_i Participant i's contribution or offer
$\sum C_j$ Sum of contributions from all members of the group
V_i Participants value or return when the good is provided, i.e., when the provision point was reached.

Alternative mechanisms are evaluated in order to assess whether decision-making is altered when the rules differ on the marginal unit. The proportional rebate (PR) mechanism has been shown to generate revenues sufficient for the public good (Spencer et al. 2009; Marks and Croson 1998). PR requires that the provision point be met and returns any money in excess of the provision point to the participants in proportion to their offer, on the infra-marginal unit. The PR mechanism is examined both with and without an opportunity for participants to revise their offers on any units not provided by initial auction rounds. A secondary mechanism, the Pivotal Mechanism (PM) also uses a provision point. However, PM requires participant payment on the marginal unit, only if it is expressly needed to reach the provision point and provide the good. The PM has attractive incentive compatible qualities but has not been shown to generate sufficient funds for provision (Swallow et al 2008).

Results / Analysis

Description of study population (pilot and 2009 field experiment)
More than half the respondents were women (55%). The average age was 50, with a range between 23 and 72 and average residency of 13.6 years, with a range between 1 and 45 years. The majority of our sample owned their own home (89%) and had some college or more. While not representative of the regional population, this sample is representative of those that contribute to environmental projects, as did 80% of our sample. More than half of the sample self-identified as being recreational fishermen and bird watchers (56% and 58%, respectively), with only 20% self-identifying as recreational hunters and 4% as commercial fishers. Two sessions of the 2009 field test were conducted, income distribution for both is in table 1. While some differences existed between the two sessions, session 2 did have more participants with incomes greater than 75k. Overall, the majority of participants in both sessions have incomes that are less than 50k.

IC Model
Analysis to-date indicates that participants did reveal support for higher quantities (e.g., more acres) of ecosystem restoration, yet the average individual did not show a statistically significant difference in value for alternative restoration types, as seen in table 2, estimated using a conditional logit model. Preliminary results and participant feedback indicate that factors

beyond the purely theoretical assessment of incentive compatible properties (such as framing effects or science-information) may have played an integral role in individuals' choices (votes). Additionally, the sign on the individual personal cost coefficient is positive, indicating that participants were not making decisions consistent with theory, although results from the remainder of the pilot do suggest results consistent with decreasing marginal benefit theory. With this in mind, the 2009 field experiment included additional science information in early instructions and reminders that money not used for restoration was money that they could take home. Results from this field experiment (table 3) also show similarities between the restoration activity coefficients but a change in sign (now negative and consistent with theory) on individual personal cost.

Individualized pricing

Session two of the pilot field experiment used a process to identify marginal (or individualized) prices for increments of each of the ecosystem restoration activities (e.g., sea-grass, birds, clams). This was done by asking participants to complete a series of decisions to offer a per-increment price for additional units of restoration with the researcher evaluating whether the sum of per-unit prices exceeded the costs of providing each unit. As in the first session, participants were given a $100 endowment or budget within which to make decisions.

An interval regression is used to analyze the individualized pricing sections, results are shown in table 4. Highlights include the coefficient on new residents (< 10years), both significant and negative. Qualitative discussions indicate that those residents who grew up in the community (e.g., old residents) may be more likely to support restoration activities. This may be explored further in future studies. Despite the variability in income across participants, income (greater than/less than $50,000), did not seem to play a role in the marginal willingness to pay for incremental units of restoration.

Several mechanisms are tested, including a proportional rebate mechanism, whereby money collected from a group that exceeded the total monies needed to provide the public good was rebated to individuals in proportion to their offer. In addition, the participants were split into two groups, where one group was told, conditional on their decisions for one restoration activity, a unit of an additional restoration activity would be provided as long as funds to provide a single unit on the first activity were collected. Results from the interval regression show that as the number of increments increased, participants' offered price declines, consistent with the concept of diminishing marginal benefits (table 5). The overall shape of the graph held true for each of the three ecosystem restoration activities. Additionally, participants making decisions on conditional units of ecosystem restoration consistently displayed a higher willingness to pay for each incremental unit.

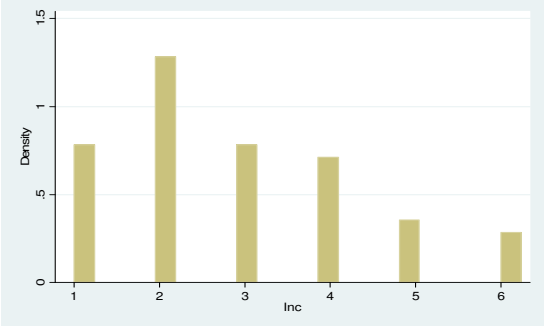
Conclusions

The study is intended to initiate development on new approaches for financing public goods, beyond government and philanthropic efforts. Individualized pricing based on the Lindahl approach has long been considered impractical in microeconomics. This study initiates a direct test of this long-held assumption. Preliminary results suggest it may be possible to generate

sufficient funds for public good provision. Our results indicate that participants were making decisions consistent with theory while simultaneously generating adequate funds to provide the public goods. The methods explored in this study may be most appropriate for localized public goods, but there is potential to adapt such incentive mechanisms for use with existing programs by which government pays landowners for ecosystem services. Auction methods could serve as an alternative (or complementary approach) to stated preference methods as a means for guiding the investment of public funds for ecosystem services.

Tables

Table 1: INCOME DISTRIBUTION VCR.LTER 2009



1 = Under 25k
2 = 25-40k
3 = 40-50k
4 = 50-75k
5 =75-100k
6=100k+

Table 2: (Logit) Choice Model: Pilot

Variable Name	**B**	**Std. Err.**	**P<**
Birds	0.6530	0.1093	0.001
Clams	0.6582	0.1336	0.001
Sea Grass	0.6686	0.1435	0.001
Individuals' cost	0.0066	0.0028	0.018
LR chi2 (df)	87.76 (4)	0.0001	

Table 3: (Logit) Choice Model: 2009 Field Experiment

Variable Name	**B**	**Std. Err.**	**P<**
Birds	**2.1942**	**0.4073**	**0.001**
Sea Grass	**1.8977**	**0.3845**	**0.001**
NU2	**-0.1029**	**.0467**	**0.027**
Individuals' cost	**-0.0358**	**0.0052**	**0.001**
LR chi2 (df)	**284.79 (4)**	**0.0001**	

Table 4: Interval Regression Results, Individualized Pricing (pilot)

Variable affecting mWTP	**B.**	**Std. Err**	**P<**
Constant	42.43	8.859	0.000
No. of units	-10.83	1.076	0.000
New Resident (<10yrs)	-26.39	4.135	0.000
Dummy Clams	2.473	3.090	0.424
Dummy Birds	2.840	3.115	0.362
Dummy Conditionality	8.917	3.168	0.005
DConSG*No. Units	-.5323	1.421	0.708
Female	-5.933	2.501	0.018
Age	.8774	.1185	0.001
Education (< B.S.)	11.09	4.502	0.014
Education (> B.S.)	5.591	4.881	0.252
Years of residency	-1.489	.1851	0.001
Dummy if previously donate to environmental restoration	-1.319	3.410	0.699
Dummy if Retired	-1.028	3.202	0.748
Income <50k	19.24	3.173	0.001
Income >75k	17.10	2.710	0.001

Table 5: Mean responses for Sea Grass (Pilot)

	Mean	**Std Dev**	**Min**	**Max**
1 unit	64.24	32.98	0	100
2	35.78	14.38	0	50
3	26.15	8.69	0	33.33
4	20.91	6.40	0	25

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