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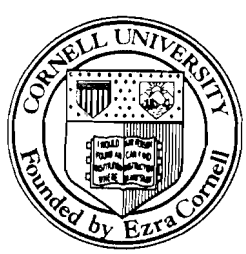

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THE PRIVATE PROVISION OF PUBLIC GOODS: TESTS OF A PROVISION POINT MECHANISM FOR FUNDING GREEN POWER PROGRAMS[1]

Steven K. Rose, Jeremy Clark, Gregory L. Poe, Daniel Rondeau, William D. Schulze[2]

Abstract

This paper utilizes field and laboratory experiments to test the use of a provision point mechanism to finance renewable energy programs, commonly known as green pricing programs. In contrast to most green pricing programs, relatively high participation is found in the field, while laboratory results suggest that demand revelation is achieved by the mechanism in a single shot environment with a large group of potential participants.

Key Words: public goods, provision point, green pricing, renewable energy, experiments, free riding, altruism.

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1. Introduction

Despite market research that has uniformly predicted substantial customer interest in paying higher electric power rates to support renewable energy generation and environmental programs, experience with green pricing indicates that participation levels have not exceeded 1 to 2 percent (Byrnes *et al.*, 1995; Farhar and Houston, 1996).[3] Three explanations for this discrepancy seem possible. First, hypothetical market research studies of program support may have been upwardly biased. Second, most utility customers may have been unaware of such programs, in spite of attempts by electric utilities to inform them using bill inserts, mailed brochures and advertising. Note that market research, by necessarily informing customers of a potential green pricing program, inherently creates perfect awareness concerning the program in the sample population. As a result, forecasts derived from market research depend critically on assumptions about customer awareness which in turn depend on the effectiveness of marketing. A third possibility is that actual customer participation in green programs may have been lowered by free-riding, because participation has commonly been structured as a charitable voluntary contribution.

From the viewpoint of economics, the possibility of free riding in actual participation is of primary concern. Provision point mechanisms have been shown to have desirable theoretical properties (Bagnoli and Lipman, 1989) and to substantially reduce free riding in experimental tests when compared to the voluntary contribution mechanism (VCM) (Isaac, Schmidtz, and Walker, 1989; Suleiman and Rapoport, 1992; Dawes, Orbell, Simmons, and van de Kragt, 1986). There are also anecdotal reports of provision points being used to successfully resolve actual free riding problems (Bagnoli and McKee, 1991). Motivated in part by this literature, as well as by

recent utility industry interest in voluntarily funded green power programs, this paper reports the results of a paired field and laboratory experimental application of a provision point mechanism using a green pricing program implemented by Niagara Mohawk Power Corporation. Both theoretical and experimental economists have long hoped for a practical mechanism for the private funding of public goods (see for example Groves and Ledyard, 1977; Smith, 1980). This research is designed to test whether this goal can be realized given our current understanding of public good mechanisms.

In Section 2 we provide the specifics of the Niagara Mohawk Power Corporation *GreenChoice*™ program and the provision point mechanism used. The third section describes the field experiment and estimates a random utility model of actual program participation on the basis of individual characteristics. The primary advantage of the field experiment is that, by phoning customers, describing the *GreenChoice*™ program, and allowing them to sign-up or decline the offering on the phone, complete awareness is assured in the sample population. In spite of this control, it is still uncertain whether the sign-up rates observed in the field experiment (which are much higher than those of previous programs using voluntary contributions) reflect actual demand or if free-riding problems remain. Thus, in Section 4, we replicate the Niagara Mohawk Power Corporation mechanism in an induced value laboratory experiment under the assumption that, if the mechanism fails to eliminate free riding in the laboratory, then it will fail to eliminate free riding in the field. The hypothesis that this provision point mechanism eliminates free riding and induces demand-revealing behavior is tested by comparing individual and group contributions relative to induced values.[4] A random utility model is used to predict the probability of participation, but now as a function of induced value. Finally, Section 5

presents our conclusions concerning use of provision points for the private provision of public goods and discusses remaining issues.

2. The Niagara Mohawk Power Corporation GreenChoice™ Program

The Niagara Mohawk Power Corporation (NMPC), a public utility in New York State, sought to accelerate the development of renewable energy sources of electricity by offering its customers "green rates" as proposed by Moskovitz (1992, 1993). Moskovitz argued that customers would voluntarily sign up and agree to pay higher electricity rates if the additional money collected were earmarked to support renewable energy projects or other environmental activities. Economists were quick to point out that the selection of such a rate by a customer would be a charitable contribution since the mechanism proposed by Moskovitz would allow free riding (see Schulze, 1994).[5] NMPC in turn developed the *GreenChoice*™ program, using a modified contribution mechanism in an attempt to reduce free-riding incentives.

The mechanism adopted by NMPC employed three features that have been tested in the experimental literature. First, it contained a *provision point* of $864,000 to be raised through customer contributions. This minimum level of funding would provide for the construction of a renewable energy facility to serve 1,200 homes, and for the planting of 50,000 trees in the NMPC service area. The addition of a provision point to a voluntary contribution mechanism adds multiple, efficient Nash equilibria at the threshold, and has been shown to increase individual pledges towards the provision of public goods. Unfortunately, if the threshold is not met, a provision point results in a complete loss of efficiency, unlike the VCM (Isaac, Schmidtz and Walker, 1989).

Second, NMPC's funding mechanism offered a *money back guarantee* to customers which assured them that, if contributions failed to reach the threshold, all money collected would be refunded. The money-back guarantee provided insurance to potential contributors against the risk of losing their contributions should the provision point not be met. In experiments where subjects can contribute all or none of their endowment to a public good, Dawes et al. (1986) find no evidence to support the use of a money-back guarantee. However, in an environment where subjects can contribute any amount, Isaac, Schmidtz, and Walker (1989) report that the guarantee significantly increases contributions.

Third, the mechanism offered the possibility of *extended benefits*. Money collected in excess of the provision point would be used to extend benefits, or increase the production of the public good. Here, excess contributions were to be used to increase the number of homes served with renewable energy or to plant more trees. Extending benefits beyond the provision point does not modify individual incentives in theory, but simply creates a VCM environment beyond the threshold (Marks and Croson, 1996). Marks and Croson refers to this use of excess contributions as a "utilization rebate" rule. In evaluating alternative rebate rules for provision point mechanisms experimentally, Marks and Croson finds that offering extended benefits has the greatest positive effect upon group contributions.

One theoretically undesirable feature of NMPC's mechanism was that, to legally qualify as a rate offering, the program could only be offered at a posted price. Thus, customers could choose only to contribute a fixed amount of $6.00 per month or not participate at all. A posted price is undesirable because it does not allow households to self-select a monthly fee that better represents their preferences for the program. Note that, despite the posted price, the mechanism

does not reduce to a referendum, because the only individuals to pay are those who choose to participate.

Interestingly, the only other green pricing programs to use a provision point mechanism of which we are aware were fully subscribed. Traverse City Light and Power attempted and completed a windmill project using a funding mechanism similar to NMPC's, except that it did not offer extended benefits. Participation was instead curtailed after the program's provision point was successfully reached with 200 customers at an estimated residential premium of $7.58 per month (23 percent of the average residential bill) (Holt and Associates, 1996a). The City of Fort Collins also used a series of provision points to solicit funds for up to three separate wind turbines. (Holt and Associates, 1996b). To date, enough customers have agreed to pay an estimated average premium of $10 per month to exceed the minimum provision point established to fund two turbines (Clements-Grote, 1997; Holt and Associates, 1997).

In comparing these offerings with the *GreenChoice*™ program it is important to note that there are substantial differences in magnitude and scope. Both the Fort Collins and Traverse City programs were small, locally based programs able to focus on well-defined projects, so that awareness was easily achieved. In contrast, the NMPC program, although initially intended to be offered only in the Buffalo area, had to be offered, for legal reasons, to NMPC's entire service area, which covers well over fifty percent of the area of New York State. Thus, marketing became a major impediment to the program.

Unfortunately, though the *GreenChoice*™ program was formally approved by the New York Public Service Commission, it was ultimately suspended before completion because NMPC developed serious financial difficulties and was unable to promote customer awareness of the

program. Before suspension, the program was briefly mentioned in a bill insert and described in a brochure sent to about three percent of NMPC's customers. Most of the planned marketing campaign, including a substantial advertising budget and tree plantings at public schools throughout the service territory, was canceled. Before the program was terminated, however, we were able to conduct a field experiment with NMPC customers.

3. Field Experiment

3.1. Experimental Design

The field experiment was conducted as part of a larger National Science Foundation/Environmental Protection Agency research effort to investigate environmental values for public programs (Poe, Clark, and Schulze, 1997). A telephone survey was utilized to attempt to contact a random sample of 206 households in the Buffalo area.[6] The telephone survey began by screening customers to identify the person in the household who usually pays the NMPC electric bill. Once that person is on the phone, the interviewer describes the purpose of the survey and the sponsors of the study. The individual is then asked to rate NMPC's service. This allows the small number of dissatisfied customers to vent frustration before answering the remaining questions. Customer awareness of the *GreenChoice*™ program is obtained next, and then the goals of the program are described in turn. As the goals are described, the respondent is asked:

> *How interested are you in the goal of replacing fossil energy with renewable energy sources? On a scale from 1 to 10, where 1 is not at all interested and 10 is very interested, how interested are you?*

and later:

How interested are you in the goal of planting trees on public lands in upstate New York? As before on a scale from 1 to 10, where 1 is not at all interested and 10 is very interested, how interested are you?

The funding plan is then described as follows:

The GreenChoice program would be funded voluntarily. Customers who decide to join the program would pay an additional fixed fee of $6 per month on their NMPC bill. This fee would not be tax deductible. Customers would sign up or cancel at any time. While customers sign up, NMPC would ask for bids on renewable energy projects. Enough customers would have to become GreenChoice partners to pay for the program. For example if 12,000 customers joined the first year, they would invest $864,000, which would allow Niagara Mohawk to plant 50,000 trees and fund a landfill gas project. The gas project could replace all fossil fuel electricity in 1,200 homes. However, if after one year, participation were insufficient to fund GreenChoice activities, Niagara Mohawk would cancel the program and refund all the money that was collected.

The program description was taken more or less directly from the program brochure prepared by NMPC. Note that NMPC was deliberately vague about the exact level of the provision because the renewable energy project was to be sent for competitive bid.

The survey then asks respondents whether the features of the funding program make them more or less interested in the program (see section 3.2 for details). This is followed by the participation question. It is phrased as follows:

You may need a moment to consider the next couple of questions. Given your household's income and expenses, I'd like you to think about whether or not you would be interested in the GreenChoice program. If you decide to sign up, we will send your name to Niagara Mohawk, and get you enrolled in the program. All your other answers to this survey will remain confidential. Does your household want to sign up for the program at a cost of $6.00 per month?

Although actual monies were never collected because the program was suspended, this sign up now/pay later approach corresponds with the following stepwise process typically used in green pricing programs: 1) potential projects are described; 2) subscriptions from customers are elicited through direct marketing, bill inserts and advertising; and 3) money is collected through regular

billing. Experience from the Traverse City project suggests that the payment to intention ratio is very high--in that case, Traverse City Light and Power found that approximately 5% of those who originally signed-up reneged.

The survey ends with socioeconomic questions useful for modeling demand.

3.2. Results and Analysis

Of the sample of 206 households, contact was made with 179.[7] Of these, 34 refused to participate and three could not complete the questionnaire. Thus, 142 respondents completed the survey, yielding a response rate of 69% of the base sample. Of the 142, 29 signed up for the program, resulting in a participation rate of 20.5 percent. If we assume that the 37 households who refused or could not complete the survey would also have refused the program, the participation rate would fall to 16.5 percent. Both these estimates stand in marked contrast to the actual sign-up rate of less than 0.1 percent observed by NMPC throughout the period *GreenChoice*™ was offered. As discussed previously, this low participation was likely caused by the minimal marketing and low customer awareness of the program. Indeed, none of the 142 randomly sampled respondents in our survey recalled having heard about the program. Participation rates of 16.5 and 20.5 percent are consistent with a preliminary market evaluation of the NMPC service area conducted by the Research Triangle Institute (RTI) (Wood *et al.* 1994), which estimated that with full awareness there was a 17 percent probability of adopting a green planting program at a $6 monthly premium. The RTI data were taken from a sample that over sampled "green" customers, since such customers were regarded as the target group for an actual program. Based on prior information, approximately 25 percent of urban NMPC

customers were classified as "green".

It is important to note that a participation rate of 16%-20% is, however, substantially higher than the 1% needed to fund *GreenChoice*™ (12,000 of a total of 1.2 million NMPC customers), and those observed in the majority of actual green pricing experiments reported in the literature (Baugh *et al.* 1995; Brynes *et al.* 1995; Holt and Associates, 1996; Farhar and Houston 1996). As suggested earlier, however, there are notable differences between our experiment and the majority of previous studies. First, reported participation rate estimates have not generally been adjusted to account for program awareness, which was controlled in our study at 100 percent. Instead, participation rates have typically been defined over total customer base or over the base of customers targeted with direct mailings. Previous participation experiments have also (with the two exceptions noted previously) relied on voluntary contributions rather than the provision point mechanism used here.

To investigate individual specific factors associated with participation decisions, the linear logistic distribution, which can be derived from a random utility model (McFadden, 1976), is assumed to characterize individual decisions,

$$(1) \qquad \Pr\{\text{"Yes" response}\} = \frac{1}{1 + e^{-\alpha \underline{X}}}$$

where $\underline{X}$ depicts a vector of covariates characterizing individuals and their perceptions of the program (including a constant term), and $\underline{\alpha}$ is the corresponding set of coefficients to be estimated.

Assuming this logistic distribution, participation decisions are modeled as a function of

three categories of covariates elicited in the questionnaire. The first concerns respondents' perceptions of the program's worth. Respondents registered their interest in the twin goals of the *GreenChoice*™ program -- replacing fossil fuels and planting trees in upstate New York -- using a scale of one (*"not at all interested"*) to 10 (*"very interested"*) for each goal.[8] It is expected that the sign on these variable would be positively correlated with the probability of joining the program.

The second category of covariates includes variables specific to the respondent, such as sex (Male=1), age (Years), education (College Graduate or higher =1), and recent financial support of environmental groups (Yes=1). Such characteristics are widely used as explanatory covariates in the environmental valuation literature. Based on this literature, it is expected that age will be negatively correlated with WTP while recent financial support for environmental groups would be positively correlated with joining the program. The other variables have provided mixed results in the literature. As noted earlier, individual perceptions of NMPC service were elicited using a one (*"unfavorable"*) to 10 (*"very favorable"*) scale and included as a covariate in this analysis.

The final category of covariates concerns respondents' perceptions of the provision point mechanism itself. After hearing of the funding provision point and money back guarantee, respondents were asked the following two questions:

> *Does the fact that a minimum level of customer participation is required for GreenChoice to operate make the program of less interest to you, more interest, or does it not affect your interest?*
>
> *Does the fact that Niagara Mohawk would refund all the money it collects -- if support is insufficient -- make GreenChoice of less interest to you, more interest, or does it not affect your interest in the program?*

These variables are admittedly *ad hoc*, in the sense they do not proxy for the value of the program. However, they do provide information about perceptions regarding specific components of the provision point mechanism. Over 55 percent responded that their interest was not affected by including a provision point and about 16 and 27 percent indicated that it increased or decreased their interest in the program, respectively. In contrast, the money back guarantee was widely favored: only 9 percent of respondents indicated that this attribute reduced their interest in the program, while 46 percent indicated that it increased their interest. For the purpose of modeling the participation decision, these response categories were re-coded as binary variables assigned '1' if the *"more interest"* option was selected, and zero otherwise. We expect their estimated coefficients to be positive.

The logit model of program participation is reported in Table 1, together with the sample means, standard deviations, and the expected signs of the estimated coefficients of all the explanatory variables described above. Given the single $6 threshold, the estimation results are fairly strong: 80 percent of the responses are correctly predicted and the overall likelihood greatly exceeds the critical value (LR=31.03 > 14.68 = $\chi^2_{0.10}(9)$).

Considered jointly, the estimated coefficients on the two program goals are significant using a likelihood ratio test (LR = 7.23 > 4.61 = $\chi^2_{0.10}(2)$), leading to the conclusion that there is a positive response to the tree-planting and renewable energy objectives of the NMPC program. Comparison of the individual coefficient estimates suggests that, in spite of the observation that more people favored the tree planting objective, interest in fossil fuel replacement is a more significant predictor of participation decisions. The implication is that tree programs will have broad based general support, but that interest in the fossil fuel component will be the significant

Table 1. Estimated Logit Models of NMPC Phone Participants

Variable [Scale]	Mean	Expected Sign	Estimated Coefficients
Constant	1	n.a.	-4.386 (2.184)**
Replace Fossil Fuel [1-10]	6.27 (2.82)	+	0.233 (0.118)**
Plant Trees [1-10]	8.35 (2.18)	+	0.216 (0.186)
Sex [Male = 1]	0.46 (0.50)	?	0.954 (0.517)*
Age [Numeric]	55.09 (15.70)	-	-0.0396 (0.0192)**
Give to Environment [Yes = 1]	0.19 (0.39)	+	0.666 (0.624)
College Graduate [Grad = 1]	0.45 (0.50)	+?	0.002 (0.546)
Rating of NMPC Service [10=very good]	8.49 (1.67)	+?	0.082 (0.644)
Min. Participation [More Interested = 1]	0.17 (0.38)	+	1.416 (0.588)**
Money Back Guarantee [More Interested = 1]	0.47 (0.50)	+	-0.098 (0.550)
n	128		128
Likelihood Ratio χ^2			31.03***
Percent Correctly Predicted			80

Numbers in () are standard errors.
*,**, and *** indicate significance levels of 10, 5, and 1 percent, respectively.

explanatory factor in participation decisions. This finding is consistent with the NMPC market research (Wood *et al.*, 1994).

A joint test of the null hypothesis that restricts all demographic coefficients to zero was

rejected at the 10 percent level (LR = 10.28 > 9.24 = $\chi^2_{0.10}(5)$). The estimated coefficients on respondent attributes vary in significance, consistent with other studies in the environmental valuation literature. Age was negatively correlated with participation, a factor that may be attributed to the life cycle hypothesis of value in which potential use values decline with age (Cropper and Sussman, 1990). This negative relation may also be associated with the fact that age is also inversely correlated with income in this data set.[9] The finding that male respondents had a higher likelihood of participation contrasts with evidence suggesting that this variable is not substantially related to environmental concerns (Van Liere and Dunlap, 1980). The coefficients on the other socio-demographic covariates were not significantly different from zero.

From our perspective, the coefficients on the funding mechanism variables are of considerable interest, despite their *ad hoc* nature. Considered jointly, these variables are significant ((LR = 5.84 > 4.61 = $\chi^2_{0.10}(2)$). In particular, interest in the provision point mechanism is a significant, and positive, explanatory variable in participation decision. The minority of respondents with interest in that feature clearly had a higher participation rate, suggesting that addition of this feature increases the likelihood of funding. In contrast, interest in the money back guarantee is not a significant explanatory variable in the estimated model in spite of the fact that there appears to be a widespread interest in the money back guarantee.

In summary, modeling of participation decisions indicates that the content and structural attributes of the NMPC mechanism are influential in participation decisions. The program goals of replacing fossil fuel energy and planting tree are important to participation decisions, particularly the former. In addition, the provision point feature increases participation.

4. Laboratory Experiment

4.1. Experimental Design

The provision point mechanism adopted by NMPC appears, given the field experiment results, to yield a high participation rate with full consumer awareness. In addition, there seems to be a consistent relationship between individuals' stated preferences and program involvement. Nevertheless, without direct knowledge of individual valuations, we have no way of knowing how successful the mechanism is in eliminating free riding or if the mechanism is demand revealing. A laboratory experiment was thus designed to test this funding mechanism in an environment where program values could be induced. If this mechanism fails to eliminate free riding in the laboratory, then we would expect it to fail to eliminate free riding in the field. Note that provision point mechanisms theoretically have Nash equilibria where costs are just covered by contributions. Often, in laboratory experiments with small groups, subjects just miss the provision point by slight under-contribution, a behavior termed "cheap riding" (Bagnoli and Lipman, 1989). In contrast, there is some evidence that large groups reveal demand when faced with a single shot provision point mechanism (see discussion next paragraph).

This section describes a classroom laboratory experiment specifically designed to evaluate the demand revelation properties of the NMPC mechanism. In addition to designing a laboratory mechanism paralleling the NMPC program, this experiment deviated from the body of previous public goods research in two important ways. First, in contrast to most public good experiments which have relied on "small groups" of less than 10 individuals, this experiment involved 100 participants. In part, this "large group" approach was adopted so as to more closely reflect the NMPC field conditions. The decision to use large groups was also based on

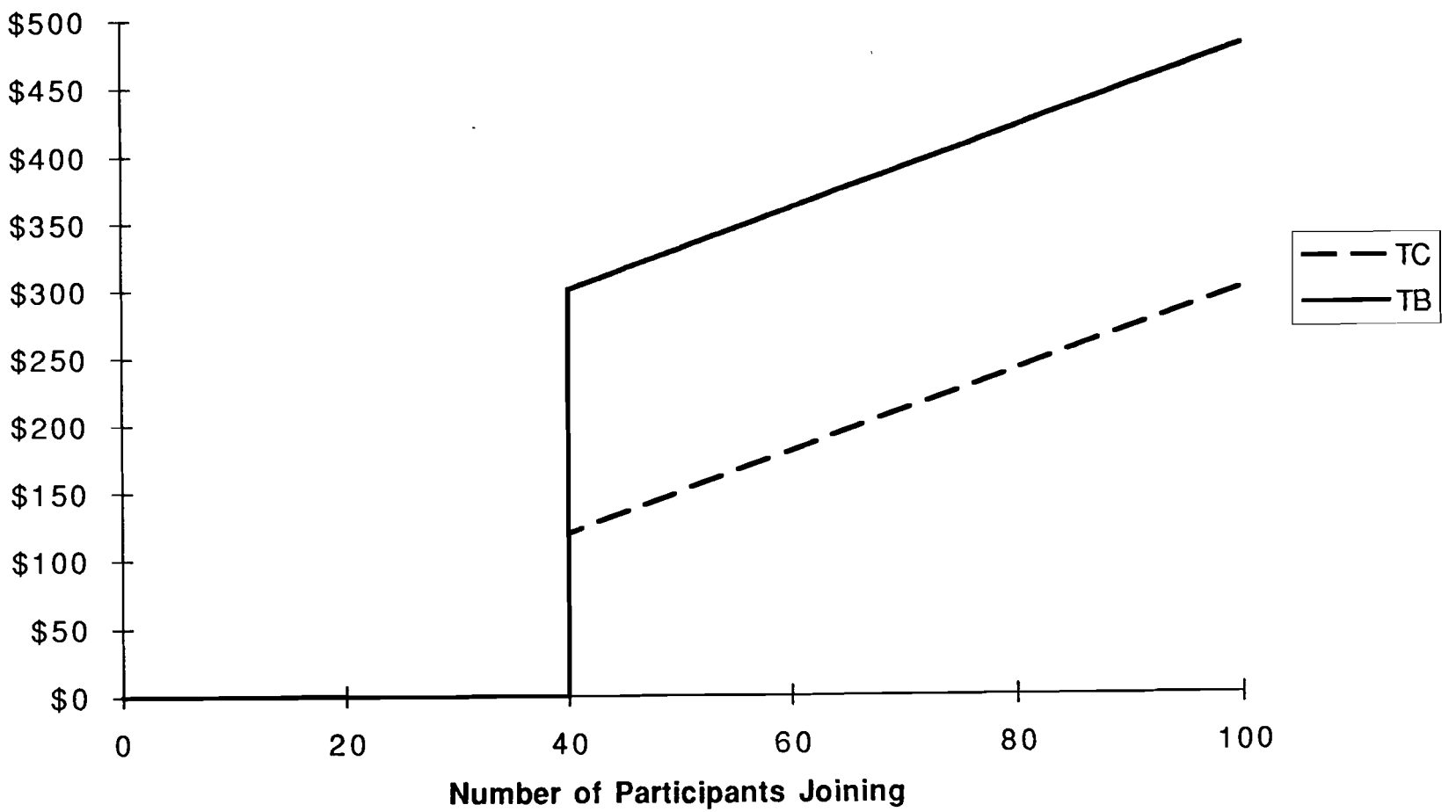
experimental findings of Isaac, Walker and Williams (1994) that individuals in groups of 40 and 100 contributed significantly more to a VCM public good experiment than did subjects in small groups (n=4 and 10). Experimental results reported in Rondeau, Schulze, and Poe (1996) further suggest that a provision point mechanism using a proportional rebate conducted in a large group (n=45) setting approximates demand revelation in the aggregate while the same mechanism results in under-revelation in small groups (n=6). A second manner in which the analysis of the experiment contrasts with previous public goods research is that it models individual contribution decisions in a random utility framework.

The experiment was performed in an undergraduate economics principles class. The students had experience in market experiments but not in public goods experiments. An experiment "in decision-making" was introduced at the beginning of a regularly scheduled class, and printed instructions were distributed after students were seated. Students were instructed to copy the subject number written on their instructions onto a blank envelope which they were also provided. Students read their instructions (see sample in Appendix A), after which a brief oral summary was given. Questions were answered privately by monitors. Students were then allowed approximately ten minutes to make a decision which shall be described shortly. They then sealed their instructions and decision responses in their envelopes. Follow-up questions were distributed immediately afterward, and subject numbers were copied from the envelopes to follow-up questionnaires. All materials were collected after the follow-up forms were completed. The sealed envelopes ensured that students could not alter their decisions after answering the follow-up questions. Students were not allowed to communicate during the experiment.

The nature of the decision was as follows. Each participant was given a starting balance of $5 and the opportunity to join a group investment program for a one-time fixed fee of $3. Before a participant decided whether or not to join, the group investment program and payoff calculations were described. The group investment program would yield a return only if 40% or more of the participants joined. Each participant was informed that they would receive their pre-specified "return" if this provision point was met or exceeded regardless of whether or not they had joined. Each subject was randomly assigned to a return from the set {$0.50, $1.75, $3.00, $4.25, $5.50}. Twenty subjects were assigned to each "return" and subjects were told their own return but were not made aware of the returns of other subjects. These returns were the induced values, designed to reflect the heterogeneous values NMPC customers hold for the *GreenChoice*™ program. If more than 40% joined, each participant also received a fixed "bonus payment" of 3¢ for each participant that joined in excess of the provision point. If fewer than 40% joined, the group investment program was canceled and all contributions were refunded. The bonus payment was public information.

The fixed participation fee was selected in conjunction with the induced values to insure that 1) the average payoff would equal or slightly exceed the participation fee and that 2) the total group benefits would equal or exceed twice the total group cost if the provision point were met or exceeded. Total costs (TC) and benefits (TB) are illustrated in Figure 1 for a group of 100 participants. This sample size was chosen to correspond with a large group setting, and to enable statistical analysis. The investment return values were chosen to be symmetric around the fixed fee and, based on pre-test results, to vary sufficiently to identify any relationship between induced value and participation for this sample size.

Figure 1: Total Costs and Benefits



The bonus mechanism was incorporated to reflect NMPC's offer of extended benefits financed by funds in excess of the provision point. The bonus amount of 3¢ was chosen so as to equate the aggregate group marginal benefits and marginal costs, as shown in Figure 1. The instructions were worded so as to avoid intrinsic value associated with program context; we sought to isolate the effectiveness of the mechanism alone in reducing free-riding behavior. Though this removed an important aspect of realism associated with NMPC's *GreenChoice*™ program, it allows for an unbiased evaluation of the program's financing mechanism. Finally, follow-up questions were posed to collect additional information on the participation decision (see Appendix B). The questions attempted to measure self interest and altruistic factors that might exogenously enter into participation decisions.

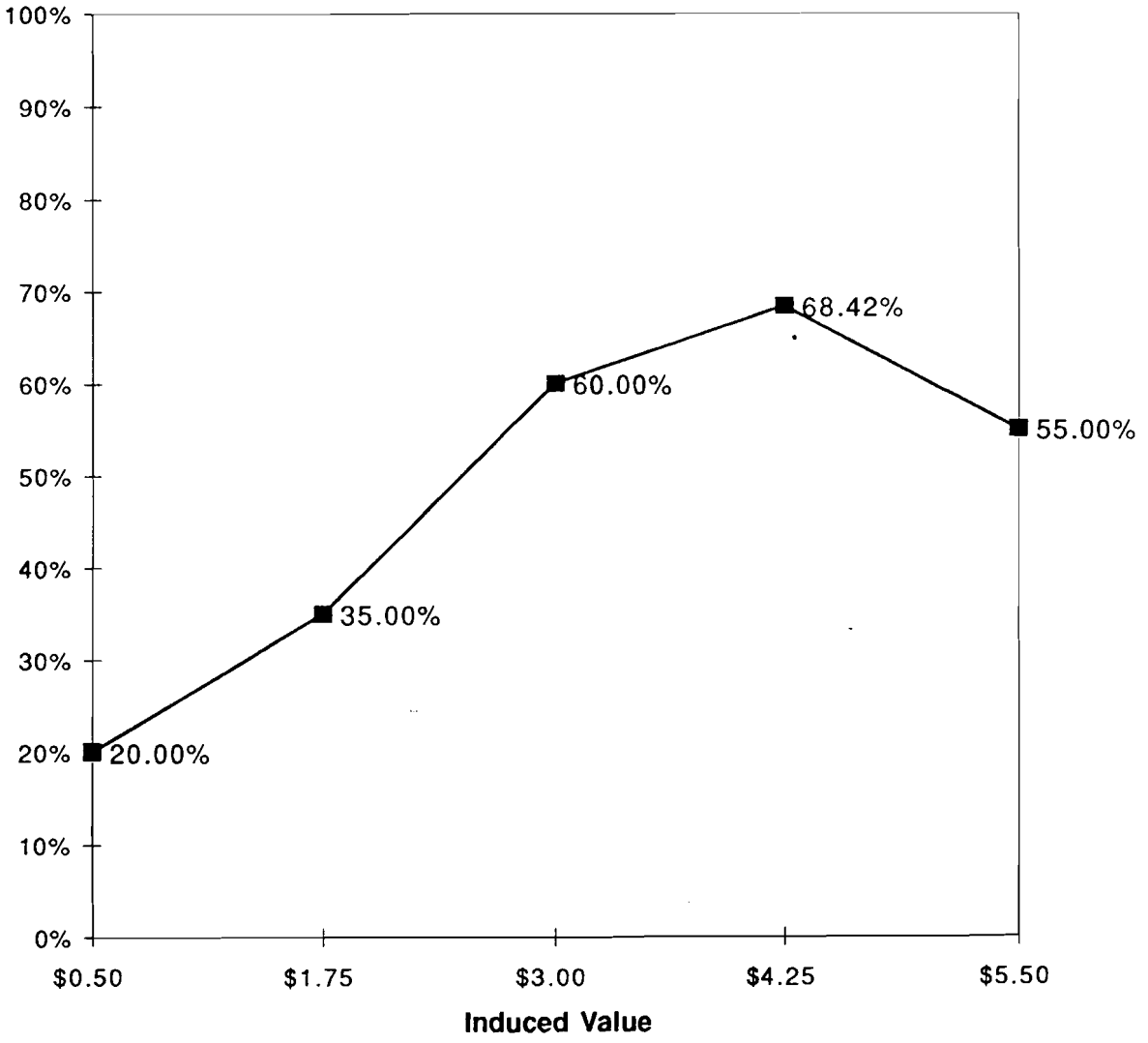
In summary, this experiment was designed to test the "naive" hypothesis that the provision point mechanism used by NMPC induces demand-revealing behavior under laboratory conditions. That is, we test if subjects with induced values above a posted price contribute and those with induced values below the posted price do not. If the mechanism is perfectly demand revealing, 50% of the 100 subjects should choose to participate in the program at a cost of $3, given the distribution of induced values: the 40% with induced values less than $3 should not sign up, the 40% with induced values exceeding $3 should sign up, and the 20% with the $3 induced value should be indifferent between joining and not joining. If, like the voluntary contribution mechanism, the provision point features fail to induce participation to levels approximating demand revelation, then we would expect that the results of the field experiment underestimate the "true" demand for the program.

4.2 Experimental Laboratory Results and Analysis

At the aggregate level, 47 percent of the subjects chose to join the program and pay the $3 fee, resulting in the funding of the public good. Clearly, this participation level closely approximates the 50 percent participation rate expected under our naive hypothesis. Thus, given this sample design, the mechanism appears to provide an approximately demand revealing outcome in the aggregate. In reaching this conclusion, it is interesting to note that in the week following the experiment described here, the same students participated in a standard computerized VCM public goods experiment developed by the Economic Science Laboratory at the University of Arizona. The experiment was conducted (using monetary incentives) as part of the students' regular weekly sections held in the Laboratory for Experimental Economics and Decision Research at Cornell. Contributions in the first round of this multiple round experiment were 41 percent of the maximum possible *payoff* (where the payoff corresponds to the induced value in the provision point experiment).[10] Thus, the subjects participating in these experiment appear typical, in that they exhibit substantial free-riding when in a single or initial period VCM environment (Davis and Holt, 1993).

As shown in Figure 2, participation is also generally responsive to increases in induced return. Contrary to our naive hypothesis, however, the response proportions do not exhibit a sharp step at $3. And thus, demand revelation associated with this mechanism is not perfect. Using a random utility framework first developed by McFadden (1976), it is possible to test the internal consistency of participation rates observed and the hypothesis that participation rates increase with induced value. In this framework, it is assumed that individuals know their own preferences with certainty, but that they may make errors in decision-making because of

Figure 2: Actual Joining Distribution (By Induced Value) .



imperfect information or errors in optimization. In addition, some aspects of the individuals' preferences are not observable by the analyst, and treated as random. These limitations introduce a stochastic error component into the modeling of decisions (Maddala, 1983).

Using such a model, we shall first specify the random utility equivalent of the naive null hypothesis, in which a customer will sign-up for the program at posted price \$C if the utility associated with having the program and paying \$C is greater than the utility associated with not having the program. If we assume that indirect utility is additively separable, the probability of a "yes" response to a particular posted price is then:

$$(2) \qquad \Pr\{\text{"Yes" response}\} = \Pr\{V - C + \epsilon > 0\}$$

where V is the value or willingness to pay of an individual for the green program and ϵ is an error term. Assuming that the error is logistically distributed, Equation (2) can be expressed as:

$$(3) \qquad \Pr\{\text{"Yes" response}\} = \frac{1}{1 + e^{-(\alpha + \beta(V - C))}}$$

where α and β are location and slope parameters to be estimated. The null hypothesis H_o^1: $\alpha = 0$ corresponds to the hypothesis that, at V = C, there is a 50 percent participation level. A positive value for α would shift the entire distribution to the left in a manner consistent with over-revelation relative to induced values, while under-revelation would correspond to $\alpha < 0$. The null hypothesis for the slope parameter H_o^2: $\beta = 0$ has only a one-sided alternative $\beta > 0$. That is, we are testing the hypothesis that participation does not increase with induced value.

Note from Equation (3) that for $\beta > 0$, the relationship between induced value and participation takes on an "S" shaped function through the introduction of logistically distributed random errors. Additionally, if $\alpha = 0$, when induced value equals cost (V = C), participation is

50%; as V-C becomes large, participation approaches 100%; and for small V relative to C, participation ultimately approaches 0%. The shape, or rather steepness, of the response function does vary with the magnitude of β. If $\beta = 0$, the probability of participation is a constant, but for large β, a step function is predicted. Figure 3 shows this relationship for a range of β values.

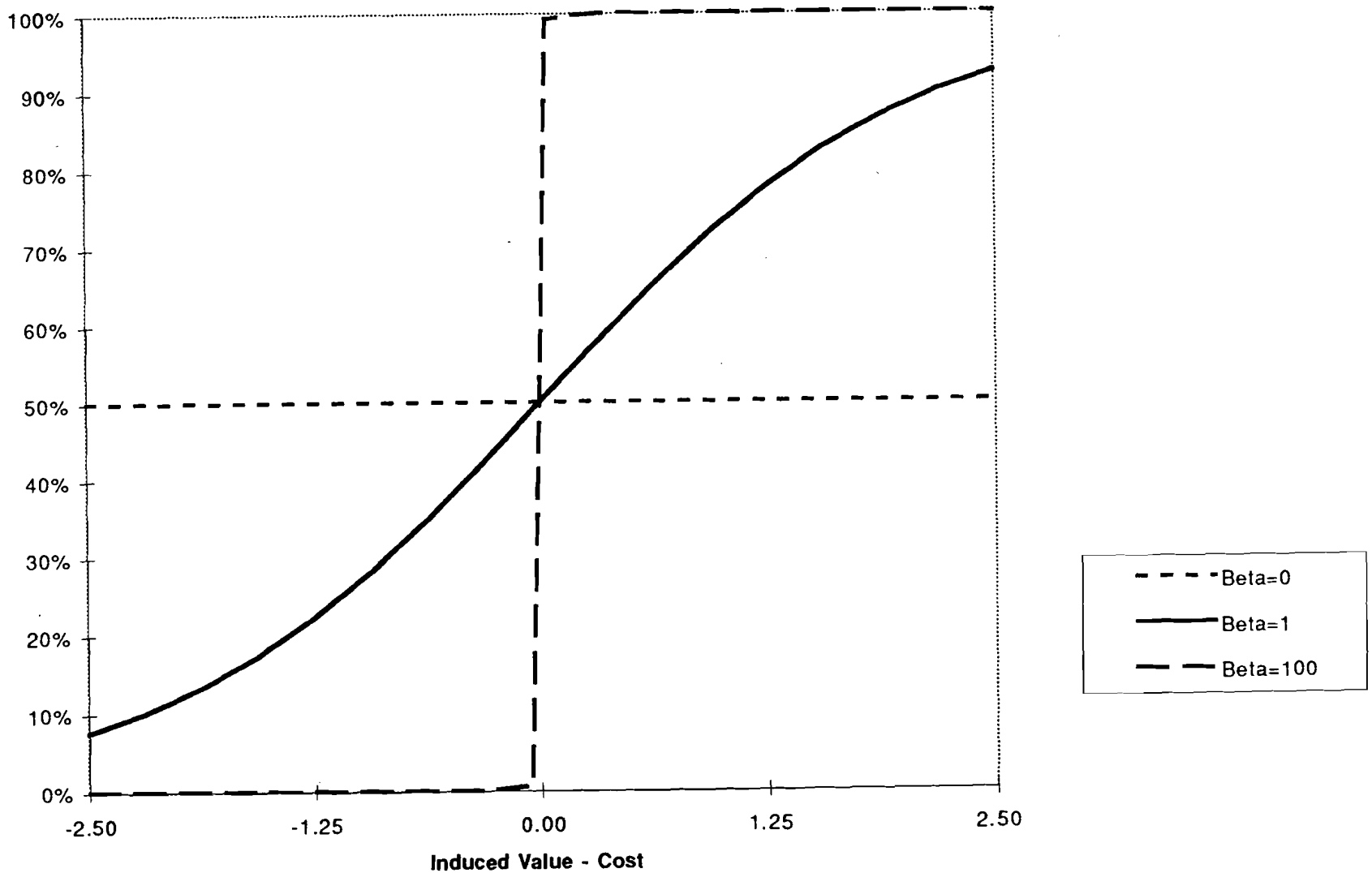
Estimates of α and β using maximum likelihood techniques are found in the "base" column of Table 2.[11] Consistent with our hypotheses, α is not significantly different from zero, indicating that the hypothesis of 50% participation at V-C = 0 cannot be rejected statistically. In addition, the estimated coefficient on V-C, β, is positive and significant. This latter result supports the hypothesis that participation is positively correlated with induced value. In all, these results are consistent with the hypothesis that this mechanism is demand revealing.

Table 2: Estimated Logit Models Using Induced Values

Variable (coefficient)	**Mean (s.d.) [Range]**	**Base**	**Long**
Constant (α_0)	1	-0.093 (0.211)	-2.26 (0.537)***
Group/Self (α_1)	0.61 (0.44) [0.14, 2.50]		3.688 (0.856)***
Induced Return (β)	0.01 (1.77) [-2.50, 2.50]	0.337 (0.123)***	0.301 (0.143)***
n		98	98
Likelihood Ratio χ_2		8.02***	38.19***
Percent Correctly Predicted		61	73

*,**,*** indicate significance levels of 10, 5, and 1 percent, respectively.

Figure 3: Random Utility Model for Various Betas
(By Induced Value minus Cost) .

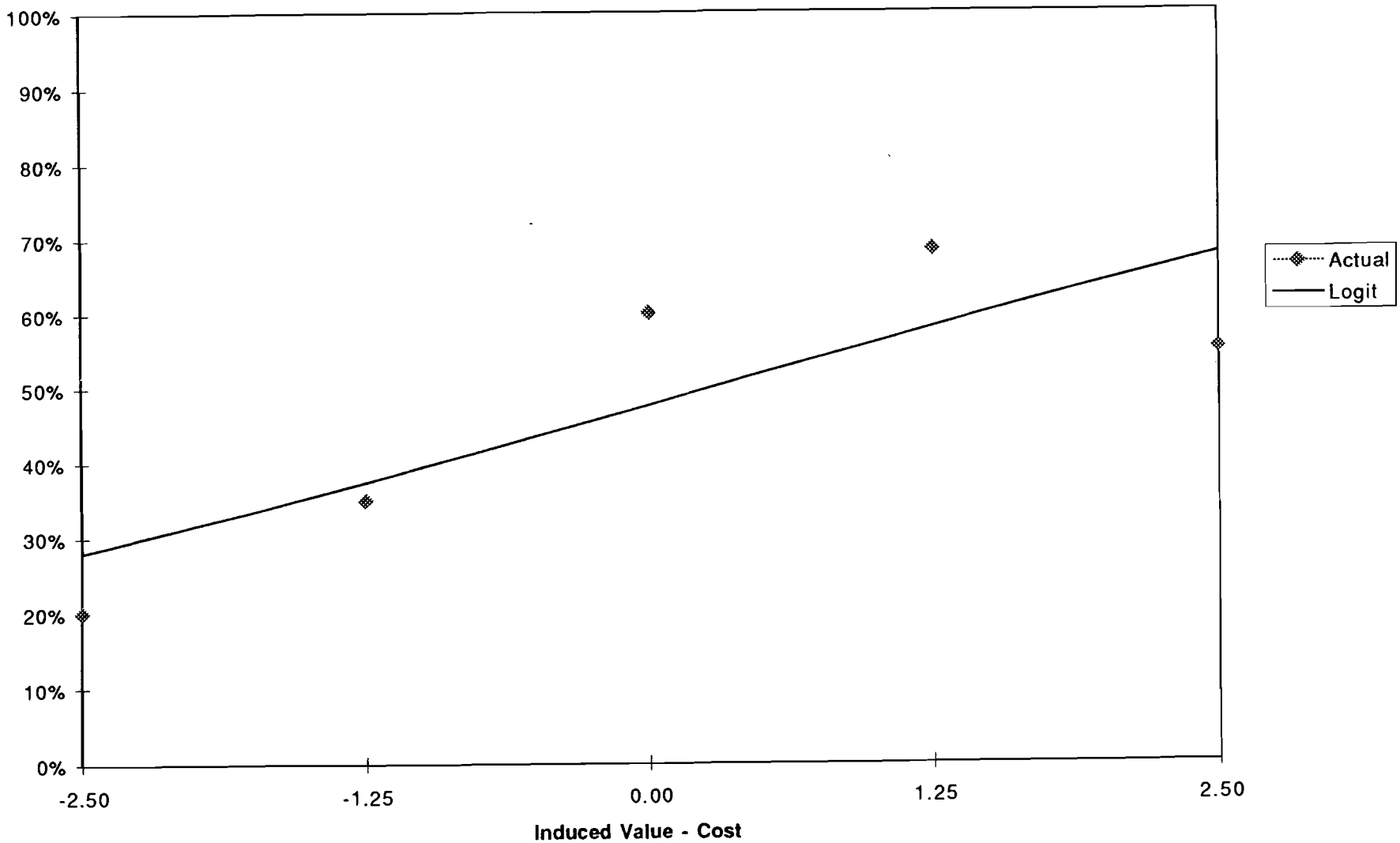


However, in spite of the highly significant estimation results reported in Table 2, closer examination of the data reveals that the model is not completely characterizing individual decisions. For example, as depicted in Figure 4, participation at lower values (e.g. V-C = -$2.50) exceeds the zero percent participation expected. There is also an obvious dip at the induced value of $5.50 (V-C = $2.50) The remainder of this section summarizes an exploratory investigation of why these deviations occur by focusing on altruistic and free-riding motivations. This extended analysis is intended, in part, to demonstrate the opportunities arising from a random utility modeling framework in future experimental economics research. The objective is to also provide an empirical base and motivation for future theoretical research.

An advantage of the random utility modeling is that it can incorporate other explanatory variables into the error based decision framework. In an effort to account for differential, exogenous motives, subjects were asked to indicate the importance they attached in making their decision to maximizing their own earnings, and to maximizing group earnings, both on seven-point scales (1 = Not Important, 7 = Extremely Important). Each of these questions are provided in Appendix B.

The self-reported interest in maximizing "group" and "self" earnings were combined in a "group/self" ratio so as to normalize relative responses at the individual level. In other words, a response pattern group=5, self=5 would be assigned a group/self ratio of 1, as would the response pattern group=2, self=2. In terms of Equation (3), this ratio (group/self) is included by expanding α from a constant to a vector and treating the ratio group/self as a separate element. As such, argument α in Equation (3) becomes $\alpha_{Grand} = \alpha_0 + \alpha_1$*(group/self). The expectation is that participation is positively related to group orientation, and thus α_1 should be positive with a corresponding null hypothesis H_0^3: $\alpha_1=0$. To account for this ratio, the null hypothesis H_o^1: $\alpha=0$, must be restated as H_0^4: $\alpha_{Grand} = (\alpha_0 + \alpha_1$*(group/self)) = 0. As before, a positive value for

Figure 4: Actual vs. Logit Estimated Distribution
(By Induced Value minus Cost)



α_{Grand} would shift the entire distribution to the left, indicating "over-revelation" associated with altruism. A negative α_{Grand} would shift the distribution to the right, providing evidence of free-riding.

The results from including this ratio in the estimation are provided in the "long" column of Table 2. Consistent with Andreoni's (1995) arguments concerning the role of altruism in public goods experiments, the estimated coefficient α_1 is positive and significant. Notably, the inclusion of this variable does not have a significant effect on the slope coefficient, but does greatly increase the explanatory power of the estimated model, as demonstrated by the jump in the percentage of responses correctly predicted and the likelihood ratio chi square values. Thus we argue that the addition of this variable makes a significant contribution to the explanatory power of the decision making model.

Setting the group/own ratio at its mean (0.61), α_{Grand} equals -0.01 (s.e. = 0.25) and is not significantly different from zero at any standard level of significance. As such the naive null hypothesis H_o^4: $\alpha_{Grand}=0$ still cannot be rejected for the average respondent in spite of the fact that the individual coefficients used in calculating α_{Grand} are each significantly different from zero. In other words, the altruistic behavior of subjects with induced values of \$0.50, \$1.75, and \$3.00, as captured by the positive and significant α_1 estimate, is being canceled out by the free-riding behavior of subjects with the higher induced values (recall Figure 2). It is interesting to note however that α_{Grand} is significantly different from zero in expected directions when the ratio group/self falls below 0.47 or exceeds 0.77. These results are consistent with previous research using split-sample designs to examine subject group effects in public good provision experiments, and provide additional evidence that participants bring different motives into experimental settings (Ledyard, 1995). From the perspective of this paper, these results in the "controlled environment" of the laboratory further heighten the importance of identifying

respondent characteristics and preferences that may affect actual participation levels in field experiments.

5. Discussion and Conclusions

Green pricing programs have come under substantial criticism in the electric utility industry because of their cost and poor customer participation. Our field experiment shows that customers who are made fully aware of a green pricing program, and who face a provision point mechanism, participate at a relatively high rate (between 16 and 20 percent). The two completed programs in which provision points were utilized succeeded in funding local projects with relatively high levels of participation. Further, our laboratory examination of the NMPC mechanism found that it approached demand revelation both at the aggregate and individual level. These results suggest that the disappointing sign-up rates of most green pricing programs to date could well be due to free riding associated with mechanism design, as well as to the problem of limited customer awareness. It should be noted that it is difficult, time consuming, and expensive to raise customer awareness for new programs such as *GreenChoice*™. However, employing a provision point mechanism is a relatively costless way to increase participation. On a practical note, economists should recognize the large impediment that consumer awareness plays for the private provision of public goods. Our results suggest that the NMPC program may well have failed simply because the company was unable to expend sufficient resources to effectively market a statewide program. The successful provision point programs in Traverse City and Fort Collins funded local rather than statewide projects, so, given the high profile nature of wind energy projects, awareness was easily achieved. Finally, this research suggests that, where large groups are involved, provision point mechanisms may fulfill the objective of privately funding public goods.

APPENDIX A: Sample Subject Instructions for the Laboratory Experiment

Subject Number ____
PRINT your Name and Social Security Number so that we can pay you
Name _____
Social Security Number _____

INSTRUCTIONS

First, please write your subject number on the front of the envelope you have been given. You have been given the envelope to insure confidentiality.

This is an experiment in the economics of decision making. If you follow the instructions closely and make decisions carefully, you can earn money. Please do not communicate with any other students during the experiment. If you have any questions please do not hesitate to raise your hand so that someone can come over and answer your questions individually.

In this experiment all participants are given a starting balance of $5, which is yours to keep or use any way you like. At the end of these instructions, all of you will be asked if you want to join a group investment program for a one-time fee of $3. **The exact amount of money that you will earn in the experiment depends on your answer to this investment question, as well as on the answers of ALL the other participants in your group.** At the end of the experiment, your earnings will be calculated and you will be paid in cash.

Once you understand the group investment program and how your earnings will be calculated, your task is to decide whether or not you want to join the group investment program for a fixed fee of $3.

The group investment program works as follows. You are a member of a group of 100 people in this class. The program will only be funded and implemented if at least 40 of the 100 participants in your group join the investment program. If enough participants join the investment program so that the program is implemented, the return on the investment will be **SHARED BY ALL** participants in the experiment, **investors and non-investors alike**. Specifically, **regardless of whether or not you have joined the group investment program,** if enough people join, you will receive a return of $5.50. You will also receive a bonus payment of 3¢ for each participant that joins in excess of the minimum number of 40 necessary for the group program to be implemented. Furthermore, you keep your initial credit of $5 from which $3 will be deducted if you decide to join the investment program. Note that other participants may have a different return but do **not** have a different bonus.

If **not** enough participants join the investment program, the program will **not** be funded and will be canceled. In this case all the $3 fees collected will be refunded to those who joined. Thus, regardless of your decision to join the program or not, you would keep your $5 starting balance.

To Summarize:

- You must decide whether or not to join a group investment program for a cost of $3.
- If fewer than 40 participants out of 100 join, the program will be canceled and all $3 fees will be refunded.
- If 40 or more participants join, the program will be implemented and you will receive a return of $5.50 plus a bonus of 3¢ for each household that joins above 40.
- Recall, that you do not need to join to receive your payment from the investment program if 40 or more other participants join.
- But if you do join, you must pay the $3 fee.

This is the end of the instructions. If you have any questions please raise your hand.

THE QUESTION

Do you want to join the group investment program for a fixed fee of $3?

(Circle one only)

YES I wish to join

NO I do not wish to join

Please place this sheet in the envelope provided and seal it. When everyone has sealed their envelope, you will each be handed another sheet of questions. You must complete these additional questions in order to get paid.

APPENDIX B: Follow Up Questions for Laboratory Experiment

TO BE PAID, YOU MUST COMPLETE THESE QUESTIONS

Please enter your Subject Number from your envelope ___
PRINT your Name and Social Security Number as you did before
Name _____
Social Security Number _____

(1) Do you think that enough people joined to fund the group investment program? (Circle one answer)

YES NO

(1a) More precisely, how many people do you think joined--excluding yourself?

_____

(2) On a scale from 1 to 7, where 1 is not important and 7 is extremely important, how important were the following in your decision?

2a. I wanted to make as much money as I could for myself. (Circle one number)

1 2 3 4 5 6 7

Not Important Extremely important

2b. I wanted the group to make as much money as possible. (Circle one number)

1 2 3 4 5 6 7

Not Important Extremely important

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2. The authors are, respectively: Research Assistant, Department of Agricultural, Resource, and Managerial Economics (ARME), Cornell University; Visiting Assistant Professor, Department of Economics, University of British Columbia; Assistant Professor, ARME, Cornell University; Research Assistant, Department of Economics, Cornell University; and Robinson Professor, ARME, Cornell University.

3. See Baugh et al. (1995) for a detailed discussion of Green Pricing programs.

4. In a series of papers, Palfrey and Rosenthal (1984, 1988, and 1991) develop theoretical models of contributions to public goods when individuals face the binary choice of contributing either a posted price or nothing. Unfortunately, the complex environment under consideration in our experiment (a large group, heterogeneous valuations, and incomplete information about others' preferences) precludes a direct test of this theory. Note that Palfrey and Rosenthal analyze environments with homogeneous values, so demand revelation is not an issue.

4. In designing this program, NMPC asked William Schulze to suggest mechanisms to reduce free riding in green pricing programs (Schulze, 1994).

6. The survey instrument followed the Dillman Total Design Method for telephone surveys (Dillman, 1978) which is designed to achieve a high overall response rate by keeping text blocks short and clear and by engaging the respondent with frequent questions throughout the survey. The response rate was just under 70%. The survey was pretested by administering successive draft versions by phone until respondents clearly understood the instrument. Hagler Bailly Consulting, Inc. was contracted to administer the survey. Prior to telephone contact, potential respondents were sent a hand-signed cover letter on Cornell University stationery. The letter informed them that they had been selected as one of a small sample of customers to participate in the study of a new type of environmental program. It identified the study's sponsors as the National Science Foundation and the Environmental Protection Agency, together with NMPC, and enclosed a two dollar bill as a token of appreciation for participation. The two dollar bill has been found to be cost effective in increasing response rates.

7. Households were classified as "unable to contact" based on a minimum of eight attempts.

8. Respondents were also asked how they viewed the program in comparison with other causes they might support "*like the United Way, public television, or environmental groups,*" using a scale of one ("*much less favorably*") to 10 ("*much more favorably*") as a means of consolidating their preferences immediately prior to answering the participation question. Responses to this question are not included here, as they are a statistically significant function of the type of the

project as well as the mechanism attributes.

8. In the linear random utility model used in this analysis, income cancels out of the equation (Hanemann, 1984) and is thus not included here.

10. This contribution figure is based on 84 valid VCM observations from the same 100 students. The 16 invalid observations were due to computer malfunction, student absence, or untraceable student information data.

11. Only 98 observations are reported in Table 2, due to the fact that two respondents had missing values for various parts of the questionnaire.

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