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Michael A. Spencer
Stephen K. Swallow
Jason F. Shogren
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ABSTRACT

This paper considers how six alternative rebate rules affect voluntary contributions in a threshold public-good experiment. The rules differ by (1) whether an individual can receive a proportional rebate of excess contributions, a winner-takes-all of any excess contributions, or a full rebate of one's contribution in the event the public good is provided and excess contributions exist, and (2) whether the probability of receiving a rebate is proportional to an individual's contribution relative to total contributions or is a simple uniform probability distribution set by the number of contributors. The paper adds to the existing experimental economics literature on threshold public goods by investigating both aggregate and individual demand revelation under the winner-take-all and random full-rebate rules. Half of the rules (proportional rebate, winner-take-all with uniform probability among *all group members*, and random full-rebate with *uniform* probability) provide total contributions that nearly equal total benefits, while the rest (winner-take-all with *proportional* probability, winner-take-all with uniform probability among *contributors only*, and random full-rebate with *proportional* probability) exceed benefits by over 30 percent. Only the proportional rebate rule is found to achieve both aggregate and individual demand revelation. Our experimental results have implications for both fundraisers and valuation practitioners.

Michael A. Spencer
Department of Economics
Minnesota State University
150 Morris Hall
Mankato, MN 56001
michael.spencer@mnsu.edu

Stephen K. Swallow
Department of Environmental and
Natural Resource Economics
University of Rhode Island
Kingston Coastal Institute Building
1 Greenhouse Road
Kingston, RI 02881
swallow@uri.edu

Jason F. Shogren
Department of Economics and Finance
College of Business
University of Wyoming
P.O. Box 3985
Laramie, WY 82071-3985
Jramses@UWYO.EDU

John A. List
Department of Economics
University of Chicago
1126 East 59th
Chicago, IL 60637
and NBER
jlist@uchicago.edu

1. Introduction

Many public goods cannot be provided in part, but only in whole after their cost of provision is covered. For example, it would not make much sense to provide half a lighthouse, two-thirds of a bridge, or one-quarter of a trail needed for a public bike path to connect two towns. The cost of providing such public goods is often called a "threshold" or "provision point," which may or may not be known with certainty before soliciting contributions to fund it.[1] If fundraising efforts meet or exceed the provision point, then the public good is provided; otherwise, it is not and all contributions are refunded.[2]

In the threshold public-good case, what happens to the excess contributions if the total amount collected exceeds the provision point? In Niagara Mohawk Power Corporation's proposed green power program to finance a renewable energy facility and plant 50,000 trees in the state of New York (see n. 1; and Rose et al., 2002), any excess contributions would be used to plant additional trees or service additional homes by the renewable energy facility; i.e., excess contributions supply extra or extended benefits. Swallow, Spencer, and Whinstanley (2000) offer another example where excess contributions beyond that needed to fund a ten-year conservation easement with an (*a priori*) unknown provision point on two parcels of forested wetland in the state of Rhode Island would be returned (or rebated) to contributors. It is also conceivable that excess contributions could be frivolously used in a way that provides little or no benefit to the contributor, such as funding a pizza party for fundraiser workers. How excess contributions are used can be a significant issue in the minds of would-be contributors—will the excess contributions be used to supply extra benefits, be returned, or be wasted? This concern could affect individuals' willingness to contribute toward funding and thus to reveal their value for a public good.

Marks and Croson (1998), for example, investigate the differences in contributions between a no rebate, proportional rebate, and extended benefit provision rule.[3] Their results suggest that contributions are highest with extended benefits, while the no rebate and proportional rebate policies generate similar contributions, which are not statistically different from the Nash equilibrium level. The current paper offers no more comparisons between these three rules, but rather concentrates on the middle ground, where excess contributions are rebated.

Herein we concentrate on how six different rebate rules affect voluntary contributions to a threshold public good. The rules differ by (1) whether an individual can receive a proportional rebate of excess contributions, a winner-takes-all of any excess contributions, or a share of any excess contributions equal to his or her contribution (i.e., a full-rebate of one's contribution),[4] and (2) whether the probability of receiving a rebate is proportional to an individual's contribution relative to total contributions or is a simple uniform probability distribution set by the number of contributors. As explained later, the rules are (1) proportional rebate, (2) winner-take-all with *proportional* probability, (3) winner-take-all with uniform probability among *contributors only*, (4) winner-take-all with uniform probability among *all group members*, (5) random full-rebate with *uniform* probability, and (6) random full-rebate with *proportional* probability.

Our main objectives are to (1) identify rebate rules that are empirically efficient in that the public good (where total benefits exceed total costs) is provided and (2) identify rebate rules that are empirically demand revealing on the *aggregate* and *individual* levels. For fundraisers, provision of the public good is most important, but for benefit-cost and valuation practitioners, accurate measurement of the value of a public good is important (e.g., Brookshire and Coursey, 1987; Poe et al., 2002; Rondeau, Poe, and Schulze, 1996; Spencer, 2007; Spencer, Swallow, and

Miller, 1998). Thus, in addition to public good provision, we seek [as in Rondeau, Schulze, and Poe (1999)] a public-good provision mechanism that is, at least, empirically demand revealing and easily understood and implemented in environments that mimic natural field conditions, such as the case in which contributors donate only once to a public good.[5]

We reconsider the *proportional rebate* rule used by Rondeau, Schulze, and Poe (1999, Treatment B) and compare it to several variations of the *winner-take-all* and *random full-rebate* rules. If a fundraising effort results in excess contributions, a proportional rebate rule returns to a contributor a share of the excess contributions in proportion to her contribution relative to the total contributions collected.[6]

Alternatively, we consider the winner-take-all and random full-rebate rules. If a fundraising effort results in excess contributions, a winner-take-all rule returns the entire excess contributions to one randomly chosen individual, and a random full-rebate rule returns individual contributions to randomly chosen contributors until all excess contributions equal zero. Both rules are relatively simple.

It is worth mentioning, however, the redistributive consequences of each rule. Any excess contributions are redistributed among all the contributors in a proportional rebate rule, to the sole winner of the lottery under a winner-take-all rule, and among the winners of rebates in a random full-rebate rule. Although an additional unit of endowment contributed by an individual beyond the provision point is not wasted under any of our rebate rules because it is redistributed among other individuals in the group who receive a positive earning from the over contribution, Marks and Croson (1998) show that the individual's earning (or payoff) from her over contribution is negative under the proportional rebate rule. This is also true in general for the winner-take-all and random full-rebate rules; however, if the aggregate amount of excess contributions exceeds the individual's contribution amount and if the individual is a winner of a rebate, then the individual's earning from her over contribution can be positive under a winner-take-all rule and zero under a random full-rebate rule.

The winner-take-all rule (or lottery) is interesting for two reasons. First, it is of practical importance to fundraising organizations. Many non-profit organizations rely on lotteries (or charitable gambling) as a significant source of revenue to finance public goods (e.g., Morgan, 2000). Second, as will be shown, our winner-take-all with *proportional* probability rule is particularly interesting because it is mathematically identical, in terms of expected earnings, to the proportional rebate rule. Although these rules have the same expected earnings, one might conjecture that individuals will contribute more for the chance to win a large prize (or rebate, as possible under a winner-take-all rule) than they will for the certainty of a small prize (or rebate, as under the proportional rebate rule).[7] It is an empirical question to answer whether the winner-take-all and proportional rebate rules will yield similar results in terms of demand revelation.

In the random full-rebate rule, the rebating of excess contributions can result in a full rebate of one's contribution so that a contributor may benefit from provision of the public good at no cost to herself. Random full-rebates are used by some non-profit organizations in their efforts to raise funds. For example, the Mankato Area Hockey Association (MAHA), which is a non-profit organization devoted to the education and competitive play of youth hockey in southern Minnesota, uses the random full-rebate principle in their "calendar raffle" fundraiser. All members of MAHA are required to sell team calendars to raise funds for the association, which helps cover MAHA's operating expenses. The calendars are sold for $20 each, and each purchaser of a calendar has their name entered in a raffle to win their $20 back. This example represents our main interest in the rule.

Overall, the current paper adds to the existing literature on threshold public goods in several respects. First, it investigates the use of winner-take-all and random full-rebate rules in the provision of a threshold public good. The proportional rebate rule has been investigated by others (e.g., Marks and Croson, 1998; Rondeau, Schulze, and Poe, 1999), but the random full-rebate rule, to our knowledge, has not been previously investigated. The literature has examined the use of lotteries with fixed prizes in the provision of a continuous public good, but not the use of a winner-take-all lottery of excess contributions in the provision of a threshold public good (in the lab see Morgan and Sefton, 2000; Lange, List, and Price, 2007; and in a field experiment see Landry et al., 2006). Second, the current paper econometrically models individual contributions as an explicit function of individual induced values and rebate rule. Rondeau, Schulze, and Poe (1999) discuss the relationship between individual contributions and values, but they primarily focus on the performance of the proportional rebate rule to achieve *aggregate* demand revelation.[8] Rondeau, Poe, and Schulze (2005) conduct a meta-analysis that econometrically models *mean* and *median* contribution levels from various experimental sessions as a function of individual induced values and other treatment parameters. They show that contribution levels are generally more responsive to changes in induced values under a proportional rebate rule than under a simple voluntary contribution mechanism. Thus, although other researchers have considered the relationship between contributions and values, the current paper offers a perspective on this relationship across new rebate rules.

Finally, our study more generally advances our understanding of the economics of charity. As List (2008) details, the demand side of the economics of charity is only beginning to be studied and our work pinpoints potential mechanisms that can be employed in the field to enhance fundraising success. In this sense, our work not only speaks to theorists and empiricists, but also holds importance for practitioners.

All treatments in our experiment were run in a one-shot laboratory setting with heterogeneous induced values. The experimental results suggest that all of the rebate rules are empirically efficient in that the public good is provided under each rule, but all rebate rules do not achieve aggregate demand revelation. Half of the rules (proportional rebate, winner-take-all with uniform probability among *all group members*, and random full-rebate with *uniform* probability) provide total contributions that nearly equal total benefits, while the rest (winner-take-all with *proportional* probability, winner-take-all with uniform probability among *contributors only*, and random full-rebate with *proportional* probability) exceed benefits by over 30 percent. Our proportional rebate, winner-take-all with uniform probability among *all group members*, and random full-rebate with *uniform* probability treatments yield comparable results to Rondeau, Schulze, and Poe's (1999) proportional rebate treatment in terms of *aggregate* demand revelation. Although these rules achieve aggregate demand revelation, our model of individual behavior suggests that only the proportional rebate rule achieves *individual* demand revelation. This suggests the proportional rebate rule may be an empirically viable demand-revealing mechanism on the individual level in the threshold public-good case.

The remainder of the paper is organized as follows. Section 2 details the rebate rules used in the experiment. Section 3 presents the experimental design and procedures. Section 4 defines the hypotheses tested in this paper. Section 5 discusses the results, and section 6 offers some concluding remarks, which include implications for fundraisers and valuation practitioners.

2. Rebate Rules and Individual Earnings

Consider a group of N individuals each endowed with an initial sum of money equal to I. Each individual decides how much of I to keep for themselves and how much to contribute to the provision of a public good which costs PP. If the sum of individual contributions ($\sum C_j$) equals or exceeds the cost of providing the public good, then the public good is provided and each individual receives a payoff value equal to V_i. Here, individuals have the same endowment I but their valuation V_i for the public good is different (i.e., heterogeneous). If the sum of individual contributions falls short of PP, then each individual receives their contribution (C_i) back; i.e., there is a money-back guarantee (MBG) in the event the public good is not provided. The MBG has been used to reduce free-rider behavior in previous public good experiments (see Isaac, Schmidtz, and Walker, 1989).

The group does not pay more than the cost of providing the good. Any excess contributions beyond PP are returned or rebated to the group. We compare the winner-take-all and random full-rebate rules to the proportional rebate rule first discussed by Smith (1980) and later used by Brookshire and Coursey (1987), Marks and Croson (1998), and Rondeau, Schulze, and Poe (1999). As mentioned earlier, we consider the winner-take-all and random full-rebate rules under both a proportional and a uniform probability element. A person's proportional probability of receiving a rebate depends on the magnitude of her contribution relative to the total contributions collected, while a person's uniform probability of receiving a rebate depends on whether she contributes and the total number of contributors (N_D). A proportional probability structure resembles the proportional rebate rule, while a uniform probability structure determines the odds of winning many lotteries and raffles.

The individual earning functions (π_i) and details of each rebate rule are discussed below.

Proportional Rebate Rule

Individual *i*'s earning function, π_i, for the proportional rebate rule is

$$\pi_i = \begin{cases} I - C_i + V_i + \dfrac{C_i}{\sum_{j=1}^{N} C_j}\left(\sum_{j=1}^{N} C_j - PP\right) & \text{if } \sum_{j=1}^{N} C_j \geq PP \\ I & \text{if } \sum_{j=1}^{N} C_j < PP \end{cases}.$$

With a proportional rebate, if $\sum C_j > PP$, individual *i*'s earnings equal her private consumption of I, net of her contribution C_i, plus her value for the public good (V_i) and a share of the excess contributions in proportion to the magnitude of her contribution relative to the total contributions collected.

Winner-Take-All Rules

For the winner-take-all rules, individual *i*'s earning function is the same, but the probability of receiving a rebate differs across the rules. The common form of the individual earning function is

$$\pi_i = \begin{cases} I - C_i + V_i + \left(\sum_{j=1}^{N} C_j - PP\right) & \text{if } \sum_{j=1}^{N} C_j \geq PP \text{ and } i \textit{ wins} \text{ the rebate lottery} \\ I - C_i + V_i & \text{if } \sum_{j=1}^{N} C_j \geq PP \text{ and } i \textit{ loses} \text{ the rebate lottery} \\ I & \text{if } \sum_{j=1}^{N} C_j < PP \end{cases}$$

In the winner-take-all rules, any excess contributions are returned as one payment to a single individual.

In the winner-take-all with *proportional* probability rule, individual *i*'s expected earnings are the same as in the proportional rebate rule, given the same excess ($\sum C_j - PP$), personal (C_i), and set of contributions. The mechanics of the two rules, however, are quite different. With a proportional rebate rule, all contributors receive a partial rebate if $\sum C_j > PP$, each with probability one. In contrast, under a winner-take-all with *proportional* probability rule, only one contributor is randomly selected to receive a rebate, which equals all the excess contributions. It is possible $C_i < (\sum C_j - PP)$, so individual *i* receives more than she contributed if she wins the lottery over the excess contributions. In the winner-take-all with *proportional* probability rule, individual *i*'s chances of winning the lottery are directly proportional to the size of her contribution relative to the total contributions collected, $C_i/\sum C_j$. Note, if $\sum C_j$ and C_i are identical under the winner-take-all with *proportional* probability rule and the proportional rebate rule, individual *i*'s *expected* rebate under the winner-take-all with *proportional* probability rule equals her actual rebate under the proportional rebate rule. Of course, it is an empirical question to find whether the winner-take-all with *proportional* probability rule generates contributions equal to those under the proportional rebate rule.

The next rule is the winner-take-all with uniform probability among *contributors only* rule. If $\sum C_j > PP$, individual *i*'s chances of winning the excess contributions depend on whether she contributed and the total number of contributors. If $C_i >$ \$0, individual *i*'s chances of winning the excess contributions equals the ratio of 1 to N_D, where N_D equals the number of people who contributed (or donated) to the provision of the public good.

We also consider a winner-take-all with uniform probability among *all group members* rule. This rule is similar to the winner-take-all with uniform probability among *contributors only* rule, except the winner-take-all with uniform probability among *all group members* rule gives all group members a chance to win all of the excess contributions if $\sum C_j > PP$. Regardless of whether individual *i* does or does not contribute to the provision of the public good, individual *i*'s chances of winning the excess contributions is equal to the ratio of 1 to *N*, where *N* equals the total number of group members. This rule allows one to investigate whether a "*no* contribution necessary" element depresses contributions under the winner-take-all rule. To explain, since a winner-take-all rule may conceptually lead to some type of "embedding effect," where a subject's contribution reflects not only her individual value for the public good but also her value for having the chance to "win it all" (cf., Clotfelter and Cook, 1989), we consider the1/N probability rule in an attempt to capture an individual's value for the public good under the winner-take-all rule without any confounding embedding effect.

Random Full-Rebate Rules

For the random full-rebate rules, π_i is

$$\pi_i = \begin{cases} I - C_i + V_i + R_i & \text{if } \sum_{j=1}^{N} C_j \geq PP \text{ and } i \textit{ wins} \text{ a rebate} \\ I - C_i + V_i & \text{if } \sum_{j=1}^{N} C_j \geq PP \text{ and } i \text{ does } \textit{not} \text{ win a rebate} \\ I & \text{if } \sum_{j=1}^{N} C_j < PP \end{cases},$$

where R_i equals individual i's rebate which is less than or equal to i's contribution. Note that $0 \leq R_i \leq C_i$. If the remaining excess contributions are greater than or equal to i's contribution [i.e., $(\sum C_j - PP) \geq C_i$], then i has a chance to win back her contribution, where $R_i = C_i$. If the excess contributions are less than i's contribution, then i only has a chance to win the remaining excess contributions where $R_i < C_i$. Contributors are randomly drawn until the excess contributions equal zero, at which point all other contributors receive a rebate of $R_i = 0$.

We consider two probability structures—uniform and proportional—to determine the winners of rebates. Under the random full-rebate with *uniform* probability rule, contributor i's chance of receiving a rebate is $1/N_D$, where N_D equals the number of people who contributed to the provision of the public good. Under the random full-rebate with *proportional* probability rule, contributor *i*'s chance of receiving a rebate is determined by the proportion of *i*'s contribution relative to the total contributions collected.

3. Experimental Design and Procedures

The experiment was run at the University of Central Florida. The sample consisted of 270 student-subjects from two, junior level, economics courses, titled “Quantitative Tools I” and “Quantitative Tools II.” The experiment took place during regular class hours, and none of the students were forced or pressured to participate in the experiment. Subjects were aware that the experiment was not a class assignment, but that it would involve them in making economic decisions, which could earn them real money. The experiment was a *one-shot* game in that each subject only made one decision.[9] Subjects were informed that not everyone would be given the same set of experimental instructions, so subjects were asked to remain quiet and read their instructions silently to themselves.

Although subjects knew that not everyone in the classroom was participating in the same group (i.e., not given the same set of instructions), they all knew how many people were in their specific group. To maintain anonymity among group members, no communication between subjects was allowed at any point during the experiment. Each rebate rule was tested with a group size of N = 45 subjects.[10] Moreover, all subjects were endowed with I = \$6.

All language and experimental parameters used in this experiment adhered to that used in Treatment B of Rondeau, Schulze, and Poe (1999), where the subjects were told the group size but not the provision point, nor the distributions of the provision point and induced values. In fact, the current experiment’s proportional rebate treatment used the same experimental instructions as in Rondeau, Schulze, and Poe (1999; Treatment B). It is plausible, at least in the United States (U.S.), that would-be contributors in the field would be familiar with their group size, since many “city limit” signs throughout the U.S. state the population size of the city. However, for reasons discussed below, many would-be contributors in the field may not necessarily be expected to know the *PP* or the distributions of the *PP* and individual values.

Following Rondeau, Schulze, and Poe (1999), the experimental instructions stated that the provision point (*PP*, called “investment cost” in the experimental instructions) was “predetermined but unknown to you.” An unknown provision point was used (1) to provide a better test of individual demand revelation under realistic conditions that mimic field scenarios where the final cost of provision is subject to competitive bid (see n. 1), and (2) to prevent subjects from focusing on a simple strategy of equal cost sharing, whereby subjects contribute an amount equal to the provision point (*PP*) divided by the group size (*N*). Equal cost sharing is an interesting strategy, which leads to public good provision. However, given heterogeneous induced values, application of such a strategy would compromise a test of *individual* demand revelation. As argued in Rondeau, Schulze, and Poe (1999, p. 465), uncertainty about the cost of a public good or the sample size “…may encourage demand revelation by forcing individuals to formulate a contribution strategy more strongly based on their private incentives rather than on the availability of a simple rule of thumb,” and Bohara et al. (1998, p. 145) have noted that complete information on the *PP* and *N* “…may be used by players to focus on stating the average per person cost of the good.”

Individual induced valuations (V_i) for the public good ranged, in $0.75 increments, from $1.50 to $4.50. Since individual values for a public good usually are private information in real life, individuals in our experiment knew their own valuations but the range (or distribution) of others’ induced values was not made common knowledge. Rondeau, Schulze, and Poe (1999, p. 461) note “This feature mimics field conditions where individuals value public goods differently but are generally unaware of other peoples' values (Alston and Nowell, 1996)," and Bohara et al. (1998, p. 145) state "…individuals will presumably know their own valuations but not likely those of others." Within each group (i.e., treatment), nine subjects were assigned to each valuation, so that the mean and median induced value was $3 for each group. Each subject was allowed to contribute any amount they wanted within a range of $0 to $6—that is, contributions could not exceed the endowment of *I* = $6.

Each set of experimental instructions contained an "information and decision sheet," which listed the subject's endowment, valuation, group size, and stated that the investment cost was predetermined but unknown to them. The sheet also asked for personal information regarding their gender, age, academic major, and family income, and it required the subject to state their official contribution to the public good. If an individual did not wish to make a contribution, the individual wrote the number "0" in the space next to the statement "my bid is: $ _____."

The investment cost (*PP*) for each group was randomly chosen, via a computer, from a normal distribution with mean $45 and variance $9. In an attempt (1) to provide a realistic situation where would-be contributors in the field may not necessarily know the true probability distribution of the *PP* (e.g., because of unforeseen delay and transaction costs in construction, land acquisitions, legal fees, negotiations, etc.), and (2) to replicate the experimental results under Treatment B of Rondeau, Schulze, and Poe (1999), which fits the unknown distribution scenario, our procedure for randomly determining the *PP* was not described to the subjects. The procedure resulted in a *PP* of $47.10, $46.23, $47.98, $41.23, $43.45, and $45.12 for the proportional rebate, winner-take-all with *proportional* probability, winner-take-all with uniform probability among *contributors only*, winner-take-all with uniform probability among *all group* *members*, random full-rebate with *uniform* probability, and random full-rebate with *proportional* probability rules, respectively.

After each subject filled-out their information and decision sheet, the experimental monitors collected the sheets. Total contributions were tallied for each group and subject earnings were distributed during the following class meeting. As in Rondeau, Schulze, and Poe (1999), social security numbers identified subjects for disbursement purposes. In the rules that used *uniform* probability (i.e., winner-take-all with uniform probability among *contributors only*, winner-take-all with uniform probability among *all group members*, and random full-rebate with *uniform* probability), we randomly drew identification numbers from a fishbowl to determine winners of rebates. In the rules that used *proportional* probability (i.e., winner-take-all with *proportional* probability and random full-rebate with *proportional* probability), we used a computer to randomly determine winners of rebates based on their contributions relative to the total contributions collected.

As a final note, one might question several features of our experimental design, namely (1) an unknown *PP* drawn from an unknown (to the subjects) probability distribution and (2) incomplete information regarding the distribution of induced values for the public good. These design features admittedly hinder one's ability to make game-theoretic predictions. In particular, our experimental design is a game of incomplete information, which means that any equilibrium must be Bayesian Nash, but without knowing the subjective distributions of the subjects, which we did not determine, one cannot characterize them. This is a limitation of the experimental design, but we have made this sacrifice in favor of realism.

Suleiman (1997, pp. 165-166) notes "Common to the theoretical and empirical research of step-level goods is the assumption that all parameters of the situation are common knowledge.

In fact, such an assumption fails to capture many naturalistic situations involving uncertainty about various parameters of the situation."[11] Our experimental design attempts to mimic a field situation where many would-be donors would not necessarily be expected to know the distribution of individual values for the public good, the *PP*, or the probability distribution of the *PP*. For example, consider a non-profit organization or community group trying to raise funds to establish a greenway complete with a hiking/biking trail, where the total cost of provision (*PP*) is subject to competitive bid among contractors and to unanticipated delay and transaction costs in land purchases, negotiations, legal fees, and construction costs, which can create uncertainty in the *PP* and its probability distribution.[12] It would also be very difficult for would-be donors to know the true distribution of values that all citizens place on the proposed greenway. Although we are not the first to run experimental treatments with uncertainty in these parameters (e.g., see Rondeau, Schulze, and Poe, 1999; Bohara et al., 1998), our diversity of rebate rules run with such uncertainty offers a contribution to the growing literature on the study of uncertainty in threshold public good cases—see McBride (2006) for an excellent extension and review of the literature on uncertainty in threshold public goods.

4. Hypotheses

In conjunction with the first objective of this paper—identify rebate rules that are empirically efficient—our first hypothesis is as follows:

Hypothesis 1: All the rebate rules yield empirically efficient results in that the public good (where total benefits exceed total costs) is provided.

As mentioned earlier, our experimental design represents a game of incomplete information, where any equilibrium must be Bayesian Nash. This means that the equilibrium actions of any group depend on each group member's subjective beliefs about the distributions of the *PP* and individual values and others' beliefs about these distributions. However, since such beliefs were not determined during the experiment, one cannot make equilibrium predictions.[13] This is true for the experiment and the field scenario for which the design is meant to mimic. These features are limitations of the experimental design, but they do not necessarily preclude the subjects from providing the public good, and they might be viewed as providing a more stringent test of the rebate rules in terms of demand revelation.

In conjunction with the second objective of this paper—identify rebate rules that are empirically demand revealing on the aggregate and individual levels—our second hypothesis is composed of two parts as follows:

Hypothesis 2A: All the rebate rules empirically achieve *aggregate* demand revelation.

Hypothesis 2B: All the rebate rules empirically achieve *individual* demand revelation.

Rejection of Hypothesis 2A would suggest that at least one of the rebate rules does not achieve aggregate demand revelation. Based on Rondeau, Schulze, and Poe's (1999) experimental work, we expect the proportional rebate rule to achieve aggregate demand revelation. However, whether our winner-take-all and random full-rebate rules achieve comparable results to the proportional rebate rule is an empirical question. One might conjecture that the prospect of winning one's money back, plus others' money, as in a winner-take-all rule, will yield higher mean contribution-to-induced-value (C_i/V_i) ratios than the proportional rebate rule,[14] while the random full-rebate rule might be expected to yield closer results to the proportional rebate rule. We empirically test these conjectures.

Later we test Hypothesis 2B in a model of individual behavior. Hypothesis 2B offers a stricter test of demand revelation than does Hypothesis 2A.

Another factor that we consider is the potential effect of a "no contribution necessary" element in the winner-take-all rule, which (as discussed earlier) is implemented to help counteract any potential embedding effect in having the chance to "win it all." Unlike the winner-take-all with *proportional* probability and winner-take-all with uniform probability among *contributors only* rules, the winner-take-all with uniform probability among *all group members* rule gives all group members the chance to win the rebate lottery if excess contributions exist. It is plausible to assume a "no contribution necessary" rule might depress contributions and the mean C_i/V_i ratio compared to a "contribution necessary" rule for eligibility to win all the excess contributions, which leads us to the following hypothesis:

> *Hypothesis 3*: The winner-take-all with uniform probability among *all group members* rule yields a lower mean C_i/V_i ratio than the winner-take-all with *proportional* probability and winner-take-all with uniform probability among *contributors only* rules.

5. Results and Discussion

Table 1 summarizes the descriptive statistics of several indicators of mechanism performance by rebate rule. We investigate the mean and median individual contribution (C_i), the mean and median ratio (in percent) of individual contribution to induced value, C_i/V_i (i.e., the proportion of individual induced value contributed toward the provision of the public good), and the ratio (in percent) of aggregate demand revealed to aggregate demand induced, $\sum C_j/\sum V_i$ (i.e., the percentage of aggregate demand revealed).

Result 1: *We find empirical support for Hypothesis 1. All rebate rules appear empirically efficient in that the public good (where total benefits exceed total costs) is provided under each rule.*[15]

Total contributions exceed the provision point under each rule. All subjects receive their induced value from provision of the public good, plus any rebate coming to them.

These efficiency results hold under any of the provision point draws realized. As discussed earlier, the provision points ranged from a low of $41.23 in the winner-take-all with uniform probability among *all group members* rule to a high of $47.98 in the winner-take-all with uniform probability among *contributors only* rule. Total contributions ranged from a low of $121 in the winner-take-all with uniform probability among *all group members* rule to a high of $188.17 in the winner-take-all with *proportional* probability rule—see Table 1 for a comparison of total contributions across rules. Given a range of provision point values from $41.23 to $47.98 and a range of total contributions from $121 to $188.17, each rule would have led to public good provision (i.e., aggregate efficiency) had any of the other rule's provision point draws been realized instead.

Result 2: *We find no empirical support for Hypothesis 2A. Half the rebate rules (i.e., proportional rebate, winner-take-all with uniform probability among all group members, and random full-rebate with uniform probability) achieve aggregate demand revelation, while the rest (i.e., winner-take-all with proportional probability, winner-take-all with uniform probability among contributors only, and random full-rebate with proportional probability) lead to demand over-revelation.*

The proportional rebate, winner-take-all with uniform probability among *all group members*, and random full-rebate with *uniform* probability rules are comparable in terms of aggregate demand revelation. These rules provide total contributions that nearly equal total benefits (or values). The percentage of demand revealed by the proportional rebate, winner-take-all with uniform probability among *all group members*, and random full-rebate with *uniform* probability rules are 99%, 108%, and 90%, which are comparable to the 95% aggregate demand revelation reported in Rondeau, Schulze, and Poe (1999; Treatment B). The mean contribution for these rules is not statistically different from the mean induced value of $3, and the mean ratio (in percent) of individual contribution to induced value (C_i/V_i) is not statistically different from 100% for these rules. An analysis of median contributions and ratios also reveals no statistical difference from $3 and 100% for these rules—in fact, the median ratio of individual contributions to induced values *is* 100% for these rules.

These results are comparable to those reported in Rondeau, Schulze, and Poe (1999; Treatment B), in which the mean contribution, median contribution, mean of C_i/V_i, and median of C_i/V_i are $2.86, $3, 103%, and 93%. The winner-take-all with uniform probability among *all group members* rule and the random full-rebate with *uniform* probability rule represent comparable alternatives to the proportional rebate rule as *aggregate* demand revealing mechanisms. Pairwise means *t*-tests and Wilcoxon rank-sum *Z*-tests indicate no differences in mean and median C_i/V_i ratios among these rules (for proportional rebate versus winner-take-all with uniform probability among *all group members* $t = 0.1970$ and $Z = 0.7444$ with both $p >$ 0.45; for proportional rebate versus random full-rebate with *uniform* probability $t = -0.9292$ and $Z = -0.4770$ with both $p > 0.35$).

The winner-take-all rules with *proportional* probability and uniform probability among *contributors only* and the random full-rebate with *proportional* probability rule result in aggregate demand over-revelation. These rules provide total contributions that exceed total benefits by over 30%. For these rules, the mean and median contributions range from $3.96 to $4.50, and they are statistically different from the mean (and median) induced value of $3.

Similarly, the mean and median C_i/V_i ratios range from 125% to 157%, and these ratios are statistically different from 100%.

Although the proportional rebate and winner-take-all with *proportional* probability rules have the same expected earning structure, a (one-tailed) pairwise means t-test and Wilcoxon rank-sum Z-test indicate that the proportional rebate rule yields lower mean and median C_i/V_i ratios than the winner-take-all rule [$t = -2.9929$ and $Z = -2.6697$ (both $p < 0.004$)]. This suggests that having the potential to win more than one contributes in the winner-take-all rule positively affects contributions, but it may entice individuals to over-contribute (i.e., $C_i > V_i$).

Overall, the above results suggest that contributions (and C_i/V_i ratios) are (1) an increasing function of potential earnings (or the size of potential rebate) and (2) positively affected by proportional, compared to uniform, probability rules. Winner-take-all rules, which can generate higher potential earnings than the other rules, tend to yield higher contributions than the other rules. This appears consistent with Morgan and Sefton (2000), who show that contributions are an increasing function of prize amount, and it suggests that our experimental subjects may prefer higher skewness of earnings to risk (cf., Golec and Tamarkin, 1998). Moreover, although higher contributions under any rebate rule increase the likelihood of exceeding the *PP*, and thus the likelihood of receiving a rebate, a higher contribution may, *ceteris paribus*, lead to a higher chance of winning a rebate under proportional probability than under uniform probability, which may entice individuals to contribute more under a proportional probability rule. We find that the winner-take-all and random full-rebate rules yield higher contributions under a proportional probability rule than under a uniform probability rule (see Table 1). Given these arguments, it is not surprising Table 1 shows that total contributions are highest under the winner-take-all with *proportional* probability rule.

Result 3: *We find empirical support for Hypothesis 3. A "no contribution necessary" element leads to lower contribution-to-induce-value (C_i/V_i) ratios in the winner-take-all rule.*

The attraction of having a chance to win all the excess contributions if one makes a positive contribution to the public good is reduced by a "no contribution necessary" element. A winner-take-all rule with uniform probability among *all group members* yields lower C_i/V_i ratios than a winner-take-all rule with *proportional* probability ($t = -2.7874$ and $Z = -3.1824$ with both $p < 0.004$) and a winner-take-all rule with uniform probability among *contributors only* ($t = -2.0180$ and $Z = -2.4656$ with both $p < 0.03$). These results suggest that if one can win the rebate lottery over excess contributions without making a contribution, then there is little incentive to contribute above one's value.

Model of Individual Behavior

In Rondeau, Schulze, and Poe (1999), *aggregate* demand revelation occurs not because everyone contributes an amount equal to their induced value, but because "…overbidding by some subjects essentially offsets the cheap-riding of others in all treatments" (p. 468). If people simply flip a fair coin to decide between contributing $0 and their entire $6 endowment, the expected mean contribution would equal the mean induced value of $3. Although this is an extreme case, and Rondeau, Schulze, and Poe (1999, Treatment B) find 13% (6 out of 45) and 11% (5 out of 45), respectively, of subjects contribute $0 and $6, it remains an open question as to whether demand revelation occurs at the individual level as well as the aggregate level.

To help address this question, we model individual contributions as a function of rebate rule and induced value: $C_i = f\left(Rule_k, Rule_k * V_i\right)$, where $Rule_k$ is a dummy variable representing the type (k) of rebate rule under which individual i participated and $Rule_k * V_i$ represent interaction terms between the rebate rule and induced value V_i. We consider a linear model of varying intercepts and slopes.[16] If a rebate rule were empirically demand revealing, one would expect a one-to-one relationship between contributions and induced values, which (in terms of our linear model) implies an intercept of zero with a slope of one for each rebate rule.

Given individual contributions to the public good have a lower limit of $0 and an upper limit of $6, we estimate the behavioral model with a two-limit Tobit model. Table 2 presents the estimation results, which were estimated in LIMDEP™. The χ^2-statistic for a likelihood ratio test of model significance is highly significant with $p \approx 0.0001$. All rebate rules, except the proportional rebate rule, have intercepts that are statistically greater than zero. And only the proportional rebate and winner-take-all with uniform probability among *contributors only* rules have slopes (0.77 and 0.84, respectively) that are statistically different from zero but not statistically different from 1 (both two-tailed $p > 0.50$).

These results lead to a rejection of Hypothesis 2B. The proportional rebate rule is the only rule that appears to achieve *individual* demand revelation by having an intercept and a slope not statistically different from 0 and 1, respectively. Despite the aggregate demand revelation results for the winner-take-all with uniform probability among *all group members* and the random full-rebate with *uniform* probability rules (see Table 1), contribution amounts under these rules are not sensitive to induced values. Also, contribution amounts are not sensitive to induced values under the random full-rebate with *proportional* probability rule. The winner-take-all with *proportional* probability rule has a positive slope of 0.50 that is not statistically different from one, but it is also not statistically different from zero, which suggests contribution amounts under this rule are not too sensitive to induced values.

6. Concluding Remarks

This paper explored the empirical performance of six rebate rules in the provision of a threshold public good. Our objectives were to (1) identify rebate rules that are empirically efficient in that the public good (where total benefits exceed total costs) is provided and (2) identify rebate rules that are empirically demand revealing on the aggregate and individual levels. All of our rebate rules led to public-good provision, but not all the rules achieved demand revelation. The proportional rebate, winner-take-all with uniform probability among *all group members*, and random full-rebate with *uniform* probability rules achieved *aggregate* demand revelation, but only the proportional rebate rule also achieved *individual* demand revelation. Thus, we found even stronger support than Rondeau, Schulze, and Poe (1999) for the empirical usefulness of the proportional rebate rule in providing and valuing threshold public goods under one-shot conditions.

The winner-take-all rules with proportional *probability* and uniform probability among *contributors only* and the random full-rebate rule with *proportional* probability lead to demand over-revelation. Demand over-revelation, especially under the winner-take-all with *proportional* probability and the winner-take-all with uniform probability among *contributors only* rules, suggests the presence of an embedding effect, where individuals appear to be valuing both the public good and the chance to "win it all." Such results are problematic for those who seek to place a value on public goods, but they can be advantageous for fundraisers. If a fundraiser wants to increase total contributions, without intending to estimate the value of the good, then implementing one of these winner-take-all rules or the random full-rebate rule with *proportional* probability would be choices to consider. Demand over-revelation also suggests that fundraisers could provide a public good where the costs exceed the benefits. Providing a public good for which the costs exceed the benefits could be beneficial for some people but not for others. We leave such redistributional issues for future research and discussion.

The power of the winner-take-all element to stimulate demand over-revelation, however, appeared to be eliminated by a “no contribution necessary” element. The winner-take-all rule with uniform probability among *all group members* yielded results that were empirically demand revealing in the aggregate, and were not statistically different from the proportional rebate or random full-rebate with *uniform* probability rules.

Overall, our experimental results have implications for both fundraisers and valuation practitioners. From a fundraising perspective our results could be beneficial in devising alternative fundraising strategies. For example, where state laws governing lotteries and gambling may preclude the use of a winner-take-all rule in some field applications, some form of a random full-rebate or proportional rebate rule may be a better choice. For valuation practitioners seeking a one-shot demand-revealing rule on the individual level, our Tobit model results are encouraging for the proportional rebate rule.

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Table 1. Descriptive Statistics by Rebate Rule

		Winner-Take-All with			Random Full-Rebate with	
	Proportional Rebate	Proportional Probability	Uniform Probability-Contributors	Uniform Probability-All-Members	Uniform Probability	Proportional Probability
Total Contributions ($\sum C_j$) [a]	\$133.31	\$188.17	\$178.12	\$121.00	\$146.03	\$180.24
Mean Contribution (C_i)	\$2.96	\$4.18*	\$3.96*	\$2.69	\$3.25	\$4.01*
Standard Deviation of C_i	\$1.93	\$1.75	\$1.97	\$2.09	\$1.82	\$1.88
Median C_i	\$3.00	\$4.25**	\$4.50**	\$2.50	\$3.25	\$4.25**
Mean of C_i/V_i	106%	156%†	142%†	103%	122%	157%†
Standard Deviation of C_i/V_i	72%	83%	85%	96%	87%	110%
Median C_i/V_i	100%	141%‡	133%‡	100%	100%	125%‡
Percentage of Demand Revealed ($\sum C_j$)/($\sum V_i$)	99%	139%	132%	90%	108%	133%

Note: the sample size (N = 45), individual endowment (I_i = \$6), and mean induced value ($\overline{V}$ = \$3) are the same across rebate rules.

[a] For comparison, the sum of induced values ($\sum V_i$) equaled \$135 for each rebate rule.

[*] Different from \$3 at the 5% significance level (*t*-test).

[**] Different from \$3 at the 5% significance level (sign and Wilcoxon signed-rank tests).

[†] Different from 100% at the 5% significance level (*t*-test).

[‡] Different from 100% at the 5% significance level (sign and Wilcoxon signed-rank tests).

Table 2. Estimation Results for the Two-Limit Tobit Model

Variable	Parameter Estimate	*p*-value [b] (Parameter = 0)	*p*-value [c] (Slope = 1)
Proportional Rebate Rule:			
Proportional Rebate	0.6830 (1.1415) [a]	0.5496	
*Proportional Rebate * VALUE*	0.7729 (0.3612)	0.0324	0.5294
Winner-Take-All (WTA) Rules:			
WTA-Proportional	3.1965 (1.1434)	0.0052	
*WTA-Proportional * VALUE*	0.5008 (0.3632)	0.1679	0.1693
WTA-Uniform-Contributors	1.9716 (1.1482)	0.0860	
*WTA-Uniform-Contributors * VALUE*	0.8395 (0.3659)	0.0218	0.6609
WTA-Uniform-All-Members	2.6554 (1.1427)	0.0201	
*WTA-Uniform-All-Members * VALUE*	–0.0137 (0.3577)	0.9694	0.0046
Random Full-Rebate (RFR) Rules:			
RFR-Uniform	3.5842 (1.1279)	0.0015	
*RFR-Uniform * VALUE*	–0.0735 (0.3542)	0.8357	0.0024
RFR-Proportional	4.8522 (1.1705)	< 0.0001	
*RFR-Proportional * VALUE*	–0.1519 (0.3650)	0.6772	0.0016
Number of Observations	270		
σ	2.4778		
Log-likelihood	–524.0684		
χ^2-statistic	36.4184	0.0001 [d]	
Degrees of Freedom	11		

[a] Numbers in parentheses represent standard errors.

[b] The *p*-values for a *two*-tailed test of parameter estimate different from zero.

[c] The *p*-values for a *two*-tailed test of slope coefficient different from one.

[d] The *p*-value for a likelihood ratio test of model significance.

Footnotes

[1] Although some public goods have an *a priori*, known provision point, others have an unknown provision point. When construction or landscaping is required, the exact cost of providing a public good may be subject to competitive bid among contractors. For example, Rose et al. (2002) investigate the provision of a green power program, proposed by the Niagara Mohawk Power Corporation (NMPC) in the state of New York, which would involve the construction of a renewable energy facility and the planting of 50,000 trees in NMPC's service area. The exact provision point for the program was not known before soliciting monetary support for it because the project had to be sent out for competitive bid. Additionally, McBride (2006, p.1182) notes "…there is often not full certainty about the threshold. It might not be known how much money will be needed to complete the project, or coup plotters might not know if their faction will be large enough to successfully take power." As discussed later, our paper investigates voluntary contributions to a threshold public good that has an unknown provision point.

[2] Not all threshold public good cases refund contributions in the event that total contributions collected fall short of the provision point. As discussed later, our experiment provides for such a refund policy, which is known in the literature as a "money-back guarantee."

[3] Marks and Croson (1998) use the terms "no rebates" and "utilization rebate" to refer to wasted funds and extended benefits, respectively.

[4] We use the term "full-rebate" in this study to indicate rebates of contributions in the situation when the public good *is* provided and to distinguish this situation from outcomes where contributors receive a full refund under a money-back guarantee when the public good is *not* provided. If total contributions collected exceed the provision point, then the public good is provided and all excess contributions are rebated. As explained later, under a random full-rebate rule, contributors are randomly selected to win their contribution back until all the excess contributions are returned, at which point the lottery ends and no other contributors receive a rebate.

[5] Here, simple, one-shot mechanisms are more pragmatic than the more operationally complex Clarke-Groves (Clarke, 1971; Groves, 1973), Groves-Ledyard (Groves and Ledyard , 1977), and Smith Auction (1979, 1980) demand-revealing mechanisms.

[6] Although the proportional rebate rule seems straightforward and easy to understand in theory, one can envision an implementation problem in practice. Suppose a field experiment involves 400 subjects whose contributions are equal and yield an excess of $40. By the rules of an experiment with proportional rebates, this outcome implies processing a trivial rebate of $0.10 per contributor. In a policy setting, say for a public good provided by town government, citizen-donors could view the processing of trivial rebates as a hidden cost, detracting from the gross value of the public good.

[7] For lotteries with a fixed prize (or rebate) and continuous public good, Morgan and Sefton (2000) show that contributions are an increasing function of prize amount. Our public good scenario, however, deals with a continuous prize and threshold public good. Thus, our

experiments are not exactly comparable to Morgan and Sefton (2000), but it seems reasonable to expect contributions to increase, in both cases, as the size of the prize or potential prize increases. Our conjecture that the winner-take-all rule may generate higher contributions than the proportional rebate rule is also consistent with the notion that individuals prefer higher skewness of earnings to risk (Golec and Tamarkin, 1998).

[8] Rondeau, Schulze, and Poe (1999) define "aggregate demand revelation" as the situation where the ratio of total contributions to total benefits (or induced values) equals 1 (or 100%), and mean (median) contributions equal mean (median) benefits. "Demand revelation" as an individual concept, however, is defined as a one-to-one relationship between contributions and benefits (or values). A provision rule could yield *aggregate* demand revelation without being demand revealing at the *individual* level. We explore both issues in this paper.

[9] One-shot experiments eliminate the possibility of any reputation effects and strategic behavior that can exist in early rounds of repeated-play experiments. One-shot games also mimic real situations for fundraisers or analysts measuring public good values (cf., Rondeau, Schulze, and Poe, 1999).

[10] Group size can be an important treatment variable in public good experiments. And compared to the majority of public good experiments which typically use group sizes of $N \leq 10$, a group size of $N = 45$ is considered large and more realistic (Rondeau, Schulze, and Poe, 1999). As noted in Ledyard (1995), arguments and experimental evidence exist both for contributions increasing and decreasing as group size increases. Under the proportional rebate rule, Rondeau, Schulze, and Poe (1999) found that small groups of size $N = 6$ contributed on average only 64% of their induced value, while large groups of $N = 50$ and $N = 45$ contributed on average around 100% of their induced value. It would be interesting in a future experiment to vary the group size under our winner-take-all and random full-rebate rules to see if group size matters.

[11] Threshold public goods are also called step-level, binary, discrete, lumpy, or provision point goods.

[12] See Brewer (2003, Chapter 13) for a discussion of the obstacles and uncertainties in providing greenways, which are linear landscapes that connect open spaces by following either natural corridors (such as riverfronts or stream valleys) or developed lands (such as roadways or abandoned railroad lines).

[13] Additionally, although the existence of a money-back guarantee leads to one inefficient outcome, where each individual ends up with his or her initial endowment if $\sum C_j < PP$, there are many vectors of contributions that might be equilibria that support this outcome.

[14] In our treatment comparisons we follow the standard procedure of testing a null hypothesis of equality versus a research (i.e., alternative) hypothesis of strict inequality. Given differences in uncertainty over receiving a rebate, a null hypothesis of equality between the proportional rebate and winner-take-all rules (and random full-rebate rules) requires an assumption of risk neutrality. We do not attempt to measure the risk preferences of our subjects, but our research hypothesis may remain valid regardless of risk preference if one assumes individuals prefer higher skewness

of returns to risk. Golec and Tamarkin (1998) provide insights into why individuals sometimes over-bet low-probability/high-variance/high-skewness (of returns) games and under-bet high-probability/low-variance/low-skewness games. Golec and Tamarkin's (1998) work, along with Garrett and Sobel (1999), show that individuals (at least for horse racing and state lottery games) prefer higher skewness of returns to risk. That is, larger prizes entice risk-averse individuals to play. Although this study does not test whether subjects prefer higher skewness of earnings to risk, we conjecture that the moderately low-risk nature of contributing (largely created by a MBG), in conjunction with a potential chance to win a sum of money greater than one's contribution (as in a winner-take-all rule), might entice one to contribute more relative to a situation where one may have the chance to only receive part of their contribution back (as in a proportional rebate rule).

[15] An anonymous reviewer speculates that our efficiency results might be an artifact of the unknown provision point. In a field experiment involving the provision of a threshold public good with an unknown provision point, Rose et al. (2002, p. 146) argue that information on the level of the provision point "…should be irrelevant, since changing the threshold level and even knowledge of the exact threshold level has been shown to be inconsequential in the presence of a money-back guarantee (Cadsby and Maynes, 1999; Rondeau, Schulze, and Poe, 1999)." Rondeau, Poe, and Schulze (2005) also find that the threshold level has no statistically significant effect on mean and median contributions in laboratory experiments. In conjunction with our second objective to identify rebate rules that are empirically demand revealing, one might also suggest that the provision point should be irrelevant since individual valuation theory is based on what the good is worth to the individual, not the good's cost. Whether our efficiency results would hold under different levels of a known provision point would be interesting to explore in future experiments.

[16] The linear equation is

$$C_i = \sum(\alpha_k \, Rule_k + \beta_k \, Rule_k * V_i)$$

where each α_k and β_k pair represents the intercept and slope for rebate rule k, so the summation is over the six rebate rules considered in the experiment. Estimates of α_k and β_k for each rebate rule appear in Table 2. We also considered several demographic variables (family income, gender, class level, and academic major) in the model, but these variables, as a group, were not statistically significant ($p \approx 0.1260$)—see Spencer (2002) for more details.