Other-Regarding Preferences and Voting For Public Goods: An Exploration Using a New Preference Revealing Mechanism*

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This version: February 24, 2007

Abstract
Recent papers show that in group decisions individuals have social preferences for efficiency and equity. However, the effect of social preferences on voting, the predominant funding mechanism for public goods, has not been thoroughly examined. This study investigates whether voting decisions are affected by the distribution of net benefits associated with a proposed public program using a new Random Price Voting Mechanism (RPVM). Theoretical and econometric analysis of experimental results presented in the paper suggests that observed differences from selfish voting are caused by a concern for social efficiency.

JEL: C91, C92, D64, D72, H41

*The research presented in this paper was funded by National Science Foundation Program in Decision, Risk, and Management Science. All opinions, errors, and conclusions are the sole responsibility of the authors.

I. Introduction

Majority-voting rules are used extensively by representative legislative bodies and in ballot initiatives (referenda) to determine the provision of public goods. Such programs and their funding often impose unequal costs and benefits on individuals. If voters have social preferences, we should expect their decisions to be influenced by the perceived or actual impact of the voting outcome on others. For instance, a strong supporter of a school bond may be worried that voting yes on the associated tax may impose costs on the elderly that exceed their benefits. The elderly may worry that by voting no they hurt kids even though their own children are grown.

There exists a thin empirical literature on the determinants of voting patterns in real ballots beyond early discussions by Deacon and Shapiro (1975) and Mueller (1989). Holmes (1990) used the county level results of a California referendum on the Safe Drinking Water and Safety Enforcement Act. He inferred from instrumenting this aggregate data that care for other's well-being had a statistically significant but small effect on the probability of voting in favor of the water quality protection proposal. Shabman and Stephenson (1992, 1994) relied instead on individual survey data collected in the wake of a city-wide referendum to fund a flood protection projects that would protect fewer than 10% of Roanoke (Virginia) residents. They too report that concerns for others played a measurable role in determining voting choices.

In parallel, mounting evidence from the fields of experimental and behavioral economics suggests that at least a portion of individuals exhibits social preferences (see, for example, Fehr and Schmidt, 1999, Bolton and Ockenfels, 2000, Charness and Rabin, 2002, Engelmann and Strobel, 2004, and Fehr, Naef, and Schmidt, forthcoming).

This study seeks to better understand the behavior of individuals in voting situations. We introduce a new preference-revealing voting mechanism, detail its theoretical properties, and test its empirical performance in an application that aims to discern which currently debated theories of social preferences best explain observed behavior.

The new Random Price Voting Mechanism (RPVM) is best thought of as an extension of the Becker-DeGroot-Marschak (BDM) mechanism (1964) to public goods. A proposed public good is implemented whenever a majority of individuals indicate a maximum willingness to pay (WTP) greater than or equal to a randomly selected price. In that event, all subjects must pay the random price.[1] Thus, instead of generating a yes-no vote that only crudely bounds an individual's true valuation of the proposed good, the RPVM aims to elicit a point estimate of the value of the good. Yet, its coercive tax feature closely parallels the format of many referenda. The RPVM is less complex than existing incentive compatible public goods funding mechanisms, such as the Smith (1979) Auction and the Groves-Ledyard (1977) mechanism. However, unlike these mechanisms, the RPVM does not seek to efficiently provide the collective good. Rather, it is constructed to elicit the value that an individual places on the good.

The paper contributes to the literature in several ways. In addition to introducing a new mechanism to elicit individual values for a public good, we analyze its theoretical properties and experimentally demonstrate its demand revealing properties under all four Hicksian measures of welfare change. We finally identify econometrically which type of social preferences most powerfully explains observed voting patterns.

We report four key findings. First, the RPVM elicits preferences that are consistent with observed dichotomous (yes/no) votes. Second, we show that behavior under the new mechanism

[1] In a willingness to accept (WTA) setting, an individual indicates his minimum WTA. If a randomly chosen compensation level exceeds the individual's signal, this amount of compensation is paid. If not, no payment is made and the loss is incurred.

is consistent with theory, which predicts truthful demand revelation in groups of one or when a program results in equal distribution of benefits to all members of a group (regardless of the type of social preferences postulated). Third, no evidence of a WTP/WTA discrepancy is found. Finally, an econometric analysis of voting patterns leads us to conclude that voters in our experiments were motivated by the appeal of their own potential gains as well as by a concern for the overall efficiency of proposed programs (consistent with altruism as defined by Bergstrom, 2006).

This is how the remainder of the paper is organized. In Section 2, we formally describe the RPVM and show that it is a weakly dominant strategy for selfish individuals to truthfully reveal their value for the public good. We also develop theoretical predictions of behavior for four alternative types of social preferences, and for both WTP and WTA with both gains and losses. Voting behavior and the empirical properties of the mechanism itself are explored experimentally with a design described in Section 3. Results are presented in Section 4 and their implications for public policy, future research, and the overall efficiency of voting are further discussed in conclusion.

II. The Random Price Voting Mechanism and Behavioral Predictions

In this section, we formally introduce the Random Price Voting Mechanism and develop theoretical predictions of individual behavior for it. For ease of exposition, we focus the presentation on the case where the game is played in the WTP for gains domain, and for the case where individuals have "social welfare" motives (Charness and Rabin, 2002). These results are readily extended to the other three Hicksian measures (WTP to avoid a loss and WTA a loss or forego a gain) and for three other forms of preferences considered in this paper. Once the results

for the social welfare function have been established, we briefly discuss these extensions. Behavioral predictions for all permutations are summarized in Table 1.

The mechanism proposed here combines the incentive compatible properties of the private goods BDM with a majority voting rule. In the BDM, a person is asked to provide a signal of their WTP for an object. If a randomly drawn price is no greater than the individual's signal, the individual buys the good at the random price. If the price is higher, no transaction takes place. For expected utility maximizers, the "second price" property of the BDM mechanism eliminates the incentives for strategic bidding, making truthful revelation of one's value for the object a dominant strategy. This is confirmed by experimental tests (Irwin et al. 1998). The traditional BDM mechanism, however, cannot readily be used to elicit the value of a public good. Anyone in a group of players might alter his signal (free-ride) if the object was a non-excludable good and only one buyer is required for all to enjoy full benefits. While the RVPM maintains the second price property, it is necessary to add an allocation rule that prevents this type of strategic behavior. We do this with a majority rule. In addition to being a simple and familiar approach to collective decision-making, laboratory experiments have shown that majority voting can be incentive compatible (Plott and Levine, 1978) like more general binary choice approaches (Farquharson, 1969).

A. The RPVM

N individuals are asked to signal the maximum amount of money they would be prepared to pay for a program defined by a known vector $\prod = (\pi_1, \pi_2, ..., \pi_N)$. In the WTP for gains domain, π_j represents the individual benefits to be received by individual *j* if the program is implemented.

The public program that is submitted to a "vote" has two components: 1) the individual values Π and 2) an uncertain transfer payment (C) from each individual to the implementing authority. This cost (a uniform tax) is a random number drawn from a distribution with probability density p(C) over the interval $[0, C_{\max}]$ after all individuals have signaled their WTP. In what follows, we refer to individual *i*'s signal as his "bid" and denote it by B_i.

For implementation of the program, a clear majority of individuals (>50%) must have expressed a WTP that exceeds the per-person cost *C.* If a majority of bids is greater than or equal to *C,* individual *i* receives a monetary payoff $\pi_i - C$ (the sum of which could be negative) to be added to their initial wealth *Y,* for a utility level $U_i = u_i(Y + \pi_i - C)$. If the majority of bids is below *C*, the program is not implemented and subjects retain their initial wealth, for utility $U_i = u_i(Y)$. We assume that *U* is increasing.

B. Value Revelation as a (Weakly) Dominant Strategy of Selfish Players

It can readily be argued that a self-interested individual has a weakly dominant strategy to choose the truthful signal $B_i^* = \pi_i$. The demonstration proceeds from a standard second price argument.[2] Denote a vector of strategies chosen by the *N*-1 other players by B_{-i}.[3] For our purposes, it will be sufficient to characterize an admissible strategy profile simply by the pair of numbers (B_m, B_k). B_m is defined as the $Round[(N+1)/2]^{\text{th}}$ largest bid in the vector and B_k as the $Round[(N-1)/2]^{\text{th}}$ largest bid in B_{-i}. For *N*=3, for example, B_m is the smallest and B_k is the largest of the two bids in B_{-i}. In general, B_m and B_k bound the range of value in which player *i*'s signal would be pivotal (i.e. the range in which *i* is the median voter).

[2] As Karni and Safra (1987) and Horowitz (forthcoming) demonstrate, the simpler BDM is not always incentive compatible outside of the expected utility framework. For this reason, we limit our analysis to expected utility.

To establish that $B_i^* = \pi_i$ is a weakly dominant strategy it suffices to establish that $EU_i(B_i = \pi_i, B_{-i}) \geq EU_i(B_i \neq \pi_i, B_{-i}) \forall B_{-i}$. We proceed by considering different subsets of B_{-i}, defined by the location of B_m or B_k relative to π_i. For all possible configurations, we show that no strategy exists for player *i* that provides greater expected utility than $B_i = \pi_i$.

Case 1: $\pi_i < B_m$

Consider the subset of all strategy profiles B_{-i} for which $\pi_i < B_m$ and the impact of deviating from $B_i = \pi_i$ on player *i*'s expected utility. First, examine alternative bids where $B_i < \pi_i$. Note that for any bid such that $B_i \leq \pi_i < B_m$, the probability that the program is implemented remains unchanged at $\int_0^{B_m} p(C)\, dC$ since, in this range of *C*, a majority of other players form a majority. Since the utility of player *i* is independent of her bid, $U_i = u_i(Y + \pi_i - C)$ whenever $C \leq B_m$ and $u_i(Y)$ otherwise. Therefore, lowering B_i below π_i leaves player *i*'s expected utility unchanged at $\int_0^{B_m} p(C) u_i(Y + \pi_i - C)\, dC + \int_{B_m}^{C_{\max}} p(C) u_i(Y) dC$. There are no gains (nor any losses) to be realized by reducing one's bid below π_i.

Next, consider the possibility of increasing B_i above π_i. By the same argument we just made, increasing the bid beyond π_i has no consequences on *i*'s expected utility if the new bid is $\tilde{B}_i \leq B_m$. Once again, increasing B_i up to B_m has no effect on *i*'s expected utility.

Bidding above B_m would, however, decrease expected utility. For $B_m < \tilde{B}_i \leq B_k$, $\tilde{B}_i$ becomes the pivotal bid in the sense that it defines the largest realization of *C* that leads to the implementation of the program. Expected utility is now equal to

$\int_0^{\tilde{B}_i} p(C)u_i(Y+\pi_i-C)\,dC + \int_{\tilde{B}_i}^{C_{\max}} p(C)u_i(Y)dC$ but this is less than the expected utility derived from $B_i = \pi_i$ since the increase in the probability of funding the program (i.e. for $C \in (B_m, \tilde{B}_i]$) is associated with instances where $C > \pi_i$.

Finally, consider $\tilde{B}_i > B_k$. For all such strategies, B_k is the highest value of C leading to implementation of the program and the expected utility is always equal to $\int_0^{B_k} p(C)u_i(Y)\,dC + \int_{B_k}^{C_{\max}} p(C)u_i(Y+\pi_i-C)dC$. It follows that any strategy $\tilde{B}_i > B_k$ leads to the same expected utility as the strategy $B_i = B_k$, which we have just established as being dominated by $B_i = \pi_i$.

By virtue of the above discussion, we conclude that for any strategy profile B_{-i} such that $\pi_i < B_m$, $EU_i(B_i = \pi_i, B_{-i}) \geq EU_i(B_i \neq \pi_i, B_{-i})$.

Case 2: $B_k < \pi_i$

We now turn to the subset of B_{-i} strategy profiles for which $B_k \leq \pi_i$. First consider any bid $\tilde{B}_i > B_k$. Since $B_k \leq \pi_i$, it follows as previously discussed that the probability of implementing the program remains unchanged for all $B_i \geq B_k$ and $EU_i(B_i \geq B_k, B_{-i}) = EU_i(\pi_i, B_{-i})$.

Next, consider the possibility of reducing *i*'s bid from $B_i = \pi_i > B_k$ to $\tilde{B}_i < B_k$. Such a bid strictly reduces expected utility since it lowers the probability of implementing the program from $\int_0^{B_k} p(C)\,dC$ to $\int_0^{\tilde{B}_i} p(C)\,dC$ if $B_m < \tilde{B}_i < B_k$, or to $\int_0^{B_m} p(C)\,dC$ $\tilde{B}_i \leq B_m$). Unfortunately, this reduction in probability is associated with a range of costs for which $C < \pi_i$ and thus can only prevent the implementation of programs that would benefit player *i*.

Collecting the results establishes that $EU_i(B_i = \pi_i, B_{-i}) \geq EU_i(\pi_i, B_{-i})$ for all B_{-i} such that $B_k < \pi_i$.

Case 3: $B_m \leq \pi_i \leq B_k$

This last case includes all remaining strategy profiles B_{-i} not yet considered. As we have pointed out in the analysis of previous cases, these strategy profiles make the strategy $B_i = \pi_i$ the median bid and determines the probability that the program will be implemented. Deviating from $B_i = \pi_i$ to $\pi_i < \tilde{B}_i \leq B_k$ increases the probability of funding but the higher probability is associated with cases where $C > \pi_i$ and lowers expected utility. As before, further increases of $\tilde{B}_i$ beyond B_k do not result in additional changes in probability of funding nor in expected utility. It follows that the strategy $B_i = \pi_i$ strictly dominates $\tilde{B}_i > \pi_i$ when B_{-i} is such that $B_m \leq \pi_i \leq B_k$.

By similar reasoning, $B_i = \pi_i$ also strictly dominates $\tilde{B}_i < \pi_i$. The reduction in bid into the region $\tilde{B}_i \leq B_m$ decreases the probability that beneficial programs (with $C < \pi_i$) will be implemented but offers no offsetting gain. A further decrease in $\tilde{B}_i$ below B_m has no additional effect on expected utility. Thus, we conclude that $EU_i(B_i = \pi_i, B_{-i}) > EU_i(B_i \neq \pi_i, B_{-i})$ for all B_{-i} such that $B_m \leq \pi_i \leq B_k$.

With Cases 1, 2 and 3, we have explored the entire strategy space of the *N*-1 other players and considered all possible deviations from the strategy $B_i = \pi_i$. Departing from the strategy $B_i = \pi_i$ always results in either no change or in a reduction in the expected utility of player *i*. $B_i = \pi_i$ is therefore a weakly dominant strategy. With all players postulated to be self-interested and with an increasing utility function, all other players also have a weakly dominant strategy to

play $B_j = \pi_j$. This establishes that truthful revelation by all players is a Bayesian Nash Equilibrium of the RPVM game (though it may not be unique).

C. Behavioral Predictions for Players with Other-Regarding Preferences

In this section, we look more closely at theoretical predictions emanating from more explicit models of individuals with other-regarding preferences. Following recent developments in the behavioral economics literature, we impose additional structure on the utility function and focus on linear Nash equilibria of the RPVM game. We present with some detail the solution for individuals with social efficiency preferences (Charness and Rabin, 2002) who are asked to signal their WTP for a program conferring gains. We then summarize the predictions for four alternative models and for the remaining three welfare settings.

An individual *i* with social efficiency preferences is postulated to have utility that is increasing in the gains of others such that $U_i = u\left(Y + \pi_i - C + \sum_{j \neq i} \left(\alpha_i \cdot (\pi_j - C) \right) \right)$. Here $\alpha_i \geq 0$ parameterizes the intensity of individual *i's* altruism (for pure selfishness, $\alpha_i = 0$). This is a purely altruistic individual who weights equally the gains and losses to others.

To compute the Bayesian Nash Equilibrium we once again rely on the critical values B_m and B_k, the interval defining the range over which the bid of voter *i* makes this individual the median voter. In this framework, *i*'s expected utility can be expressed as

$$
\begin{aligned}
EU_i\left(B_i, B_{-i}\right) = & \int_0^{B_m} p(C) U\left(Y + \pi_i - C + \alpha_i \sum_{j \neq i} (\pi_j - C) \right) dC \\
& + \int_{B_m}^{B_i} p(C) U\left(Y + \pi_i - C + \alpha_i \sum_{j \neq i} (\pi_j - C) \right) dC \\
& + \int_{B_i}^{B_k} p(C) U\left(Y\right) dC + \int_{B_k}^{C_{\max}} p(C) U\left(Y\right) dC
\end{aligned}
\tag{1}
$$

The first term is the expected utility conditional on the randomly drawn cost being below B_m. Here, i's bid is irrelevant since there is already a majority of voters willing to pay more than the cost of implementing the program. The second and third terms cover the interval over which the bid of individual i will have a marginal effect on the probability that the program is implemented. Conditional on C falling in that range, B_i is effectively the median bid. The last term is the interval over which i has no effect on the outcome since no matter how large B_i is, too few individuals have bid high enough to implement the program.

We focus on affine bidding strategies. Let individual i conjecture that all others (m and k in particular) choose bids of the form

(2) $$B_m = \gamma_m \left(\pi_m + \sum_{j \neq m} \alpha_m \, \pi_j \right)$$

and

(3) $$B_k = \gamma_k \left(\pi_k + \sum_{j \neq k} \alpha_k \, \pi_j \right).$$

where γ_k and γ_m are positive (still unknown) constants. Substituting these expressions in Equation 1 and maximizing with respect to B_i yields the first order condition:

(4) $$p(B_i)U\left(Y + \pi_i - B_i + \sum_{j \neq i} \left(\alpha_i \cdot (\pi_j - B_i) \right) \right) = p(B_i)U(Y).$$

This equation has a degenerate solution at $p(B_i) = 0$ that can safely be ignored. The interior solution equates expected utility under the two states of the world (the program is funded or not). Solving for B_i, the optimal bid is then given by:

(5) $$B_i^* = \frac{\pi_i + \sum_{j \neq i} \alpha_i \, \pi_j}{1 + (N-1)\alpha_i}.$$

The optimal strategy has a form that matches the conjecture of individual *i* regarding the bidding strategies of players *m* (Equation 2) and *k* (Equation 3) for $\gamma_i = 1/\left(1+(N-1)\alpha_i\right)$. Thus, if all *N* players adopt this linear conjecture and bid their optimum, all conjectures are simultaneously proven correct and no one has incentives to deviate from their optimal bidding function. This establishes that (Equation 5) is a Bayesian Nash Equilibrium. Note that an individual's optimal bid does not require knowledge of the α_j of other individuals. Note also, the private BDM is nestled in the RPVM: setting *N*=1 yields the familiar BDM result that $B_i^* = \pi_i$.

A number of testable behavioral predictions emerge from this solution.

1) If $\pi_j = \pi_i \ \forall j$, $B_i^* = \pi_i$. Bidding one's own private value is optimal when all players have equal payoffs since bidding above induced value increases the probability that the program will be funded in the range where costs exceed everyone's benefits. Bidding below value is also sub-optimal since it reduces the probability that the program will be implemented in the range where everyone would benefit.

2) Not surprisingly, the optimal bid is increasing in one's induced value:

(6) $$\frac{\partial B_i^*}{\partial \pi_i} = \frac{1}{1+(N-1)\alpha_i} > 0 .$$

3) For social welfare preferences, an increase (decrease) in the sum of gains of others increases (decreases) *i*'s optimal bid:

(7) $$\frac{\partial B_i^*}{\partial \pi_j} = \frac{\alpha_i}{1+(N-1)\alpha_i} > 0 .$$

4) By direct extension of Equation 7, individual *i* will increase (decrease) his bid when moving from a homogenous distribution where $\pi_i = \pi_j = \pi \ \forall j$, to a heterogeneous distribution where all payoffs other than his own are increased (decreased). For example, while everyone in a

$\Pi = (\$2,\$2,\$2)$ distribution of payoffs is predicted to bid \$2, the \$2 individual in a (\$2,\$5,\$8) distribution would set $B_i^* > \$2$. The individual values the higher benefits to others and is thus prepared to incur (in expectation) a personal cost to increase the probability that the program will be implemented. On the other hand, an \$8 type would bid less in the (\$2,\$5,\$8) distribution than for a (\$8,\$8,\$8) program. These results are summarized in the first row and column of Table 1.

WTA compensation to Forego Gains, WTP to avoid Losses, and WTA Compensation for Losses

The theory can be reinterpreted to describe the optimal bidding strategy of individuals faced with all three other Hicksian measures of welfare change. In the case of a group asked to express their individual minimum Willingness-to-Accept (WTA) compensation to forego gains, *C* represents the randomly determined compensation to be paid in exchange for not receiving a payoff defined by Π. B_i then denotes the smallest amount that individual *i* would accept. If a majority of bids are less than or equal to *C,* compensation *C* is paid but the gains Π are not, for a utility level $U\left(Y + C + \alpha_i \sum_{j \neq i} C\right)$. Otherwise, Π is paid and utility is $U\left(Y + \pi_i + \alpha_i \sum_{j \neq i} \pi_j\right)$.

Re-deriving the optimal bidding strategy yields exactly Equation 5 and the same theoretical predictions, although the vector Π now represents individual opportunity costs of implementing the compensation program. An increase in the opportunity cost to any player implies a decrease in the social value of the compensation program, and therefore increases the minimum acceptable level of compensation required by voters. This implies, for example, that an individual would optimally bids \$2 when $\Pi = (2,2,2)$, but would increase his bid above \$2 when he is the \$2 individual in $\Pi = (2,5,8)$. To understand the last column of Table 1, "smallest π" refers to the smallest absolute induced value, be it a gain or a loss.

The optimal strategies for the WTA compensation for a program that imposes a loss and for the WTP for a program that eliminates a loss also replicate Equation 5 and can be interpreted by similar adjustments of the language.

Alternative Forms of Other-Regarding Preferences

Similar approaches can be followed to analyze the optimal bidding strategy of voters who have different forms of social preferences. Of interest are three other specifications of the utility function currently debated in the literature. They are the Maximin utility (Charness and Rabin, 2002) (MM), a version of Bolton and Ockenfels (2000) (ERC) theory of equity, and Fehr and Schmidt (1999) (FS) inequity aversion preferences. For empirical reasons discussed later, we also produce behavioral predictions for a model where players care simultaneously about social efficiency of the program and the welfare of the poorest player (i.e. Maximin preferences).

Perhaps the most intuitive approach to understanding the results of Table 1 is to focus immediately on summary of predictions presented in the last column. First, regardless of the type of preferences postulated, and whether one is interested in gains or losses, in WTA, or in WTP; the predicted bid when all payoffs are equal (homogenous distribution) is $B_i^* = \pi_i$. In contrast, heterogeneous distributions will have varied effects under alternative preferences. To review these effects, consider as an example the vector Π=(2, 5, 8).

B.1 Maximin

With Maximin preferences, utility depends on one's own payoff as well as on the potential gains (losses) of the individual who stands to gain the least (lose the most) from implementing the program. Denoting the payoff for this "worst off" player by π_w, we write the social component into the utility function by adding the term $+\alpha_i\left(\pi_w - C\right)$ to player *i*'s own earnings. In WTP cases, the person who potentially gains the least (loses the most), is the one

with the smallest induced value ($\pi_w = \$2$ in our example). This is true regardless of whether the WTP is for a gain or to avoid a loss. The prediction is that the worst of person will bid exactly \$2, while the others will bid less than induced value in order to reduce the probability that a net loss will be imposed on the \$2 individual.

In WTA scenarios, the individual with the highest absolute payoff value (\$8) is the worst off and the prediction is that those with lower values will set $B_i^* > \pi_i$ to reduce the probability of imposing costs on the \$8 individual.

B.2 ERC Equity Preferences

With ERC preferences (Bolton and Ockenfel, 2000), individual inequity aversion manifests itself as disutility when the individual's payoff differs from the mean group payoff. The social component of utility assumed here is $-\alpha_i \left| (\pi_i - C) - \frac{1}{N}\sum_{j=1}^{N}(\pi_j - C) \right|$ (written for a WTP gains context). Those with a payoff exactly equal to the mean will continue to optimally bid $B_i^* = \pi_i$. However, others will behave differently. In the gains domain, individuals will be willing to pay less than their private value for a program that provides additional income, and will require a smaller amount of compensation to forego such gains. This happens because the program creates inequities that reduce the individual's utility and offset part of his own payoff. The opposite behavior should be observed in the loss domain. Individuals will require more than their private value in compensation in order to accept a loss that creates inequities, and be willing to pay more to avoid such losses.

B.3 FS Inequality Aversion Preferences

FS preferences (Fehr and Schmidt, 1999) differ from ERC preferences in two aspects. First, the aversion to inequity comes from a direct comparison of one's payoff with that of other

individuals (rather than with the mean). Second, FS preferences allow for different valuations of positive and negative differences between individual payoffs. The function we employ is $-\frac{\alpha_i}{N-1}\sum_{j\neq i} Max\left[(\pi_j - C)-(\pi_i - C),0\right]-\frac{\beta_i}{N-1}\sum_{j\neq i} Max\left[(\pi_i - C)-(\pi_j - C),0\right]$. Fehr and Schmidt postulate that individuals are less affected by differences in their favor than by situations where they are the poor party in the comparison ($\alpha_i \geq \beta_i$). Practically, this implies that all individuals (even those with a payoff equal to the mean) get disutility from a heterogeneous distribution. It follows that all individuals in any game with heterogeneous distributions will be willing to pay less than their induced value for gains and willing to accept less than induced value to forego a gain. By the same logic, all individuals will be willing to pay more than induced value to avoid group losses that generate inequities and require greater compensation to accept them.

B.4 Combining Social Efficiency (Pure Altruism) and Maximin Preferences

As Charness and Rabin (2002) postulated in their work, it is possible that individuals may have preferences that simultaneously reflect a concern for both social efficiency and care for those who stand to gain least or lose most from the implementation of a program. Because we will be estimating this model in the empirical section of the paper, we introduce it here and in Table 1. The combined components of social concerns are given by $+\alpha_i \sum_{j\neq i}(\pi_j - C)+\beta_i\left(\pi_w - C\right)$. While we still obtain that individuals in groups of one or facing homogeneous distributions optimally bid their induced values, combining these two types of preferences modifies the behavioral predictions in interesting ways.

The worst off player in heterogeneous distributions (the lowest absolute induced value in WTP and largest in WTA) (qualitatively) abandon their Maximin bid because they now care

about the fate of others whose welfare could be improved by the program. Thus, the worst off player in WTP games increases his bid above π_w and decreases it in WTA games.

A player with a payoff equal to the mean of the distribution on the other hand, would now definitely behave like a Maximin. The pure social efficiency model left this player equally affected by the payoffs to the best off or worst off individuals. This ambivalence is shattered in favor of the worst off individual who now has greater weight on the average player's utility. For individuals at or above average payoff, the concerns for efficiency and the worst off individual both push the bid in the direction of π_w. However, for individuals with induced values between π_w and the average payoff of the distribution, the two sources of utility are actually in conflict and weight in opposite direction. On the one hand, concern for the worst off pulls the optimal bid toward π_w to minimize potential losses for that player. Efficiency, on the other hand, calls for moving one's bid away from own payoff and in the direction of the average payoff. This implies a fixed point between π_w and the average payoff where bid is equal to private payoff.

III. Experimental Design

To test the theories outlined above, 276 participants were recruited from a variety of undergraduate business and economics courses at Cornell University. Each session consisted of either two WTP experiments: WTP-Gains and WTP-Losses (n=138) or two WTA experiments: WTA-Gains and WTP-Losses (n=138), representing all four welfare settings. All sessions consisted of four parts; an example session is as follows:

Part A: WTP-Losses, low-incentive practice rounds using the RPVM in a private setting where the cost and payoffs were determined for each round.

Part B: WTP-Losses, high-incentive private and public RPVM treatments where the treatment and cost which resulted in earnings were determined for one randomly selected treatment at the end of the experiment.

Part C: WTP-Gains, low-incentive practice rounds using the RPVM in a private setting where the cost and payoffs were determined for each round.

Part D: WTP-Gains, high-incentive private and public RPVM treatments where the treatment and cost which resulted in earnings were determined for one randomly selected treatment at the end of the experiment.

To control for potential order effects, the order of parts was varied across sessions switching between ABCD and CDAB as described above. Further, Part B and Part D varied the order of the treatments with respect to the amount of the induced values, voting group size, and the distribution of values among group members. In public RPVM treatments, subjects were provided complete information about the payoff amounts of the other subjects. To prevent order effects from potentially deteriorating social preference behavior as is common in repeated voluntary contribution games (Davis and Holt, 1993), subjects submitted bids for the treatments in Part B and Part D without feedback. At the end of the experiment one of the nine RPVM programs was implemented from both Part B and Part D by having the subjects draw from a bag of marked poker chips. The exchange rate for Part A and Part C was fifteen experimental dollars for one US dollar, while the exchange rate for Part B and Part D was one experimental dollar for one US dollar. The experiment lasted approximately one and one-half hours and the average payoff was $35.

Subjects received written instructions (see the example for WTP-Gains in Appendix A) and were permitted to ask questions at the beginning of each part of the experiment. The

instructions used language parallel to that found in public referenda. The WTP instructions directed each subject to *vote* whether to *fund* a *program* by submitting a *bid* that represented the "highest amount that you would pay and still vote for the program." The WTA instructions directed each subject to *vote* whether to *implement* a program by submitting an *offer* that represents the "lowest amount of compensation that you would accept and still vote against the program." Each subject was seated at an individual computer equipped with a privacy shield. Subjects were assigned into voting groups of varying size of either one or three. For the groups of three, the administrators announced the groups and asked each group member to raise their hand so that they could be identified by other members of their group. This ensured that subjects were aware of who was in their voting group for all treatments. No communication was allowed.

For simplicity, consider the WTP-Gains experiment. In each treatment, subjects started with an initial balance of $10 and were assigned an induced value ($1, $2, $4, $5, $6, $8 or $9). Subjects then decided how much to bid ranging from zero to the entire initial balance. After the subjects submitted their bids, the cost for the program was determined by using a random numbers table with values from zero to nine. The first random number from the table represented the dollars amount, the second number the dimes amount, and the third number the pennies amount. For example, if the first random number was a four, the second was a nine, and the third was a four, the determined cost would have been $4.94. Consequently, the cost was uniformly distributed between $0.00 and $9.99 with discrete intervals of $0.01.

Treatments consisted of groups of three or one participant where treatments with group size of one were identical to the private good BDM as each subject's bid constitutes a majority. In WTP-Gain treatments, if the majority of the bids were *greater than or equal to* the randomly determined cost, then the program was funded. In this case, all of the subjects in the voting group

received their personal payoff amount in addition to the initial balance, but also had to pay the determined cost. If the majority of bids were *less than* the randomly determined cost, then the program was not funded. In this case, all of the subjects in the voting group neither received their personal payoff amount nor paid the cost, and thus, the subjects received only their initial balance.

For all welfare settings, the majority of the public good treatments with heterogeneous values were conducted with a symmetric distribution, i.e. ($2,$5,$8) (93 subjects for WTP; 93 for WTA). In addition, to help identify the parameters of the alternative social welfare bid functions, sessions were conducted that had heterogeneous values with asymmetric distributions, i.e. ($4,$5,$9) and ($1,$5,$6) (45 subjects for WTP; 45 subjects for WTA). For the WTP experiments, in the private good treatments, a subject's optimal strategy was to either submit a bid equal to her induced value or one penny less, due to discrete costs. For the voting groups of three, the majority rule introduced a coercive tax element, because if a majority of the group submitted bids *greater than or equal to* the randomly determined price, then everyone had to pay the price regardless of their individual bids.

For the WTP-Losses experiments if a majority of the bids was *less than* the random cost, the program was *not funded*. Consequently, all group members have their personal loss amount deducted from their initial balance of $10. If the majority of bids were *greater than or equal to* the determined cost, the program was funded and all voting group members had to pay the determined cost from their initial balance of $10 but did not have the personal loss amount deduced. For WTP-Losses, the same logic holds as the majority rule could force a low value subject to pay a higher cost then their induced value and the high value subject may be denied the opportunity of paying a cost lower than their induced value. The logic of how the vote creates

a coercive tax element for both the induced gains and induced losses treatments is identical in the WTA-Gains and WTA-Losses experiments.

For the WTA experiments, subjects submitted *offers* that represented the lowest amount of compensation they would accept where the optimal offers were either the induced value or one penny above it. The induced gains and losses were the same as the WTP setting and the possible compensation again ranged from $0.00 to $9.99. To avoid income effects, the initial balance was $5 which made the expected earnings in the WTA setting equivalent to the WTP setting. In WTA-Gains, an offer was the lowest amount a subject would accept to vote *against* the program which otherwise would provided the subject a gain. If the majority of the offers were *less than or equal to* the random compensation, then the program was not implemented and all voting group members received the compensation in addition to their initial balance. If the majority of the offers were *greater than* the random compensation, the program was implemented and the group members received their personal payoff amount in addition to their initial balance.

In contrast, in WTA-Losses, an offer represented the lowest amount a subject would accept to vote *in favor* of the program, which forced the subject to pay the induced loss if funded. Therefore, if the majority of offers were *less than or equal to* the random compensation, the program was implemented and all group members received the compensation and the initial balance but had to pay their induced losses. If the majority of the offers were *greater than* the random compensation, the program was not implemented and all group members kept their initial balance.

IV. Results

Similar to other studies using the BDM mechanism (Boyce et al. 1992; Irwin et al. 1998), the goal of the initial low-incentive practice rounds was to give subjects an opportunity to gain experience with the mechanism before introducing additional complexities to the decision environment. Repeated low incentive private rounds provided subjects an opportunity to receive feedback on how their bids and offers affected their payoff. Over ten practice rounds, subjects' bids/offers converged towards induced value, starting at $0.69 above induced value in the first round and declining by 70% to only $0.21 above induced value in the tenth round. By the last practice round subjects' offers/bids were statistically indistinguishable from their induced values in all four welfare settings (One Sample T-test).

The RPVM experiments yield 76 unique (high incentive) treatments, where a treatment is defined by a specific welfare setting (e.g. WTP-gains), the subject's induced value, and the distribution of other players' values. To facilitate comparisons between bidding behavior and induced values, we pool the data from all treatments and regress individual bids on 76 indicator variables to produce estimates of the average bid in each treatment. As each individual produces multiple observations, we estimate robust standard errors adjusted for clustering at the individual level. Given all decisions from the individual are made without feedback, no controls for learning behavior are required. Tables 2 and 3 present the treatment-specific mean bids for the gains and loss settings, respectively, for both WTP and WTA. Estimates that are statistically different than induced value at the 5% level are italicized. Inspection of these results suggests that behavior does not appear to exhibit WTP/WTA discrepancies.

Bidding behavior for the heterogeneous value treatments suggests that social preferences do play a role. Whereas mean bids are statistically equal to value in 39 of the 40 treatments

involving private good or homogeneous value settings, there are many instances in heterogeneous treatments where mean bids are statistically different than induced value. Overall, as illustrated in Figure 1, low-value subjects tend to bid above value and high-value subjects to bid below value. As can be seen in the cumulative distributions in Figure 2, subjects' bids/offers in the heterogeneous value treatments systemically deviated from their bids/offers in either the private treatments or the public homogeneous value treatments.

As can be seen by inspecting Tables 2 and 3, in seven out of the eight treatments where the lowest-value subject has an induced value more than a dollar less than the middle-value subject (subjects with induced gains and losses of $1 and $2), subjects significantly raise their WTP/WTA relative to the induced value. Likewise, when the highest-value subjects had an induced value that was more than a dollar higher than the middle-value subject ($8 and $9 values), subjects significantly lowered their WTP/WTA in seven of the eight treatments. When the low-value (high-value) subject has a value close to the middle-value subject, statistical differences between bids and induced values are not generally observed.

There is not a systematic divergence from induced values for middle-value ($5) subjects. Symmetric distributions produce bids that are roughly equal with value, although in one of four cases there is a statistical difference. In asymmetric distribution treatments, there is a weak tendency for middle-value subjects to bid below value when their value is above average (i.e. the $1, $5, $6 distribution) and a weak tendency to bid average value when their value is below average (i.e. the $4, $5, $9 distribution).

Finally, we investigate the extent to which the social welfare theories discussed in Section 3 are consistent with observed bidding behavior using data from public good treatments. In particular, we estimate the unknown parameters (i.e. α and β) of the theory-specific optimal

bid functions. Estimated parameters that are statistically different than zero, with the correct sign, provide evidence that a particular theory has the ability to organize the data. Further, estimated parameters shed light on the relative importance of social versus selfish preferences on bidding behavior.

Consistent with our previous framework, we use a linear regression approach to estimate unknown parameters; to allow for heteroscedasticity and the correlation of individual-level responses, we estimate robust standard errors adjusted for clustering at the subject level. The bid function parameters for the two equity models are directly estimable (imposing the constraint that the coefficient on π_i equals one). However, the bid functions for the Social Efficiency, Maximin, and the combined Efficiency-Maximin theory are nonlinear in the unknown parameter(s). This does not preclude linear regression as the bid functions can be re-written as linear in unknown parameters and our estimates of interest recovered from these in a straightforward fashion. For example, we can express the Maximin bid function as:

$$B_i = \delta_1 \pi_i + \delta_2 \pi_w \tag{8}$$

where $\delta_1 = 1/(1+\alpha_i)$ and $\delta_2 = \alpha_i/(1+\alpha_i)$. The parameter α_i is overidentified. It can be easily shown that $\delta_2 = 1 - \delta_1$, and we can impose this restriction directly into the model to resolve the identification issue. The restricted model is:

$$B_i - \pi_w = \delta_1(\pi_i - \pi_w) \tag{9}$$

With an estimate of δ_1 in hand, an estimate of α_i and its standard error can be obtained using the delta-method. In a similar vein, exactly identified specifications that correspond to the Efficiency and Efficiency-Maximin theories can be constructed.

Unfortunately, it is not possible to estimate individual-specific coefficients from our design. We instead constrain the unknown parameters to be equal across individuals, and what we estimate are best thought of as bid functions for the representative individual in the sample. Further, for estimation purposes we include an error term and an overall model constant. Although the theoretical bid functions do not imply a constant term, whether or not one should be included is essentially an empirical question. If the mean of the error term is not zero, for instance, omitting the constant term would serve to distort coefficient estimates.

Table 4 presents bid functions, estimated by pooling the entire sample as well as estimated separately for the WTP and WTA treatments. Pooling WTP (WTA) gains and loss data is justified by statistical tests, and data from all welfare settings can be justifiably pooled for all but the Maximin specification. The two equity-based specifications are not supported by the data. The parameter of the ERC model is not statistically different than zero and has the incorrect sign. The two parameters of the FS model are statistically different than zero. However, the result $\alpha < 0$ is inconsistent with the theory. In particular, it suggests that individuals bid to *increase* disadvantageous inequality (i.e. reduce equality).

Consistent with the respective theories, the estimated parameter for both the Social Efficiency and Maximin model is positive and statistically different from zero at the 1% level. The estimate of $\alpha = 0.057$ in the WTP Efficiency model implies that the weights on self-interest, $1/(1+2\alpha)$, and efficiency, $\alpha/(1+2\alpha)$, are equal to 0.90 and 0.05, respectively. This suggests that if own payoff from a program increases by \$1, ceteris paribus, the average individual increases his bid by \$0.90. If the program payoff to another group member increases by \$1, ceteris paribus, an individual increases his bid by \$0.05. This suggests an individual is willing to give up \$0.05 in order to give a \$1 to someone else. In a similar vein, the WTP

Maximin model implies that an individual, ceteris paribus, increases his bid by \$0.92 for a \$1 increase in own payoff and by \$0.08 for a \$1 increase in the payoff to the worst-off group member.

The empirical support of both the Social Efficiency and Maximin theories motivated an examination of whether a model that accounts for both motives (along with self-interest) would be a better depiction of observed behavior, and is the reason we considered such a theory in Section 3. However, the estimated parameters of this Efficiency-Maximin model lend support for a Social Efficiency-only model. In particular, we find that $\alpha > 0$ and $\beta = 0$. This suggests that efficiency is a statistically significant motive and, once efficiency preferences are controlled for, Maximin preferences explain little about bidding behavior. Thus, the combined theory model essentially breaks down to a pure social efficiency model and, if anything, the inclusion of Maximin preferences simply serves to add noise to the relationship between efficiency and bidding behavior.

A casual comparison between theoretical predictions and simple tests of mean bid against induced value provides further evidence that Maximin preferences, if present, are not the main driving force. For instance, in the heterogeneous treatments with a symmetric distribution one would expect that both middle- and high-value respondents would bid below value to help the worst-off individual. However, middle-value respondents tended to bid equal to value. Further, we should see worst-off individuals bidding at value, but it is clear that these individuals have concerns for the persons who are better off. In sum, while some evidence exists that Maximin considerations may drive observed bidding behavior, preferences for efficiency seem most consistent with the data and explain a wider range of observed bidding patterns.

V. Conclusion

The evidence presented in this paper suggests that the public good version of the BDM mechanism, which involves submitting a bid/offer as a vote in a coercive tax setting, is demand revealing both for induced values and for social preferences. In addition, no WTP/WTA discrepancies are evident for the induced values used in these experiments or for revealed social preferences. However, the result that participants with high induced gains (low induced gains) tend to understate (overstate) their WTP and WTA relative to the induced value (this pattern is mirrored in the induced loss treatments) is most succinctly explained by social concerns for efficiency (or, similarly, pure altruism).

Equity or relative rank concerns do not seem to add much explanatory power in this setting utilizing induced values and undergraduate business/economics majors. These results are consistent with evidence presented by Charness and Rabin (2002) for efficiency preferences but not with the evidence they provide for equity preferences. The results presented here are entirely consistent with those of Engelmann and Strobel (2004). Both of these studies use student subjects. It also should be noted that our findings are consistent with a conjecture made by Johannesson *et al*. (1996) based on hypothetical voting among randomly chosen survey participants. These results are somewhat surprising, in that several studies (Engelmann and Strobel, 2006, Fehr, Naef, and Schmidt, forthcoming) have shown that non-business/economics students or adult participants are more likely to show concerns for equity than undergraduate business/economics majors. It is possible that the context of voting itself favors efficiency preferences over equity preferences. In contrast, other contextual settings, such as dictator games, may make equity much more salient both to business/economics student participants and others.

The experiments presented in this paper represent a first step from which a number of issues can be examined further. Extensions of the RPVM include changes in voting group size when values are heterogeneously distributed, changes in the distributions of the heterogeneous treatments, multiple-round voting using heterogeneous distributions, the use of a variety of actual public goods, field application of the mechanism in situations where costs are unknown and the application of the mechanism to examine how various behavioral anomalies respond to different public good settings. Of particular importance is the impact of increasing both stakes and group size. It is trivial to show that efficiency preferences will decrease the probability of inefficient programs being funded. Consider a referendum on a program which has negative total net benefits but, because of heterogeneous benefits, the median voter has her own selfish benefit slightly greater than cost. If she has efficiency concerns similar to those found in a number of studies she will take into account that the sum of the net benefits to others is negative and weight those in her decision along with her own selfish net benefit. With a sufficiently large number of other voters, the effect of negative net benefits could easily outweigh her own positive net benefit and result in a vote against the program. Thus, the presence of preferences for efficiency raises the possibility that voting may be more efficient than is commonly supposed.

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APPENDIX A – RANDOM PRICE VOTING MECHANISM INSTRUCTIONS (WPT-GAINS)

Part A – Low-Incentive Private Practice Rounds

This is an experiment in the economics of decision making. In the course of the experiment, you will have opportunities to earn money. Any money earned during this experiment is yours to keep. It is therefore important that you read these instructions carefully. Please do not communicate with other participants during the experiment.

In today's experiment, you will be asked to indicate the highest amount of money you would pay and still vote for different programs. In this experiment, a *program* is simply a distribution of money. As you will see, the amount that you indicate as the highest amount that you would pay for the program will become a vote in favor or against the program, and will determine whether or not the program is funded. It is therefore important that you consider all of the information given to you about the different programs and that you make judicious decisions. The procedures that will be followed are the same for all programs. However, each program and vote is independent from the other. Therefore, the decisions you make and the result of a vote for one program will not affect the results for other programs.

For each program, the experiment proceeds as follows:

First, you will receive an initial balance of $10.00.

You will then be informed of your "personal payoff amount" for this program. Your personal payoff amount is the amount of money that you will receive if the program is funded. Your personal payoff amount will vary during the course of the course of the experiment. The possible amounts are $2.00, $5.00, and $8.00.

You will then be asked to write down the highest amount that you would pay and still vote for this program; we will call this your "bid". For each program, you can bid any amount between $0.00 and your initial balance of $10.00. Once you have decided your bid, you will write it on a Voting Sheet and enter it into the computer spreadsheet. We will then collect the Voting Sheets and determine the cost of the program.

The cost of the program will be determined by reading off three numbers from a random number table. The starting number will be determined by dropping a pen onto the random number table. (If more than one mark occurs from the drop, then the one closest to the upper-left corner will be used.) The numbers will be read from left to right on the table. The first number will represent the dollar amount. The second number will represent the dime amount. The third number will represent the penny amount. Together, the three numbers will form a cost between $0.00 and $9.99. Note: since these numbers have been generated by a random number table each cost between $0.00 and $9.99 is equally likely. Once the cost has been determined, you will be asked to enter it into the spreadsheet on your computer.

Whether or not the program is funded depends on the amount of your bid and the cost of the program. There two possible outcomes:

The program is NOT FUNDED: The program is not funded if your bid is *less than* the cost determined from the random number table. In this case, you will not receive your personal payoff amount and you will not have to pay the cost. Therefore, your earnings for this portion of the experiment would simply be your initial balance of $10.00.

The program is FUNDED: The program is funded if your bid is *equal to or greater than* the cost determined from the random number table. In this case, you will receive your personal payoff amount in addition to your initial balance. However, you will also have to pay the determined cost. Therefore, your cash earnings for this portion of the experiment would be your initial balance ($10.00), plus your personal payoff amount, minus the cost.

Note how your bid is like a vote for or against funding the program. With your bid, you are writing down the highest amount you would pay and still vote for the program. Therefore, your bid is like a vote in favor of the program if you are prepared to pay an amount equal to or greater than the randomly determined cost. On the other hand, your bid is like a vote against the program if your bid turns out to be less than the cost. Since you are the only voter, your bid will determine whether the program is funded or not.

While your bid helps determine whether the program is funded or not, your earnings for a particular program are based on your initial balance, your personal payoff amount and the determined cost. For example, if a program was *not funded* and your personal payoff was $5.00 and the determined cost was $9.00, your earnings would be $10.00. However, if the program was *funded* with the same personal payoff and cost, your earnings would be only $6.00 ($10 + $5 - $9). Consider another example where your personal payoff was $5.00 and the determined cost was $2.00. In this example if the program was *funded* your earnings would be $13.00 ($10 + $5 - $2), while if the program was *not funded*, your earnings would be only $10.00.

Calculation of Your Earnings

Once you enter the cost of the program determined from the random number table, the computer will automatically determine whether the program was funded and calculate your earnings. At the end of the experiment, the computer will add your experimental earnings for all of the programs, and convert this amount to US dollars by applying an exchange rate of one US dollar for twenty experimental dollars. For example, if you earn $232.45 experimental dollars, your monetary payoff from this part of the experiment would be $11.62. At the end of the experiment, we will audit all of the spreadsheets to ensure accuracy.

It is important that you clearly understand these instructions.
Please raise your hand if you have any questions.
Please do not talk with other participants in the experiment.

Part II – High Incentive Private and Public Treatments

For the second part of this experiment, you will now be asked to indicate how much you would pay for each of 12 separate programs. The procedures are similar to the ones used in the first part of the experiment, except for four important differences.

1) For each of the programs, you may be the only voter (as in the first part of the experiment), but you may also be part of a group of 3 or 15 voters. For programs where the group size is 3 or 15, the payoff amounts that the other voters in your group would receive if the program is funded are indicated on your Voting Sheet.

2) Only one of the 12 programs will actually be implemented and result in cash earnings. Therefore, all votes will be made prior to determination of any costs. After the Voting Sheets are collected, we will randomly determine which of the programs will generate cash earnings by drawing from a bag containing 12 chips lettered A through L. Each letter corresponds to one of the 12 programs.

3) For the program that generates cash earnings, the exchange rate will be one US dollar for one experimental dollar. For example, if you earn $12.25 experimental dollars in the second part of the experiment, your monetary payoff would be $12.25.

4) Again, you must decide the highest amount that you would pay and still vote for the program. However, now you will be part of a group. Therefore, in determining your bid you may want to consider how your bid will impact others in your group.

For each program, the experiment proceeds as follows:

You and every other member of your group will receive an initial balance of $10.00.

For each program, your personal payoff amount may be $2.00, $5.00, or $8.00. Other participants will also receive one of these three payoff amounts.

For each program, you will be asked to write your bid on the Voting Sheet provided and enter the same amount into the second spreadsheet on the computer. Consider all of the information for the program before writing down your bid. For each program, you can bid any amount between $0.00 and your initial balance of $10.00.

Once everyone has written down his/her bid and entered the bid into the computer, we will collect the Voting Sheets and distribute the new Voting Sheets for the next program. After bids for all the programs have been entered and Voting Sheets collected, we will determine which of the programs will be implemented and produce cash earnings.

Next, we will determine the cost of the program to be implemented and whether or not it will be funded by your group. The cost of the program will be determined in exactly the same manner as before, except that a new random number table will be used. However, this cost will now be a cost that each person in your group will have to pay if the program is funded. Each person will have to pay the same amount.

Whether or not the program is funded depends on the bids by members of your group and the cost of the program. Once again, there are two possible outcomes:

The program is NOT FUNDED: The program is not funded if a majority of bids from your group are *less than* the cost determined from the random number table. In this case, neither you nor any other member of your group will receive a personal payoff amount and no one will pay the cost. Therefore, your cash earnings for this part of the experiment would simply be your initial balance of $10.00.

The program is FUNDED: The program is funded if a majority of bids from your group are *equal to or greater than* the cost determined from the random number table. In this case, you will receive your personal payoff amount in addition to your initial balance. However, you will also have to pay the randomly determined cost. Every other member of your group will also receive their personal payoff amount and they will also have to pay the determined cost. Therefore, your cash earnings would be your initial balance ($10.00), plus your personal payoff amount, minus the cost.

The programs, in which you are a group of one, are identical to the programs you experienced in the first part of the experiment. Therefore, the program is not funded if your bid is *less* than the cost determined from the random number table, and program is funded if your bid is *equal to or greater* than the determined cost.

Note once again how your bid is like a vote for or against funding the program. With your bid, you are writing down the highest amount you would pay and still vote for the program. Therefore, your bid is like a vote in favor of the program if you are prepared to pay an amount equal or greater than the randomly determined cost. On the other hand, your bid is like a vote against the program if it turns out to be less than the cost. When a majority of bids are equal to or greater than the determined cost, this translates into a majority vote in favor of the program. Similarly, a majority of bids below the cost translates into a majority vote against the program at that cost.

Calculation of Final Earnings

To calculate your earnings from Part B, you will be asked to enter into the spreadsheet the cost for the implemented program and whether this program was funded. Your computer will then calculate your earnings for Part B, add them to your earnings from Part A, and award you an additional $5 show up fee. We will audit the spreadsheets to ensure accuracy.

It is important that you clearly understand these instructions.
Please raise your hand if you have any questions.
Please do not talk with other participants in the experiment.

Table 1. Optimal Bidding Strategy and Behavioral Predictions for Alternative Social Preferences Illustrated for a ($2,$5,$8) Distribution

	Optimal Bid				Summary of Predictions
	WTP GAINS	WTP LOSSES	WTA LOSSES	WTA GAINS	
Social Efficiency (Pure Altruism)	$\frac{\pi_i + \sum_{j\neq i} \alpha_i \pi_j}{1+(N-1)\alpha_i}$ 2:>2; 5:=5 8:<8	$\frac{\pi_i + \sum_{j\neq i} \alpha_i \pi_j}{1+(N-1)\alpha_i}$ 2:>2; 5:=5 8:<8	$\frac{\pi_i + \sum_{j\neq i} \alpha_i \pi_j}{1+(N-1)\alpha_i}$ 2:>2; 5:=5 8:<8	$\frac{\pi_i + \sum_{j\neq i} \alpha_i \pi_j}{1+(N-1)\alpha_i}$ 2:>2; 5:=5 8:<8	N=1 or Homo $\Rightarrow B_i^* = \pi_i$ Heterogeneous Mean π: $B_i^* = \pi_i$ Lower π: $B_i^* > \pi_i$ Higher π: $B_i^* < \pi_i$
Maximin	$\pi_w = \$2$ $\frac{\pi_i + \alpha_i \pi_w}{1+\alpha_i}$ 2:=2; 5:<5 8:<8	$\pi_w = \$2$ $\frac{\pi_i + \alpha_i \pi_w}{1+\alpha_i}$ 2:=2; 5:<5 8:<8	$\pi_w = \$8$ $\frac{\pi_i + \alpha_i \pi_w}{1+\alpha_i}$ 2:>2; 5:>5 8:=8	$\pi_w = \$8$ $\frac{\pi_i + \alpha_i \pi_w}{1+\alpha_i}$ 2:>2;5:>5 8:=8	N=1 or Homo $\Rightarrow B_i^* = \pi_i$ Heterogeneous $\pi_w \Rightarrow B_i^* = \pi_i$ If $\pi_i > \pi_w \Rightarrow B_i^* < \pi_i$ (WTP) If $\pi_i < \pi_w \Rightarrow B_i^* > \pi_i$ (WTA)
ERC Equity	$\pi_i - \alpha_i \left\lvert \pi_i - \sum_{j=1}^{N} \frac{\pi_j}{N} \right\rvert$ 2:<2; 5:=5 8:<8	$\pi_i + \alpha_i \left\lvert \pi_i - \sum_{j=1}^{N} \frac{\pi_j}{N} \right\rvert$ 2:>2; 5:=5 8:>8	$\pi_i + \alpha_i \left\lvert \pi_i - \sum_{j=1}^{N} \frac{\pi_j}{N} \right\rvert$ 2:>2; 5:=5 8:>8	$\pi_i - \alpha_i \left\lvert \pi_i - \sum_{j=1}^{N} \frac{\pi_j}{N} \right\rvert$ 2:<2; 5:=5 8:<8	N=1 or Homo $\Rightarrow B_i^* = \pi_i$ Heterogeneous Mean π: $B_i^* = \pi_i$ Others: $B_i^* < \pi_i$ (Gains) $B_i^* > \pi_i$ (Losses)
FS Equity	$\pi_i - \frac{\alpha_i}{N-1}\sum_{j\neq i} Max\left[(\pi_j - \pi_i, 0\right]$ $-\frac{\beta_i}{N-1}\sum_{j\neq i} Max\left[(\pi_i - \pi_j, 0\right]$ 2:<2; 5:<5 8:<8	$\pi_i + \frac{\alpha_i}{N-1}\sum_{j\neq i} Max\left[\pi_i - \pi_j, 0\right]$ $+\frac{\beta_i}{N-1}\sum_{j\neq i} Max\left[\pi_j - \pi_i, 0\right]$ 2:>2; 5:>5 8:>8	$\pi_i + \frac{\alpha_i}{N-1}\sum_{j\neq i} Max\left[\pi_i - \pi_j, 0\right]$ $+\frac{\beta_i}{N-1}\sum_{j\neq i} Max\left[\pi_j - \pi_i, 0\right]$ 2:>2; 5:>5 8:>8	$\pi_i - \frac{\alpha_i}{N-1}\sum_{j\neq i} Max\left[(\pi_j - \pi_i, 0\right]$ $-\frac{\beta_i}{N-1}\sum_{j\neq i} Max\left[(\pi_i - \pi_j, 0\right]$ 2:<2; 5:<5 8:<8	N=1 or Homo $\Rightarrow B_i^* = \pi_i$ Heterogeneous $B_i^* < \pi_i$ (Gains) $B_i^* > \pi_i$ (Losses)
Efficiency and Maximin	$\frac{\pi_i + \alpha_i \sum_{j\neq i} \pi_j + \beta_i \pi_W}{1+(N-1)\alpha_i + \beta_i}$ 2:>2; 5:<5 8:<8	$\frac{\pi_i + \alpha_i \sum_{j\neq i} \pi_j + \beta_i \pi_W}{1+(N-1)\alpha_i + \beta_i}$ 2:>2; 5:<5 8:<8	$\frac{\pi_i + \alpha_i \sum_{j\neq i} \pi_j + \beta_i \pi_W}{1+(N-1)\alpha_i + \beta_i}$ 2:>2; 5:>5 8:<8	$\frac{\pi_i + \alpha_i \sum_{j\neq i} \pi_j + \beta_i \pi_W}{1+(N-1)\alpha_i + \beta_i}$ 2:>2; 5:>5 8:<8	N=1 or Homo $\Rightarrow B_i^* = \pi_i$ Hetero: <u>WTP</u> <u>WTA</u> π_w $B_i^* > \pi_w$ $B_i^* < \pi_w$ Mean π: $B_i^* < \pi_i$ $B_i^* > \pi_i$ Better off π: $B_i^* < \pi_i$ $B_i^* > \pi_i$

Table 2. Random Price Voting Mechanism Experiment Results, Induced Gains.

	Private[a]		***Homogeneous***[b]			***Heterogeneous***[c]		
Value	**WTP**	**WTA**	**Others**	**WTP**	**WTA**	**Others**	**WTP**	**WTA**
$1			**$1, $1**	$1.25	$1.28	**$5, $6**	*$1.40*	*$1.91*
$2	$2.10	$1.96	**$2, $2**	$2.06	$2.06	**$5, $8**	*$2.64*	*$2.47*
$4			**$4, $4**	$4.06	$3.90	**$5, $9**	$4.26	*$4.77*
						$1, $6	$4.95	$4.74
$5	$5.09	$5.12	**$5, $5**	$5.10	$5.03	**$2, $8**	$5.19	$5.06
						$4, $9	$5.31	$5.35
$6			**$6, $6**	$6.08	$6.14	**$1, $5**	$5.90	$5.64
$8	$8.11	$8.15	**$8, $8**	$8.14	$8.18	**$2, $5**	$7.78	*$7.75*
$9			**$9, $9**	$8.75	$8.84	**$4, $5**	*$8.24*	*$8.41*

Note: estimates that are statistically different than induced value at 5% level are italicized.

[a] For both WTP and WTA, n=93.

[b] For both WTP and WTA, n = 138 for the homogeneous distribution of values of $5; n = 93 for the homogeneous distribution of values of $2 and $8; and n = 45 for the homogeneous distribution of values value of $1, $4, $6, and $9.

[c] For both WTP and WTA, n = 93 for the heterogeneous distribution of values of $2, $5, $8 and n = 45 for the heterogeneous distribution of values of $1, $5, $6 and $4, $5, $9.

Table 3. Random Price Voting Mechanism Experiment Results, Induced Losses.

	Private[d]		***Homogeneous***[e]			***Heterogeneous***[f]		
Value	**WTP**	**WTA**	**Others**	**WTP**	**WTA**	**Others**	**WTP**	**WTA**
$1			**$1, $1**	$1.04	$1.07	**$5, $6**	$1.24	*$1.77*
$2	$2.23	$2.06	**$2, $2**	$2.14	$2.11	**$5, $8**	*$2.67*	*$2.54*
$4			**$4, $4**	$3.93	$3.98	**$5, $9**	$4.18	$4.47
						$1, $6	$4.74	*$4.36*
$5	$5.19	*$4.68*	**$5, $5**	$4.98	$4.92	**$2, $8**	*$5.38*	$4.82
						$4, $9	$5.05	$5.67
$6			**$6, $6**	$6.01	$6.26	**$1, $5**	$5.73	*$5.42*
$8	$7.99	$7.91	**$8, $8**	$7.80	$7.94	**$2, $5**	*$7.68*	*$7.29*
$9			**$9, $9**	$8.91	$8.87	**$4, $5**	*$8.30*	*$8.35*

Note: estimates that are statistically different than induced value at 5% level are italicized.

[d] For both WTP and WTA, n=93.

[e] For both WTP and WTA, n = 138 for the homogeneous distribution of values of -$5; n = 93 for the homogeneous distribution of values of $2 and $8; and n = 45 for the homogeneous distribution of values value of $1, $4, $6, and $9.

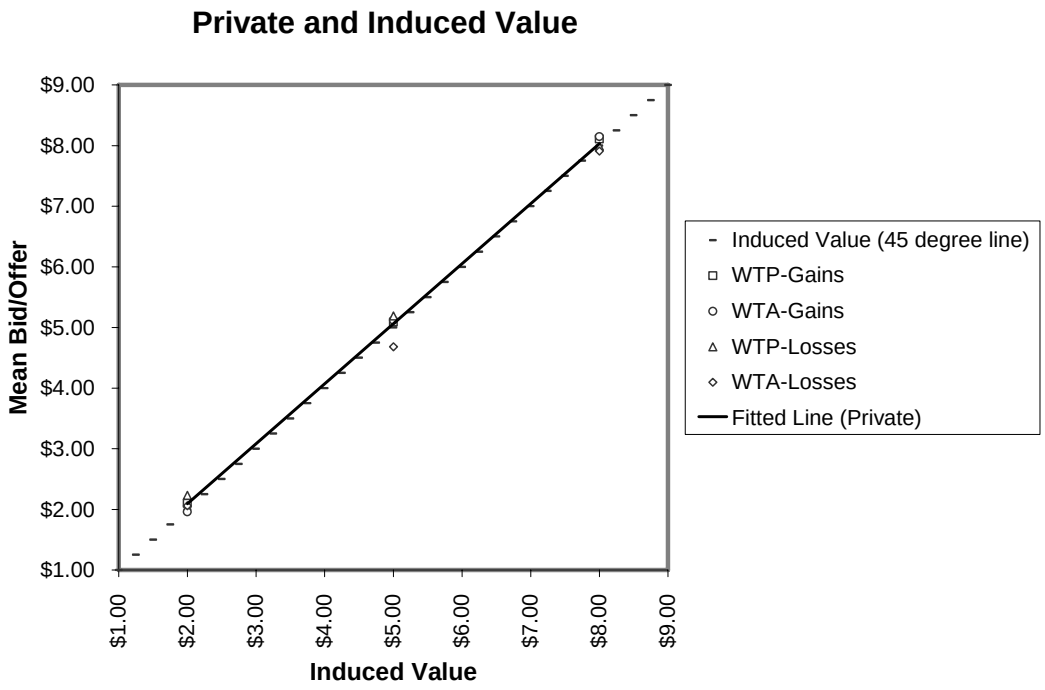
[f] For both WTP and WTA, n = 93 for the heterogeneous distribution of values of $2, $5, $8 and n = 45 for the heterogeneous distribution of values of $1, $5, $6 and $4, $5, $9.

Table 4. Estimated Bid Functions†

	Efficiency	Maximin	ERC	FS	Efficiency and Maximin
			WTP Data, n = 2106		
α	0.057** (0.013)	0.082** (0.023)	-0.013 (0.019)	-0.108** (0.025)	0.069** (0.016)
β	–	–	–	0.097** (0.023)	-0.037 (0.023)
			WTA Data, n = 2106		
α	0.084** (0.017)	0.140** (0.032)	-0.023 (0.021)	-0.164** (0.029)	0.087** (0.019)
β	–	–	–	0.125** (0.028)	-0.009 (0.030)
			WTP & WTA Data, n = 4212		
α	0.070** (0.011)	0.070** (0.018)	-0.018 (0.014)	-0.136** (0.019)	0.076** (0.014)
β	–	–	–	0.111** (0.018)	-0.019 (0.024)

Notes: *, ** denote estimate is statistically different than zero at 5% and 1% level, respectively.
† Pooling the WTP & WTA data is not supported statistically for the Maximin model.
Standard errors in parentheses.

Figure 1. Bids and Offers in Private, Public Homogeneous, and Public Heterogeneously Value Treatments



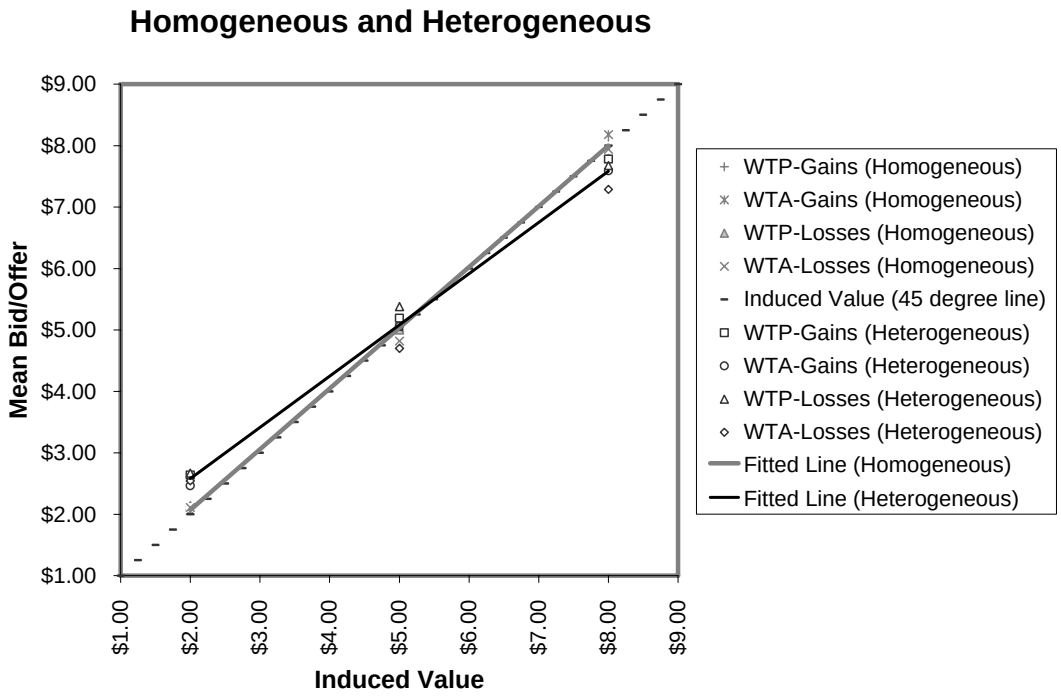
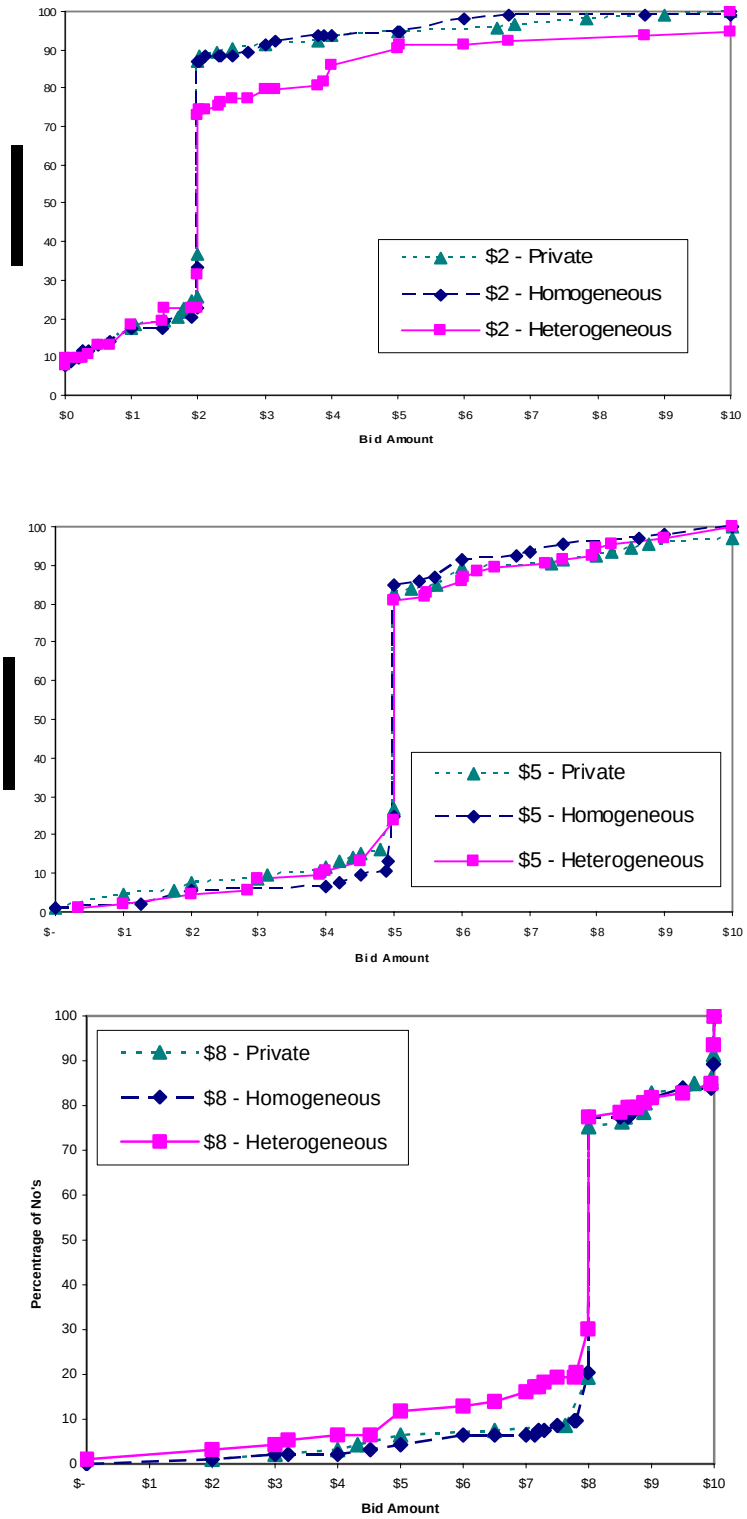


Figure 2. Cumulative Distributions of WTP for Gains
Private, Public Homogeneous, and Public Heterogeneous Treatments[4]



[4] Similar patterns exist for the other three welfare treatments and are available upon request from the authors.