Pure Altruism and the Valuation of Risk: An Experimental Test of the Johannesson et al. Conjecture

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Abstract: Johannesson et al. (1996) conjecture that in a coercive, uniform tax setting like dichotomous choice contingent valuation, willingness to pay for public programs would be affected by altruistic consideration of the costs imposed on others. Using a voting-BDM elicitation mechanism, we demonstrate such valuation patterns in an experimental economics setting.

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1. Introduction

The effects of distributional concerns and other-regarding behavior (ORB) on voting are relatively unknown. Yet majority-voting rules are increasingly used in ballot initiatives (referenda) to determine the provision of public programs that impose disproportionate costs and benefits on individuals. To the extent that individuals exhibit ORB, voting decisions are likely to be influenced by the perceived or actual impact on others. Similarly, pure altruism (i.e. concern about the overall change in another's utility rather than the specific source of utility) is expected to affect respondent decisions in hypothetical discrete choice contingent valuation referenda, Building on a longstanding discussion of the role of altruism in valuation and welfare economics (e.g. Bergstrom, 1982; Jones-Lee, 1991, 1992; Milgrom, 1993), Johannesson et al. (1996) conjecture that

> "Let us assume that [an individual] is willing to pay $t for a ceteris paribus increase in his own safety. His total WTP for a uniform public risk reduction of the same magnitude will fall short of $t if he believes that others are willing to pay less than $t but will still be forced to pay that amount ($t) for the project. This is because other individuals, for whom he cares will experience a lower utility if the program is implemented. In turn, this decrease in the utility of others reduces the pure altruist's WTP for the public safety project" (p. 264)

In essence, stated WTP for those who are made better off (worse off) by the combined risk reduction and uniform tax, incorporates consideration of the negative (positive) impacts on others associated with a coercive, uniform tax.

Johannesson et al. attempt to demonstrate their conjecture using hypothetical dichotomous choice contingent valuation data. To control for the respondent's perception that his/her personal willingness to pay is higher than average -- and hence voting yes for a specific value might impose excessive costs on other -- they adopt what they term a "rough way of handling this complication" (p. 266): asking "a follow-up question, where we inquire whether respondents believe they are willing to pay more or less than the average car owner". Using this indirect approach, Johannesson et al. incorporate a binary variable indicating whether a subject believed their private willingness to pay exceeded the average into an ordered logit random utility models, wherein the ordering is associated with three different levels of payment certainty. In general their results indicate that the coefficient is positive, but is not always significant across models. Nevertheless, they argue that the fact that estimated willingness to pay for a specific private safety improvement exceeds willingness to pay estimates for a public safety measure that provides an equal reduction in risk is consistent with their conceptual framework. Other researchers have instead argues that the existence of such directional inequality may be due to strategic "free-rider" effects in the public good setting(e.g. Jones-Lee et al. 1985)

In this paper we employ experimental economics techniques to directly investigate what we term the "Johannesson et al. conjecture": that voting decisions by pure altruists will be affected by the distribution of gains and losses associated with imposing a uniform tax on others. To do this we employ a Voting-BDM mechanism that theoretically can obtain maximum WTP for both private and public goods. As described in Messer et al. (2004), the Voting-BDM mechanism extends the private good Becker-DeGroot-Marshack (BDM) mechanism (1964) to a public good setting where subjects indicate the highest tax they would accept before voting no and the tax is then drawn randomly. For private goods, it has been shown that the traditional incentive-compatible BDM is a transparent mechanism with demand revealing properties (Irwin et al. 1998). The BDM eliminates the incentives for strategic bidding as subjects only have to pay the randomly determined cost if their bid is greater than or equal to this cost, thereby making the true statement of maximum WTP the optimal strategy.

The Voting-BDM operates in much the same way as the traditional private good BDM mechanism with the exception that, when the number of participants is greater than one, the voting rule provides the incentive for demand revelation. In the Voting-BDM, a majority of the bids greater than the randomly drawn cost determines whether the program is funded. Consequently, treatments with group size of one are identical to the private good BDM as each subject's bid constitutes a majority.

The majority rule introduces a coercive tax element, because if a majority of the group submitted bids *greater than or equal to* the randomly determined cost, then everyone has to pay the cost regardless of their individual bids. This coercive element is highlighted in the heterogeneous treatments where majority rule can force a low expected loss subject to pay a cost that is greater than their value. Likewise, this coercive element could deny a high value subject the benefits that they would have otherwise obtained in a private treatment. This coercive tax feature closely parallels referenda settings.

In the experiments described here, subjects state their WTP for an insurance policy that protects against a probabilistic loss in both a private and public good setting. In conjunction with the voting BDM, this experimental setting enables us to directly test the Johannesson et al. conjecture by comparing a subject's WTP in a private setting to a subject's WTP in a public setting where the expected losses are homogenously and heterogeneously distributed. The paper is organized as follows: Section 2 presents the conceptual foundations and resulting hypotheses; Section 3 presents the experimental design; Section 4 describes the econometric methods and results; and Section 5 provides a summary of our results.

2. Theoretical Foundations

For obvious reasons we closely follow the Johannesson et al. (p. 255-266) conceptual foundations in this paper. Using an alternative approach that builds upon the more recent "social welfare" preferences model of Charness and Rabin (2002), Messer et al (2004) derive symmetric Bayesian Nash equilibria expectations appropriate for the voting-BDM framework. Both methods lead to the same theoretical predictions.

Without loss of generality, Johannesson et al. present a simple situation in which two individuals (i = 1, 2 - wherein 2 represents all other individuals) face two future states of the world with a known loss (L_i) with known probabilities (π_i). Letting one state be the status quo, the expected loss (EL_i) from this risk equals $\pi_i L_i$. It is further assumed that individuals have preferences over their own wealth and those of others. Letting y_i represent wealth, a well-behaved indirect utility function for the individual can be depicted as follows:

$$V_1 = V_1(EL_1, y_1, EL_2, y_2) \tag{1}$$

The function $V_1(.)$ is assumed to be strictly decreasing (increasing) in EL_1 (y_1) and strictly nonincreasing (nondecreasing) in EL_2 (y_2). As Jones-Lee (1992) notes, this utility formulation is sufficiently general to accommodate virtually all the main approaches to the treatment of choice under uncertainty, including, for example, the expected utility approach. For perfectly selfish individuals, note that $\partial V_1(.) / \partial EL_2 = 0$ and $\partial V_1(.) / \partial y_2 = 0$. These relationships will be strictly negative and positive, respectively, if individual 1 is a pure altruist. Although Johannesson et al. use the above framework to distinguish between paternalistic and pure altruism, such a distinction is not needed here because our experimental design only concerns monetary gains and losses. Hence, only pure altruism is germane to our situation and this conceptual framework.

For the private risk case, wherein other individuals do not face a risk and, hence, their utilities remain constant, we arrive at the following monetary measure (p_1) of maximum willingness to pay:

$$V_1(EL_1, y_{10} - p_1, y_2) = V_1(y_{10}) \tag{2}$$

where the subscript i0 indicates the initial conditions for the ith individual. The null hypothesis for private willingness to pay is:

$$H^o{}_1\text{:} \;\; p_i = EL_i \tag{3}$$

with the alternative hypothesis $H^A{}_1$: $p_i < EL_i$ because of loss or risk aversion.

For the public voting case, the maximum willingness to pay via a coercive tax (t_1), provided that everyone else is also required to pay t_1 for the project in question, is:

$$V_1 = V_1(EL_1, y_{10} - t_1, EL_2, y_{20} - t_1) = V_1(y_{10}) \tag{4}$$

This framework allows us to postulate the following null hypotheses for the ith individual.

$$H^{o}{}_{2}: \quad p_i = t_i \qquad \text{if } EL_i = EL_j \quad \forall i, j \tag{5}$$

Following Johannesson et al., if individuals are homogenous in the sense that the ith individual believes that $t_i = t_j \; \forall j$, then the jth individual stays at his/her initial level of utility in both equations (2) and (3). Thus, it must hold that $p_i = t_i$ if the ith individual is a pure altruist and $t_i = t_j$. The alternative hypothesis $H^{A}{}_{2}$ is simply one of inequality and hence a two-tailed hypothesis test is appropriate.

In cases where individuals are not homogeneous, but that the average expected loss equals across the j individuals just equals the ith individual, we adopt the following null hypothesis:

$$H^{o}{}_{3}: \quad p_i = t_i \qquad \text{if } \frac{\sum_{j \neq i} |EL_j|}{n-1} = |EL_i| \tag{6}$$

In essence this is tantamount to adopting a Benthamite, linear in income, expected utility framework in which the utility gains and losses across associated with improvements and decrements in the well-being of others enters equally into an individual's utility function. While it is likely that individuals in real world situations have individual-specific altruism (I care more about the well being of close friends) or that altruism is asymmetric across improvements and decrements in the well-being of others (I worry more about imposing losses than awarding gains), we specify no alternative hypothesis. Hence, a two-tail hypothesis test is employed.

For situations in which the average jth individual is made worse off relative to the ith individual, the following null hypothesis is specified:

$$H^{o}{}_{4}: \quad p_i = t_i \qquad \text{if } \frac{\sum_{j \neq i} |EL_j|}{n-1} < |EL_i| \tag{7}$$

The alternative hypothesis ($H^{A}{}_{4}$) is that $p_i > t_i$, corresponding to a one-tailed significance test. In other words, a pure altruist would report a lower value in the public setting if the tax is such that the welfare of the other(s) is reduced.

Finally, if on average the jth individual is made better off with the tax than the ith individual, the following null hypothesis is appropriate.

$$H^{o}{}_{5}: \quad p_i = t_i \qquad \text{if } \frac{\sum_{j \neq i} |EL_j|}{n-1} > |EL_i| \tag{8}$$

The alternative hypothesis ($H^{A}{}_{5}$) is that $p_i < t_i$, corresponding to a one-tailed significance test. In other words, a pure altruist would report a lower value in the public setting if the tax is such that the welfare of the other(s) is reduced.

3. Experimental Design:

All experiments were conducted in the Laboratory for Experimental Economics and Decision-Making Research at Cornell University in the fall of 2003. 176 subjects volunteered for the experiments and were recruited from a variety of undergraduate economics courses. Subjects received written instructions. As part of the verbal protocol, subjects were permitted to ask questions at the beginning of each part of the experiment. The instructions used language parallel to that found in surveys for referendum voting settings (Carson et al., 2000). The instructions directed each subject to *vote* whether to *fund* a *insurance program* by submitting a *bid* that represented the "highest amount that you would pay and still vote for the insurance program."

Each subject was seated at an individual computer and was assigned to 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 group for all treatments. No communication was allowed and subjects in the same group size of three were not seated next to each other. Subjects decided how much to bid ranging from zero to the entire initial balance of $25.00. Using Excel spreadsheets programmed with Visual Basic for Applications, subjects submitted their WTP for insurance to the experiment administrator.

The Voting-BDM operated in much the same way as the traditional private good BDM with a couple of key differences. In the Voting-BDM a majority of the bids determines whether the program is funded. Consequently, treatments with group size of one are identical to the private good BDM as each subject's bid constitutes a majority. The cost was determined by using a random numbers table with values from 0 to 2,500 where the number represented the cost in pennies. For example, if the random number was a 1,529, then the determined cost would have been $15.29. Consequently, the cost was uniformly distributed between $0.00 and $25.00 with discrete intervals of $0.01. The potential loss was determined by having subjects draw ten chips, with replacement, from a bag containing a known number of red and white chips. Each red chip drawn meant that the subject lost a predetermined amount of money; the amount of loss for each red chip drawn depended upon the experiment design as described below. After the random cost and loss were determined, subjects retrieved this information and their spreadsheets calculated the profit.

All sessions consisted of two parts. The first part consisted of ten low-incentive private BDM rounds where the subjects received feedback as the cost and loss were determined at the end of each round. The second part consisted of high-incentive public Voting-BDM treatments where the one treatment that resulted in cash payment was determined at the end of the experiment, thereby ensuring independence of bids and preventing potential deterioration of ORB as traditionally observed in public good settings with multiple rounds (Davis and Holt 1993). Subjects were provided complete information about the payoff amounts of the other subjects. The exchange rate for the second part of the experiment was set at forty times greater than the exchange rate for the first part of the experiment and subjects received an average payoff of $15.00 per hour.

Subjects participated in one of two designs, where the expected loss were -$2.00, -$5.00, and -$8.00 (Table 1). In the first design, referred to as the *Probability Variation* design, the expected losses are derived by drawing ten chips from a bag where the loss for each loss drawn (red chip) was constant at $1.00 and the probability of experiencing a loss had three variants, 20%, 50% and 80%. In the second design, referred to as the *Loss Amount Variation* design, the expected losses are derived by drawing ten chips from a bag where the loss for each red chip drawn has three variants, -$0.50, -$1.25 and -$2.00, and the probability of experiencing a loss was constant at 40%.

These alternative methods of arriving at the same expected loss lead to yet another testable hypothesis, that of procedural invariance in the underlying source of change in expected payoffs. While we do compare the results from the alternative methods in the results section, we do not formally test this hypothesis.

4. Econometric Methods and Results

For each experiment design, we treat the set of bids from each individual as a panel data set and use a two-factor fixed effects model. Indicator variables capture the differences across the (i=1,…,93) individuals, S_i, as well as the (k=1,…,9) treatment conditions, T_k. The individual fixed effects capture the unobserved heterogeneity across individuals, such as differences in other-regarding behavior. We estimate the following model:

$$B_{ik} = \alpha + \sum_{i=1}^{93} S_i + \sum_{k=1}^{9} T_k + \varepsilon_{ik} \tag{9}$$

where the dependent variable is individual i's bid, α is an overall constant term, and ε_{ik} is a mean-zero random error term. Note since subjects do not receive any feedback in the Voting-BDM treatments until the end of the experiment, and hence there are no learning effects, we need not address subject-specific autocorrelation. The problem of perfect colinearity – the treatment and individual indicator variables both sum to one – is avoided by imposing the restrictions that the set of individual and treatment fixed effects independently sum to zero via a restricted least squares estimator.

Hypothesis 1 - Private Good, Loss Treatments. In the private good treatments, a risk neutral (i.e. in the Von Neumann-Morganstern sense) and loss neutral (i.e. in the

Kahnemann and Tversky sense) individual's optimal strategy is to submit a bid equal to the expected value of their induced loss. Recall, the expected values in both experiment designs were -\$2.00, -\$5.00, and -\$8.00.[1] As reported in Messer et al (2004), when these losses occur with certainty, subjects submit bids that are statistically indistinguishable from the induced loss (\$2.10, \$5.09, and \$8.11, respectively). However, in the present case where the loss is probabilistic and where the potential exists for experiencing a higher than expected loss, a risk/loss averse subject would be expected to submit bids higher than the expected loss. As demonstrated in Table 2 and Table 3, subjects consistently submitted bids that were higher than expected loss in both the Probability Variation (\$2.31, \$5.57 and \$8.78) and Loss Amount Variation (\$2.19, \$5.57 and \$8.62) designs. However, the bids only were statistically different at the $\alpha=0.10$ level from the expected loss for the higher loss treatments of -\$5.00 and -\$8.00. It therefore appears that in these experiments subjects showed behavior consistent with loss aversion. The relatively small magnitude of the possible loss rules out the possibility of measurable risk aversion (Rabin and Thaler 2000; Rabin 2001)

Hypothesis 2: Public Good, Homogeneous Loss Treatments. Similar to the pattern observed in the private loss treatments, subjects in homogenous loss treatments submitted bids higher than then the expected loss (Table 2 and Table 3). Only the bids in the -\$2.00 treatment in the Loss Amount Variation design were not statistically different than the expected loss at the $\alpha=0.05$ level, indicating that for most cases loss aversion seemed to

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[1] Due to the discrete costs, another optimal strategy for a risk/loss neutral person is to submit a bid which is one penny less than the expected value of the induced value.

characterize bid levels. However, consistent with prior research on the Voting-BDM (Messer et al 2004), subjects' bids in the public homogeneous loss treatments were not statistically different than the subjects' bids in the private treatment. Hence, $p_i = t_i$ when expected losses without an insurance program are homogenous in the public goods case.

Hypothesis 3 – Public Good, Heterogeneous Loss Treatments, Symmetric Relative Gains and Losses. Subjects in the middle expected loss situation were in a position that a small increase in the tax created offsetting expected losses and gains to the other members of the group. Results of the null hypothesis could not be rejected in the Loss Amount Variations scenario but could be rejected in the Probability Variations scenario. In addition, the estimated coefficients were of different signs, leading us to conclude that there is no systematic weighting of relative gains and losses incurred by others. In terms of the notation used, we are unable to reject the equality $p_i = t_i$ for homogenous public goods settings.

Hypothesis 3 - Public Good, Heterogeneous Loss Treatments. When subjects know that their private expected loss is different than others in the group, their behavior appears to differ systematically from their behavior in the private good treatments. As conjectured by Johannesson et al., subjects who know that they stand to gain more from a public good than others (in this case those with expected losses of -$8.00) will lower their WTP in comparison to their private WTP. As seen in Table 2 for the Probability Variation design, subjects in the heterogeneous treatment lowered their bids by $0.68 (7.7%) from the private treatment and in the Loss Amount Variation design, subjects submitted bids in the heterogeneous treatment that were \$0.44 (5.1%) less than their bids in the private treatment (Table 2). Both shifts are significant.

Hypothesis 4 - Public Good, Heterogeneous Loss Treatments, Best-Off Subjects. When subjects know that they stand to gain the least from the public insurance policy due to them having the lowest expected loss (in other words they are the best off), subjects significantly *raise* their bids, thereby increasing the probability that the insurance will be purchased. Not only are these bids statistically higher than the expected loss, but in the Probability Variation design, subjects raised their bids by \$1.60 (69.3%) over their bids in the private good treatment (Table 2). In the Loss Amount Variation design, subjects again raised their bids in the heterogeneous treatments. These bids were \$0.68 (31.1%) higher than their bids in the private good treatment (Table 3).

Interestingly, as shown in Figure 1, the level of overbidding by the best-off subjects is the Probability Variation Design (\$1.60) was higher in the overbidding in the Loss Amount Variation design (\$0.68).[2] Furthermore, this amount of overbidding was more than three times as much in the design where the loss experienced with certainty as described in Messer et al. 2004 (\$1.60 versus \$0.44).[3] A potential explanation for this rise in bids is that subjects are more concerned about projecting other subjects against frequent losses, instead of being as concerned about the magnitude of these losses. Consider the situation of the worse-off subject. Even though the expected loss of -\$8.00 was the same in both cases, in the Probability Variation design subjects experience, on average, eight separate losses of \$1.00. In contrast, in the Loss Amount Variation,

[2] Two sample, two-tailed test (p=0.028).
[3] Two sample, two-tailed test (p=0.004).

subjects, on average, only experience four losses, though each of these losses is twice as much ($2.00). Therefore, it appears that the best-off subjects, while concerned about both subjects, are more concerned about the subjects who lose $1.00 eight times.

6. Summary

The results form our experimental economics investigation of ORB in referenda situations suggest the following results, each of which is consistent with particular elements of the Johannesson et al. conjecture.

(1) When subjects are homogenous in terms of initial endowments and expected loss, equality of willingness to pay for private and public insurance programs cannot be rejected.

(2) The subjects with the most to gain from an insurance policy significantly *lower* their willingness to pay in a public heterogeneous distribution setting in comparison to their willingness to pay in the private setting for the same expected loss. This corresponds to the Johannesson et al. conjecture that willingness to pay for the best off subject will be lower in a heterogeneous public good setting than in a private setting

(3) The subjects with the least to gain from an insurance policy significantly *raise* their willingness to pay in a public heterogeneous distribution setting in comparison to their willingness to pay in a private setting for the same expected loss. This supports the Johannesson conjecture that the

> willingness to pay for the worst of subjects in a heterogeneous public goods setting will exceed their willingness to pay in a private setting.

These results will provide fodder for the continuing debate on how hypothetical and actual referenda results can be incorporated into welfare analyses.

We also found that the level of altruism demonstrated by the subjects with the least to gain from the insurance *increased* when the expected loss resulted from a frequent, but small loss, in comparison to when the expected loss resulted from a higher loss amount which happened less often. This result suggests that valuation of public risks in referenda settings demonstrates procedural variance between expected loss preserving changes in the magnitude of the loss and the probability of a loss.

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Figure 1. Private and Heterogenous Bids

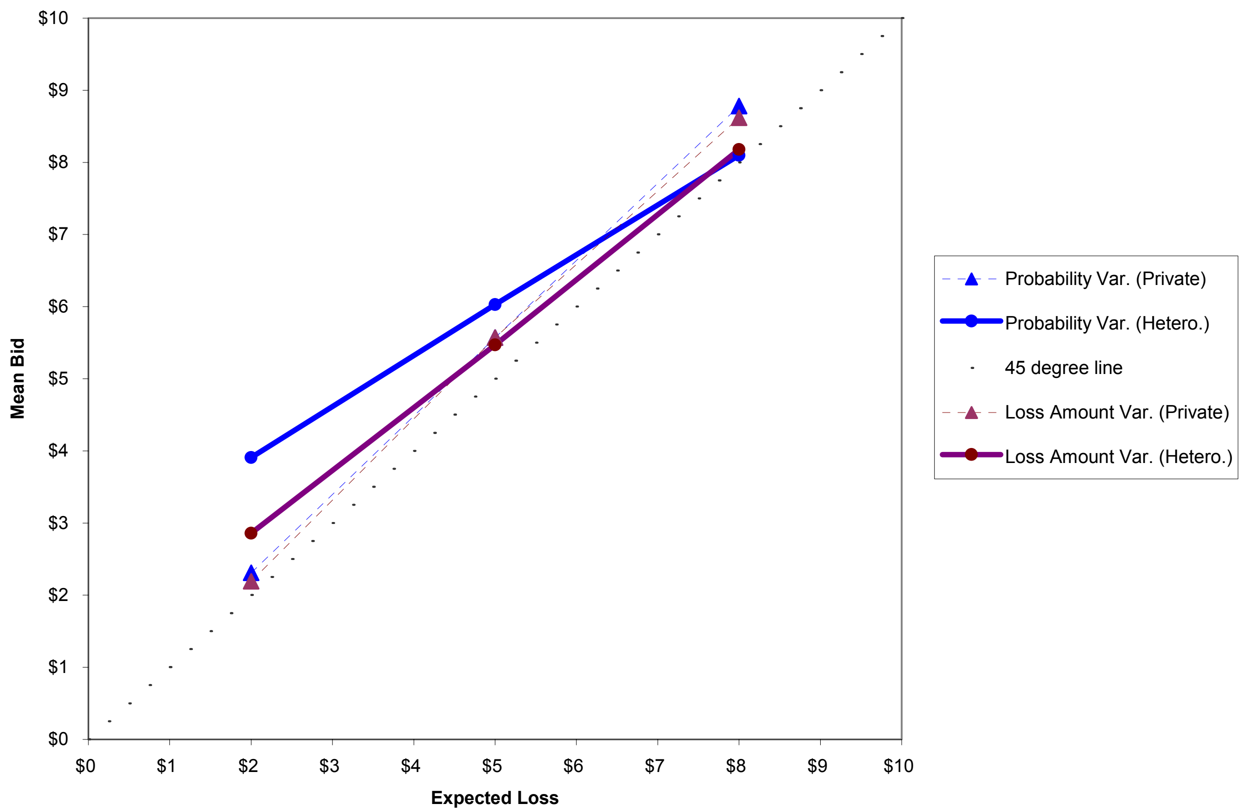

Table 1. Two Experiment Designs						
	"Probability Variation"			"Loss Amount Variation"		
Probability of Loss	**20%**	**50%**	**80%**	40%	40%	40%
Loss Amount	-$1.00	-$1.00	-$1.00	**-$0.50**	**-$1.25**	**-$2.00**
Expected Number of Losses (Out of 10 draws)	2	5	8	4	4	4
Expected Value of Loss	-$2.00	-$5.00	-$8.00	-$2.00	-$5.00	-$8.00

Table 2. Probability Variations

		Group Size = 1	Group Size = 3	
		Private	**Homogeneous**	**Heterogeneous**
Low Value	Mean	**$2.31**	**$2.62**	**$3.91** †
-$2	Median	$2.00	$2.00	$2.00
	Difference from Expected Loss	$0.31	$0.62 *	
	Difference from Private, N=1		$0.30	$1.60 **
Middle Value	Mean	**$5.57**	**$5.75**	**$6.03**
-$5	Median	$5.00	$5.00	$5.00
	Difference from Expected Loss	$0.57 *	$0.75 *	
	Difference from Private, N=1		$0.18	$0.46 *
High Value	Mean	**$8.78**	**$9.09**	**$8.10** †
-$8	Median	$8.00	$8.00	$8.00
	Difference from Expected Loss	$0.78 *	$1.09 **	
	Difference from Private, N=1		$0.31	-$0.68 **

n=87

* < 0.05; ** < 0.01

† one-tailed test

Table 3. Loss Amount Variations

		Group Size = 1	Group Size = 3	
		Private	Homogeneous	Heterogeneous
Low Value -$2	Mean	**$2.19**	**$2.17**	**$2.86** †
	Median	$2.00	$2.00	$2.00
	Difference from Expected Loss	$0.19	$0.17	
	Difference from Private, N=1		-$0.01	$0.68 **
Middle Value -$5	Mean	**$5.57**	**$5.63**	**$5.47**
	Median	$5.00	$5.00	$5.00
	Difference from Expected Loss	$0.57 **	$0.63 **	
	Difference from Private, N=1		$0.06	-$0.10
High Value -$8	Mean	**$8.62**	**$8.57**	**$8.18** †
	Median	$8.00	$8.00	$8.00
	Difference from Expected Loss	$0.62 *	$0.57 *	
	Difference from Private, N=1		-$0.05	-$0.44 *

n=87

* < 0.05; ** < 0.01

† one-tailed test