THE EFFECTS OF FRAMING, RISK, AND UNCERTAINTY ON CONTRIBUTIONS TOWARD A PUBLIC ACCOUNT: EXPERIMENTAL EVIDENCE

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ABSTRACT

This paper uses laboratory evidence from four strategically equivalent voluntary contribution games to evaluate differences in contributions toward a public account due to framing, risk, and uncertainty. I test four hypotheses. (1) Individuals contribute more to a public account when the dilemma is framed as the mitigation of a public loss than the provision of a public good. (2) Individuals contribute more to a public account when the loss is certain than when faced with the risk of a loss. (3) Individuals contribute more to a public account when the loss is certain than when environmental uncertainty is associated with the public loss. (4) Individuals contribute more to a public account when the probability of loss is known than when the probability of loss is unknown. I find that contributions are greatest when the dilemma is framed as the mitigation of a certain public loss. Contributions diminish when environmental risk and uncertainty are introduced, but remain higher than for public good provision. Preliminary laboratory evidence suggests that government intervention may be more necessary in the provision of a public good than in the mitigation of a public bad. Furthermore, much of the debate surrounding optimal allocations of insurance and infrastructure investment seems to be the result of environmental uncertainty as opposed to strategic uncertainty.

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I. INTRODUCTION

Decisions under risk and uncertainty frequently deviate from the risk neutral predictions associated with expected utility theory. Infrastructure and insurance markets provide two examples where policy makers find it difficult to accurately forecast benefits and costs often leading to inefficient decision making. Chichilnisky (2006) estimates that an investment of 18 billion dollars in New Orleans' infrastructure prior to Hurricane Katrina could have averted a 200 billion dollar loss. Conversely, Viscusi (1996) estimates the cost of asbestos removal to be upwards of 104.2 million dollars per life saved[2]. Chichilnisky claims that our decision-making tools under uncertainty have failed. More precisely, she is referring to expected utility theory. Tversky and Kahneman (1986) argue that expected utility theory is fundamentally flawed, as it emerged as a normative model of the ideal decision maker instead of from a psychological analysis of risk and value. They claim that accounting for psychological preferences allows for a better representation of decision making under risk. This paper uses the Voluntary Contributions Mechanism to examine decision making in the presence of definite, risky, and uncertain losses.

The Voluntary Contributions Mechanism (VCM) is a conventional experiment used to analyze decision making in the presence of a public good. In a VCM game, participants are endowed with a set amount of tokens or currency and then given the option to contribute a portion of their endowment toward the provision of a public good. The contribution is multiplied by some efficiency factor greater than one and then distributed evenly to all group members. The payoff to the group is greater than the sum of individual contributions, but the payoff to the individual is less than their contribution. The Pareto efficient outcome occurs when every player chooses to contribute their entire endowment into the group account, as this strategy maximizes

[2] Estimate was made in 1996 using 1984 dollars.

the aggregate payoff. However, each player has incentive to defect from Pareto optimum and contribute nothing, causing free riding to become the unique dominant strategy of the game.

Choices in the VCM game emulate public policy decisions such as the provision of public parks, museums, police protection, or schools. The decisions made in the laboratory should reflect decisions made in these instances and results can be used to draw inferences about public choice on a much larger scale. The use of real monetary incentives reduces inaccuracies that occur when using hypothetical bids.

VCM games similar to those used in this paper have been studied extensively in the past (e.g., Fehr and Gätcher 1999; Holt and Laury 2002; Isaac and Walker 1988; Sonnemans and Schram 1998). However, the vast majority of existing research focuses on environments where contributions to the public account add to the wealth of subjects in a deterministic manner that is known to participants. In reality, most local public goods are provided to limit potential damages with risky or uncertain outcomes such as fire and police protection, infrastructure development, public defense, or health risk-reducing regulations.

Experimental research incorporating risk and uncertainty is limited with few exceptions (e.g., McClelland et. al 1993; Gangadharan and Nemes 2009). In McClelland's experiments individuals could choose whether or not to purchase insurance that protects from a loss at varying probabilities. While only a portion of the players with the highest bids were able to obtain the insurance, bidding did not benefit other players. Gangadharan and Nemes' public good experiments add elements of environmental risk and uncertainty, but do so maintaining a positive framework.

In order to capture the effects of framing, risk, and uncertainty with respect to voluntary contributions, this paper utilizes four treatments of the VCM game. These treatments include a standard positively framed VCM game, a variation where individuals contribute towards the mitigation of a public loss instead of the provision of a public good, and two treatments where individuals contribute to mitigate a potential public loss with a 50% chance of realization. In one of these two treatments the probability of loss is known to participants and in the other treatment the probability is unknown. Group size and the marginal per capita return on contributions toward the public account are equivalent across all treatments. I find that there are statistically significant differences in contributions depending upon the framing of the dilemma, and whether or not risk or uncertainty are associated with the public loss. Contributions are greatest when the dilemma is framed as the mitigation of a definite public loss and diminish when environmental risk and uncertainty are introduced, but remain higher than contributions toward the provision of a public good.

In Section II, I provide a review of the literature and experimental methods used to examine similar topics. Section III presents the theoretical model and section IV translates the model into the experimental design. In Section V, I state the hypotheses to be tested. Section VI contains the statistical results of the experiment with respect to those hypotheses. In Section VII, I examine the limitations of the results. In Section VIII, I discuss the results and possibilities for future research. Complete instructions are available in the appendix.

II. LITERATURE REVIEW

Expected utility theory is based on four key assumptions: cancelation, transitivity, dominance, and invariance. While these assumptions are intuitively attractive, they are often violated and do not provide a realistic view of human decision making. Tversky and Kahneman (1986) discuss these assumptions and propose an alternative by modifying the value function to incorporate preferences that are anomalous in expected utility theory.

Cancellation claims that states of the world that yield equivalent outcomes, regardless of one's choice, are eliminated. For example, suppose there are two different gambles, Gamble A and Gamble B. In Gamble A there is a 50% chance that *x* will be realized with nothing happening otherwise. In Gamble B there is a 50% chance that *y* will be realized with nothing happening otherwise. If *x* is preferred to *y*, then Gamble A will be preferred to Gamble B since the two gambles yield the same outcome if not realized. Under this assumption individuals make decisions based solely on states that yield different outcomes. Allais (1953) provides a counter example that is supported by an experiment by Kahneman and Tversky (1979).

In this experiment subjects faced two paired lottery choice situations. In the first situation, individuals chose between having a 33% chance to gain $2,500, a 66% chance to gain 2,400, and a 1% chance to gain nothing (option A) or gaining $2,400 with certainty (option B). In the second situation, individuals chose between a 33% chance to gain $2,500 and a 67% chance to gain nothing (option C) or a 34% chance to gain $2,400 and a 66% chance to gain nothing (option D). Out of the 72 subjects, 82% chose option B over option A and 83% chose option C over option D, conflicting with the cancellation axiom.

The transitivity assumption states that A is preferred to B whenever the utility gained by A is greater than the utility gained by B. For example, suppose one has three options: A, B, and C. If A is preferred to B and B is preferred to C, then A will be preferred to C. Loomes, Starmer, and Sugden (1991) found that this axiom does not hold up in the laboratory. In their experiment they constructed two sets of twenty choice problems. Subjects chose between A and B, then between B and C, then between A and C where options A, B, and C were all random lotteries with different expected values, returns, and probabilities of return. One option used was a 30% chance of gaining $18 and a 70% chance of gaining nothing (option A), a 60% chance of gaining

$8 and a 40% of gaining nothing (option B), and a 100% chance of gaining $4 (option C). Individuals participating in the experiment consistently violated the transitivity axiom in a way that could not be explained by random error.

Dominance states that if option A provides more utility than option B in one state and at least as much utility as option B in all other states, then option A is dominant over option B. The dominant option should be chosen. Kahneman and Tversky (1979) refuted the Dominance axiom with another experiment. Subjects considered the following two lotteries describing the percentage of marbles of different colors in each box and the amount of money they won or lost depending on the color of the randomly drawn marble. They were then asked to specify which lottery they preferred.

Option A

90% white	6% red	1% green	1% blue	2% yellow
$0	win $45	win $30	lose $15	lose $15

Option B

90% white	6% red	1% green	1% blue	2% yellow
$0	win $45	win $45	lose $10	lose $15

In this example the dominance of option B over option A is transparent. The payoff of option B is at least as high as the payoff of option A, regardless of the color. All of the 88 participants chose option B over option A. Next, Tversky and Kahneman combined the outcomes for drawing red or green marbles in B and yellow and blue marbles in A and asked 124 subjects which lottery they preferred.

Option C

90% white	6% red	1% green	3% yellow
$0	win $45	win $30	lose $15

Option D

90% white	7% red	1% green	2% yellow
$0	win $45	lose $10	lose $15

In this problem, the dominance of option D over option C is not transparent and 58% of the participants chose C. This suggests that the dominance rule is obeyed when its application is transparent, but not when its application is masked.

Finally, invariance states that different representations of payoff equivalent dilemmas will yield the same preferences. Refuting Invariance, McNeil et al. (1982) present a study of preferences between two potential medical treatments, surgery and radiation therapy. They used a survey containing statistical information about the effects of treating lung cancer using two different frames. In the first frame, the statistics were given in terms of survival rates and in the second frame statistics were given in terms of mortality rates. Respondents indicated their preferred treatment.

Radiation therapy had a higher mortality rate (lower survival rate) than the surgery treatment after the end of five years and the expected survival/mortality rates were equal across treatments, but the respondents' preferences were not. Only 18% of the respondents preferred radiation therapy in the survival frame, while 44% of the respondents preferred radiation therapy in the mortality frame. Results were similar for physicians, business students, and the clinic patients, refuting the invariance assumption.

Instead of using a weighted average of potential outcomes and their respective probabilities, Kahneman and Tversky (1979) argued that individuals make decisions by evaluating alternative prospects with respect to a subjective reference point. In this model people are risk averse in the domain of gains and risk seeking in the domain of losses. One criticism of Kahneman and Tversky's work is the use of hypothetical bids as opposed to real monetary incentives. However, decades of experimental research finds that their proposed challenges to expected value theory hold up when using monetary incentives.

Gangadharan and Nemes (2009) define a risk as a situation where all possible future outcomes and the probabilities of those outcomes are known. Examples include the chance that a building will catch on fire, a crime will be committed, or that a person will be involved in a car accident. In these instances the law of large numbers allows for the extrapolation of probabilities of occurrence. Knowledge of these probabilities allow for a risk to be mitigated using infrastructure investment, insurance, and laws or regulations.

Uncertainty refers to the case in which outcomes are known, but the probabilities associated with those outcomes are not known, or impossible to know. A further distinction is made between 'strategic' and 'environmental' uncertainty. Environmental uncertainty refers to cases in which the probability distribution of potential losses is not known. Examples include terrorist attacks, rare natural disasters, and climate change. In these cases, it is not clear what the optimum group action is regardless of how individuals respond. Strategic uncertainty refers to the unknown probability distribution of potential decisions made by others.

Gangadharan and Nemes (2009) investigate differences in the perception of risks and uncertainties when making decisions about private and public goods. In their experiment subjects received an endowment and chose between contributing to a private account and a group account. Their experiment contained seven different treatments: a standard public goods game, 2 treatments where there is a known probability of obtaining the return for the private and public accounts, 2 treatments were there is an unknown probability of obtaining the return for the private and public accounts, and 2 treatments were the participants have the opportunity to increase the probability of return from the private and group accounts. Each of the seven treatments lasted for 15 periods. Environmental risk and uncertainty varied along treatments, but strategic uncertainty was held constant. At the end of each period, subjects were told the aggregate level of contribution to the public good and their return from the private and public accounts. They find that environmental risk and uncertainty with respect to the provision of private and public goods is a significant factor when making decisions.

McClelland et al. (1993) created an experiment to determine how individuals respond to different levels of environmental risk. Subjects faced risks of various magnitudes and probabilities with a constant group size of eight over eight periods. The magnitudes of the potential losses were $4 and $40 and the probabilities ranged from 0.1 to 0.9. The risk was operationalized using a bag containing 100 poker chips. Subjects received an endowment at the beginning of the experiment and each round the experimenters drew a chip from the bag. If a red chip was drawn the loss would be realized and if a white chip was drawn each individual would have a marginal increase in their wealth in order to keep them funded. An auction for insurance was held before each period. Participants entered a bid for insurance against the loss and the fifth highest bid became the reigning insurance price. The four players bidding higher than the reigning bid received insurance at that price.

Mean bids for both the $4 and the $40 treatments were close to the expected value at all probabilities except for the lowest (0.1). At this probability, the distribution of bids became bimodal (players chose to either ignore the risk entirely or overestimate its chance of occurrence). The most pronounced difference between the two treatments was a decrease in the amount of zero bids when the loss was increased to $40. McClelland claimed that results of the study may have been influenced by the gambler's fallacy. That is a series of white chip draws would be accompanied by higher insurance bids and a series of red chip draws would be accompanied by lower insurance bids even though the probability that the loss would be realized was independent across periods.

McClelland claims that while the $4 and $40 losses do not approach those found in the high-consequence situations he is trying to model, the losses are high enough to entice players into acting as they would in those situations as individuals would all prefer to avoid the losses. In addition, he cited that players reacted with visible unhappiness when the losses occurred, providing some antidotal evidence that players were concerned with the earnings from the experiment. Furthermore, Smith and Walker (1993) found that real monetary rewards limit deviations from expected utility theory. Providing evidence that using monetary incentives instead of hypothetical bids will cause the decisions made in experiments to approach decisions made in similar real world situations.

Sonnemans and Schram (1998) provide laboratory evidence that the framing of a dilemma as a public good or a public bad has a significant impact on the decision making processes of the subjects involved. Their experiment consisted of several periods with two different frames. The first frame was a provision of a public good that would only occur if investment into the public account exceeded a certain threshold. The second frame was prevention of a public bad in which individuals could withdraw resources from a public pool yielding negative externalities to the other group members. Both of the frames were made strategically equivalent.

They did not find a statistically significant difference in decision making between frames in the initial periods; however, differences developed during the game. Differences in the observed behavior from expected utility theory could not be explained by differences in value orientation. This is largely because they did not have an a priori way of determining the subjective reference point of those participating. The experiment also tests the Pruitt hypothesis that subjects will perceive themselves to be more interdependent in step level public goods games than in the step level public bads games. The Pruitt hypothesis was not refuted; although it was unable to explain why differences in cooperation between the two frames increased over the periods.

Their explanation for the differences in decisions over time was learning. When players were dissatisfied with their choices in previous periods, they modified their decisions in the new periods. Most of this dissatisfaction arose from inequity aversion on the behalf of the contributors as subjects had a greater distaste for contributing to a public good or prevention of a public bad when the contribution was so small that they did not reach the threshold than when their decision was not necessary to reach the threshold.

My design synthesizes the negative frame similar to that in Sonnemans and Schram (1998) and the environmental risk and uncertainty elements found in some treatments of Gangadharan and Nemes (2009). Unlike Sonnemans and Schram (1998), I incorporate elements of environmental risk and uncertainty. Unlike Gangadharan and Nemes (2009), the environmental risk and uncertainty treatments are framed negatively. Each treatment is a single period. Since each treatment is strategically equivalent, differences in contributions towards the public account should be the result of the frame and whether or not environmental risk or uncertainty exists in the treatment.

III. MODEL

The four treatments use the payoff function found in equation 1. Each treatment is strategically equivalent[3].

[3] In a strict sense the first two treatments are strategically equivalent and the second two treatments are strategically equivalent, but the ex post payoff in the environmental risk and uncertainty treatments are slight modifications designed to keep the payoff reasonable.

where is the payoff to player . Each participant is endowed with m_i and chooses to contribute x_i into a public account. L represents the loss faced by the group, b represents the efficiency factor of contribution, Σg_i is the sum of the contributions from other group members, and n is the number of participants in a group. In the environmental risk and uncertainty treatments the loss has a probability of occurrence equal to . If the loss is not realized any contributions made to mitigate the public loss are forfeited.

The public account is given by . making the public account non-rival and non-excludable. In addition, , so individuals can only benefit from the contributions of others, making the public account a public good. For all treatments, . Therefore, it is impossible for participants to leave the experiment with less money than they entered with. Each individual must choose a value of between 0 and 6. Participants view each treatment as a utility maximization problem represented by the following equation.

Since, , utility is maximized at regardless of the contribution of the other group members. is the unique dominant strategy of the game. The aggregate payoff function is given below in equation 3. Introducing a probability to the loss and public account terms does not alter the dominant strategy of the game.

Since, , group utility is maximized when each player chooses to invest everything into the public account . Notice that while individuals benefit from cooperation and suffer from defecting, the game provides incentives for individuals to choose the inefficient strategy of defecting.

IV. EXPERIMENTAL DESIGN

The laboratory experiments were conducted in two sessions involving 12 and 16 participants, respectively[4] for a total of 28 observations; 25 observations were used. In each of these sessions, decision-making scenarios differed in framing, probability of loss, and knowledge of the probability of loss. At the beginning of each treatment subjects were placed randomly in anonymous groups of four. At the end of each period, subjects learned the aggregate level of contribution to the public account; but were not told the individual contribution of each other group member. Subjects were also told their payoff from each treatment.

The baseline treatment was a positively framed VCM game. Equation 4 represents the expected payoff of each group member with the loss that the group faces, , equal to 0. The first variation is the negatively framed treatment where the loss is equal to -$24. Investing $1 into the public account decreases the loss to each group member by $0.40. The endowment in this treatment was increased to $16. The expected payoff for the negatively framed treatment is described in Equation 5.

The third and fourth treatments were also negatively framed with an endowment of $16. The probability of loss in these treatments was equal to 0.5. In order to determine if the loss is

[4] Participants were undergraduate students taking Game Theory or Advanced Topics in Microeconomics seminar at Gettysburg College. Three of the observations in the second session were excluded from the final data. Two of these observations consisted of the people who ran the experiment and the other subject was omitted due to participation in the previous session. Participation of these individuals was necessary to produce balanced groups.

realized, a poker chip was drawn from a bag containing 50 red chips and 50 white chips. If a red chip was drawn, the loss would be realized, if a white chip was drawn, the loss would not be realized. If the loss was not realized, all money invested into the public account would be lost. In the environmental uncertainty treatment the probability of loss was unknown to participants. However, they were shown that both a red chip and a white chip existed in the bag making it possible for the loss to occur and the loss to not occur. The expected payoff functions of the environmental risk and uncertainty treatments are described in equations 6 and 7, respectively. Notice that the efficiency factor was increased to 3.2 to preserve the marginal per capita return on contributions.

The order of the treatments was the environmental uncertainty treatment, the environmental risk treatment, the negative frame treatment, and then the positive frame treatment. Subjects were told prior to the experiment that upon completion they would be paid for one of the four treatments to be determined randomly by the flip of two coins in front of the students.

V. HYPOTHESES

I tests four hypotheses. (1) Individuals contribute more to a public account when the dilemma is framed as the mitigation of a public loss than the provision of a public good. (2) Individuals contribute more to a public account when the loss is certain than when faced with the risk of a loss. (3) Individuals contribute more to a public account when the loss is certain than when environmental uncertainty is associated with the public loss. (4) Individuals contribute more to a public account when the probability of loss is known than when the probability of loss is unknown.

The results from Sonnemans and Schram (1998) provide some reason to believe that the quantities contributed toward the public account in the positively framed treatment and the negatively framed treatment will be statistically significant in difference from each other. Prospect theory suggests that contributions will be higher in the negative treatment. The payoff from contributing in the public account in the negatively treatment is framed as prevention of a loss. Since individuals weigh losses heavier than gains, contribution in the negative treatment is seen as having greater return than contribution in the positive treatment.

Hypothesis 2 stems from the reflection effect described in Kahneman and Tversky (1979). The reflection effect states that individuals are risk-averse in the domain of gains and risk-seeking in the domain of losses. The risk treatment is framed as mitigation of a probabilistic loss, so participants should also choose to invest less to the public account than when the loss is certain.

Gangadharan and Nemes (2009) find that when the probability distribution of the environmental risk is unknown, individuals tend to be “optimistic” and predict that the desired outcome will be realized. Since individuals should all prefer a higher payoff to a lower payoff, the desired outcome should be the loss not being realized. Therefore, contributions toward the public account should be lower in the environmental uncertainty treatment than in the negatively framed treatment. In the environmental risk treatment, the probability of loss is clearly defined and individuals are therefore able to evaluate the expected value of the loss. The optimism effect should also cause the investment levels to be higher in the environmental risk treatment than in the environmental uncertainty treatment.

Hypotheses will be tested using t-tests, Wilcoxon signed-rank tests, and an OLS regression. Hypothesis 1 would be supported by statistically significant differences in the average contribution in the negative and positive treatments with a greater average contribution in the negative treatment. Also, a positive and statistically significant coefficient on the dummy variable representing the negatively framed treatment would support this hypothesis. Hypothesis 2 would be supported by mean contributions in the environmental risk and negatively framed treatment being statistically significant in difference from each other with the average contribution being greater in the negatively framed treatment. A coefficient on the dummy variable representing the environmental risk treatment that is statistically significant and greater than the coefficient on the negatively framed treatment dummy variable would also support this hypothesis.

Hypothesis 3 would be supported by the mean contribution in the negative treatment being statistically significant in difference from and greater than the mean contribution in the environmental uncertainty treatment. The dummy variable representing the environmental uncertainty treatment having a statistically significant coefficient that is greater than the coefficient on the dummy variable representing the negatively framed treatment would also support this hypothesis. Mean contribution in the environmental risk treatment that is greater and statistically significant in difference from mean contribution in the environmental uncertainty treatment would support hypothesis 4. A statistically significant coefficient on the environmental risk dummy that is greater than the coefficient of the environmental uncertainty dummy would also support this hypothesis.

VI. RESULTS

A. Overview

Figure 1 reports the amount of strong free riders in each treatment. Following the definition used in Isaac and Walker (1988), strong free riders are participants that chose to contribute less than one third of the Pareto efficient contribution into the public account . The vast majority of the subjects in the positively framed treatment chose to invest nothing. While free riding did not disappear entirely in any of the treatments, it is much less prevalent. Isaac and Walker (1988) found in their public good experiment that the level of strong free riders tends to increase over periods. In this experiment the trend is not as distinct.

Figure 1

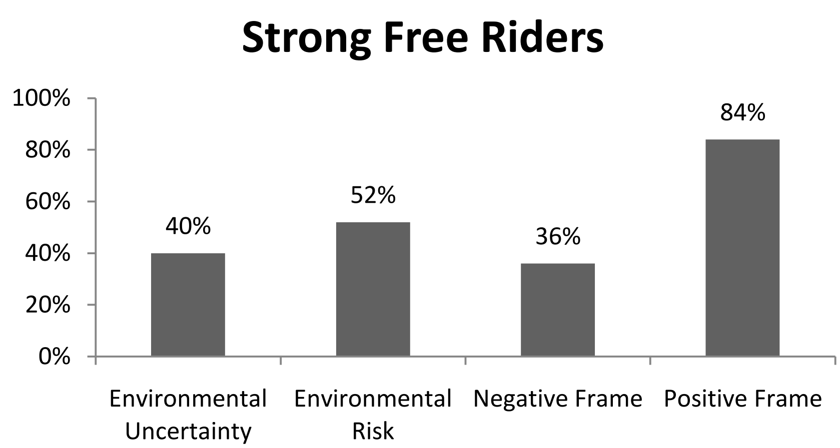


Figure 2 presents the distribution of contribution toward the public account over each treatment. Using the negative frame, more contributions approached the Pareto optimum than in any other treatment. The data suggests that individuals are more likely to cooperate when faced with a public loss than a public gain. As environmental risk is introduced into the loss, the amount of Pareto efficient contributions falls by 85%. Comparatively, Pareto efficient contributions fall by only 57% when the probability of loss is uncertain. The distribution of contributions in the uncertainty treatment does not seem to indicate optimism. If individuals predicted the desired outcome, then one would expect the majority of contributions to approach zero; however, in this treatment many individuals contributed slightly over one-third of the Pareto efficient amount.

Figure 2

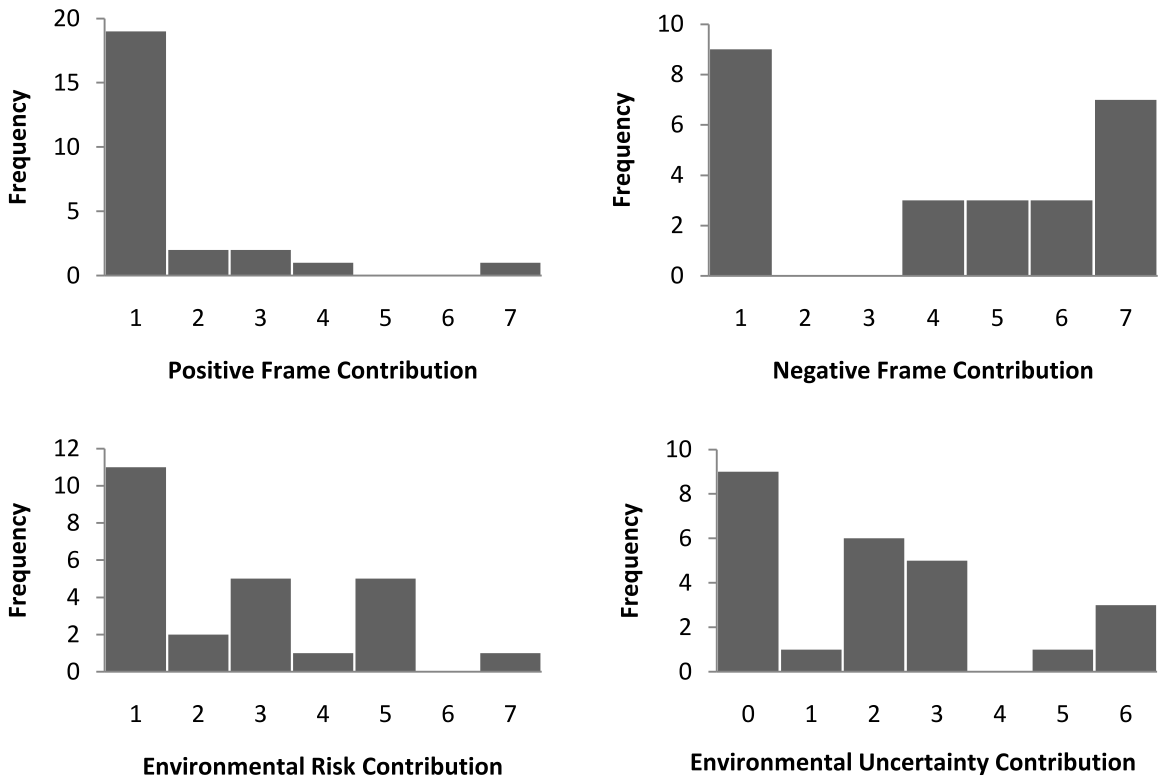


Table 1 presents the average contributions to the public account for individuals and as a group in dollars and as a percentage of maximum possible investment. The average contribution toward the public account is five times greater when the dilemma is framed negatively than when the dilemma is framed positively. When environmental risk or uncertainty is introduced to the negative frame, average contributions fall by approximately 20% of the endowment with the decline being slightly more distinct with environmental risk than environmental uncertainty.

Table 1

	Individual			Group Sum	
	Total	Mean	Std. Dev	Mean	Std. Dev
Positive Frame	15	0.60 (10%)	1.38	2.2 (9.1%)	2.66
Negative Frame	78	3.12 (52%)	2.57	11.56 (48%)	4.44
Environmental Risk	41	1.64 (27%)	1.80	6.36 (26%)	3.69
Environmental Uncertainty	51	2.04 (34%)	2.03	7.84 (32%)	3.68

It is clear from these results that the framing of the dilemma and whether environmental risk or uncertainty is associated with potential losses has a significant impact on contribution towards public account. This data supports hypotheses 1, 2, and 3, but refute hypothesis 4. Statistical tests for significance reinforce these results. Table 2 contains pairwise t–tests for significant difference in the means across treatments as well as Wilcoxon signed-rank tests. The results for the Wilcoxon signed-rank tests are presented in parenthesis under the results for the t-tests. These two measures of significance are particularly attractive as require minimal statistical assumptions. Both tests find that all treatments are statistically significant in difference from each other at the 10% level of significance.

Table 2

Pairwise T-Tests and Wilcoxon Signed-Rank Tests			
Treatment	Positive Frame	Negative Frame	Environmental Risk
Negative Frame	-4.178*** (-3.388)***	--	--
Environmental Risk	-2.355** (-2.969)***	3.997*** (3.427)***	--
Environmental Uncertainty	-2.879** (-3.117)***	3.038** (2.757)***	-1.922* (-1.800)*
*Difference is significant at the 10% level, ** difference is significant at the 5% level, and *** difference is significant at the 1% level. Wilcoxon signed-rank test results in parenthesis.			

B. Econometric Results

The following multivariate regression model evaluates the contribution of individuals to the public account, , as a function of three dummy variables. The first variable, , is equal to 1 if contribution was made in the negatively framed treatment and 0 otherwise. The second variable, , is equal to 1 if contribution was made during the environmental risk treatment and 0 otherwise. The last variable, , is equal to 1 if contribution occurred during the environmental uncertainty treatment and 0 otherwise. The regression uses ordinary least squares with the functional form given below in equation 8. A summary of the results are reported in Table 3.

The omitted dummy variable is contributions made during the positively framed treatment. The coefficients of all of the variables are statistically significant in difference from zero at the 10% level of significance. At the 5% level the coefficient on the environmental risk dummy is no longer statistically significant. The R^2 value in this regression is very low, 0.17, but statistically significant in difference from zero. Moreover, low R^2 values are not unusual in VCM experiments because of the innate randomness surrounding the participant's decisions.

The most striking result is that using a negative frame as opposed to a positive frame increases the predicted value of the contribution by $2.52. This supports the evidence found using t-tests and Wilcoxon signed-rank tests and the hypothesis that individuals will contribute more to mitigate a public bad than they would to provide a public good.

The introduction of environmental risk or uncertainty to the mitigation of a public bad reduces the contribution, while remaining greater than contribution for provision of a public good. It is possible that individuals chose to invest less in the environmental risk and uncertainty treatments because of risk-seeking preferences. Decisions are more cooperative with uncertain losses than when the probability of the loss is well defined. The relative magnitudes of the coefficient estimates support Hypotheses 1, 2, and 3, but refute hypothesis 4.

Table 3

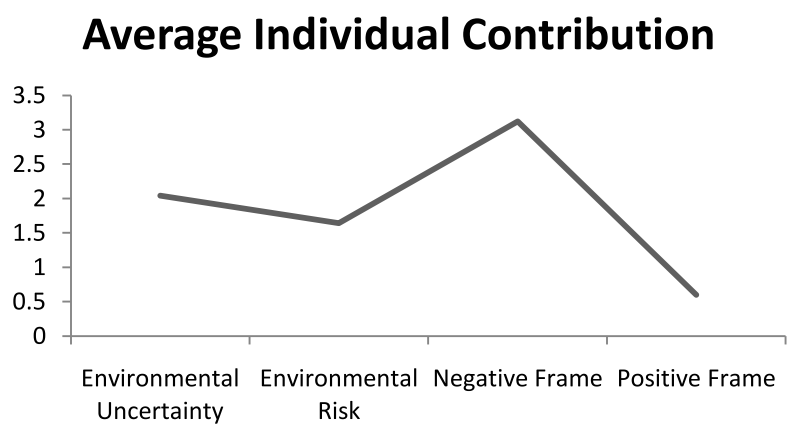
Regressor	Coefficient Estimate
	2.52*** (0.56)
	1.04* (0.56)
	1.44** (0.56)
Constant	0.6 (0.137)
R^2	0.17
F	0.0003
Observations	100
*Coefficient is significant at the 10% level, ** coefficient is significant at the 5% level, and *** coefficient is significant at the 1% level.	

VII. LIMITATIONS

The claim that contributions toward a public account depend on framing, risk, and uncertainty is supported by the laboratory evidence obtained in this study. However, decades of previous VCM research document that learning occurs in experiments similar to mine, which could cause the explanatory power of framing, risk, and uncertainty to appear greater than it actually is. Running these 4 treatments with the same subjects causes the results to be statistically interdependent. However, this was a deliberate and necessary design choice made to reduce the cost of the experiments and adhere to time constrains. In addition, previous research documents decay in contributions using the same treatment over several periods. Each period in my experiment is a new treatment.

Figure 3 shows the average individual contribution for each treatment. Overall, there is a decay trend similar to that found in Isaac and Walker (1988). The decay appears to be linear; however, average individual contribution in the negatively framed treatment is an outlier. If learning was the only effect causing differences in contributions across treatments, this trend would not be seen. Moreover, the results of the experiment are not indicative of the gambler's fallacy. The potential loss in the first treatment was not realized in either of the sessions. If the participant's were falling victim to the gambler's fallacy, one would expect an increase in the amount invested into the public account from treatments 1 to 2, predicting the loss to be realized in the second treatment. On average this trend was not present, so changes in individual contribution cannot be explained by the gambler's fallacy.

Figure 3



Sonneman and Schram (1998) found that subjects altered their behavior when unsatisfied with the results in the previous period. For that experiment, dissatisfaction was seen if the threshold level of the public good was not reached. In this experiment, subjects may be dissatisfied with other group members contributing small portions of their endowment toward the public account. Two OLS regression models, given in equations 9 and 10, are used to test for learning in the experiment.

where is the contribution to the group account made by other group members in the previous period. A summary of the results follow in Table 4.

Table 4

Regressor	Coefficient Estimate	Coefficient Estimate
	0.28** (0.11)	0.477*** (0.09)
	-.014 (0.07)	0.13** (0.06)
	--	3.66*** (0.54)
	--	1.85*** (0.51)
Constant	1.25** (0.54)	-1.94*** (0.67)
R^2	0.08	0.44
F	0.052	0.000
Observations	75	75
*Coefficient is significant at the 10% level, ** Coefficient is significant at the 5% level, and *** Coefficient is significant at the 1% level.		

Individual contribution in the previous period has statistically significant effect on the predicted value of contributions to the public account in the current period in both of the regression models. In both of these models the coefficient estimate is less than one. This suggests that learning occurs during the experiment and that the learning is in the form of decay found in previous work. The contribution of other group members toward the public account in the previous treatment does not have a statistically significant impact on the contribution of the individual in the current treatment in the first regression model. However, the coefficient is statistically significant in the second model. Overall, the first model is not statistically significant while the second model is jointly significant. Controlling for learning, both the coefficient estimates for the negatively framed treatment and the environmental risk treatment are still statistically significant[5].

[5] The residuals of both of the models are not normally distributed and plagued with other violations of the Gauss-Markov assumptions making their results unreliable.

VIII. CONCLUSIONS

The number of strong free riders in each treatment as well as the distribution of individual contributions in each treatment supports the claim that the framing of the dilemma and whether or not environmental risk or uncertainty is associated with the potential loss has a statistically significant impact on contribution toward the public account. Statistical tests as well as an OLS regression find that contributions across all treatments are statistically significant in difference from each other. Individuals contribute more to a public account when the dilemma is framed negatively than positively. Contribution is also greater when the loss to the group is certain than when there is a probability of loss (known or unknown). My hypothesis that individuals would contribute less to a public account when the probability of loss was unknown than when the probability of loss was known was not supported by laboratory evidence. This could be due to 0.5 probability chosen for environmental risk. McClelland et al. (1993) provide reason to believe results may be different at different probabilities.

Two possible concerns regarding the validity of the results are the small sample size and that all of the treatments were done in succession with the same group of participants causing the results to be statistically interdependent. Similar VCM research documents decay in contributions over time in multi-period environments. Decay found in previous research occurs when experiments run the same treatment over a series of periods. In this experiment, each period is a new treatment. In addition, these design choices were deliberate and necessary in order to reduce the cost of the experiments and to adhere to time constraints. Contributions in the negative frame treatment deviate from the overall downward trend in contributions. When controlling for learning, coefficient estimates for the negative frame and environmental risk treatments remained statistically significant in difference from zero.

Another possible area of concern is the necessary trivialization of losses. The losses in this experiment do not approach those from a hurricane, terrorist attacks, or asbestos poisoning; however, it is not possible to replicate high-loss situations in the laboratory. The use of real monetary incentives should be sufficiently high so that each participant makes decisions in a way analogous to much larger losses.

Assuming these concerns are not a significant factor in determining individual contribution, these results suggest that individuals are able to reach more cooperative decisions when faced with public losses than when faced with public good provision. In terms of public policy, this suggests that it may be more necessary for the government to intervene to provide public goods than protection against public bads. Individuals are less likely to make Pareto efficient contributions when environmental risk or uncertainty is involved. Moreover, difficulties in reaching efficient levels of infrastructure and insurance investment are largely due to environmental uncertainty as opposed to strategic uncertainty. Unlike Gangadharan and Nemes (2009), an optimism effect was not seen for losses with an unknown probability. When environmental risk was defined at 0.5, subjects appear to be more risk-seeking. It may also be necessary for the government to intervene in instances such as natural disasters (where the probability distribution of losses is not well defined) or public health hazards (where aggregate losses are well-defined). Also, in VCM type fundraising may be most effective when phrased as mitigation of a certain public loss.

Two interesting questions arise from these results that I will pursue in future research. First, contributions when the probability of loss was known to be 0.5 were less and statistically significant in difference from contributions in the negative frame. However, it is possible that the probability associated with the loss influenced decision making. Replicating the experiment using probabilities ranging from 0.1 to 0.9 would add some robustness to these results and better examine how decisions are made in low risk high-consequence scenarios as compared to high risk low-consequence scenarios. Second, one of the most interesting features of public dilemmas such as climate change is that the probability of the loss's occurrence is endogenous to the actions of those facing the losses. Private consumption and pollution emission today increases public damages in the future. Further experiments could examine the actions of individuals in situations where private investment in the current period increases the probability of potential losses in later periods.

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The experiment was programmed and conducted with the software z-Tree (Fischbacher 2007).
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APPENDIX

<u>Instructions</u>:

This is an experiment in decision making. The instructions are designed to inform you of the types of decisions you will be making and the results of those decisions. All earnings you make during the experiment will be totaled and paid to you in cash, privately, at the end of the experiment. If you have any questions concerning the instructions feel free to raise your hand and one of the experiment monitors will assist you.

You will be randomly and anonymously placed in a group with 4 members (you and three other participants). Each member of the group begins the experiment with an endowment of $10.

Each member of your group will decide how much to allocate to a 'group account.' In particular, you must choose how many dollars to allocate to the group account with a minimum of $0 and a maximum of $6. Allocations must be made in $1 increments. In other words, you must choose among the following allocations to the group account: $0, $1, $2, $3, $4, $5, or $6. The amount you choose to allocate to the group account will be deducted from your endowment. Each member of the group will be informed of the total amount allocated to the group account, but will not receive any information about the specific choices made by any individual. Since group pairings are anonymous and individual allocations will not be revealed, your decision will be confidential. In other words, no member of your group or any other participant in the experiment will be able to identify your allocation decision.

The return from the group account will be determined as follows. Each dollar that is contributed to the group account (by you or any other member of your group) will be multiplied by 1.6. Thus the final amount in the group account will be:

1.6 * (Total Group Contributions).

The return from the group account will be split evenly among the group members. This means you will receive ¼ the of the final amount in the group account.
To summarize, your payoff from the experiment will be determined as follows:

$10 - your contribution to the group account + ¼ * (1.6*(Total Group Contributions))

Another way to think about this decision is as follows. You are part of a group with 4 people. You can invest in a group account. Every dollar you invest increases group's payoff by $1.60, meaning that for every $1 you invest your payoff increases by $0.40, and so does the payoff to each other member of your group.

If you have questions, please raise your hand at this time, and an experiment monitor will assist you. Otherwise, simply follow the instructions on your computer screen. Once you have completed all of your decisions, please wait for the experiment to conclude. The experiment monitors will then call participants out of the room one at a time and pay you your earnings from the experiment.

Instructions:

This is an experiment in decision making. The instructions are designed to inform you of the types of decisions you will be making and the results of those decisions. All earnings you make during the experiment will be totaled and paid to you in cash, privately, at the end of the experiment. If you have any questions concerning the instructions feel free to raise your hand and one of the experiment monitors will assist you.

You will be randomly and anonymously placed in a group with 4 members (you and three other participants). Each member of the group begins the experiment with an endowment of $16.

Each member of your group will decide how much to allocate to a 'group account.' In particular, you must choose how many dollars to allocate to the group account with a minimum of $0 and a maximum of $6. Allocations must be made in $1 increments. In other words, you must choose among the following allocations to the group account: $0, $1, $2, $3, $4, $5, or $6. The amount you choose to allocate to the group account will be deducted from your endowment. Each member of the group will be informed of the **total** amount allocated to the group account, but will **not receive any information about the specific choices made by any individual**. Since group pairings are anonymous and individual allocations will not be revealed, your decision will be confidential. In other words, no member of your group or any other participant in the experiment will be able to identify your allocation decision.

The return from the group account will be determined as follows. The account begins with a deficit of $24. Each dollar that is contributed to the group account (by you or any other member of your group) will be multiplied by 1.6. Thus the final amount in the group account will be:

-$24 + 1.6 * (Total Group Contributions).

The return from the group account (which may be either positive or negative) will be split evenly among the group members. This means you will receive ¼ th of the final amount in the group account.

To summarize, your payoff from the experiment will be determined as follows:

$16 – your contribution to the group account + ¼ * (-$24 +1.6*(Total Group Contributions))

Another way to think about this decision is as follows. You are part of a group with 4 people. Initially, your group has to pay a cost of $24, of which your share is $6. You can invest in a group account to lower the cost your group must pay. Every dollar you invest lowers the group's cost by $1.60, meaning that for every $1 you invest your cost decreases by $0.40, and so does the cost of each other member of your group.

If you have questions, please raise your hand at this time, and an experiment monitor will assist you. Otherwise, simply follow the instructions on your computer screen. Once you have completed all of your decisions, please wait for the experiment to conclude. The experiment monitors will then call participants out of the room one at a time and pay you your earnings from the experiment.

<u>Instructions</u>:

This is an experiment in decision making. The instructions are designed to inform you of the types of decisions you will be making and the results of those decisions. All earnings you make during the experiment will be totaled and paid to you in cash, privately, at the end of the experiment. If you have any questions concerning the instructions feel free to raise your hand and one of the experiment monitors will assist you.

You will be randomly and anonymously placed in a group with 4 members (you and three other participants). Each member of the group begins the experiment with an endowment of $16.

Each member of your group will decide how much to allocate to a 'group account.' In particular, you must choose how many dollars to allocate to the group account with a minimum of $0 and a maximum of $6. Allocations must be made in $1 increments. In other words, you must choose among the following allocations to the group account: $0, $1, $2, $3, $4, $5, or $6. The amount you choose to allocate to the group account will be deducted from your endowment. Each member of the group will be informed of the **total** amount allocated to the group account, but will **not receive any information about the specific choices made by any individual**. Since group pairings are anonymous and individual allocations will not be revealed, your decision will be confidential. In other words, no member of your group or any other participant in the experiment will be able to identify your allocation decision.

Whether the return from the group account is realized is uncertain. In particular, the return from the group account will be realized with probability **1/2**. *Importantly, your allocation to the group account will be deducted from your endowment whether or not the return from the group account is realized.*

The return from the group account, if it is realized, will be determined as follows. The account begins with a deficit of $24. Each dollar that is contributed to the group account (by you or any other member of your group) will be multiplied by 3.2. Thus the final amount in the group account will be:

-$24 + 3.2 * (Total Group Contributions).

If realized, the return from the group account (which may be either positive or negative) will be split evenly among the group members. This means you will receive ¼ th of the final amount in the group account, if it is realized.

To summarize, your payoff from the experiment will be determined as follows:

$16 – your contribution to the group account +**½***{¼ * (-$24 +3.2*(Total Group Contributions))}

Another way to think about this decision is as follows. You are part of a group with 4 people. With probability ½ , your group has to pay a cost of $24, of which your share is $6. You can invest in a group account to lower the cost your group must pay in the event that cost is realized. Every dollar you invest lowers the group's cost by $3.20, meaning that for every $1 you invest your cost decreases by $0.80, and so does the cost of each other member of your group. Your investment in the group account is deducted from your endowment even if the cost is not realized.

If you have questions, please raise your hand at this time, and an experiment monitor will assist you. Otherwise, simply follow the instructions on your computer screen. Once you have completed all of your decisions, please wait for the experiment to conclude. The experiment monitors will then call participants out of the room one at a time and pay you your earnings from the experiment.

Instructions:

This is an experiment in decision making. The instructions are designed to inform you of the types of decisions you will be making and the results of those decisions. All earnings you make during the experiment will be totaled and paid to you in cash, privately, at the end of the experiment. If you have any questions concerning the instructions feel free to raise your hand and one of the experiment monitors will assist you.

You will be randomly and anonymously placed in a group with 4 members (you and three other participants). Each member of the group begins the experiment with an endowment of $16.

Each member of your group will decide how much to allocate to a 'group account.' In particular, you must choose how many dollars to allocate to the group account with a minimum of $0 and a maximum of $6. Allocations must be made in $1 increments. In other words, you must choose among the following allocations to the group account: $0, $1, $2, $3, $4, $5, or $6. The amount you choose to allocate to the group account will be deducted from your endowment. Each member of the group will be informed of the **total** amount allocated to the group account, but will **not receive any information about the specific choices made by any individual**. Since group pairings are anonymous and individual allocations will not be revealed, your decision will be confidential. In other words, no member of your group or any other participant in the experiment will be able to identify your allocation decision.

Whether the return from the group account is realized is uncertain. In particular, the return from the group account will be realized with probability **p**. This probability is greater than 0 and less than 1. No other information about the probability will be revealed to you until after you make your allocation decision. *Importantly, your allocation to the group account will be deducted from your endowment whether or not the return from the group account is realized.*

The return from the group account, if it is realized, will be determined as follows. The account begins with a deficit of $24. Each dollar that is contributed to the group account (by you or any other member of your group) will be multiplied by 3.2. Thus the final amount in the group account will be:

-$24 + 3.2 * (Total Group Contributions).

If realized, the return from the group account (which may be either positive or negative) will be split evenly among the group members. This means you will receive ¼ th of the final amount in the group account, if it is realized.

To summarize, your payoff from the experiment will be determined as follows:

$16 – your contribution to the group account +**p***{¼ * (-$24 +3.2*(Total Group Contributions))}

Where **p** is not known to you. Another way to think about this decision is as follows. You are part of a group with 4 people. With probability **p**, your group has to pay a cost of $24, of which your share is $6. You can invest in a group account to lower the cost your group must pay in the event that cost is realized. Every dollar you invest lowers the group's cost by $3.20, meaning that for every $1 you invest your cost decreases by $0.80, and so does the cost of each other member of your group. Your investment in the group account is deducted from your endowment even if the cost is not realized.

If you have questions, please raise your hand at this time, and an experiment monitor will assist you. Otherwise, simply follow the instructions on your computer screen. Once you have completed all of your decisions, please wait for the experiment to conclude. The experiment monitors will then call participants out of the room one at a time and pay you your earnings from the experiment.