The Fair Side of Chance: How Uncertainty, Power and Fairness Impact Strategic Behavior

Abstract

Uncertainty plays a fundamental role in contribution decisions for public goods. Previous research is focused primarily on strategic uncertainty (ambiguity about other players' decisions) and to a lesser extent, resource uncertainty (ambiguity about the public good itself). In this paper, we explore how the way in which resource uncertainty is framed – particularly around power and parity – affects both contributions to a public good, and perceptions of fairness. We employ a 2 player, repeated public goods game in which we manipulate how uncertainty is determined, and who it affects. We show that participants reliably contribute more to a public good under resource uncertainty even when freeriding is observable. While we were unable to operationalize fairness, our findings challenge the conclusions of previous literature on resource uncertainty.

Keywords: Public Goods Game, Uncertainty, Cooperation, Power, Parity, Fairness

By:

Andrew Cullen (atcullen@sas.upenn.edu)

Steven Jacobs (shjacobs@sas.upenn.edu)

Jordan Selesnick (jselesni@sas.upenn.edu)

Introduction

In economics, public goods are defined as commodities or services that are non-rivalrous and non-excludable.(Cowen, 1985) That is to say that supply of the good does not decrease as people use them and they are available to everyone. From providing access to clean drinking water to keeping the air that we breathe clean, public goods are maintained collectively. This usually takes the form of contributions to the public good directly through monetary contributions to a government or organization that provides the public good.

As with any collective action, there is always an element of uncertainty when contributing to a public good. A unique quality of public goods is that a person can consume it without contributing. For example, one can listen to and get all the benefits that come from public radio without donating to keep the station running. Therefore, assuming your opponent is rational, the optimal strategy is to freeride and allow others to maintain the public good for you. This freerider problem poses what is often called ‘strategic uncertainty.’ That is, how do individuals behave in the presence of others who refuse to contribute? Research shows that most individuals are ‘conditionally cooperative,’ i.e. they contribute so long as others do too. (Fischbacher., Gächter, & Fehr, 2001).

In reality, however, the provision of the public good is not necessarily guaranteed. Environmental, regulatory, and other types of resource uncertainty make the benefits of contributing more difficult to quantify. Public goods that were once provided freely, regardless of contribution, may not be around for future generations to enjoy. This decreases the expected value of the public good and should therefore impact an individual's willingness to contribute to them.

In this paper we examine how ‘resource uncertainty’ impacts contribution decisions to a public good. We build on previous work by Butera and List (2017), who introduced Knightian uncertainty to a public goods game (PGG). They found, counterintuitively, that individuals contributed more to the public good when its payoff was uncertain. While they conjecture that their result is likely due to the noisy signals players received, we explore the impact of framings of fairness on this phenomenon.

Literature Review

Most research on uncertainty in PGGs examines the effects of strategic uncertainty on contributions to the public good. Strategic uncertainty specifically refers to the inability for one player to perfectly predict another players' decisions. Optimal strategies in PGGs are dependent on strategic uncertainty e.g., the actions of others (Mcbride, 2010) .

Some papers instead focus on what is called ‘environmental uncertainty’ which makes specific structural elements of the game uncertain. The majority of research in this domain is focused on making the threshold at which a discrete public good is distributed uncertain (Dannenberg, et al., 2011, Mcbride, 2006; Suleiman, 1997). In these examples, participants must contribute above a certain “threshold” for the public good to receive payouts. These studies make the threshold unknowable to participants at the time of their donation. Under these uncertain thresholds, the incentives to contribute are much weaker, leading to increased freeriding, and thus lower contribution rates.

A subset of environmental uncertainty is something we will call ‘resource uncertainty,’ which specifically refers to uncertainty about the multiplier which determines payouts in PGGs. In basic PGGs each players payout is calculated by the function:

$$P = ((YC + PC) *M)/N$$

Where the payout (P) you receive is equal to your contribution (YC) plus your partner’s contribution (PC) multiplied by some number (M) all divided by the number of participants (N). With known multipliers is it easy to discern whether your partners are contributing to the public good or freeriding. This information can then be used by participants to inform future contribution decisions.

Under strategic uncertainty, players typically make decisions based on information from previous rounds. Resource uncertainty, however, disrupts this decision making pattern, as seen in Butera and List (2017). In their experiment, the researchers send participants noisy signals by randomly manipulating the multiplier between rounds and hiding partner’s contribution amounts. Under these conditions participants are unable to distinguish if a payout was a result of the multiplier or their partner's contribution. While the researchers argue that this is the most likely explanation for their result, subsequent failures to replicate, (Butera, List, and Villareal, 2020), suggest that the true mechanism of this phenomenon has yet to be identified. In the next section of this paper, we discuss potential mechanisms of power and parity in relation to increased prosociality under uncertainty.

Theory of Change

As mentioned previously, one of the most popular strategies in PGGs is conditional cooperation – only contributing as long as one's partner contributes (Keser & Van Winden, 2000). Previous research has found that this strategy is primarily motivated by fairness; players punish those who they believe acted unjustly by mirroring their behavior and freeriding. (Choi & Ahn, 2013). This reasoning was cited by Butera and List as a possible explanation for prosocial behavior under Knightian uncertainty. Their subjects could not distinguish whether a low outcome was due to others freeriding, or a poor multiplier, leading to low rates of punishment in future rounds. They believed that the result was presumably because participants thought punishment unjust, given that they were not certain of their partner's behavior (Butera & List, 2017).

This research suggests that perceptions of fairness could be a large contributing factor to prosocial behavior among conditional cooperators in PGGs. Yet, much of the work to date focuses only on fairness surrounding strategic uncertainty. We believe that fairness may also play a crucial role in affecting behavior that stems from resource uncertainty. It has been claimed that fairness beliefs about resource allocation could be a strong impetus for action (Evers, O'Donnell, & Inbar, 2020). In fact, some empirical studies indicate that fairness is one of the most successful motivators for sustaining prosocial behavior (Brasini et al., 2018).

While there are a plethora of factors that could affect perceptions of fairness, we have identified two that are directly linked to resource uncertainty. The first factor is power. The way in which a public resource is managed, and how it is presented could influence how people interact with it. When a disaster is due to the actions of a select group, people are more outraged as compared to a disaster that happened randomly (Falk, Fehr, & Fischbacher, 2008). Using this moral logic, we believe that people are more likely to contribute to a public good when rules are determined randomly, instead of intentionally.

The second factor is parity. In practice, some people have more information about public goods than others. This is important given the role of equality in prosociality; inequality aversion and mimicking have been shown to be integral factors for behavior in public goods games (Dong, Zhang, & Tao, 2016). As such, we expect that those with less information will copy the behavior of their favored counterparts.

Methods

Experimental Design

For this study, we used a two by two between-subject design for our treatments, and a control. The aim of the study was to explore the impact of subjects' perceptions about source (power) and information inequality (parity) on their willingness to contribute to a public good. Power based resource uncertainty was operationalized by informing participants how the rules of the game were decided. Parity based uncertainty was operationalized by revealing certain aspects of the game differently to different players. This experiment was conducted via an online Qualtrics survey with participants recruited from Amazon Mechanical Turk (MTurk).

Participants entered the survey via MTurk, and were given an explanation of the PGG. They were told that they would play multiple rounds, and receive 10 game tokens at the beginning of each round. The tokens functioned as raffle tickets for $50 Amazon gift cards that were selected after the study. Thus, the study was incentive compatible because the more they earned, the more likely they were to win. They were then told that all donations to the public fund would be multiplied by a multiplier, and would then be split evenly regardless of who donated. They were made aware that the multiplier would change each round. At this point, additional information was given based on their randomly assigned condition.

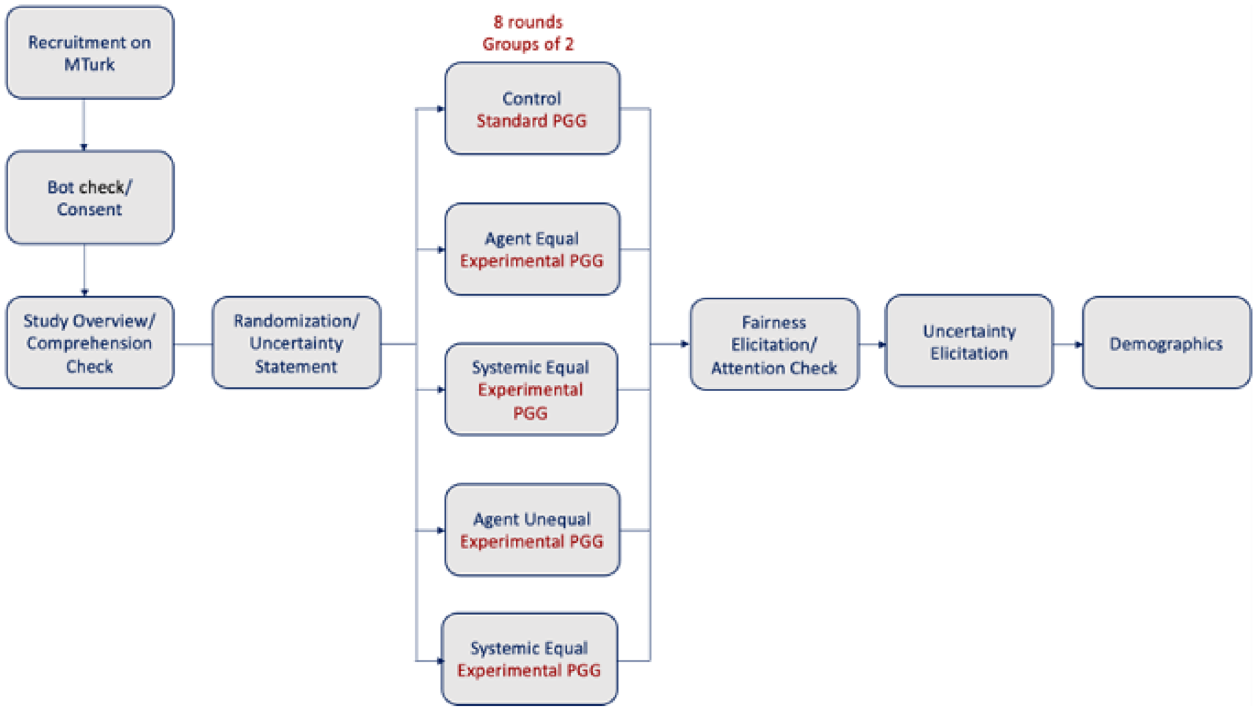

Figure 1: Experimental Flow

The conditions had two of the following attributes (one from power, and one from parity):

Power

Systemic: Participants were told that the multipliers were determined randomly.

Agent: Participants were told that the experimenters deliberately chose the multipliers.

Parity

Equal: Every individual was given the same amount of information. They did not know the multipliers before they made their contributions.

Unequal: Participants were randomly assigned to 'favored' or 'unfavored' roles within their condition.

- Favored: participants were shown the multipliers before they made their contributions.
- Unfavored: participants were not shown the multipliers until after they made their contributions.

Thus, our conditions were the following:

(a) SystemicEqual

(b) SystemicUnequal

(c) AgentEqual

(*d*) AgentUnequal

(*e*) Control

In the game, participants were paired with one other participant from their treatment. At the end of each round, they saw a feedback screen which displayed the multiplier, contributions, and payouts from the previous rounds. There were 8 rounds in total. Once they completed the game, they answered a series of questions about their perceptions of fairness, and how fairness affected their decisions. The survey concluded with demographic questions.

Hypotheses

Resource uncertainty will impact contribution decisions:

H_1: Contribution rates for individuals in the Agent Equal condition will be significantly greater than those in control condition.

H_2: Contribution rates for individuals in Agent Unequal will be significantly less than in the control.

H_3: Contribution rates for individuals in Systemic Equal condition will be significantly greater than those in the control condition.

H_4: Contribution rates for individuals in Systemic Unequal condition will be significantly less than those in the control conditions

Fairness, operationalized through framing surrounding power and parity, will impact contribution decisions:

H_5: Contribution rates for individuals in Equal conditions will be significantly greater than in Unequal conditions.

H_6: Contribution rates for individuals in the Systemic condition will be significantly greater than those in the Agent condition.

H_7: Fairness scores will be positively correlated with contribution rates across conditions

Framing surrounding power and parity successfully impact participants perceptions of fairness:

H_8: Participants in Equal conditions will give higher fairness scores than those in Unequal conditions.

H_9: Systemic conditions will give higher fairness scores than in Agent conditions

Analysis & Results

Analysis

Sample

The final analysis includes results from 794 participants who completed the survey on MTurk. 1,331 participants took the survey, but 334 were removed because they did not finish the survey or failed either the bot or attention checks, as detailed in the pre-registration plan. Upon reviewing the data, the authors decided to remove the 203 participants in the "favored" arm of the Unequal conditions. This was not registered. These participants were shown the multiplier ahead of their contribution decision, which limited the ability to isolate the impact of parity on decision making under uncertainty. (All analyses are replicated in the full dataset and can be found in the R Markdown file published on OSF.)

Dependent Variables

Results are broken down based on the three main groups of hypotheses: impact of resource uncertainty on contribution decisions, impact of fairness on participants' contribution decisions under resource uncertainty, and impact of power and parity framing on participants' perceptions of fairness. For the first two groups (H1-7), the dependent variable is the mean contribution rate for participants over eight rounds of play; for the third group (H8-9), the dependent variable is a self-disclosed fairness rating collected after the main task of the experiment.

Results

Summary Statistics

Descriptive statistics for the sample used in the analysis can be found in Table 1. On average, participants contributed 12.1 tokens (SD = 5.2) to the public account per round. The experiment took 9.2 minutes on average for participants, including introduction, main task and post-hoc questionnaire.

(H_1-H_4) Resource Uncertainty Will Impact Contribution Decisions

A primary goal of the experiment was to determine whether resource uncertainty significantly impacted contribution rates. As discussed, previous research has found mixed results. Our results found that resource uncertainty had an effect on contribution rates. Participants in the experimental conditions (who did not see the multiplier) contributed significantly more to the public account (m = 12.45, p = .0004) than individuals in the control condition that did see the multiplier (m = 11).

Figure 2 shows the results of mean contribution rates by condition as well as the results of pairwise comparisons Wilcoxon test comparing experimental conditions against the control. Mean contribution rates were significantly higher than control in EqualAgent (m = 12.3, p = .046), EqualSystemic (m = 12.54, p = .015), UnequalSystemic (m = 12.4, p = .046) and approaching significance in UnequalAgent (m = 12.14, p = .07).

Summary Statistics

Fair Side of Chance

Condition	Count	Median	Mean	SD
Control	187.0	10.9	11.0	4.9
Equal Agent	193.0	12.6	12.3	5.1
Equal Systemic	213.0	13.0	12.5	5.3
Unequal Agent	97.0	11.6	12.1	5.5
Unequal Systemic	104.0	12.4	12.8	5.2

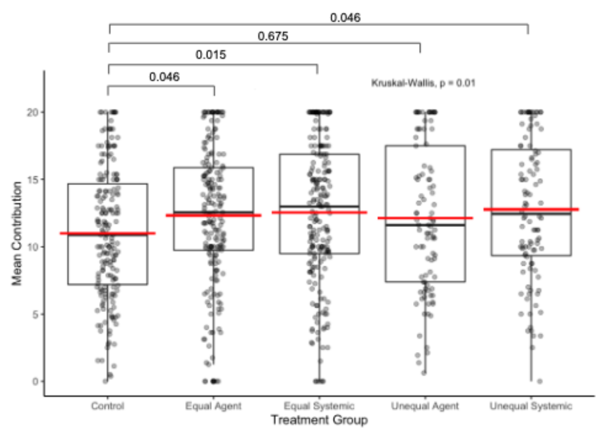

Fig. 2: Left: Summary statistics for experiment including count, median contribution rate, mean contribution rate, and standard deviation of contribution rate by condition. Right: Boxplot showing pairwise comparison between control and experimental conditions. Holm adjustment used.

(H_5-H_7) Fairness, operationalized through framing surrounding power and parity, will impact contribution decisions

The secondary hypotheses in the experiment sought to explain contributions under resource uncertainty as a function of fairness. Fairness was operationalized across two vectors: parity, in which some participants knew the multiplier (Equal) and others did not (Unequal) and power, in which some participants were told the multiplier was set by a computer (Systemic) while others were told it was set by the experimenters (Agent). We also collected self-reported measures of perceived fairness after participants completed the main task: participants were asked to rate the degree to which they felt that a) the rules of the game were fair, b) fairness impacted their decision making and c) the way in which the multiplier was determined impacted their perception of fairness.

Results show that fairness predicted a small increase in contribution rate. Regression analysis found that self-reported perceptions of the fairness of the rules of the game significantly and positively predicted mean contribution rates (estimate 0.16, $p = .03$) . Inversely, self-reported ratings by participants on the impact fairness had on their contribution decision negatively predicted contribution ratings (estimate = -0.242, $p = 0.0003$) datasets. The low estimates suggest that the impact of fairness on contributions decisions was small – albeit, statistically significant.

We also examined mean contribution rates by experimental condition. Contribution rates did not differ significantly for either the parity or power conditions. Perceptions of parity in the experiment did not impact contribution rates in the experiment. Mean contribution rate for participants in the Equal condition ($m = 12.44$) and Unequal condition ($m = 12.47$) did not significantly differ ($p = 0.91$). Mean contribution rates were slightly higher in the Systemic condition (mean = 12.61) than Agent condition (12.26), but did not differ significantly (Wilcoxon | $p = .87$). However, as discussed below, it is not clear that framing techniques used in this experiment successfully manipulated participants' perceptions of power.

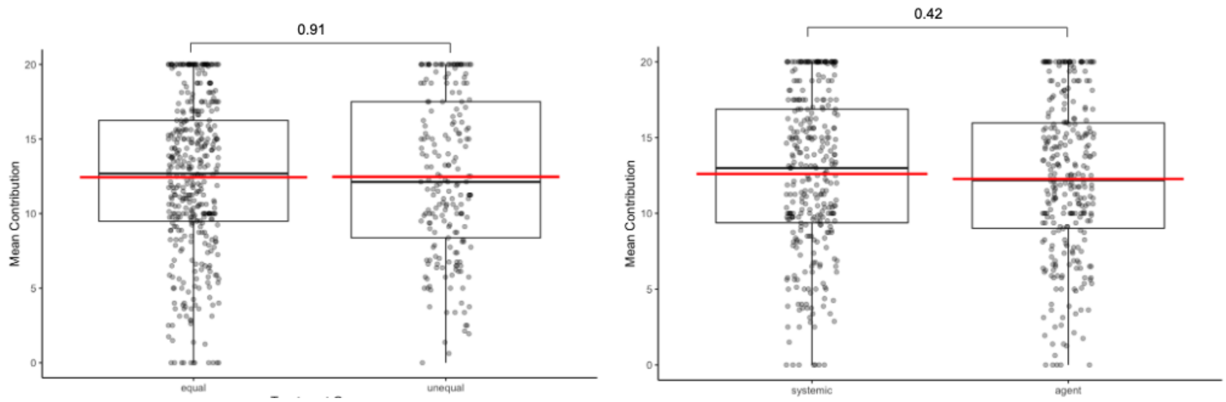

Fig. 3: Left: Boxplot showing comparison of mean contribution rate between Equal and Unequal conditions. No significant difference (Wilcoxon Rank Sum) Right: Boxplot showing comparison of mean contribution rate between Equal and Unequal conditions. No significant difference (Wilcoxon Rank Sum)

(H_8-H_9) Framing Surrounding Power and Parity Successfully Impact Participants Perceptions of Fairness

The empirical findings above rely on the assumption that the framing effects intended in each condition were successfully manipulated. To evaluate the effect, we analyzed results from the three fairness questions referenced above.

Results suggest that perceptions of fairness were adequately manipulated, and consequently, perceptions of parity did not significantly impact contribution decisions under resource uncertainty. When asked to rate the degree to which they perceived the rules of the game to be fair, participants reported significantly higher rates of fairness in the Equal condition (m = 2.56) vs. the Unequal condition (m = .9). However, when asked the degree to which fairness impacted their contribution decisions, there was no significant difference between ratings for participants in the Equal vs. Unequal conditions. This suggests that while participants perceived the manipulation as unfair, as intended, the unfairness did not impact their contribution decisions.

Alternatively, the power conditions (Agent / Systemic) did not effectively illicit perceptions of fairness among participants. When asked to rate the degree to which the way the multiplier was selected impacted their perceptions of fairness, there was no significant difference between the Agent and Systemic conditions. There was also no significant difference in reporting rates when asked whether the rules of the game were fair or whether fairness impacted their contribution decisions. These results suggest that the framing techniques were not adequately salient for participants – and that therefore, we cannot accept the null hypothesis that perceptions of power do not impact contribution decisions for individuals under resource uncertainty.

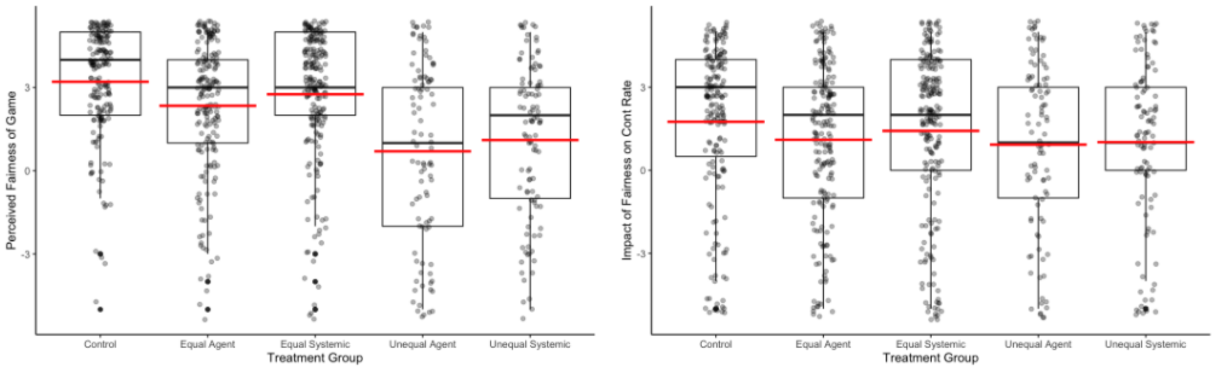

Fig. 4: Left: Boxplot showing perceived fairness of the game by condition. Participants in Unequal conditions perceived the game to be significantly less fair than those in Equal conditions. Right: Boxplot showing perceived self-reported impact of fairness on contributions decisions. Results from the pairwise wilcox test show that experimental conditions were not significantly different from one another.

Demographics and Confounding Variables

After the main task of the experiment, participants were asked to fill a brief questionnaire to share demographic information. The questions were optional.

In order to evaluate the impact of demographic variables on the findings, we conducted a regression analysis, which regresses mean contribution rates against age, gender and race of respondents as well as their experimental condition. Results from the regression (Appendix) shows that only age was predictive of mean contribution rate. While it was predictive, the estimate was extremely small – and we believe does not significantly impact our results.

Unregistered Panel Analysis

In an effort to offer alternative explanations to the primary finding that participants in experimental conditions gave more than those in control, we conducted several unregistered panel analyses to evaluate drivers for round-by-round decision making. Figure 5 shows the results of panel regressions for participants in both the control and experimental groups in which the information that participants had before each contribution decision – the current / past multiplier, their partners contribution from the last round, and the current round – was regressed against their own contribution in that round.

Results show that in the control group, where participants saw the multiplier for each round, information about the current multiplier strongly predicts contribution rate. Partner contributions from the last round (strategic information) also predicts contribution but with a substantially smaller effect. Lastly, the round did not significantly predict contribution rate suggesting that end-game effects were not at play. In the experimental groups, on the other hand, the multiplier from the last round only very weakly predicted contribution rate. Strategic information, on the hand plays, a larger role predicting behavior with more significance than in the control group.

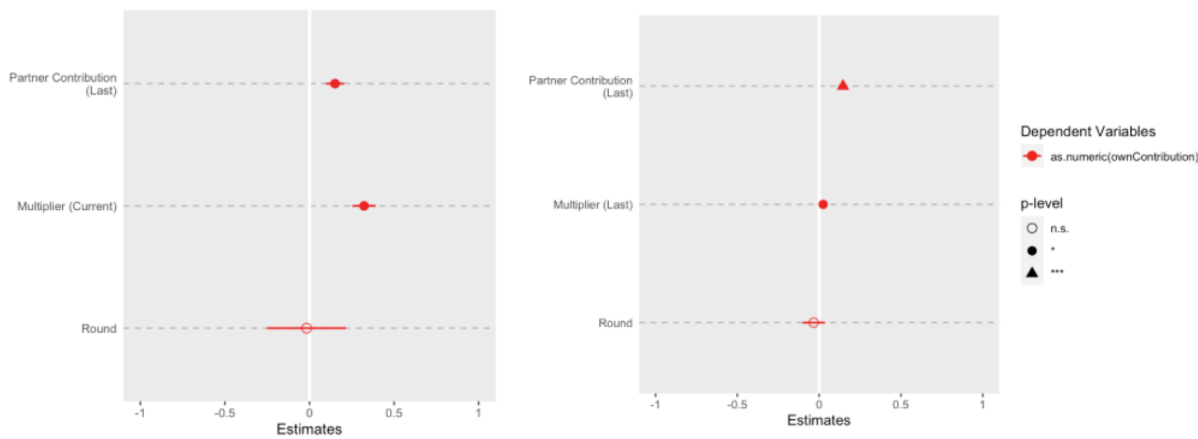

Fig. 5: Left: Results from panel analysis of the control sample regressing key information available at the time of decision against a participants contribution rate in a given round. Right: Similar regression for participants in the experimental sample. Key difference is that the multiplier information is the multiplier from the previous round versus the current one since participants in experimental condition were not shown the multiplier.

One interpretation of these results is that participants in the control group made decisions based largely on the multiplier for each round. Importantly, the multipliers peaked in round 2 and decreased directionally for the remaining rounds. Meanwhile, participants in the experimental conditions who did not know the multiplier, anchored to an early high multiplier and were slower to update their beliefs about the multiplier as the rounds went on.

Discussion & Conclusion

Today, policy makers face a daunting challenge: cooperation around public goods is essential to solving crises like climate change but political, social and economic forces are eroding trust in the institutions needed to coordinate action (Gallup, 2021). Existing research offers contradictory evidence on the impact of this type of uncertainty with some studies suggesting that environmental uncertainty leads individuals to be more selfish, and others suggesting that it leads to more prosocial behavior.

In this paper, we examine how environmental uncertainty impacts decision-making in a coordination game – and the effects perceptions of fairness have on decisions in these environments. We conducted an experiment in which individuals participated in an interactive, online PGG where certain participants see the multiplier ahead of a contribution decision and others do not. We then examine the effect of perceptions of fairness on decision making under environmental uncertainty by altering the framing around the way in which the multiplier was selected and the parity of experience between participants.

The main contribution of this paper is to conceptually replicate a counter-intuitive finding from Butera and List. In this experiment, participants gave significantly more throughout the experiment when they did not know the multiplier. Additionally, we can reject Butera and List's explanation that this prosocial behavior was the result of participants failing to punish partners because they could not clearly identify freeriders. Participants in the current experiment were presented with a clear breakdown of their partners' contribution decisions on a results screen after each round.

In the experiment, we sought to explore the effect of fairness on participants' contribution decisions under uncertainty. The results here were less clear. Self-reported perceptions of fairness did predict a small change in contribution rate, but participants in our experimental conditions did not give significantly different amounts from one another. We can accept the null hypothesis that inequality did not affect contribution rate under resource uncertainty in this game. However, we cannot do the same with the *power* conditions. We show that the framing techniques used in the experiment did not successfully elicit the feeling of intentionality implicit in power dynamics (e.g. someone is doing this to you) we sought to test. Further research could use other techniques, such as those explored in research surrounding self-driving cars, or human computer interaction more generally to better manipulate the effect.

This leaves an open question – why did participants give more when they did not know the multiplier? A combination of order effects and optimism bias could offer one plausible explanation. The multipliers in the experiment were structured so that all participants received the same multipliers. However, the multiplier was largest in Round 2 and then directionally decreased as the game went on. The large multiplier early in the game followed by smaller multipliers might have led participants in the control to decrease contributions as they followed the new multiplier; while participants in the experimental conditions remained anchored on the large early multiplier and failed to update their beliefs.

This paper offers important new evidence that resource uncertainty can lead to prosocial behavior – but the motivating factors remain unclear. We provide evidence that fairness weakly predicts proscial decision-making in a public goods game, but the findings are not conclusive. Further research is needed to explore the effect of power, in particular, as a potential mediator of decision-making under resource uncertainty.

References

Butera, L., Grossman, P. J., Houser, D., List, J. A., & Villeval, M. C. (2020). *A new mechanism to alleviate the crises of confidence in science-with an application to the public goods game* (No. w26801). National Bureau of Economic Research.

Butera, L., & List, J. A. (2017). *An economic approach to alleviate the crises of confidence in science: With an application to the public goods game* (No. w23335). National Bureau of Economic Research.

Cowen, T. (1985). Public goods definitions and their institutional context: a critique of public goods theory. *Review of Social Economy*, *43*(1), 53-63.

Choi, J. K., & Ahn, T. K. (2013). Strategic reward and altruistic punishment support cooperation in a public goods game experiment. *Journal of Economic Psychology*, *35*, 17-30

Dannenberg, A., Löschel, A., Paolacci, G., Reif, C., & Tavoni, A. (2015). On the provision of public goods with probabilistic and ambiguous thresholds. *Environmental and Resource economics*, *61*(3), 365-383.

Dong, Y., Zhang, B., & Tao, Y. (2016). The dynamics of human behavior in the public goods game with institutional incentives. *Scientific Reports*, *6*(1), 1-7.

Evers, E., O'Donnell, M., & Inbar, Y. (2020). Simple Beliefs About Fairness. *ACR North American Advances*.

Falk, A., Fehr, E., & Fischbacher, U. (2008). Testing theories of fairness—Intentions matter. *Games and Economic Behavior*, *62*(1), 287-303.

Fischbacher, U., Gächter, S., & Fehr, E. (2001). Are people conditionally cooperative? Evidence from a public goods experiment. *Economics letters*, *71*(3), 397-404.

Gallup. (2021, August 13). *Confidence in institutions*. Gallup. https://news.gallup.com/poll/1597/confidence-institutions.aspx

Keser, C., & Van Winden, F. (2000). Conditional cooperation and voluntary contributions to public goods. *scandinavian Journal of Economics*, *102*(1), 23-39.

McBride, M. (2006). Discrete public goods under threshold uncertainty. *Journal of Public*

Economics, *90*(6-7), 1181-1199.

McBride, M. (2010). Threshold uncertainty in discrete public good games: an experimental study. *Economics of governance*, *11*(1), 77-99.

Suleiman, R. (1997). Provision of step-level public goods under uncertainty: A theoretical analysis. *Rationality and Society*, *9*(2), 163-187.