Department of Economics Working Paper

Number 23-10 | November 2023

Inequality and the Allocation of Collective Goods

Caleb Cox
Virginia Commonwealth University

Brock Stoddard
Appalachian State University

Department of Economics
Appalachian State University
Boone, NC 28608
Phone: (828) 262-2148
Fax: (828) 262-6105
www.business.appstate.edu/economics

Inequality and the Allocation of Collective Goods

Caleb A. Cox* Brock Stoddard†

October 8, 2023

Abstract

We examine the allocation of a voluntarily-provided collective good with inequality in endowments or productive capabilities. After group members choose their contributions to a collective good, a third-party allocator distributes the resulting value among the group members. With and without inequality, we find that allocators significantly improve efficiency compared to automatic equal division of the collective good. However, inequality creates a conflict between various notions of equitable distribution, potentially diminishing the allocator's ability to incentivize contribution. Our results show that inequality in endowments or productive capabilities indeed reduces the effectiveness of allocators compared to the baseline case of equality.

1 Introduction

Inequality is common among team members working to produce a joint surplus or collective good. Examples of voluntarily provided collective goods include public goods and common-property resources. Some individuals may be more productive than others or have greater endowments of productive resources. Incentivizing teamwork to increase the production of collective goods in such settings could be particularly challenging because individuals might perceive the fairness of allocations differently. A well-known example of inequality among team members comes from the parable of the workers in the vineyard (Matthew 20:1-16). In the parable, individual workers who

*Department of Economics, Virginia Commonwealth University, Snead Hall, 301 W. Main Street, Box 844000, Richmond, VA 23284, email: *cacox@vcu.edu*

†Department of Economics, Walker College of Business, Appalachian State University, Peacock Hall, Boone, NC 28608, email: *stoddardbv@appstate.edu*

contributed much object to being paid equally with others who contributed less. The balance between equity and efficiency is at the core of the debate when allocating resources produced by teams. Remuneration based on incentivizing efficiency would increase based on contribution. Such remuneration might be perceived as fair by high contributors, but unfair by those unable to contribute as much. In contrast, remuneration based on concerns about equality might be perceived as fairer by some, but less fair by high contributors, as in the parable. A pluralism of fairness ideals can exist when production occurs by those receiving shares of the produced surplus (e.g. Cappelen et al., 2007). Even in settings with equality in productivity and initial resources, experiments provide evidence of heterogeneous fairness ideals (e.g. Frohlich et al., 2004).

For example, consider a sales manager allocating bonuses to sales staff. The top salesperson may expect greater bonuses due to their higher sales. Others may think equal bonuses are fair, or might prefer bonuses proportional to hours worked rather than sales, rewarding input instead of output. Another example is a manager dividing tips from a tip jar between employees. While some employees may expect the tip jar to be allocated based on hours worked, employees who directly interact with customers and generate more tips may expect a larger share than others. On a larger scale, organizations such as universities allocate funds to various sub-units based on various criteria such as tuition revenue brought in, number of students, or operating cost.

The implications of equitable and efficient allocations of collective goods may differ depending on the distribution of resources and productive capabilities within a team. In a homogeneous setting, both equality and efficiency can be achieved by allocating more rewards to members who produce more of the collective good. Since all members start on equal footing in terms of resources and production capabilities, the higher contributors also produce more of the collective good. Additionally, if all members are successfully incentivized to contribute optimally, then such an allocation also yields an equal distribution of rewards. In heterogeneous settings, however, incentivizing efficient contribution can lead to unequal allocations of the collective good. Moreover, perceptions of fairness may conflict between different contributors, potentially due to self-serving bias (see, e.g. Kagel et al., 1996; Babcock and Loewenstein, 1997; Johansson-Stenman and Konow, 2010; Rodriguez-Lara and Moreno-Garrido, 2012; Ubeda, 2014). For example, some contributors might view equal allocations as fair, while others view allocation proportional to contribution or production as fair. Self-serving bias in fairness notions complicates the allocator's problem of incentivizing cooperation, and may have important implications for resolving real-world social dilemmas such as climate change (see, e.g. Kesternich et al., 2021).

In this study, we experimentally examine whether such potentially conflicting fairness concerns in heterogeneous environments inhibit the ability of allocators to encourage contribution to collective goods. Previous experiments have found that allocators can effectively improve contribution in homogeneous environments relative to equal shares by allocating in proportion to contribution (Stoddard et al., 2014, 2021).[1] However, it is unknown whether such proportional allocation schemes will succeed with heterogeneous groups. We examine allocation decisions under homogeneity and under exogenous heterogeneity in endowments or productive capacity. These distinct types of heterogeneity may have differing implications for rewarding contribution and rewarding production. Allocating in proportion to contribution might tend to favor high-endowment group members, but not high-productivity group members because high- and low-productivity members are equally endowed. On the other hand, allocating in proportion to production may tend to favor both high-productivity and high-endowment group members. More equal allocation schemes might reduce inequality, but could also discourage the high-endowment or high-productivity group members from contributing.

We consider a variety of allocation benchmarks based on various notions of fairness, with different implications under different types of heterogeneity. By examining both heterogeneous endowments and heterogeneous productivity, in addition to the homogeneous baseline, we can explore how allocators balance incentives for contribution with the different types of fairness concerns arising in these settings. Ramalingam et al. (2023) examine both of these types of heterogeneity a setting with a single common member in two otherwise separate groups, considering cases where the common member had a higher endowment or higher productivity than other group members. They find higher efficiency when the common member had a greater endowment, but lower efficiency when the common member is more productive, with differing norms emerging in each case.

Other related Studies examining the effect of heterogeneity on cooperation in social dilemmas generally find that cooperation is lower in heterogeneous groups compared to homogeneous groups (e.g. Cherry et al., 2005). Tavoni et al. (2011) find endowment inequality reduces success in reaching

[1]With equal shares, the game is equivalent to a linear VCM public goods game. However, our setting differs in interpretation by the fact that the collective good is rival in consumption, unlike the case of pure public goods.

a public-good contribution threshold to avoid a large loss for the group, but the ability to communicate a willingness to reduce inequality leads to more success. Recent studies have begun to examine the effectiveness of mechanisms on increasing cooperation in heterogeneous environments. For instance, different types of punishment mechanisms have been found to increase cooperation in public goods games with heterogeneous endowments (Nockur et al., 2021; Chaudhuri et al., 2023, e.g.). The Galbraith Mechanism has also been found to increase contributions in collective goods games with endowment heterogeneity (Falvey et al., 2023). In the Galbraith Mechanism, group members first make contribution decisions and then, after observing others' contributions, collectively divide the surplus between group members by each assigning a percentage of surplus to others.

In this line of research, we use the allocator mechanism as our experimental decision environment (Stoddard et al., 2014, 2021). Team members contribute to a collective good, which is then allocated back to the contributors by the allocator. The allocator is a third party who cannot contribute private resources to the collective good and cannot take a share of the collective good, but whose payoff increases with the size of the collective good. Examples of such allocators include a department chair or dean allocating raises from a pool of funds to faculty within a department or college, and a local official allocating water shares to individuals maintaining irrigation systems. Historically, Christian groups formed communal societies in ancient Israel (Acts 5) and within the Church of Jesus Christ of Latter-day Saints in the American frontier (Warner, 1888; Gardner, 1917, 1922; Arrington, 1976) where apostles and bishops allocated resources to their congregations. More recently, Israeli kibbutz share incomes and work together to produce collective goods (Putterman, 1983; Ruffle and Sosis, 2006; Abramitzky, 2008, 2011).

In the settings we have in mind, allocators such as managers, bishops, and chairs, are likely to have information that most employees or group members do not have access to. For instance, a department chair, when allocating a raise pool, has access to teaching evaluations, working papers, and service that might not be public information to the department. Similarly, a bishop or religious leader in communal societies observed financial-donation records, productivities, and efforts of societal members. Managers in a business have information about their employees that is relevant to productivity, such as their work schedules, experience, and credentials. With these examples in mind, we implement an allocator mechanism where the allocator is informed about heterogeneity in endowments and productivity within the group.

We compare allocator treatments with equal-share baselines in a homogeneous condition and conditions with exogenous heterogeneity. In the homogeneous allocator treatment, contributing group members with equal resource endowments and equal production capabilities make contribution decisions to a collective good. After observing the contributors' decisions, the allocator allocates shares of the collective good to the group members. The allocator has flexibility to contribute any share to each group member, as long as the sum of the shares equals 100%. The heterogeneous endowment allocator treatment differs from the homogeneous allocator in that contributors have different resource endowments available for contribution. The heterogeneous productivity allocator treatment differs from the homogeneous allocator treatment in that the return to contribution to the collective good differs between contributors.[2]

We find that, in all settings, allocators improve efficiency (in terms of voluntary collective good production) relative to parallel equal-share settings without allocators. However, consistent with our hypothesis of an "efficiency penalty" in the presence of heterogeneities, allocators are less effective in treatments with heterogeneous endowments or heterogeneous productivity. Allocations frequently conform to a benchmark of proportionality with contributions as a percentage of endowment. Furthermore, in homogeneous and heterogeneous-productivity allocator treatments, an allocators' deviations from this benchmark in previous rounds correlate negatively with group-level efficiency in the current round. The allocation task appears to be more difficult when contributors have heterogeneous endowments. Contributors with heterogeneous endowments do not respond to deviations from any particular allocation benchmark, including proportionality with contribution as a percentage of endowment.

2 Related Literature

Competing fairness concerns are often referred to as normative conflict in the literature. Normative conflict occurs when there are multiple plausible rules about how one ought to behave in a

[2]Drouvelis et al. (2017) examine a setting with heterogeneous production capabilities with similarities to the allocator mechanism. Team members' contributions to a team good have heterogeneous returns for the group. A team leader allocates shares of the team good to all team members. Having a team leader increases production of the team good compared to a setting with equal shares. However, the team leaders make contribution decisions and can allocate resources to themselves. They find that team leaders use the opportunity to allocate most of the efficiency gains to themselves. Also, Drouvelis et al. (2017) do not examine heterogeneous endowments, as in this study.

given situation. A rule of behavior is a norm when a sufficient number of individuals in a group prefer to conform to the rule (Bicchieri, 2006).[3] In the context of a public goods game, possible conflicting norms could be each member contributing an equal amount or contributing so that all parties receive equal earnings. In the case of homogeneous group members and an equal-shares allocation rule, these two norms would be equivalent. However, with heterogeneity, these potential norms are likely to conflict.

Nikiforakis et al. (2012) examine a public goods game with opportunities to punish, counter-punish, counter-counter-punish, etc. Norm enforcement through a punishment institution in their game allows for feuds to exist within groups through repeated counter-punishment within a round. They find feuds are much more likely to occur in groups with heterogeneity in returns from the public good, than in homogeneous groups. Gangadharan et al. (2017) also find that normative conflict is more difficult to overcome in a public goods games with groups with heterogeneous returns from the public good than in homogeneous groups. In their case, communication and rewards are implemented as potential means for resolving the conflict brought about by heterogeneity, but these means are not as effective in heterogeneous groups. Chat between group members reveals that heterogeneous groups struggle with the equality-efficiency tradeoff. Kingsley (2016) examines punishment and endowment heterogeneity in non-linear public goods games with interior solutions. Peer punishment is not as effective at improving efficiency in heterogeneous groups as it is in homogeneous groups.

A key lesson from these studies examining normative conflict is that when efficiency and equality are not compatible, heterogeneous groups struggle reconciling the two. Also, groups rarely commit to one or the other and follow intermediate norms. Given the importance of cooperation in collective good settings, and based on the success of allocators in related studies with homogeneous groups, we examine normative conflict in unequal groups using the allocator mechanism.

The studies most closely related to this one are Stoddard et al. (2014, 2021). Both experimental studies examine the affect allocators have on increasing contributions to collective goods (common-property resources). Stoddard et al. (2014) examines an allocator mechanism where the allocator

[3] More specifically, Bicchieri (2006) defines a norm as a rule of behavior for a population if a sufficient number of individuals in that population (a) knows that the rule exists and can be applied in a particular type of interaction; (b) prefers to conform to the rule in that interaction, provided that (i) they believe that a sufficient number of others conforms to the rule, and (ii) believes that a sufficient number of others expects the individual to conform or believes that a sufficient number of others expects conformity, prefers conformity, and may punish those who do not conform.

has a fairly restrictive set of allocation rules to choose between. Relative to equal-share (VCM) and random allocation mechanisms, the allocator mechanism significantly improves efficiency. Allocators generally allocate shares of the collective good to contributors based on their contributions. Stoddard et al. (2021) examine alternative allocator mechanisms that vary the flexibility of the allocation rules available to allocators, including a mechanism with no rules except that allocated shares of the collective good must sum to 100%. Unlike the allocation rules in Stoddard et al. (2014), the more flexible rules allow for allocation schemes that make full contribution a dominant strategy. They find the mechanisms with the most flexibility (no allocation rules except that shares must sum to 100%) lead to the highest efficiency. The key difference between this study and those other allocator mechanism studies is that group members in those other studies are homogeneous in their endowment of resources and productive capabilities. We study heterogeneous groups in this paper to examine the effectiveness of allocators when efficiency and equity concerns conflict.

We are interested in how allocators will balance competing fairness concerns with incentivizing contribution to the collective good.[4] For example, will allocators seek to increase efficiency by allocating larger shares to those with more resources or greater abilities? Alternatively, will allocators seek to tighten the gap created by initial inequalities by assigning more to disadvantaged group members, even if their absolute contributions are lower than those of advantaged players?

An important element of the allocator mechanism we examine is that allocators do not have self-serving or opportunistic incentives. In contrast, related work allows allocators or team leaders to allocate shares of the collective good to themselves (Van der Heijden et al., 2009; Drouvelis et al., 2017; Karakostas et al., 2023). Related research examining fairness norms in various contexts such as dictator and bargaining games shows the importance of self-serving bias when dividing resources (e.g. Konow, 2000, 2003; Johansson-Stenman and Konow, 2010; Rodriguez-Lara and Moreno-Garrido, 2012; Ubeda, 2014). By preventing allocators from assigning shares of the collective good to themselves, we prevent purely selfish self-serving bias. Instead, our allocators' earnings increase as the value of the collective good increases. This incentive structure is also different than impartial spectators who receive a flat fee for allocating resources, without any stake in the decision (Croson and Konow, 2009). Our setting provides a unique environment for examining

[4]The issue of incentivizing contribution is generally related to the very large literature on work incentives, surveyed in Lazear (2018). Most closely related within this literature is research on incentives for working in teams (e.g. Holmstrom, 1982; Kandel and Lazear, 1992; Mas and Moretti, 2009; Kruse, 2022).

fairness norms where allocators are stakeholders incentivized to increase efficiency in the group.[5]

Our experiment is also related to studies examining heterogeneity in public goods games (linear voluntary contributions mechanism games). Inequality in endowments reduces contribution to a public good compared to an equality setting (Buckley and Croson, 2006).[6] This effect is caused by the rich contributing a smaller percentage of their endowment than do the poor group members (Hargreaves-Heap et al., 2016). Heterogeneous production capabilities, when the marginal per-capita return (MPCR) of the high productivity subjects is less than 1 (as in our experiment), lowers contribution (Tan, 2008; Dorner et al., 2021; Ramalingam et al., 2023).[7] Fellner-Röhling et al. (2020) examine heterogeneous productivity, but each member only receives benefits from the public good from others' contributions.

Ramalingam et al. (2023) compare endowment and productivity heterogeneities in linear public goods games with common group membership. In particular, two groups have a common-member, who is part of both groups and can make contributions from one endowment. The common-member is enhanced with either a larger endowment or more productive contributions than the dedicated-members in each group. When the common-member has a larger endowment, efficiency increases compared to equal endowments. However, when the productivity of the common-member's contribution is increased, group efficiency decreases compared to the homogeneous case. They find that a norm of reciprocity based on absolute contribution was more prevalent than a norm based on the effective value of contribution, even when the effective contribution of the common-member increases with heterogeneous productivity. This result illustrates an important instance of when different types of inequality result in different norms being implemented and resulting in different efficiencies. In our experiment, in addition to our equal-share treatments providing further evidence of the effect of endowment and productivity inequality relative to equality when potential efficiency is held constant, we also examine the role of the allocator mechanism when normative conflict potentially exists with different forms of inequality.

[5]There is also a related literature where group members themselves determine the allocation of a collective good or reward-sanction institution (e.g. Sutter et al., 2010; Colasante and Russo, 2017; Dong et al., 2019).

[6]However, inequality in endowments does not decrease contributions when the unequal groups have larger aggregate group-level endowments compared to aggregate endowments in equal groups (Reuben and Riedl, 2013).

[7]However, heterogeneous production capabilities increase contribution in settings where the high productive subjects have an MPCR greater than 1 (Kölle, 2015).

3 Experimental Design and Procedures

Treatment	Shares	Endowment (tokens)	Productivity	Groups (USD+ASU)	Subjects (USD+ASU)
Alloc-Hom	Allocated	10	2.4	12 (6+6)	60 (30+30)
Alloc-HetEndow	Allocated	Rich: 15 Poor: 5	2.4	18 (9+9)	90 (45+45)
Alloc-HetProd	Allocated	10	High: 3.6 Low: 1.2	18 (9+9)	90 (45+45)
ES-Hom	Equal	10	2.4	15 (7+8)	60 (28+32)
ES-HetEndow	Equal	Rich: 15 Poor: 5	2.4	17 (8+9)	68 (32+36)
ES-HetProd	Equal	10	High: 3.6 Low: 1.2	15 (8+7)	60 (32+28)

Table 1: Treatment Summary

Initial matching into groups was computerized, random, and anonymous in all treatments. Groups and roles remained fixed across 10 periods of repeated play (partners matching). Decisions were made privately using a computer. Printed instructions were provided and read aloud by the experimenter at the start of each session.[8] Subjects then completed a comprehension quiz before period of the game.

In all Equal Share (ES) treatments, there were 4 subjects per group, and the value of the collective good was automatically divided equally among the group members, equivalent to the standard linear public goods game or voluntary contributions mechanism (VCM). In the ES treatment with Homogeneous Endowments and Productivity (ES-Hom), each contributor was endowed with 10 tokens, and could keep or contribute any whole number of tokens to the collective good.[9] All tokens contributed to the collective good were multiplied by 2.4, for a marginal per capita return of 0.6. The ES treatment with Heterogeneous Endowments (ES-HetEndow) is similar to ES-Hom, but with 2 Rich and 2 Poor contributors. Rich and Poor types are randomly assigned and remain fixed throughout the experiment. Each Rich contributor started with an endowment of 15 tokens, while each Poor contributor started with an endowment of 5 tokens.

In the ES treatment with Heterogeneous Productivity (ES-HetProd), initial endowments are

[8]Full experimental instructions are provided in the Appendix B.

[9]We use the term "contributor" to refer to any group member who is not an allocator, regardless of whether the group member chose a positive contribution.

homogeneous as in ES-Hom, but there are 2 High productivity and 2 Low productivity contributors. High and Low productivity types are randomly assigned and remain fixed throughout the experiment. Each token contributed by a High-productivity contributor was multiplied by 3.6, while each token contributed by a Low-productivity contributor was multiplied by 1.2. Importantly, the total initial endowment (40) and maximum aggregate payoff (96) is the same in all treatments. The ES treatments are identical to linear voluntary contribution public goods games.

In all Allocator (Alloc) treatments, there were 5 subjects per group, including 4 contributors and 1 allocator. In Alloc treatments, the allocator observed individual contributions and then chose how to divide the value of the collective good among the contributors so that the sum of shares equals the total value. The allocator also received a payment equal to 0.25 times the value of the collective good. Importantly, the allocator could not contribute to or take from the collective good.

There are 3 Alloc treatments, including 1 with Homogeneous Endowments and Productivity (Alloc-Hom), 1 with Heterogeneous Endowments (Alloc-HetEndow), and 1 with Heterogeneous Productivity (Alloc-HetProd). Each Alloc treatment is similar to the corresponding ES treatment, except that the value of the collective good is distributed by the allocator rather than being shared equally. The allocator role is randomly assigned and remains fixed throughout the experiment.

At the end of each period in all treatments, each group member observed the total amount contributed by the group, the final value of the collective good, their own earnings from the collective good, and their own total earnings for the period. While making decisions, contributors also had a history table that reported this information, their individual provision decisions for all previous rounds, and the share of the collective good they received. Identified by ID letters (and endowment/productivity capability in treatments with heterogeneity), the history table available to the allocator reported each contributor's provision decision and allocated share of the collective good for all previous rounds.

The treatments are summarized in Table 1. The initial experimental sessions were conducted at the University of South Dakota (USD) between Spring 2016 and Spring 2017. Additional sessions were conducted at Appalachian State University (ASU) between Summer 2019 and Spring 2021. The number of groups and subjects at each lab is summarized in Table 1. Subjects were recruited by email and ORSEE (Greiner, 2015). All sessions were programmed and conducted using z-Tree (Fischbacher, 2007). Earnings were converted to US dollars at a rate of 12 experimental currency units per dollar. Subjects earned approximately $17 on average and the average session lasted less than one hour.

3.1 Predictions

We detail the main predictions tested, before proceeding to the results. First, as discussed in Stoddard et al. (2021) in the homogeneous case, the allocator can design an allocation scheme in a way that incentivizes full contribution by rewarding high contributors and punishing low contributors. A simple way to achieve this goal is to allocate to each contributor exactly the amount they produced. Since each token contributed is multiplied by a number greater than 1, allocating this multiplied amount to the contributor incentivizes full contribution. The same logic extends to the cases of heterogeneous endowments and heterogeneous productivity, assuming contributors are self-interested money maximizers. Based on this theoretical argument, as well as the prior experimental results in Stoddard et al. (2021) and Stoddard et al. (2014), we predict that the presence of an allocator will enhance efficiency.

Prediction 1. *Allocators will increase efficiency relative to equal shares.*

Self-serving bias in interpretations of fairness have been documented in a variety of settings (e.g. Kagel et al., 1996; Babcock and Loewenstein, 1997; Johansson-Stenman and Konow, 2010; Rodriguez-Lara and Moreno-Garrido, 2012; Ubeda, 2014). In the current context, there are a variety of potentially conflicting fairness norms. For example, allocating shares according to production would tend to favor Rich or High-productivity types in heterogeneous cases, while allocating shares equally would be more advantageous for Poor or Low-productivity types. Other possibilities include allocating shares in proportion to contribution, in proportion to the percentage of endowment contributed, or equalizing final payoffs. If different types in heterogeneous treatments have differing interpretations of fairness due to self-serving bias, it may be difficult for allocators to satisfy everyone. Moreover, it is also possible that the allocators themselves might have social preferences that may or may not align with the contributors' notions of fairness, creating an additional potential source of conflict.[10] In response to allocations that are perceived to be unfair, some contributors

[10]Importantly, however, allocators cannot influence their own payoffs directly, but only indirectly by encouraging contribution in future periods. If allocators have pro-social preferences such as altruism or a preference for efficiency, such preferences would align with the pecuniary incentive to encourage future contribution.

might reduce contribution in later rounds. Thus, we predict that the efficiency gains due to the allocators will be smaller in heterogeneous treatments.

Prediction 2. *Allocators will be less effective in promoting efficiency with heterogeneous endowments or productivity compared to the homogeneous case.*

4 Results

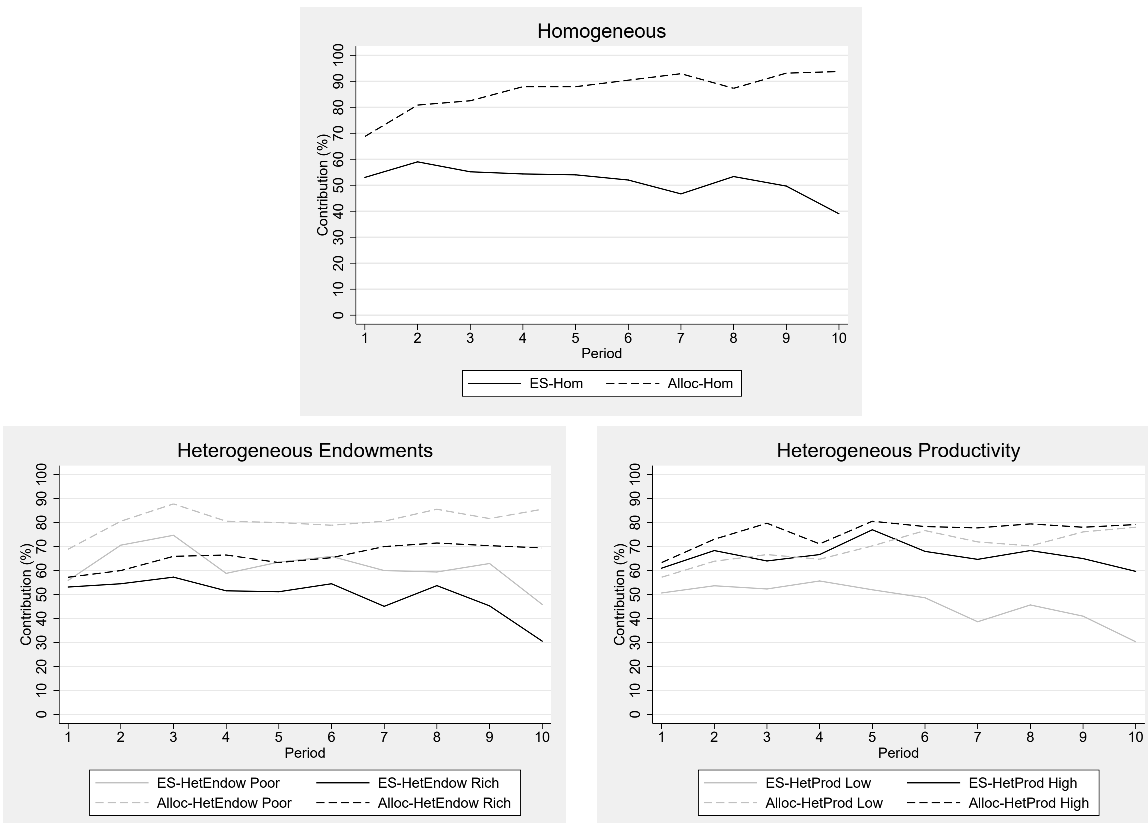

Figure 1: Average contribution as a percentage of endowment by period.

Figure 1 shows the average contribution to the group account as a percentage of the endowment across all 10 periods of play.[11] In all cases, contribution rates are higher with allocators compared to equal-share treatments. Moreover, we the appears to be a downward trend in contributions in later periods of ES treatments, consistent with many related experiments, but this trend is not apparent in Allocator treatments.

[11] Appendix A.2 reports summary statistics and hypothesis tests of individual-level contributions.

	(1) Hom	(2) Hom	(3) HetEndow	(4) HetEndow	(5) HetProd	(6) HetProd
Period 1 Contribution (%)	0.328***	0.328***	0.408***	0.408***	0.448***	0.448***
	(0.0613)	(0.0613)	(0.0495)	(0.0496)	(0.0690)	(0.0690)
Period	-0.333	-1.764***	-0.749	-2.248***	-0.167	-1.678**
	(0.488)	(0.619)	(0.468)	(0.598)	(0.524)	(0.795)
Alloc	31.89***	12.58**	14.62***	-2.874	21.58***	4.953
	(3.859)	(5.293)	(5.316)	(5.425)	(7.024)	(8.153)
Rich/High			-11.99**	-11.99**	15.78**	15.78**
			(4.495)	(4.497)	(6.607)	(6.610)
Alloc × Rich/High			1.347	1.347	-12.00	-12.00
			(5.970)	(5.973)	(7.434)	(7.437)
Alloc × Period		3.219***		2.915***		2.770***
		(0.702)		(0.793)		(0.957)
Constant	36.08***	44.66***	44.09***	53.09***	24.74***	33.81***
	(3.700)	(4.129)	(5.558)	(5.816)	(5.884)	(6.382)
Observations	972	972	1260	1260	1188	1188
Clusters	27	27	35	35	33	33
R^2	0.413	0.430	0.261	0.274	0.272	0.284

Standard errors in parentheses, clustered by group

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Linear regressions of individual-level contribution as a percentage of the endowment in Periods 2-10.

To test for these differences in contribution, we use linear regressions with standard errors clustered by group, reported in Table 2. In each case, the dependent variable is individual-level contribution as a percentage of the endowment. In addition to treatment indicators and the period of play, we control for the group's initial contribution in period 1 before the allocator has made any allocation decision. Rich types in treatments with heterogeneous endowments contribute significantly lower proportion of the endowment, consistent with previous public goods experiments with endowment inequality (e.g. Hargreaves-Heap et al., 2016). In treatments with heterogeneous productivity, High types contribute more, as their return is higher (and thus their cost of contribution is lower). In the homogeneous case, as well as with heterogeneous endowments or heterogeneous productivity, the main effect of the allocator on contribution rates is positive and significant. We examine the interaction between Alloc and Rich/High to check whether the effect of allocators on the percentage of the endowment contributed is different for Rich/High types than for Poor/Low types. In both the cases of heterogeneous endowments and heterogeneous productivity, the interactions have opposite sign compared to the coefficient for Rich/High types (suggesting allocators may somewhat reduce the difference in percentage contribution between types), but in both cases the interactions are not statically significant. We also consider an interaction term between Alloc and Period to examine whether the difference in trend apparent in Figure 1 is significant. In each of the Hom, HetEndow, and HetProd, when this interaction is included, the trend across Periods is negative and significant in ES treatments, but the interaction is positive, significant, and larger in absolute value than the estimated Period coefficient. Taking the sum of the Period and Alloc $\times$ Period coefficients we find the trend with an Allocator is significantly greater than zero in Hom (p-value < 0.001) and HetProd (p-value $= 0.048$), though not in HetEndow (p-value $= 0.209$). When the Alloc $\times$ Period interaction is included, the Alloc main effect remains positive and significant in Hom, but becomes insignificant in HetEndow and HetProd. Thus, it appears that in these cases of inequality, higher contribution with an Allocator is primarily due to the reduction or reversal of the usual decay of cooperation in the group. .

Result 1. *Consistent with Prediction 1, contribution rates are higher in allocator treatments compared to those in equal-share treatments. This effect appears largely due to Allocators reducing or reversing the decay of cooperation across Periods.*

Next, to get an idea of how aggregate earnings differed across treatments, we examine efficiency. Group-level efficiency in a period is calculated as the sum of contributors' earnings within a group divided by the maximum possible aggregate earnings of the four contributors in a group (a maximum of 96 tokens, equal to $1.2 * 20 + 3.6 * 20$ tokens in HetProd treatments or $2.4 * 40$ tokens otherwise). Figure 2 shows the average percentage efficiency at the group-level across all 10 periods of play.[12] Efficiency is higher and shows less decay across Periods with allocators, but efficiency improvements appear larger in Alloc-Hom than in allocator treatments with heterogeneity. Counting the number of groups with average efficiency across all periods greater than 85%, there are 9 out of 12 groups in Alloc-Hom, 10 out of 18 groups in Alloc-HetProd, and only 5 out of 18 groups in Alloc-HetEndow. Counting the number of groups with 95% average efficiency or higher, there are 4 out of 12 in

[12] Appendix A.1 reports summary statistics and hypothesis tests of group-level contributions and efficiency.

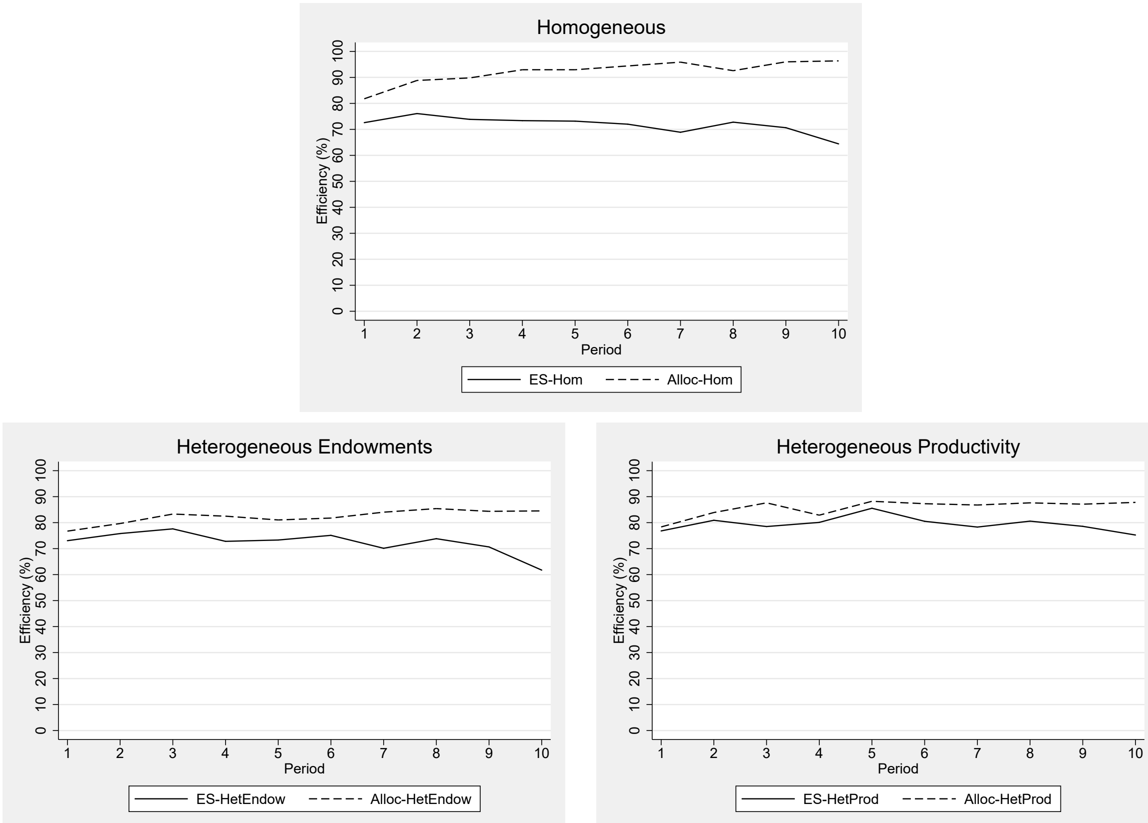

Figure 2: Efficiency (%) by period.

Alloc-Hom, 2 out of 18 in Alloc-HetProd, and 0 out of 18 in Alloc-HetEndow.[13]

Table 3 shows regressions of group-level efficiency in Periods 2-10. In addition to treatment indicators, period, and initial efficiency, we include controls for sessions run at the University of South Dakota (USD) compared to Appalachian State University, and for sessions run under COVID-19 protocols. We find no significant effects of subject pool or COVID-19. Efficiency is higher in Allocator treatments compared to ES treatments. However, examining the interaction terms Alloc × HetEndow and Alloc × HetProd, the effectiveness of the allocator is significantly decreased in treatments with either heterogeneous endowments or heterogeneous productivity. When we include an interaction between Alloc and Period, we find a negative and significant trend in efficiency in ES treatments, but the estimated interaction term is positive, significant, and greater in absolute value than the Period coefficient. To examine the trend with an Allocator, we take the sum of the Period

[13]On the low end of average efficiency in a group across all periods, the number of groups with less than 76% efficiency are 0 out of 12 in Alloc-Hom, 5 out of 18 in Alloc-HetEndow, and 1 out of 18 in Alloc-HetProd. The maximum and minimum average group efficiencies are 99% & 83% in Alloc-Hom, 94% & 60% in Alloc-HetEndow, and 99% & 64% in Alloc-HetProd, respectively.

	(1) USD Only	(2) All Data	(3) All Data	(4) All Data	(5) All Data
Period 1 Efficiency	0.621***	0.583***	0.606***	0.606***	0.606***
	(0.0773)	(0.0762)	(0.0747)	(0.0748)	(0.0749)
Period	-0.329	-0.195	-0.195	-0.953***	-0.953***
	(0.268)	(0.165)	(0.165)	(0.230)	(0.231)
Alloc	15.45***	16.26***	16.15***	7.151***	5.340**
	(2.294)	(2.019)	(2.181)	(2.594)	(2.300)
HetEndow	-3.595	0.373	1.324	1.324	1.324
	(3.022)	(2.259)	(2.293)	(2.294)	(2.297)
HetProd	7.009**	5.659**	6.599**	6.599**	6.599**
	(2.792)	(2.684)	(2.722)	(2.723)	(2.727)
Alloc × HetEndow	-8.003*	-7.790**	-8.324**	-8.324**	-6.376**
	(4.631)	(3.417)	(3.406)	(3.408)	(2.959)
Alloc × HetProd	-10.20**	-10.39***	-10.75***	-10.75***	-7.869**
	(3.834)	(3.444)	(3.635)	(3.637)	(3.474)
USD			-1.234	-1.234	-1.234
			(1.636)	(1.637)	(1.639)
COVID-19			3.591	3.591	3.591
			(2.570)	(2.571)	(2.574)
Alloc × Period				1.500***	1.801***
				(0.292)	(0.300)
Alloc × HetEndow × Period					-0.325
					(0.377)
Alloc × HetProd × Period					-0.480
					(0.375)
Constant	28.74***	30.57***	28.49***	33.04***	33.04***
	(5.505)	(5.577)	(5.333)	(5.497)	(5.503)
Observations	423	855	855	855	855
Clusters	47	95	95	95	95
R^2	0.496	0.456	0.468	0.487	0.488

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Linear regressions of group-level efficiency in Periods 2-10.

Alloc-HetEndow	Allocated Share	Share Produced	Share Contributed	Weighted Share Contributed
Poor	24.77%	15.27%	15.27%	27.74%
Rich	25.23%	34.73%	34.73%	22.26%
Alloc-HetProd				
Low	22.09%	11.70%	23.30%	23.30%
High	27.91%	38.30%	26.70%	26.70%

Table 4: Average allocated shares (out of 100%) with measures of relative contribution.

and Alloc × Period estimated coefficients, finding a positive and significant trend (p-value=0.003 in Model 4 and p-value<0.001 in Model 5). Finally, we examine triple interaction terms Alloc × HetEndow × Period and Alloc × HetProd × Period to examine whether the Allocator's effect on the trend across Periods differs with heterogeneity. In both cases, the estimated triple interaction terms are insignificant, and the other results remain similar.

Result 2. *Consistent with both Predictions 1 and 2, efficiency is higher in allocator treatments compared to equal share treatments, but this improvement is diminished by either heterogeneous endowments or heterogeneous productivity.*

The allocation behavior of allocators is examined next. Table 4 shows the average allocated percentage share by type in the Alloc-HetEnd and Alloc-HetProd treatments, along with measures of average relative contribution. Share Produced is the percentage of the total value of the collective good produced by an individual contributor. Share Contributed is the percentage of aggregate collective-good input added by an individual contributor, that is, the individual's contribution as a percentage of the total group contribution. Importantly, Share Produced and Share Contributed are not equivalent when productivity is heterogeneous. Weighted Share Contributed is similar to Share Contributed, but with contributions taken as percentages of the endowment, so that these measures differ when endowments are heterogeneous.[14]

[14] To illustrate the difference between Share Contributed and Weighted Share Contributed calculations, consider the following Alloc-HetEnd example. Suppose the average contribution by Poor members is 3 tokens each and the average contribution by Rich members is 11 tokens each. Share Contributed for an average Poor member is 3/(3+3+11+11) =

Periods	Treatment	Production	Contribution	Weighted Contribution	Equal Share	Equal Payoffs
All	Alloc-Hom	1.86	1.86	1.86	3.68	2.74
	Alloc-HetEndow	7.44	7.44	4.56	4.31	4.49
	Alloc-HetProd	8.52	3.83	3.83	4.80	4.18
1-3	Alloc-Hom	2.25	2.25	2.25	4.21	3.09
	Alloc-HetEndow	7.48	7.48	5.53	4.30	5.03
	Alloc-HetProd	9.10	4.98	4.98	6.08	5.40
8-10	Alloc-Hom	1.38	1.38	1.38	3.06	2.21
	Alloc-HetEndow	8.33	8.33	3.74	3.77	3.67
	Alloc-HetProd	8.47	3.74	3.74	4.28	3.89

Table 5: Mean absolute deviations of allocated shares from various fairness norms.

As shown in Table 4, Rich and Poor types receive approximately equal shares on average in Alloc-HetEnd, despite the larger contributions of the Rich types. A possible explanation is that allocators reward Poor types for their relatively high percentage contribution. In Alloc-HetProd, High types receive somewhat larger shares on average than Low types. However, the difference is smaller than the gap in Share Produced, tracking closer to the contribution-based measures.[15]

Next, we compare allocated shares are to the theoretical shares predicted by various fairness benchmarks. Table 5 shows the mean absolute deviations of allocated shares from these benchmarks in early periods, late periods, and across all periods. The first three benchmarks are shares allocated in proportion to each contributor's share produced, share contributed, or endowment-weighted share contributed, discussed above.[16] The last two benchmarks are shares allocated according to an equal division of the collective good or equalizing contributors' final payoffs.[17] Low mean absolute deviation indicates closer adherence of allocated shares to the benchmark. Across all periods, allocated shares are closest on average to the Weighted Contribution benchmark, except

0.107. Weighted Share Contributed multiplies contributions by Poor members by 3 (the ratio of the rich endowment to the poor endowment, 5 vs. 15). Thus, the Weighted Share Contributed is $(3*3)/(3*3+3*3+11+11) = 0.225$.

[15]Appendix A.3 reports regression analysis examining contributors' response to allocated shares of the collective good. Appendix A.7 shows the measures in Table 4 graphically by Period. These measures appear stable with repeated play, including the final period when the allocated shares cannot affect on the allocator's future payoffs.

[16]The first three benchmarks are equivalent in Alloc-Hom, as are the Production and Contribution benchmarks in Alloc-HetEndow, and Contribution and Weighted Contribution in Alloc-HetProd. In Appendix A.7 we show the mean absolute deviations from various benchmarks graphically by period.

[17]Equalizing final payoffs is sometimes infeasible in Alloc-HetEndow when contributions are low. However, such cases are rare in the data, so we use the unconstrained payoff-equalizing shares as a benchmark for simplicity.

in Alloc-HetEndow, where Equal Share is a slightly better fit. However, allocated shares are significantly farther from the weighted contribution benchmark in heterogeneous treatments than in the homogeneous case (p-value < 0.001 for Alloc-HetEndow, p-value=0.015 for Alloc-HetProd). Allocations appear to move towards the Weighted Contribution benchmark in later periods.

	(1) Alloc-Hom	(2) Alloc-Hom	(3) Alloc-HetEndow	(4) Alloc-HetEndow	(5) Alloc-HetProd	(6) Alloc-HetProd
Period 1 Efficiency	0.312***	0.309***	0.247	0.0845	0.682***	0.623***
	(0.0502)	(0.0758)	(0.280)	(0.220)	(0.154)	(0.164)
Period	0.719**	0.844***	0.425	0.451	0.281	0.334
	(0.255)	(0.205)	(0.391)	(0.312)	(0.352)	(0.336)
Wtd Contrib Dev	-2.065***		-0.699		-0.977***	
	(0.363)		(0.764)		(0.228)	
Equal Share Dev		-0.175		1.239		-0.436*
		(0.371)		(0.786)		(0.207)
Constant	67.98***	63.68***	65.11***	68.41***	35.62**	38.07**
	(5.308)	(7.115)	(21.86)	(16.02)	(12.88)	(13.74)
Observations	108	108	162	162	162	162
Clusters	12	12	18	18	18	18
R^2	0.558	0.297	0.050	0.112	0.402	0.341

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Linear regressions of group-level efficiency in Periods 2-10 on allocators' past mean deviation from the Weighted Contribution benchmark or Equal Share benchmark in all previous periods.

Table 6 shows regressions of group-level efficiency on allocators' past mean deviation from the Weighted Contribution benchmark (equivalent to the Contribution benchmark in Alloc-Hom and Alloc-HetProd) in all previous periods. We also include estimates replacing the Weighted Contribution benchmark with the Equal Share benchmark, which is a closer fit to allocation decisions in Alloc-HetEndow. Instead of using contemporaneous deviation from the benchmark, the mean past deviation over all previous periods is used to account for reputations allocators could develop in fixed groups. The estimated coefficient of the deviation from the Weighted Contribution benchmark is negative and significant in Alloc-Hom and Alloc-HetProd. This result indicates that the greater an allocator's past deviation from the benchmark, the lower the efficiency achieved in the allocator's group.[18] In Alloc-HetEndow, the coefficent of past deviation from the Weighted Contri-

[18]Stoddard et al. (2021) define "ineffective allocators" as allocators with a negative correlation between contributions and shares allocated to contributors. While they find few of these allocators, ineffective allocators have lower efficiency in their groups. In our data, there are no "ineffective allocators" with negative correlation in Alloc-Hom,

bution benchmark is negative, but not significant (Model 3). Replacing the Weighted Contribution benchmark with the Equal Share benchmark also yields an insignificant result (Model 4).[19]

5 Discussion

Our results show that third-party allocators can enhance efficiency by incentivizing contribution in social dilemmas, reducing or even reversing the decay of cooperation with repeated play. However, allocators are less effective in cases of heterogeneous endowments or heterogeneous productivity. Considering a variety of benchmark fairness norms, average shares chosen by allocators tend to follow the benchmark of allocating in proportion to the percentage of endowment contributed by group members to the collective good. Allocations deviating from this benchmark tend to result in lower efficiency in later periods in the homogeneous case and with heterogeneous productivity. With heterogeneous endowments, this correlation has the same sign, but is not significant. This result may suggest that encouraging contribution at the group level in the heterogeneous endowment case is more difficult, as Rich and Poor types have unequal outside options and potentially conflicting fairness concerns.

Unlike many related studies examining fairness norms, our allocators do not have opportunistic incentives to allocate shares of resources to themselves. However, allocators are incentivized to improve efficiency for the group as a whole. Providing evidence of fairness preferences in allocations in such a setting where equality conflicts with efficiency furthers our understanding of the complexity involved when balancing fairness and own payoffs. Many allocators in the real-world make allocation decisions when faced with similar conflicts.

Policy makers such as managers and department chairs may encourage productivity in teams, but with greater difficulty with heterogeneous contributors. Our results suggest that allocations based on relative merit lead to higher levels of efficiency. Managers and other allocators need to pay close attention to such constraints when allocating shares of a collective good, such as a pool of funds used for bonuses where the size of the funds depends on the performance of the team.

4 in Alloc-HetEndow, and 2 in Alloc-HetProd. There is also one allocator in each of Alloc-HetEndow and Alloc-HetProd who allocated a 25% share to each contributor in every period. However, ineffective allocators do not have as clear of an impact with heterogeneous groups as with the homogeneous groups in Stoddard et al. (2021). This could be due to possible conflicting fairness notions.

[19] We report similar regression estimates using the other benchmarks from Tables A7-A9 in Appendix A.6.

Tracking such information and providing it to allocators could increase efficiencies in organizations.

Future research might examine variations in the information structure of this setting. For example, incentivizing contribution might be complicated by limiting the information available to the allocator about individual endowments, productivity, or contribution. Another variation would be providing contributors with full information about others' individual contributions and the allocations assigned to each contributor. It might also be interesting to examine whether restricting allocators' flexibility might reduce the difficulty of incentivizing contribution in heterogeneous environments. Stoddard et al. (2021) find that requiring allocators in a homogeneous setting to follow rules can reduce the variance of allocation decisions and help some allocators incentivize contribution. Similar restrictions could be beneficial with heterogeneity. Another interesting direction for future research might be to consider treatment variations that better identify which fairness norms are most salient to poor and rich types. This issue could be examined in a variety of ways. Allocators could commit to an allocation scheme before contributions are chosen to make incentives more transparent to contributors. It might also be interesting to consider endogenous group formation to reduce within-group conflicts in interpretations of fairness. Earned heterogeneity may also reduce tension between equality and efficiency.

REFERENCES

Abramitzky, R. (2008): "The Limits of Equality: Insights from the Israeli Kibbutz," *Quarterly Journal of Economics*, 123, 1111–1159.

——— (2011): "Lessons from the kibbutz on the equality-incentives trade-off," *Journal of Economic Perspectives*, 25, 185–208.

Arrington, L. (1976): *Building the City of God: Community and Cooperation Among the Mormons*, Deseret Book Co.

Babcock, L. and G. Loewenstein (1997): "Explaining bargaining impasse: The role of self-serving biases," *Journal of Economic Perspectives*, 11, 109–126.

Bicchieri, C. (2006): *The grammar of society: The nature and dynamics of socil norms*, *Cambridge University Press*.

Buckley, E. and R. Croson (2006): "Income and wealth heterogeneity in the voluntary provision of linear public goods," *Journal of Public Economics*, 90, 935–955.

Cappelen, A., A. Hole, and B. T. E.O. Sorensen (2007): "The pluralism of fairness ideals: An experimental approach," *American Economic Review*, 97, 818–827.

Chaudhuri, A., S. Classens, M. Drouvelis, A. Ramalingam, B. Stoddard, and Q. Atkinson (2023): "Luck or merit: Implications for cooperation and punishment of free-riding in a public goods game," *Working Paper*.

Cherry, T. L., S. Kroll, and J. Shogren (2005): "The impact of endowment heterogeneity and origin on public good contributions: evidence from the lab," *Journal of Economic Behavior and Organization*, 57, 357–365.

Colasante, A. and A. Russo (2017): "Voting for the distribution rule in a Public Good Game with heterogeneous endowments," *Journal of Economic Interaction and Coordination*, 12, 443–467.

Croson, R. and J. Konow (2009): "Social preferences and moral biases," *Journal of Economic Behavior and Organization*, 69, 201–212.

Dong, L., R. Falvey, and S. Luckraz (2019): "Fair share and social efficiency: a mechanism in which peers decide on the payoff division," *Games and Economic Behavior*, 115, 209–224.

Dorner, Z., S. Tucker, and G. Hassan (2021): "A veil of ignorance: uncertain and ambiguous individual productivity supports stable contributions to a public good," Working Paper.

Drouvelis, M., D. Nosenzo, and M. Sefton (2017): "Team incentives and leadership," *Journal of Economic Psychology*, 62, 173–185.

Falvey, R., T. Lane, and S. Luckraz (2023): "On a Mechanism that Improves Efficiency and Reduces Inequality in Voluntary Contribution Games," *Working Paper*.

Fellner-Röhling, G., S. Kröger, and E. Seki (2020): "Public good production in heterogeneous groups: An experimental analysis on the relation between external return and information," *Journal of Behavioral and Experimental Economics*, 84.

Fischbacher, U. (2007): "z-Tree: Zurich toolbox for ready-made economic experiments," *Experimental Economics*, 10, 171–178.

Frohlich, N., J. Oppenheimer, and A. Kurki (2004): "Modeling Other-Regarding Preferences and an Experimental Test," *Public Choice*, 119, 91–117.

Gangadharan, L., N. Nikiforakis, and M. C. Villeval (2017): "Normative conflict and the limits of self-governance in heterogeneous populations," *European Economic Review*, 100, 143–156.

Gardner, H. (1917): "Cooperation among the Mormons," *Quarterly Journal of Economics*, 31, 461–499.

——— (1922): "Communism among the Mormons," *Quarterly Journal of Economics*, 37, 134–174.

Greiner, B. (2015): "Subject pool recruitment procedures: organizing experiments with ORSEE," *Journal of the Economic Science Association*, 7, 114–125.

Hargreaves-Heap, S. P., A. Ramalingam, and B. Stoddard (2016): "Endowment inequality in public goods games," *Economics Letters*, 146, 4–7.

Holmstrom, B. (1982): "Moral hazard in teams," *The Bell journal of economics*, 324–340.

Johansson-Stenman, O. and J. Konow (2010): "Fair air: distributive justice and environmental economics," *Environmental and Resource Economics*, 46, 147–166.

Kagel, J. H., C. Kim, and D. Moser (1996): "Fairness in ultimatum games with asymmetric information and asymmetric payoffs," *Games and Economic Behavior*, 13, 100–110.

Kandel, E. and E. P. Lazear (1992): "Peer pressure and partnerships," *Journal of political Economy*, 100, 801–817.

Karakostas, A., D. Matzat, M. Kocher, H. Rau, and G. Riewe (2023): "The team allocator game: Allocation power in public goods games," *Games Economic Behavior*, 140, 73–87.

Kesternich, M., A. Löschel, and A. Ziegler (2021): "Negotiating weights for burden sharing rules in international climate negotiations: an empirical analysis," *Environmental Economics and Policy Studies*, 23, 309–331.

Kingsley, D. (2016): "Endowment heterogeneity and peer punishment in a public good experiment: Cooperation and normative conflict," *Journal of Behavioral and Experimental Economics*, 60, 49–61.

Konow, J. (2000): "Fair Shares: Accountability and Cognitive Dissonance in Allocation Decisions," *American Economic Review*, 90, 1072–1091.

——— (2003): "Which Is the Fairest One of All? A Positive Analysis of Justice Theories," *Journal of Economic Perspectives*, 41, 1188–1239.

Kruse, D. (2022): "Does employee ownership improve performance?" *IZA World of Labor*.

Kölle, F. (2015): "Heterogeneity and cooperation: The role of capability and valuation on public goods provision," *Journal of Economic Behavior and Organization*, 109, 120–134.

Lazear, E. P. (2018): "Compensation and incentives in the workplace," *Journal of Economic Perspectives*, 32, 195–214.

Mas, A. and E. Moretti (2009): "Peers at work," *American Economic Review*, 99, 112–145.

Nikiforakis, N., C. Noussair, and T. Wilkening (2012): "Normative conflict and fueds: The limits of self-enforcement," *Journal of Public Economics*, 96, 797–807.

Nockur, L., S. Pfatteicher, and J. Keller (2021): "Different punishment systems in a public goods game with asymmetric endowments," *Journal of Experimental Psychology*, 93.

Putterman, L. (1983): "Incentives and the kibbutz: toward an economics of communal work motivation," *Zeitschrift für Nationalökonomie / Journal of Economics*, 43, 157–188.

Ramalingam, A., B. Stoddard, and J. Walker (2023): "Competition for talent: heterogenous abilities in team production," Working Paper.

Reuben, E. and A. Riedl (2013): "Enforcement of Contribution Norms in Pubic Good Games with Heterogeneous Populations," *Games and Economic Behavior*, 77, 122–137.

Rodriguez-Lara, I. and L. Moreno-Garrido (2012): "Self-interest and fairness: self-serving choices of justice principles," *Experimental Economics*, 15, 158–175.

Ruffle, B. J. and R. Sosis (2006): "Cooperation and the in-group-out-group bias: A field test on Israeli kibbutz members and city residents," *Journal of Economic Behavior Organization*, 60, 147–163.

Stoddard, B., C. Cox, and J. Walker (2021): "Incentivizing provision of collective goods: Allocation rules," *Southern Economic Journal*, 87, 1345–1365.

Stoddard, B., J. M. Walker, and A. Williams (2014): "Allocating a voluntarily provided common-property resource: An experimental examination," *Journal of Economic Behavior & Organization*, 101, 141–155.

Sutter, M., S. Haigner, and M. Kocher (2010): "Choosing the carrot or the stick? Endogenous institutional choice in social dilemma situations," *Review of Economic Studies*, 77, 1540–1566.

Tan, F. (2008): "Punishment in a linear public good game with productive heterogeneity," *De Economist*, 156, 269–293.

Tavoni, A., A. Dannenberg, G. Kallis, and A. Löschel (2011): "Inequality, communication, and the avoidance of disastrous climate change in a public goods game," *Proceedings of the National Academy of Sciences*, 108, 11825–11829.

Ubeda, P. (2014): "The consistency of fairness rules: An experimental study," *Journal of Economic Psychology*, 41, 88–100.

Van der Heijden, E., J. Potters, and M. Sefton (2009): "Hierarchy and opportunism in teams," *Journal of Economic Behavior and Organization*, 96, 39–50.

Warner, A. (1888): "Three phases of cooperation in the west: cooperation among the Mormons," *American Economic Association*, 106–119.