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Abstract

We analyze linear, weakest-link and best-shot public goods games in which a distinguished team member, *the team allocator*, has property rights over the benefits from the public good and can distribute them among team members. These *team allocator games* are intended to capture natural asymmetries in hierarchical teams facing social dilemmas, such as those that exist in work teams. Our results show that the introduction of a team allocator leads to pronounced cooperation in both linear and best-shot public-good games, while it has no effect in the weakest-link public good. The team allocator uses her allocation power to distribute benefits from the public good in a way that motivates people to contribute. Re-allocating team payoffs allows the team allocator to reward cooperating team members and to sanction non-cooperating members at no efficiency losses from explicit sanctioning costs. As a result, team profits are higher in the linear team allocator game but not in the best-shot case, where the lack of coordination leads to a welfare decrease for the remaining team members.

JEL-Codes: C720, C910, C920.

Keywords: public goods provision, experiment, institutions, cooperation, allocation power, teams.

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1. Introduction

Teams often have a natural or exogenously imposed hierarchical structure that gives one team member (the team leader or manager) property rights over the team's output. From early hunter-gatherer societies, ancient military units to modern-day politics, and executive teams, team efforts are, at least partly, observed by a leader with significant ex post power over the distribution of the gains from the team's output. How such natural or exogenously imposed hierarchies with allocation power help teams to overcome social dilemmas have been sparsely studied in economics.

In this paper, we compare the effectiveness of hierarchical structure in teams characterized by different public goods mechanisms or technologies.[1] To the best of our knowledge, this is the first study that provides a rigorous empirical test of the (behavioral) incentive effects of such structures. We analyze theoretically and experimentally linear, weakest-link, and best-shot public goods games (Hirshleifer, 1983; Harrison and Hirshleifer, 1989) with and without hierarchical structure. In our *team allocator games (TAG)*, one team member, *the team allocator* (TA), in addition to contributing to the team effort, has discretionary power over the gains from team production and can distribute it freely among the other *team members* (TMs) and herself. In our first experiment, team production is determined linearly, i.e., by the sum of contributions of every team member, and multiplied by an efficiency factor larger than one, as in standard public goods games. In two follow-up experiments, we examine how the introduction of a team allocator influences team output when the returns of the public good are determined by the *lowest* or the *highest* contribution in a team. Overall, our TAGs are identical to linear, weakest-link, and best-shot voluntary contribution mechanisms (i.e., public goods games), with the only difference that the team allocator has discretionary power on the returns of the public good. That is, she acts as a dictator who distributes the returns among herself and the team members.

Many real-world problems are exemplified by weakest-link or best-shot public good structures. For instance, the international efforts in finding a vaccine for COVID-19 is a potential example of a best-shot public good, as if one country invents a vaccine, everyone would benefit. In comparison, adherence to social distancing guidelines can be an example of a weakest-link public good, as if one person in a group fails to comply, then everyone is put at risk (Müller and Rau, 2021). Similar externalities exist in many employment settings. For

[1] For surveys or meta-studies on public goods games see Ledyard (1995), Zelmer (2003), Chaudhuri (2011).

instance, teams that work in research and innovation problems often face a best-shot public goods structure, as the gain of the group is often determined by the highest contributor. In contrast, trade union representatives with the power to halt production by going into strike can be seen as an example for an natural weakest link structure into a firm's production function. Broadly, in teams with increased specialization and high complementarity across the contribution of each team member, the team's output follows a weakest-link structure. Conversely, in teams with high substitutability across team members, the team's output follows a best-shot structure.

In our theory section, we derive theoretical predictions for each of our TAGs, under the assumption that every team member is self-interested or inequity averse (Fehr and Schmidt, 1999). It is straightforward to show that self-interested TMs have no incentive to contribute to the public account in a TAG, irrespectively of the production technology (linear, weakest-link, or best-shot). By contrast, TAs should contribute their entire endowment when output is determined with a linear or best-shot technology but not when it follows a weakest-link structure.

Even though we observe that TMs contribute positive amounts with all production technologies, the results of our experiments suggest that the effectiveness of introducing hierarchy through a TA to improve the outcomes in a social dilemma depends crucially on the underlying production technology. Specifically, we find that when the public good is determined by a linear or a best-shot technology, introducing a TA leads to an increase in TMs contributions. However, only for the linear public goods technology, the introduction of a TA is efficiency-improving. Surprisingly, when the public good is determined by a best-shot technology, the team members, to receive higher shares of the total output from the TA, appeal (successfully) to the TAs' reciprocity by over-contributing. In contrast to the linear and the best-shot technologies, severe coordination problems dominate in the weakest-link technology, resulting to no discernible gains on contributions or efficiency in teams' output. However, we do not find that the introduction of a TA leads to lower contributions, despite theoretical predictions under self-interest.

Although there is some heterogeneity in the behavior of team allocators, we find that they predominantly use the reward channel in case of high contributions, i.e., they allocate large shares of the public account to cooperating team members, and they punish non-contributors by excluding them from the benefits from the public account. Overall, the amounts returned to contributors are astonishingly high and generate strong incentives for team members in the linear and best-shot cases to contribute to the team effort. Theories of other-regarding preferences can partly explain the generous behavior of team allocators, but the repeated-game aspect plays a role as well, as the remaining time horizon of the team interaction clearly determines the team allocators' distribution behavior.

A key advantage of introducing a team allocator to increase contributions to a public good is that, as sanctioning non-cooperators is endogenous, it potentially comes at a lower cost than other comparable mechanisms that have been studied. One of the most prominent mechanisms to sustain cooperation in public goods is costly (decentralized) punishment (Fehr and Gächter, 2000). However, while it has been found to increase contributions dramatically, its efficiency depends crucially on the length of the interaction (Gächter et al., 2008), the extent to which it is perceived appropriate (Cohen-Charash and Spector, 2001; Cohen-Charash and Mueller, 2007) and can backfire if defectors can use it to take revenge (Dreber et al. 2008; Herman et al., 2008; Nikiforakis, 2008).[2] Thus, from an efficiency perspective, the implementation of hierarchy in teams seems promising as compared to decentralized punishment and reward.

Our findings are of relevance to the vast literature of institutional provisions in social dilemmas, and in particular, to studies on the effects of punishment and reward.[3] Our study is also related to research that examines the effects of an expulsion option from the benefits of the public good (e.g., Cinyabuguma et al., 2005), and endogenous group formation and the resulting efficiency in social dilemmas (e.g., Page et al., 2005; Ahn et al., 2009; Charness and Yang, 2014), as well as to the literature on the formal implementation of institutions in social dilemmas, usually by a voting mechanism (e.g., Kroll et al., 2007; Gerber and Wichardt, 2009; Kosfeld et al., 2009; Chen and Zeckhauser, 2018). Yet almost the entire literature has focused on the linear public goods mechanism.

There is an increasingly large literature on leadership in public goods provision (e.g., Potters et al., 2005; Guth et al. 2007; Potters, et al., 2007; Haigner and Wakolbinger, 2010; Levy et al., 2011; Rivas and Sutter, 2011; Arbak and Villeval, 2013; Drouvelis and Nosenzo,

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[2]A decentralized reward mechanism has also been explored in the literature, and even though in principle it can be more efficient than costly punishment, it has been found to be less effective in sustaining high contribution levels (e.g., Andreoni et al., 2003; Sefton et al., 2007; Sutter et al. 2010). Psychologists have been overall more optimistic than economists in the effectiveness of rewards in sustaining cooperation, with Rand et al. (2009) being a notable example. For a meta-analysis on the effectiveness of punishment and rewards including studies both from the literatures in economics and psychology, see Balliet et al. (2011).

[3]See Yamagishi (1986), Isaac and Walker (1988), Ostrom et al. (1992), Ostrom et al. (1994), Cason and Khan (1999), Fehr and Gächter (2000) Masclet et al. (2003), Andreoni et al., (2003), Brosig et al. (2003), Casari (2005), Noussair and Tucker (2005), Bochet et al. (2006), Anderson and Putterman (2006), Carpenter (2007a), Denant-Boemont et al. (2007), Sefton et al., (2007), Egas and Riedl (2008), Gächter et al. (2008), Herrmann et al. (2008), Masclet and Villeval (2008), Nikiforakis (2008), Nikiforakis and Normann (2008), Bochet and Putterman (2009), Casari and Luini (2009), Ule et al. (2009), Nikiforakis (2010), Gächter and Herrmann (2011), Cason and Gangadharan (2015), Stoop et al. (2018).

2013; Cappelen et al. 2016; Preget et al. 2016; Gächter and Renner, 2018). However, as these studies focus on leading by example, our study is only notionally related.[4]

All these papers have in common that there is no hierarchy within the team. One exception is Reuben and Riedl (2009). However, this paper is only loosely related to ours as they analyze the effects of endowment differences in a public goods game on norm enforcement. Cárdenas et al. (2011) is related more closely but they analyze a specific problem in collective water management that is modeled as a public good with asymmetric access. More precisely, in their setup there is sequential access of the team members to the benefits from the public good.[5] Their main finding in terms of cooperation is that asymmetric appropriation leads to lower levels of cooperation than the usual symmetric appropriation in the standard linear public goods game. Finally, a few articles analyze best-shot public goods (e.g., Attiyeh, et al. 2000; Kroll et al. 2007; Cherry et al., 2013) and weakest-link public goods (e.g., Sandler and Vicary; 2001; Croson et al. 2005; Riedl et al. 2016) in groups of more than two players. The findings from these studies are broadly in line with the results of our control treatments, but none of these studies examine hierarchical structures as an amelioration mechanism to public goods provision.

2. Experimental design

Table 1 summarizes our experiments and treatments. We conducted three experiments in total, each comprising of two treatments. In our first experiment, team production is determined linearly, i.e., by the sum of contributions of every team member, as in standard public goods games. In the second and third experiment, team production is determined by the lowest (weakest-link) and the highest (best-shot) contribution in a team, respectively. In each experiment, we conducted one treatment *with* a team allocator: TAG^{LIN}, TAG^{WL}, TAG^{BS}; and a control treatment *without* a team allocator: VCM^{LIN}, VCM^{WL} and VCM^{BS}. Each TAG is identical to their linear, weakest-link, and best-shot voluntary contribution mechanism counterpart (i.e.,

[4] Another way of looking at our mechanism is in relation to the seminal trust game (Berg et al., 1995). Our mechanism can be viewed as a collective trust game in which the amount that can be returned by the trustee (the team allocator) depends on the collective level of trust by the trustors (the team members). Trust games with more than one trustor are for example studied in Cassar and Rigdon (2011). However, their trustees are more restricted in their allocation power as they cannot allocate benefits from one trustor's investments to another trustor. For a meta-analysis of trust games, see Johnson and Mislin (2011).

[5] The idea of sequential access is intended to capture the situation of a collective water supply with the natural feature that upstream users (farmers) can appropriate benefits from the public good before downstream users.

public goods game), with the only difference that one player, the team allocator, has full discretionary power on the returns of the public good. That is, she acts as a dictator who distributes the returns among herself and the team members.

		Experiment 2	*Experiment 1*	*Experiment 3*
		Public Goods Mechanism		
		Weakest-Link	*Linear*	*Best-Shot*
Team Allocator	*Without*	VCM^{WL}	VCM^{LIN}	VCM^{BS}
	With	TAG^{WL}	TAG^{LIN}	TAG^{BS}

Table 1: Experimental treatments

The following parameters were common across all treatments and experiments. Team size $(n = 4)$, endowment per period ($E = 20$ points), public-good multiplier ($\gamma = 1.6$), and number of periods ($T = 10$).[6] Returned amounts $d_{i,t}$ can be chosen up to one decimal.[7] The participants were matched randomly in teams at the beginning of the experiment, and one randomly selected team member was assigned the role of TA. Roles and teams were fixed throughout the experiment. All decisions and outcomes were observable to every team member at the end of each period. Specifically, at the end of each period, all team members are informed about the vector of contributions within their teams, the resulting benefit from the public account, the distribution of this benefit among the team members (either equally in the *VCM* treatments or according to the allocation decision of the TA in the *TAG* treatments), and the final individual profits from this period. To obtain an independent measure of an individual's social motivation (i.e., her generalized other-regarding preferences), at the start of each session, we implemented a social value orientation questionnaire (henceforth referred to as ring test).[8] The test was incentivized, but to avoid any income effects on behavior in the main part of the experiments, the payoffs from the ring test were revealed only at the end of the experiment. All subjects completed a post-experimental questionnaire regarding their demographic characteristics.

[6] At the end of the experiment, earned points from all periods are summed up and converted into euro using the following exchange rate: 1 point = 4 eurocents.
[7] Note that we allow for one decimal place to ensure that the entire amount of γC_t can be distributed to the team members. This also gives TAs the ability to return exactly 1.6 times the invested amount to each TM for any possible contribution level.
[8] Van Lange et al. (1997) provide a review on the use of the ring test in the psychological literature. Economic applications of this measure can, for example, be found in Offerman et al. (1996), Park (2000), Brosig (2002), van Dijk et al. (2002) or Sutter et al. (2010).

In TAG^{LIN}, it is the optimal choice for both selfish and other-regarding TAs to contribute their full endowment *E*. As we are not interested in potential decision mistakes here (and their possible signaling effects for TMs), we decided to force all TAs in TAG^{LIN} to contribute their full endowment. To achieve exact parallelism, with TAG^{LIN}, in VCM^{LIN} one randomly selected team member is also forced to contribute her entire endowment to the public account in every period.[9] In the TAG^{WL} and TAG^{BS}, the TAs decide about their levels of contributions like TMs.[10] As all our comparisons are done within each public goods technology rather than across, the different treatment of the TAs does not affect our inference.

The first experiments (on the linear public-good technologies) took place at the University of Munich, while the second and third experiments (on the weakest-link and best-shot public good technologies) took place at the University of Göttingen (both in Germany). A total of 376 students participated in our study: 144 students in TAG^{LIN} and VCM^{LIN}, 140 students in TAG^{WL} and VCM^{WL}, and 92 in TAG^{BS} and VCM^{BS}. The sessions lasted up to 90 minutes, including instructions and final payments, and the average earnings were 16.73 EUR, including a show-up payment of 4.00 EUR. No participant could take part in more than one session, and the assignment of subjects into treatments was random. Decisions were taken anonymously in cubicles, and communication among participants was prohibited. The experimental instructions can be found in Appendix C.

3. Theoretical predictions

In this section, we introduce the team allocator game (3.1) and discuss the theoretical predictions in each of our treatments under the assumption of self-interest (3.2), Fehr and Schmidt (1999) inequity aversion preferences (3.3) and discuss potential repeated game effects and reputation building (3.4). Additionally, in Appendix A, we derive theoretical predictions for maximin-preferences (Charness and Rabin, 2002).

[9] Partial coercion does not change contribution incentives for unforced contributors compared to a standard VCM. This is shown in a study by Cettolin and Riedl (2011). They implement two coercion treatments (low and high), in which they force one randomly selected group member to contribute at least a minimum amount (approximately 25% and 75% of the endowment, respectively). The authors show that partial coercion has no influence on average contributions beyond the pure coercion effect, i.e., non-coerced subjects do not contribute significantly different amounts than subjects in a control VCM. Cettolin and Riedl argue that the lack of a cooperative intention may prevent unforced conditional cooperators from increasing their contributions.

[10] In the best-shot game, if there was forced full contribution, the public good size would automatically correspond to the team allocator's contribution. Thus, the characteristic coordination problem in VCM^{BS} would be solved by design. In the weakest-link game, it is clearly not optimal for a selfish TA to contribute *E*.

3.1 The team allocator games

Let $I = \{1, 2, \dots, n\}$ denote a team of n subjects who interact in T periods with subject 1 being called the *team allocator (TA)* and subjects $2, \dots, n$ called the *team members (TMs)*. Each period $t \in \{1, 2, \dots, T\}$ consists of two stages.

In the first stage, each individual $i \in I$ receives an endowment E, which can be allocated either to her private account or to a public account. The contribution of individual i to the public account in period t, denoted $c_{i,t}$, must satisfy $0 \leq c_{i,t} \leq E$. The size of the public account in the TAG^{LIN}, TAG^{WL}, and TAG^{BS}, is denoted by γC_t^{sum}, γC_t^{min}, and γC_t^{max}, respectively. Where C_t^{sum} is the *sum* of all team members' contributions (i.e. $C_t^{sum} = \sum_{j=1}^{n} c_{j,t}$), C_t^{min} is the *lowest* of all team members' contributions in period t (i.e. $C_t^{min} = n \min\{c_{i,t}\}$), and C_t^{max} is the *highest* of all team members' contributions in period t (i.e. $C_t^{max} = n \max\{c_{i,t}\}$). To retain the social dilemma nature C_t is multiplied by a factor γ, which satisfies $1 < \gamma < n$.[11]

In the second stage, the TA can distribute the amount γC_t among the team members (i.e., the TMs and herself), following only two restrictions for the returned amount. Every team member must get a non-negative amount that cannot be greater than γC_t, and the sum of all returned amounts has to be equal to γC_t. Formally:

$$0 \leq d_{i,t} \leq \gamma C_t \; \forall i, \quad \sum_{j=1}^{n} d_{j,t} = \gamma C_t \qquad (1)$$

where $d_{i,t}$ denotes the returned amount to team member i in period t. Consequently, individual team member i's payoff from the team allocator games in period t is then given by

$$\pi_{i,t} = E - c_{i,t} + d_{i,t}. \qquad (2)$$

3.2 Predictions under self-interest

Table 2 summarizes the theoretical predictions under self-interest. For the VCM^{LIN} treatment, the standard logic of the linear public goods game applies. As long as $1 < \gamma < n$, the marginal per capita return from investing into the public account is smaller than one. Hence, it is a

[11] Indeed, γ could also be smaller than 1 or larger than n in the TAG, without changing the standard economic incentives for TMs. In contrast to the classic public goods game, there is no individual incentive to contribute to the public account, no matter how high γ is. The condition is just imposed to keep the setup comparable to the classic public goods game.

dominant strategy for TMs to contribute nothing to the public account. In the *VCM*^{WL}, there are multiple Nash equilibria where every team member prefers to contribute as much as the other members of the team ($c_{i,t} \in [0,20]\ \forall i, with\ c_{i,t} = c_{j,t}$). However, as the equilibria are Pareto-ranked, allowing for Pareto dominance to act as a secondary criterion across equilibria (Harshanyi and Selten, 1988), full contribution by every team member is the single Pareto superior Nash equilibrium ($c_{i,t} = 20\ \forall i$).[12] In the *VCM*^{BS}, only one member has to contribute her entire endowment for the size of the public good to be maximized. However, everyone prefers that someone else contributes, and again a coordination problem arises. There are four pure strategy Nash equilibria, in which, in each, one of the team members contribute her full endowment while everyone else contributes zero.

		Allocation Process	
		VCM	**TAG**
Production technology	**Linear** $C_t^{sum} = \sum_{i=1}^{n} c_{i,t}$	$c_{i,t} = 0$	$c_{1,t} = E$ $c_{i\neq 1,t} = 0$
	Weakest Link $C_t^{min} = n \min\{c_{i,t}\}$	$c_{i,t} = 20$ *(Pareto dominant NE)*	$c_{i,t} = 0$
	Best Shot $C_t^{max} = n \max\{c_{i,t}\}$	$c_{i,t} = E = 20;\ c_{\neq i,t} = 0$	$c_{1,t} = E$ $c_{i\neq 1,t} = 0$

Table 2: Overview of theoretical predictions under self-interest

In the TAG treatments, if the TA is narrowly self-interested, she will never return a positive amount to the TMs in a one-shot setting. In a repeated setting, the equilibrium prediction remains the same due to backward induction. Consequently, contributing nothing to the public account is a dominant strategy for all TMs, i.e., $c_{i,t} = 0\ \forall i \neq 1$ and t, in all TAGs, where $i = 1$ refers to the TA. In *TAG*^{LIN} and *TAG*^{BS}, the TA would always contribute her full endowment in all periods ($c_{1,t} = E = 20$) and keep the public account for herself. The TMs anticipate that the TA would keep the entire public account and would hence never contribute. In *TAG*^{WL}, as

[12] For a discussion of payoff and risk dominance as equilibrium refinements see Schmidt et al. (2003), Devetag and Ortmann, (2007), or Feri et al. (2010).

the size of the public good is determined by the lowest contribution, and the TMs have no incentive to contribute, the TA is also better off without contributing to the public account, as any contribution would be lost. Table 2 summarizes the theoretical predictions under self-interest for TAs' and TMs' contributions under the different production technologies.

3.3 Inequity Aversion (Fehr and Schmidt, 1999)

The model by Fehr and Schmidt (1999) assumes that subjects suffer from inequity within their reference group. More precisely, a subject i benefits from her own payoff π_i, but compares it with the payoff of the $n-1$ other members in her reference group. Thus, the corresponding utility function for subject i is the following:

$$U_i(\pi) = \pi_i - \alpha_i \frac{1}{n-1}\sum_{j\neq i} \max\{\pi_j - \pi_i, 0\} - \beta_i \frac{1}{n-1}\sum_{j\neq i} \max\{\pi_i - \pi_j, 0\} \qquad (3)$$

The vector $\pi = (\pi_1, \dots, \pi_n)$ denotes the monetary payoffs, and α_i and β_i represent subject i's attitude towards disadvantageous inequity and advantageous inequity, respectively.[13] The two weights are restricted to $\beta_i \leq \alpha_i$ and $0 \leq \beta_i < 1$.

An equilibrium with full cooperation in the VCM^{LIN} requires that *all* TMs are sufficiently averse to advantageous inequity, i.e., $\gamma/n + \beta_i \geq 1$ or $\beta_i \geq 0.6\ \forall i$. In VCM^{WL}, self-interest and inequality aversion provide identical predictions as all the Nash equilibria are symmetric. Thus, allowing for Pareto dominance to act as a second criterion leads to the prediction of full cooperation in VCM^{WL}, regardless of the TMs preferences. In VCM^{BS}, if the team members are inequality averse coordination remains an issue. For a team member to be willing to contribute regardless of the other TMs contribution, that TM must prefer income equality to an increase in profits, i.e., $\beta_i > 1$, which would violate a key assumption of the Fehr and Schmidt (1999) model.

[13] Note that for $\alpha_i = \beta_i = 0$ the model collapses into the case of standard preferences.

		Allocation Process			
		VCM		**TAG**	
Condition		*Team Members*		*Team Allocator*	
		$\beta_i < 0.6$	$\beta_i \geq 0.6$	$\beta_1 < 0.75$	$\beta_1 \geq 0.75$
Production technology	**Linear**	$c_{i,t} = 0$	$c_{i,t} = E$	$c_{1,t} = E$ $c_{i\neq 1,t} = 0$	$c_{i,t} = E$
	Weakest Link	$c_{i,t} = E$ *Pareto dominant NE*		$c_{i,t} = 0$	$c_{i,t} = E$ *Pareto dominant NE*
	Best Shot	$c_{i,t} = E$; $c_{\neq i,t} = 0$		$c_{1,t} = E$ $c_{i\neq 1,t} = 0$	$c_{1,t} = E$ $c_{i\neq 1,t} = 0$ *Risk dominant NE*

Table 3: Overview of predicted contribution levels under inequality aversion

In the TAGs, an inequity-averse TA would be willing to reduce payoff differences within the team by returning positive amounts to the TMs. Note that the weight α_i does not play any role in our settings, because the TA will never reduce the amount allotted to herself below the level of full payoff equalization as this reduces her own payoff *and* increases inequity. Thus, only the weight β_i matters for TA decisions. Notice that if the TA distributes one point from the public account to a TM instead of putting it into her own pocket, she will reduce her own payoff by one unit and decrease inequity, on average, by 4/3 units (regarding the receiving TM by two units and regarding both other TMs by one unit). Thus, returning positive amounts is optimal if $-1 + \beta_1 \cdot 4/3 \geq 0$ or $\beta_1 \geq 0.75$. Thus, if $\beta_1 < 0.75$, the TA takes the entire benefits from the public account for herself, and the TMs never contribute to the public account, irrespective of whether they are selfish or inequity averse. If $\beta_1 \geq 0.75$, and this is common knowledge, all TMs have an incentive to contribute their full endowment in TAG^{LIN}, as the TA will redistribute equally across all team members. In TAG^{WL}, if $\beta_1 \geq 0.75$ (i.e., the TA is strongly inequity-averse), as in VCM^{WL} there are multiple Nash equilibria, however the NE where every TM contributes her full endowment is Pareto dominant. In TAG^{BS} if the TA's $\beta_1 < 0.75$ the TA would contribute her full endowment to the public account and take the entire public account for herself. Thus, $c_i = d_i = 0 \; \forall i \neq 1$, and $d_1 = \gamma C = 128$. If the TA is sufficiently averse to advantageous inequity ($i.e. \beta_1 \geq 0.75$), she would be willing to redistribute the public account to the TM's as to ensure payoff equalization. However, coordination (i.e., who should contribute) remains an issue. Interestingly, in TAG^{BS} if $\beta_1 \geq 0.75$ (i.e., the TA is strongly inequity-averse), the Nash equilibrium where the TA contributes to the public account, $c_{1,t} = E$, and redistributes across TMs is risk dominant. Table 3 summarizes the predicted contribution levels under inequality aversion. Note that in the VCM with $\beta_i < 0.6$ and in the TAG with $\beta_1 < 0.75$, the theoretical predictions converge to the predictions under self-interest. In Appendix A, we show that similar predictions can be derived using Charness' and Rabin's welfare-oriented model (2002).

3.4 Heterogeneous social preferences and repeated interaction

In a *repeated* game with heterogeneous social preferences, the argument that TAs return positive amounts to TMs holds a fortiori. With repeated interaction, additionally, selfish TAs have an incentive to act as if they were other-regarding because the future stream of income created by mimicking an other-regarding TA is larger than the costs of acting non-selfishly in a specific period. This is true until the ultimate or until the penultimate period, in which the opportunistic TAs that mimic other-regarding TAs start appropriating the benefits from the public account. By returning positive amounts to TMs until the last or the second-to-last period, TAs induce higher contributions by the TMs in future periods that the TA can subsequently pocket for herself. We refrain from characterizing all equilibria in the repeated game because the argument has been used and formalized straightforwardly in connection with trust contracts (see, e.g., Fehr et al., 2007). Note, however, that both the Fehr and Schmidt (1999) and the Charness and Rabin (2002) models, taken literally, would yield mostly either zero or full contributions and no intermediate contribution amounts because of linearity in utility.

4. Results

We start with summary statistics of contributions and profits in the treatments with and without team allocators (4.1). Afterward, we focus on how contributions change over time (4.2) and report the results of OLS regressions on TM contributions (4.3). Then, we analyze the return rates of TAs and how they influence the behavior of TMs (4.4). Finally, we examine coordination and efficiency in the weakest-link and best-shot technologies (4.5). Supplementary results and robustness tests can be found in Appendix B. When applying non-parametric tests, we always report two-sided p-values based on statistically strictly independent observations.

4.1 Contributions and profits

Table 4 shows the means of subjects' contributions and profits in the three public good technologies (weakest-link, linear, and best-shot) over the ten periods. The tests in the table compare treatments with (TAG) and without team allocators (VCM). They also distinguish between team member (TM) and team allocator (TA) outcomes.

For the linear technology, we find that TMs contribute significantly more in TAG^{LIN} (14.95) than in VCM^{LIN} (9.88) (Mann-Whitney test, $p<0.05$). Consequently, the overall contributions of all members are higher in TAG^{LIN} (16.21) than in VCM^{LIN} (12.41) (Mann-Whitney test, $p<0.001$). This is in line with the Fehr and Schmidt (1999) predictions derived in the theory section that full cooperation is expected to be more prevalent in the TAG^{LIN} treatment than in the VCM^{LIN} treatment. The results show a similar pattern in the best-shot technology, where contributions are higher for TMs and overall, in TAG^{BS} than in VCM^{BS} (Mann-Whitney tests, $p<0.001$). By contrast, we find no significant impact of team allocators on average contributions when focusing on the weakest-link technology. That is, the average contributions in VCM^{WL} (11.21) are similar as in TAG^{WL} (10.52). This does not support the idea that cooperation is easier to achieve in a weakest-link setting with a team allocator.

	Weakest-Link PGG			**Linear PGG**			**Best-Shot PGG**		
	VCM^{WL}	TAG^{WL}	p-value	VCM^{LIN}	TAG^{LIN}	p-value	VCM^{BS}	TAG^{BS}	p-value
Mean Contribution									
TMs	11.16	10.19	**0.456**	9.88	14.95	**0.023**	6.85	13.98	**< 0.001**
TAs	--	11.51		20.00	20.00		--	13.48	
All members	11.21	10.52	**0.448**	12.41	16.21	**< 0.001**	6.65	13.85	**< 0.001**
Mean Profit									
TMs	24.09	22.18	**0.222**	29.98	26.54	**0.006**	38.25	30.39	**< 0.001**
TAs	--	22.73		19.86	39.30		--	56.56	
All members	24.01	22.32	**0.391**	27.45	29.73	**0.023**	38.45	36.93	**0.325**

Table 4: Means of subjects' contributions and profits in the three public goods mechanisms.

Result 1. *Introducing a team allocator leads to significantly higher contributions in TAG^{LIN} and TAG^{BS}, compared to VCM^{LIN} and VCM^{BS}. This is not the case for the weakest-link technology.*

In terms of profits of all team members, TAG^{LIN} outperforms VCM^{LIN} (Mann-Whitney test, $p<0.05$). Not surprisingly, there is a change in the distribution of profits, as TAs exploit their power. Thus, TMs earn less in TAG^{LIN} than in VCM^{LIN} (Mann-Whitney test, $p<0.01$). However, TA profits overcompensate for the reduction of TMs' profits in TAG^{LIN} compared to VCM^{LIN}. For both the best-shot and the weakest-link technology, we do not find a significant difference in profits for all team members, when comparing TAG and VCM. The basic pattern of profits in the best-shot case is very similar to the linear one: TMs earn less in TAG^{BS} than in VCM^{BS} (Mann-Whitney test, $p<0.001$), and the TA earns significantly more. For TAG^{WL} and VCM^{WL}, there is little difference in profits. Overall, the higher contributions in TAGs suggest that other-regarding motives (Fehr and Schmidt, 1999) or maximin preferences (Charness and Rabin, 2002) play a role.

Result 2. *The team allocators appropriate a significant amount of the surplus generated by the higher contributions in both linear and best-shot public goods, leading to significantly lower profits for TMs. Overall, we observe a significant welfare increase under a team-allocator regime when the public goods game is linear.*

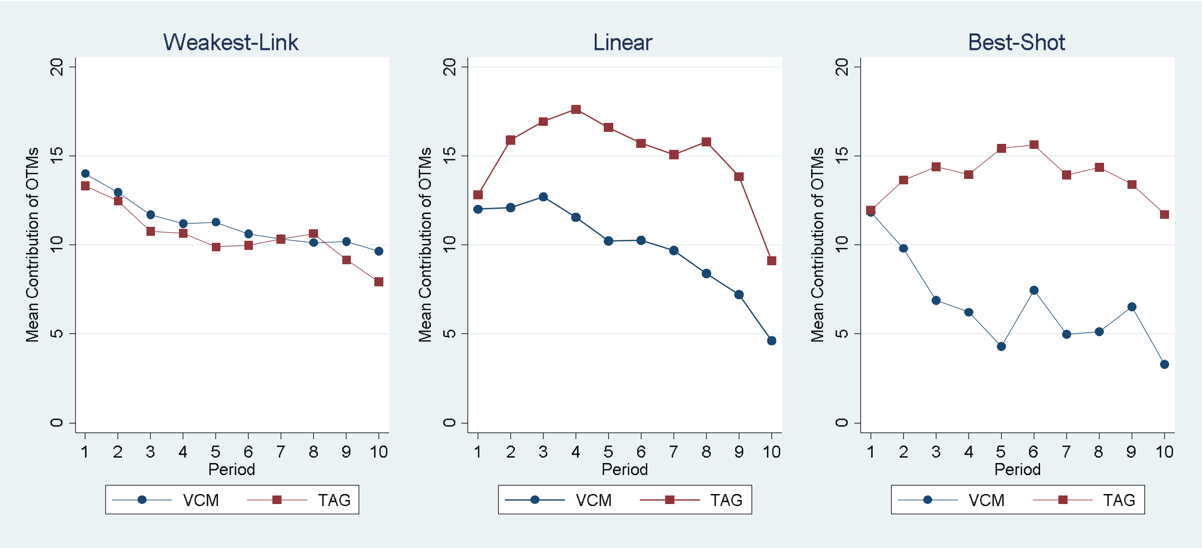

Figure 1: Mean TM contributions over time.

4.2 Development of contributions over time

Figure 1 depicts TMs' average contributions over time under the three production technologies. Two observations stand out. First, the average contribution levels in the first period are very similar in all three technologies and across the two institutions, TAG and VCM. Second, in TAG^{LIN} and TAG^{BS} the significantly higher contributions levels are a consequence of increasing contributions after the first period and a much later decay than in VCM^{LIN} and VCM^{BS}. Clearly, there is no difference in the dynamics of contributions over time between VCM^{WL} and TAG^{WL}.

Table 5 presents OLS regressions on TMs' contributions.[14] The regressions are clustered on the group level. All models incorporate the following independent variables: *TAG dummy* is positive for the TAG treatments, *Period* controls for the current period, *period²* controls for non-linear time effects, and *Period x TAG* and *Period² x TAG* are interaction variables. We run all regressions on sub-samples for the three public goods technologies, i.e., Models 1-2 focus on the weakest-link data, Models 3-4 on the linear data, and Models 5-6 on the best-shot data.

The regressions confirm the non-parametric results. Models 3 and 5 exhibit a positive and highly significant *TAG dummy*, showing that TMs contribute more in the TAG treatments of the linear and the best-shot technologies.

	Dependent variable: *Contributions of TMs*					
	Weakest-Link PGG		**Linear PGG**		**Best-Shot PGG**	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
TAG dummy	-0.693	-1.196	5.069***	-0.520	7.209***	-2.255
	(2.368)	(1.297)	(1.834)	(1.727)	(1.225)	(2.153)
Period	--	-1.017**	--	0.404	--	-1.949***
		(0.464)		(0.529)		(0.463)
Period²	--	0.054	--	-0.107**	--	0.117***
		(0.033)		(0.044)		(0.039)
Period x TAG	--	0.287	--	2.096***	--	3.613***
		(0.869)		(0.757)		(0.749)
Period² x TAG	--	-0.028	--	-0.154**	--	-0.270***
		(0.071)		(0.064)		(0.060)
Constant	11.214***	14.730	9.881***	11.786***	-7.772***	17.371***
	(1.745)	(0.693)	(1.501)	(1.284)	(1.225)	(5.659)
# Observations	1400	1400	1080	1080	920	920
R²	0.002	0.026	0.088	0.158	0.169	0.205

Notes: *** Significant at 1% level; ** significant at 5% level; * significant at 10% level. Robust standard errors in parentheses (clustered on group level).

Table 5: Contributions of TMs in the three mechanisms (OLS regressions).

[14] Panel regressions yield qualitatively similar results for Tables 5 and 6.

Focusing on dynamics over time, we find in these treatments (Models (4) and (6)) that the treatment dummy becomes insignificant once we control for the time trend. The effects are taken up by the period variables and the interactions with the treatment. In line with Figure 1, for the linear and the best-shot case, the advantage of TAG over VCM becomes larger over time (*Period x TAG*), however, with a declining trend (*Period² x TAG*). Despite the decay in contributions, no variable is significant for the comparison between VCM^{WL} and TAG^{WL}.

Result 3. *There are no significant differences in contributions of TMs between the VCM and the TAG treatments in period 1. Starting from period 2 onwards, we observe an almost linear decline in contributions in the VCM and* VCM^{BS} *treatments. In contrast, in the* TAG^{LIN} *and* TAG^{BS} *treatments, contributions increase for the first half of the experiment, but decline in the second half. No distinguishable differences are found for the weakest-link technology.*

4.3 Explaining contribution behavior in the TAG treatments

Table 6 presents OLS regressions, clustered on the group level, of TMs' contributions *in the TAG treatments*. The regressions focus on the data of TMs. All models contain only periods 2-10, as first period contributions cannot be influenced by the decisions of the other players. Additionally, based on the data of the ring test, we include a type dummy that takes either the values of 1 (for cooperative) or 0 (for selfish) participants. Furthermore, in all models we include the amount returned to TM i by the respective TA in the previous period $d_{i,t-1}$ (*Returned amount (t-1)*), and in Models 2, 4 and 6, we include the lagged average contributions of the other two TMs within the group (*Avg. contribution other TMs (t-1)*) and the lagged average returned amount to these TMs (*Avg. ret. amount other TMs (t-1)*).

Our results in Table 6 suggest that, irrespective of the public goods technology, the returned amount by the TAs in the previous period has a significantly positive effect on the contributions in the subsequent period. Furthermore, the average returned amount to other TMs in the previous period is positive and statistically significant. It is no surprise that the two independent variables are positively correlated. The positive effect of returned amounts from the previous period on contributions is highest in TAG^{LIN} (see Model (4)). This might explain why positive reciprocity to the average contribution of other TMs from the previous period has no significant effect on the contributions in TAG^{LIN}, in contrast to the other two conditions.

The comparison between the TA and the individual TM seems to overshadow the comparison with others in the group. In the presence of a TA who rewards TMs on the merit of their contribution, each TM is no longer concerned with the other TMs free riding, as commonly observed in linear VCMs.

	Dependent variable: *Contributions of TMs in TAG* Periods 2-10					
	Weakest-Link PGG		**Linear PGG**		**Best-Shot PGG**	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Period	-.755	-.011	.149	-.307	1.754**	.974*
	(.846)	(.587)	(.689)	(.643)	(.697)	(1.902)
Period²	.020	-.026	-.058	-.018	-.166***	-.109**
	(.067)	(.051)	(.058)	(.055)	(.047)	(0.156)
Type (1=Coop)	1.160	1.164**	.971*	1.154*	.282	-.264
	(2.342)	(.490)	(.547)	(.632)	(1.417)	(2.88)
Returned amount (t-1)	.553***	.171***	.410***	.295***	.268**	.216***
	(.038)	(.048)	(.047)	(.095)	(.102)	(0.094)
Avg. contribution other TMs (t-1)	--	.379***	--	.108	--	.279***
		(.074)		(0.101)		(.069)
Avg. ret. amount other TMs (t-1)	--	.192***	--	.152***	--	.130***
		(.067)		(.041)		(.036)
Constant	6.093***	2.000	6.987***	5.841***	4.097	.688
	(1.441)	(1.582)	(2.009)	(2.119)	(3.004)	(2.447)
# Observations	459	459	486	486	324	324
R^2	0.732	0.782	0.548	0.602	0.302	0.437

Notes: *** Significant at 1% level; ** significant at 5% level; * significant at 10% level. Robust standard errors in parentheses (clustered on group level). Type variable includes all observations. Conducting the same analysis only with subjects with a consistency score of 66% or higher for the type classification yields qualitatively similar results.

Table 6: Contributions of TMs for the three technologies (OLS regressions).

In TAG^{WL}, it is not surprising that *Avg. contribution other TMs (t-1)* plays such an important role. Because of the coordination requirement, only if the others contribute as well, group members want to contribute themselves. TAG^{BS} seems to provide a compromise of the two behavioral determinants for TM contributions, as reciprocity towards the TA and reciprocity towards the previous contributions of others matter to similar extents. It is possible that TMs use their (foregone) contributions as signals to the TA that she should share the gains from the public good with those group members that showed readiness to contribute.

Result 4. *Irrespective of the public goods technology, contributions of TMs depend positively on the allocation behavior of TAs. TMs do not only consider the amounts returned to them, but also the amounts returned to the other TMs in the group.*

Result 5. *In TAG^{BS} and TAG^{WL}, TMs' contributions depend positively on the previous contributions of the other TMs. In TAG^{LIN}, this effect is not significant, presumably due to a strong focus on the direct comparison between the TA and each single TM.*

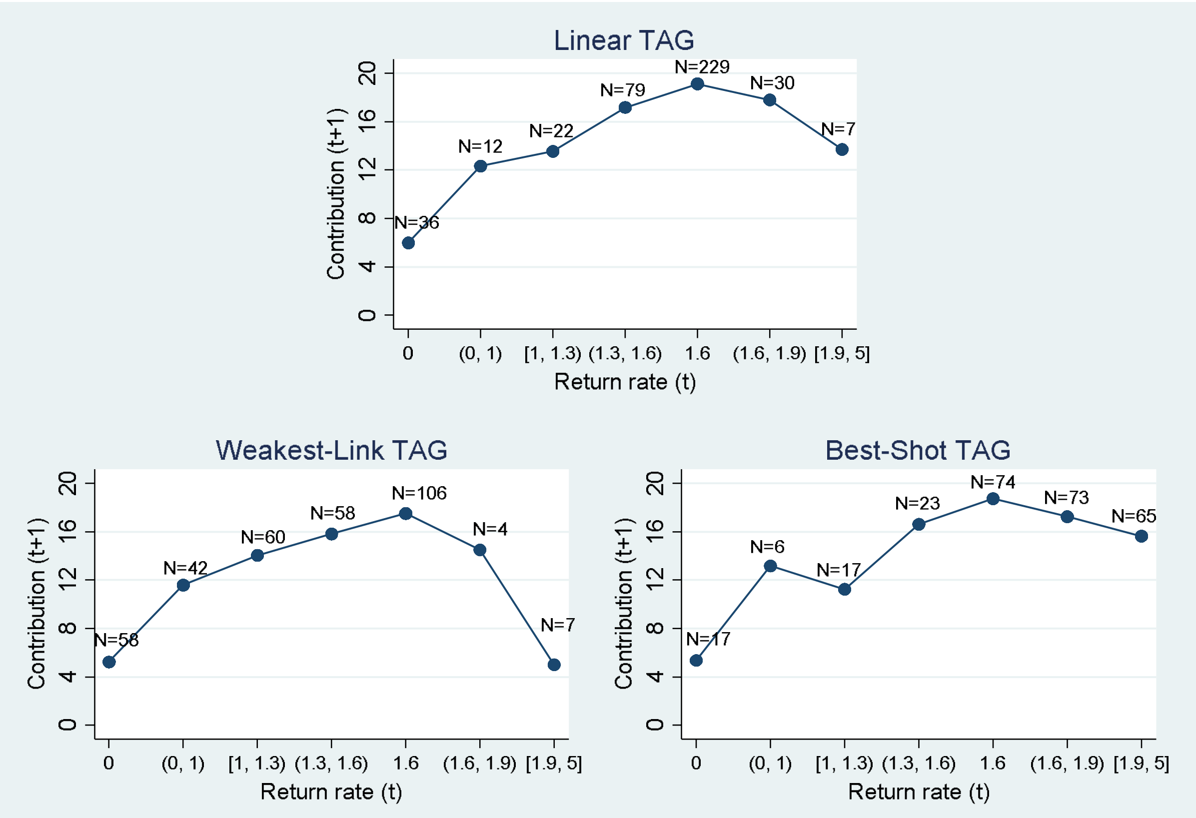

Figure 2: Contributions in the next period for different categories of the individual return rate.

Figure 2 displays average contributions in period $t + 1$, based on the individual return rate by the TA in period t for TAG^{WL}, TAG^{LIN}, and TAG^{BS}. The return rates on the x-axis are categorized in intervals. Remember that the individual return rate r is defined as $r_{i,t} = d_{i,t}/c_{i,t}$, i.e., the return conditioned on the level of contributions. Not surprisingly, we find that TMs contribute little in period $t + 1$ if they do not get any return in the preceding period t. Increasing the returned amount to a rate of 1.6 clearly raises subsequent average contributions of TMs, and a return rate of 1.6 is almost always reciprocated by full cooperation by TMs. Remember that a return rate of 1.6 means sharing the entire benefit from the public good with the TM. The number of observations (N) in Figure 2 shows that this is the modal case. Higher return rates are very rare in TAG^{WL} and TAG^{LIN}; they are usually used as signals by TAs to non-cooperative group members to join in being cooperative, with ambiguous results. Such high return rates happen more often in TAG^{BS}; there they are the consequence of turn-taking in contributing, diluting the relationship between the contribution in period $t + 1$ and the return rate in period t.[15]

Result 6. *For maximizing contributions in the subsequent period, it is the optimal strategy in all treatments to return exactly 1.6 times the contributed amount, which is exactly the benefit from the public good.*

4.4 TA return rates and consequences for TMs

Overall, the average aggregate return rates in TAG^{WL}, TAG^{LIN}, and TAG^{BS} are 1.10, 1.42 and 1.90, respectively. These values are very high, having in mind the predictions based on the assumption of narrow self-interested TAs. A mean return rate above 1 indicates that the TAs return more, on average, than TMs contribute. Thus, contributing to the public account, on average, is profitable for the TMs.

In all TAG treatments, the average return rate is always above one, except for the first two periods in the TAG^{WL}, where we observe a slight upward trend over time. However, as we saw in Figure 1, it was not sufficient for stopping the quick decay of average contributions by TMs. Combining Figure 3 with our regression results in Tables 5 and 6, we can explain why we find a significant quadratic time trend in contributions in TAG^{LIN}. While the increase in cooperation levels in the first half of the experiment is caused by TAs' high and even increasing return rates, the decrease in contributions in the second half of the experiment is due to the decline in aggregate return rates in later periods (see Figure 3). In TAG^{BS}, somewhat surprisingly, we find a U-shaped time trend. It is important to note, however, that the return rate potentially is a non-suitable metric for TAG^{BS}, because it does not take the coordination problem into account properly.

[15] A significant negative effect can also be shown for a squared expression of the lagged returned amount in Models 2, 4 and 6 of Table 6. However, due to the small number of observations the decreasing effect is less robust when we introduce such a variable in other-than-OLS estimation approaches such as fixed effects or the Arellano-Bond estimator.

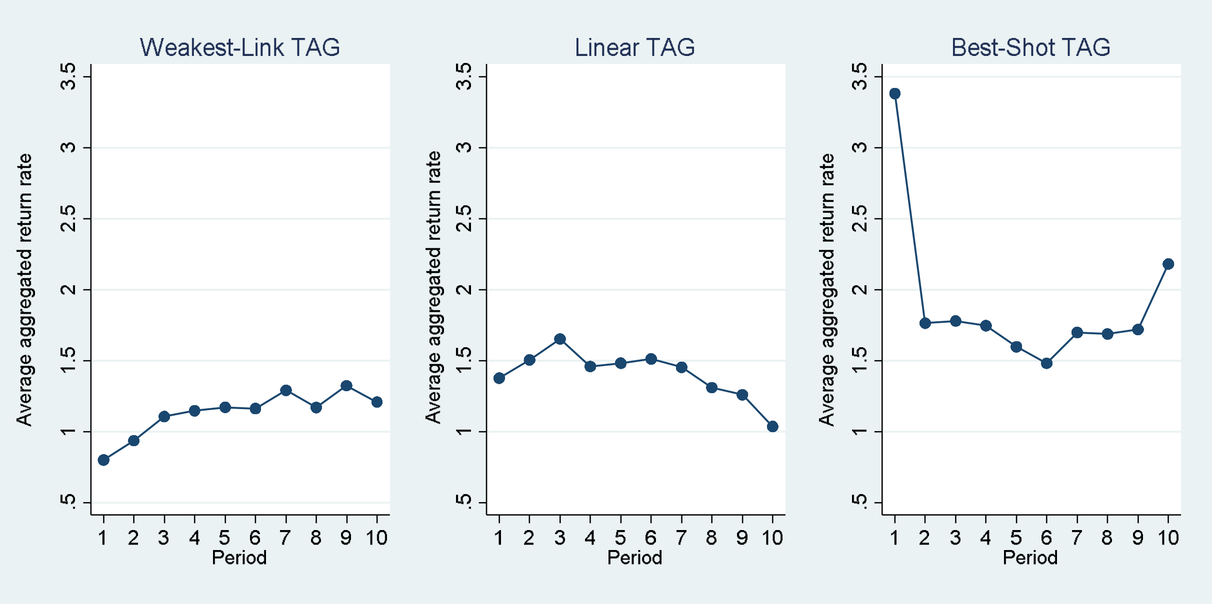

Figure 3: Evolution of the average aggregate return rate over time.

Finally, Figure 4 presents scatter plots for the TAG treatments, comparing mean returns and mean contributions for TMs at the individual level over all ten periods. Two reference lines are added. The *1.0-line*, which captures points where the mean return equals mean contributions. Subjects on this line, therefore, receive, on average, exactly the amount they invested into the public account. In contrast, the *1.6-line* consists of all points where subjects, on average, receive 1.6 times their invested amount. If a TA returns to a TM the complete amount generated by the respective contribution in all periods, the resulting scatter point will lie on the *1.6-line*. The central figure shows that in TAG^{LIN} only two observations lie clearly below the *1.0-line*. For TAG^{LIN}, there is only a single observation in the origin of the graph, i.e., complete free riding is very rare. In general, most of the points lie in the upper right corner near, on, or even slightly above the *1.6-line*. This highlights that almost all TMs in TAG^{LIN} manage to obtain large benefits from their contributions into the public account and hence contribute significant amounts. However, this is not true for the TMs in TAG^{WL}, who face severe coordination problems. Approximately 40% of the groups in TAG^{WL} fail to coordinate on a group contribution of more than five points. Consequently, we observe that, in approximately half of the cases, the returned amount was close to zero. It is worth pointing out that the TAs' power in TAG^{WL} to implicitly reward and punish non-cooperative TMs is undermined by the small amount in the public pot, which is the result of the coordination problem. The more necessary implicit punishment is, the less it is feasible because of the empty pot for redistribution in the second stage. In the TAG^{BS}, we observe that the majority of TMs contributed 15 points or more to the public account. Additionally, we find that the TAs responded with generous returns in most of the cases, which leads to inefficient over-contribution.

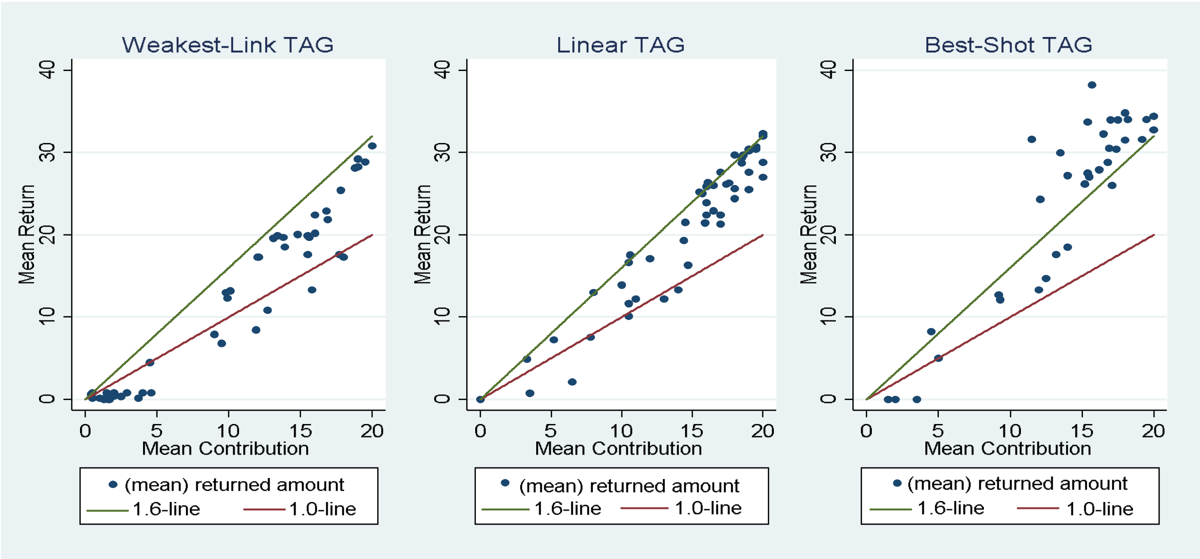

Figure 4: Mean returns and mean contributions for TMs in the TAG treatments.

Result 7. *For all production technologies of the TAG, TMs are rewarded by the TAs if they contribute high amounts to the public account. As a large fraction of TAs reciprocates high amounts, many TMs contribute, on average, close to their full endowment in TAG^{LIN} and TAG^{BS}.*

4.5 Coordination and efficiency in the weakest-link and best-shot technologies

In this section, we analyze how the introduction of a team allocator influences coordination in TAG^{WL} and TAG^{BS}, relative to VCM^{WL} and VCM^{BS}. Table 7 assigns the frequencies of the reference contributions (i.e., the relevant contributions which were used to determine the size of the public good) C_t^{min} and C_t^{max} in TAG^{WL}, VCM^{WL}, TAG^{BS}, and VCM^{BS}, to different contribution levels. The table focuses on different intervals of the reference contributions.

In 40% of the cases, the teams in TAG^{WL} coordinate on zero contributions, while in only 15% of the cases, they manage to coordinate on full contributions (see the first line in Table 7). The teams in VCM^{WL} fare a bit better, with only 24% coordinating on zero contributions and

24% coordinating on full contributions. In TAG^{BS}, we find that 86% of the teams end up with the predicted outcome of at least one team member contributing fully, while in VCM^{BS}, only in 62% of the cases the teams managed to end up with this outcome.

C_t^{min}/ C_t^{max}	**0**	**(0-10)**	**10**	**(10-20)**	**20**	**N**
TAG^{WL}	68 (40%)	21 (22%)	17 (10%)	49 (19%)	25 (15%)	170 (100%)
VCM^{WL}	44 (24%)	46 (26%)	14 (8%)	33 (18%)	43 (24%)	180 (100%)
TAG^{BS}	1 (1%)	0 (0%)	1 (1%)	16 (12%)	103 (86%)	120 (100%)
VCM^{BS}	8 (7%)	10 (9%)	12 (11%)	12 (11%)	68 (62%)	110 (100%)

Table 7: Frequency of reference contributions C_t^{min} and C_t^{max}.

Finally, Figure 5 presents *excess contributions* in VCM^{WL}, TAG^{WL}, VCM^{BS}, and TAG^{BS} over time. In the weakest-link public goods technology, excess contribution is defined as the sum of differences between each TMs contribution and the reference contribution C_t^{min}, i.e., $\sum_{j=1}^{n}(c_{j/c^{min},t} - c_{j,t}^{min})$ in each round *t*. In the best-shot public goods technology, excess contribution is defined as the difference between the sum of all contributions within the team and the reference contribution C_t^{max}, i.e., $\sum_{j=1}^{n} c_{j,t} - c_{j,t}^{max}$.[16] Thus, *excess contribution* captures the inefficiency cost of miscoordination in the weakest-link and best-shot public goods games. In both weakest-link public goods mechanisms, we observe that excess contributions decrease over time, indicating that subjects coordinate better as the game progresses. Excess contributions are slightly higher in TAG^{WL} than VCM^{WL}, but the difference is not statistically significant (Mann-Whitney test, p=0.13).

For excess contributions in TAG^{BS} and VCM^{BS}, we observe a very different pattern. In contrast to VCM^{BS} where coordination improves over time, we find that excess contributions increase up to the 6th period in TAG^{BS} and slowly decrease as the experiment progresses towards its end. Consequently, excess contributions are significantly higher in TAG^{BS} than in

[16] For example, if in VCM^{WL} team members A, B and C contributed 20 points to the public account and team member D contributed only 10 points, then the excess contribution is 30. If the same choices are observed in VCM^{BS}, the excess contribution is 50.

VCM^{BS} (Mann-Whitney test, $p<0.01$). The existence of the TA exacerbates inefficiency as TMs signal to the TA that they deserve to get a share of the pie. Coordination on more efficient equilibria, such as rotating full contributions, does not seem to work.

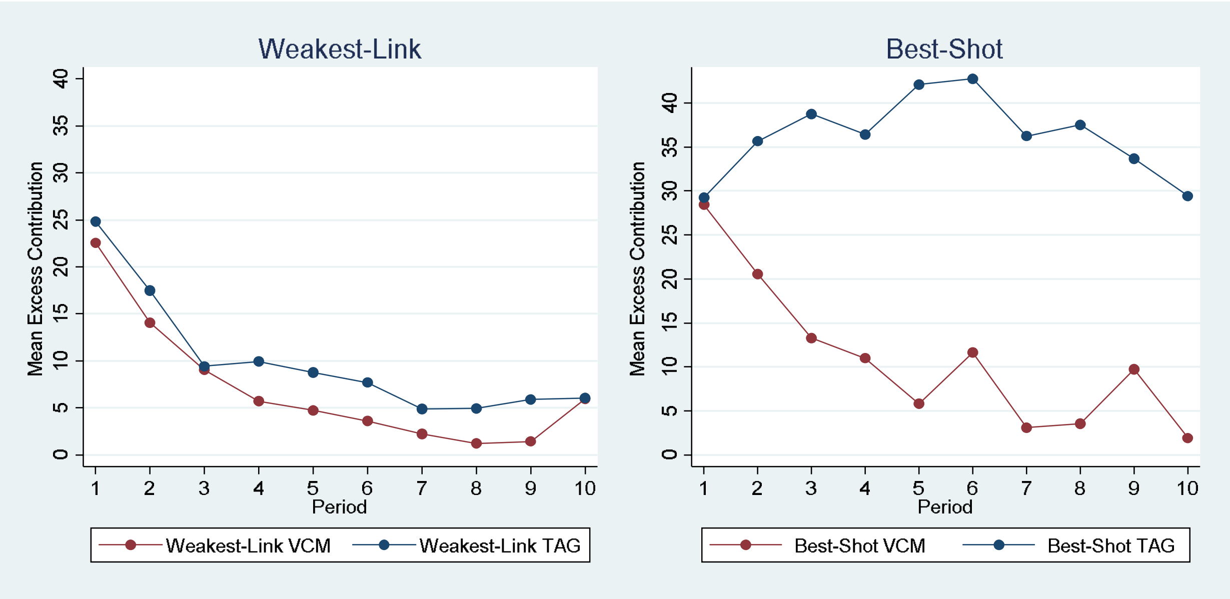

Figure 5: Mean excess contributions over time.

5. Discussion

We study how the introduction of hierarchy in linear, weakest-link, and best-shot public goods games influence cooperation, efficiency, and social welfare. In contrast to past research in public goods where the public account is distributed equally among all team members, in the *team allocator game* one team member, *the team allocator*, in addition to contributing to team effort, has discretionary power over the gains from team production and can distribute it freely among herself and the other *team members*.

Our study provides a first benchmark on the impact of hierarchies in teams that face social dilemmas by comparing two treatment structures, which focus on extremes: (i) *complete allocation power*, where the team allocator has absolute control over the distribution of the team's production (TAG), (ii) *no allocation power*, where, the production is automatically allocated equally across all team members (VCM).[17] We report the results of three experiments

[17] Using an automatic equal allocation process seemed a natural benchmark, as it is the most studied structure in the experimental literature on public goods. Furthermore, we chose to implement full rather than limited allocation power for parsimony.

on common public-good technologies in which we examine how effective teams are with and without a team allocator in maximizing social welfare when the team's output is determined by: (i) the sum of the team's efforts, (ii) the team's lowest contribution (i.e., the weakest-link) or (iii) the team's highest contributor (i.e., the best-shot).

We report five main empirical results: First, introducing a team allocator is effective in increasing contributions to the public good in both the linear and the best-shot public goods technologies but not in weakest-link public goods games, where the introduction of a team allocator has no significant effect on contributions. Second, team allocators in the linear public-good game use their allocation power to incentivize team members to contribute to the public account. Specifically, they reward high contributors with remarkably high returns but punish low contributors with returns significantly lower than the marginal per capita return of their contribution. Third, we find that team members respond to the team allocator's implicit sanctions and rewards positively, by increasing their contributions when they realize that other team members are rewarded with higher return rates for contributing more to the public account. Fourth, our results clearly and unsurprisingly refute predictions based on narrow self-interest. They are, however, largely in line with models of heterogeneous preferences and repeated interactions such as (effort-based) inequity aversion (Fehr and Schmidt, 1999) or maximin-preferences (Charness and Rabin, 2002). Fifth, team allocators – at least in the setup that we introduced – cannot solve coordination problems properly.

Our findings demonstrate that the effectiveness of hierarchy depends crucially on the underlying production process and in particular to the way how power over production and allocation is distributed within a team. In our best-shot public goods game where the team allocator has complete power over both production and allocation of profits, the introduction of a team allocator gives rise to excess contributions, as the team members use their contributions to influence how team allocators distribute the gains from team production. In contrast, in our weakest-link public goods setting, where every team member has complete veto power over the final output, introducing a team allocator has no effect on welfare. Specifically, we find that the team allocator's power to implicitly reward and punish team members is severely constrained by the power of the latter to counter-punish in subsequent rounds.

Our findings in the linear public-good game are even more remarkable, when considering that in our setting team allocators were: (a) randomly allocated rather than elected and, (b) had complete power over the distribution of team production. Several studies have demonstrated that elected leaders are better in promoting cooperation in teams than randomly selected leaders (e.g., Baldassarri and Grossman, 2011; Levy et al., 2011). As many real-life situations involve voting decisions on group leaders, our experiment most likely underestimates the true gain of endogenously formed hierarchies. Similarly, in practice, the allocation power of team allocators is often limited by law, and contractual agreements. For instance, if there are institutional provisions (e.g., collective agreements) in place that avoid that the TA keeps a high share of the pie for herself, this would lower vertical inequality, increasing the satisfaction of TMs and possibly fostering cooperation even more strongly.

Finally, our results indicate that centralized power over sanctioning and rewards can be an important alternative to decentralized sanctioning (e.g., Fehr and Gächter, 2000) for the promotion of cooperation in teams, where the production process resembles that of a linear public good. Our setting avoids the second-order public good problem that is often observed in public goods games with a punishment mechanism. Additionally, as punishment and reward are implicit, when a team allocator distributes returns, the described mechanism bears no direct monetary costs.

Thus, we conclude that the introduction of a team allocator can be beneficial for organizations. Hierarchical teams are more likely to overcome the social dilemma inherent to public goods or team effort provision. Thus, allocation power in teams can be considered as a potential alternative to a sanctioning regime, especially as the latter is often efficiency-reducing. Further studies on the role of hierarchy and power in public goods provision could be an exciting avenue for future research. In particular, abstracting from legitimization issues regarding the team allocator seems a simplification in our setup that calls for straightforward extensions in future studies.

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Online Appendix

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Appendix A: Theory

A.1 Fehr and Schmidt (1999) preferences

The model by Fehr and Schmidt (1999) assumes that subjects suffer from inequity within their reference group. More precisely, a subject i benefits from her own payoff π_i but compares it with the payoff of the $n-1$ other members in her reference group. The corresponding utility function is the following:

$$U_i(\pi) = \pi_i - \alpha_i \frac{1}{n-1}\sum_{j\neq i} \max\{\pi_j - \pi_i, 0\} - \beta_i \frac{1}{n-1}\sum_{j\neq i} \max\{\pi_i - \pi_j, 0\} \qquad (3)$$

The vector $\pi = (\pi_1, \dots, \pi_n)$ denotes the monetary payoffs and α_i and β_i represent subject i's individual attitude towards inequity. The two weights are restricted to $\beta_i \leq \alpha_i$ and $0 \leq \beta_i < 1$. They control for the impact of utility losses from disadvantageous inequity (α_i) and advantageous inequity (β_i), respectively.[18]

If we assume that the TA in the TAGs is inequity-averse and the team is the relevant reference group, then a TA might be willing to reduce payoff differences within the team by returning positive amounts to the TMs. Note that the weight α_i does not play any role here, because the TA will never reduce the amount allotted to herself below the level of full payoff

[18] Note that for $\alpha_i = \beta_i = 0$ the model collapses into the case of standard preferences.

equalization as this reduces her own payoff *and* increases inequity. Thus, only the weight β_i matters for TA's decisions. If the TA distributes one point from the public account to an TM instead of putting it into her own pocket, she will reduce her own payoff by 1 and decrease inequity, on average, by 4/3 (regarding the receiving TM by two points and regarding both other TMs by one point). Thus, returning positive amounts is optimal if $-1 + \beta_1 \cdot 4/3 \geq 0$ or $\beta_1 \geq 0.75$.

This yields the following equilibria in the one-shot game: If $\beta_1 < 0.75$, the TA takes the entire public account for herself, which implies zero contributions of TMs irrespective of whether they are selfish or whether they are other-regarding, i.e. $c_i = d_i = 0 \; \forall i \neq 1$ and $d_1 = \gamma C = 32$ in TAG^{LIN} and $d_1 = 4\gamma C = 128$ in TAG^{BS}. If $\beta_1 > 0.75$, and this is common knowledge, all TMs have an incentive to contribute their full endowment in both TAG^{LIN} and TAG^{WL}, even when they are completely selfish and rational, and of course, the more so if they are other-regarding. Hence, we have $c_i = E = 20 \; \forall i \neq 1$, and $d_i = 32 \; \forall i$ as the only subgame-perfect equilibrium in TAG^{LIN} and the Pareto dominating subgame-perfect equilibrium in TAG^{WL}. If $\beta_1 = 0.75$, the TA is indifferent in the way she allocates the public account (as long as she is not worse-off than one of the other team members). In this case, multiple equilibria exist and cooperation between some or all team members may occur in TAG^{LIN} and TAG^{WL}. Thus, TAs that are sufficiently averse to advantageous inequity ($\beta_1 \geq 0.75$) can generate full cooperation and payoff equalization in the one-shot version of the TAG^{LIN} and TAG^{WL}. In TAG^{BS} if the TA's $\beta_1 < 0.75$ the TA would contribute her full endowment to the public account and take the entire public account for herself. Thus, $c_i = d_i = 0 \; \forall i \neq 1$ and $d_1 = \gamma C = 128$. If the TA is sufficiently averse to advantageous inequity ($i.e. \beta_1 \geq 0.75$) she would redistribute the public account to the TM's as to ensure payoff equalization. As a result, there are asymmetric equilibria with one team member contributing (regardless of whether it is a TM or the TA) and the others not contributing.

It is noteworthy that Fehr and Schmidt (1999) preferences can predict full cooperation in our VCM^{LIN} treatment. Using Proposition 4 of Fehr and Schmidt (1999, p. 839) it is, however, obvious that for our parameter values, cooperation can only be achieved if all TMs are sufficiently averse to advantageous inequity, i.e., $\gamma/n + \beta_i \geq 1$ or $\beta_i \geq 0.6 \; \forall i \neq 1$. Asymmetric equilibria in the one-shot game do not exist for our setup. According to the parameter distribution given in Fehr and Schmidt (1999, p. 844), the probability of having three TMs with $\beta_i \geq 0.6$ in one team is $0.4^3 = 6.4\%$. As Fehr and Schmidt (1999) do not provide data for a threshold of 0.75, we cannot infer the probability of meeting a TA with $\beta_i \geq 0.75$

from their paper. From all calibration results that are available, the probability of meeting a TA with sufficiently high β_i to induce full cooperation is higher than 6.4%. Hence, full cooperation in the one-shot TAG^{LIN} treatment is expected to be more prevalent than in the VCM^{LIN} treatment. In the VCM^{WL}, full contribution by all TMs is the Pareto dominating Nash equilibrium, irrespective of whether the TMs are inequity averse or self-interested, as it results to equal earnings and leads to the highest payoff. As in TAG^{WL} cooperation is possible only if the TA exhibits a $\beta_i \geq 0.75$ and this is common knowledge, we expect to observe less teams cooperating in TAG^{WL} treatment relative to the VCM^{WL} treatment. In VCM^{BS}, coordination remains an issue, regardless of the TAs other regarding preferences.

Proposition A.1. *With Fehr and Schmidt (1999) preferences, the TA in the TAGs is willing to distribute positive amounts to TMs if* $\beta_1 \geq 0.75$*, i.e., if she is sufficiently averse to advantageous inequity. In that case, full cooperation and full payoff equalization within the team is an equilibrium in both TAG*^{LIN} *and TAG*^{WL}*. In TAG*^{BS}*, TMs coordination remains an issue. If* $\beta_1 < 0.75$*, in all TAGs the TA will take the entire benefit from the public account for herself, and none of the TMs have an incentive to contribute. Full cooperation can also be an equilibrium in the* VCM^{LIN} *treatment; however, it requires* $\beta_i \geq 0.6$ *for all TMs. In VCM*^{WL} *assuming Pareto dominance, it is the optimal strategy to always contribute irrespective of whether the TMs are Fehr and Schmidt (1999) inequity averse or self-interested.*

A.2 Charness and Rabin (2002) preferences

Charness and Rabin (2002) assume that subjects care about social welfare. Their model includes a subject's own payoff and, additionally, two components of social welfare: the minimum payoff in a group (the "Rawlsian" motive) and the sum of all group members' payoffs (the efficiency concern). More precisely, the utility function in their general model (see their Appendix 1) with only outcome-based components looks as follows:[19]

$$U_i(\pi) = (1-\lambda_i)\pi_i + \lambda_i[\delta_i \min(\pi_1, \dots, \pi_n) + (1-\delta_i)(\pi_1 + \pi_2 + \cdots + \pi_n)] \qquad (4)$$

The vector $\pi = (\pi_1, \dots, \pi_n)$ denotes the monetary payoffs within the group of n subjects and λ_i and δ_i are individual weights (where $\lambda_i, \delta_i \in [0,1]$). The first weight, λ_i, captures how

[19] Note that we consider here only the outcome-based version of the model and neglect the role of intentions as the more complex model with intentions does not seem suitable for deriving specific predictions in our setup.

much an individual cares for social welfare relative to her own payoff.[20] The second weight, δ_i, controls for the influence of the "maximin"-aspect relative to the general efficiency concern.

As a TA's choice in TAG^{LIN} is purely distributional, i.e., the sum of team members' payoffs is not affected by her decision, only the "Rawlsian" motive of social welfare matters for a TA's decision. TAs compare the utility loss from a reduction in own payoff, $1-\lambda_1$, with the utility gain from increasing the minimum payoff in the team ($\lambda_1\delta_1$). This implies that TAs never return amounts to TMs beyond the level of full payoff equalization. Note further that the number of subjects s that lie at the minimum payoff matters, because it determines by how much the minimum can be raised with one point. If there is more than one individual at the minimum, the returned amount would need to increase all affected subjects to result to an increase in $\min(\pi_1, \ldots, \pi_n)$. Thus, returning positive amounts to TMs is optimal for a TA if:

$$1-\lambda_1 \leq \lambda_1\delta_1 \cdot \frac{1}{s} \Leftrightarrow \delta_1 \geq s \cdot \frac{(1-\lambda_1)}{\lambda_1}$$

As s cannot be smaller than 1, $0.5 \leq \lambda_1 \leq 1$ is a necessary condition to ensure $\delta_1 \in [0,1]$. When $\lambda_1 \geq 0.5$ and $\delta_1 \geq s \cdot \frac{(1-\lambda_1)}{\lambda_1}$ would make positive returned amounts to TMs optimal, only if there is a single TM with minimum earnings. Once the minimum is raised to the level of the second-lowest payoff or once there are two subjects with the same minimum earnings, the condition tightens to $\lambda_1 \geq 2/3$. Thus, in contrast to Fehr and Schmidt (1999), Charness and Rabin (2002) preferences can lead to a partial equalization of profits. Full payoff equalization in equilibrium would only be obtained if λ_1 is large enough to make redistribution profitable in the case the points have to be split among all three TMs, i.e., $\lambda_1 \geq 0.75$.

This implies the following: If $\lambda_1 \geq 0.75$ (and $\delta_1 \geq s\,(1-\lambda_1)/\lambda_1$), there is an equilibrium in which all TMs contribute their full endowment even if they are completely selfish and rational and the more so if they are other-regarding, i.e. $c_i = E = 20\ \forall i \neq 1$, and $d_i = 32\ \forall i$.[21] If $\lambda_1 < 0.5$, selfish TMs choose $c_i = 0$, while $E = 20$ is contributed by TMs who care sufficiently about efficiency (requiring $\lambda_i \geq 0.625$ and δ_i sufficiently low[22]). If $0.5 \leq \lambda_1 < 0.75$, full cooperation will not be obtained with selfish and rational TMs. However, partial

[20] For $\lambda_i = 0$, the Charness and Rabin (2002) model nests standard preferences.

[21] There is, of course, indifference of the TA between distributions in case of $\lambda_1 = 0.75$. This leads to multiple equilibria sustaining also contribution levels below 20.

[22] To see this, note that if a single TM contributes one point to the public account, both the TM's payoff and the minimum payoff is reduced by 1, whereas the sum of payoffs increases by $\gamma - 1$. Thus, contributing is advantageous if $(1-\lambda_i) + \lambda_i\delta_i \leq \lambda_i(1-\delta_i)(\gamma-1)$ or $\delta_i \leq 1 - 1/(1.6\lambda_i)$. This implies $\lambda_i \geq 0.625$ (and δ_i appropriately). Note that the restriction on δ_i becomes weaker for further TMs contributing one point (without changing the requirement on λ_i) as their contributions do not decrease the minimum anymore.

cooperation with one or two TMs contributing positive amounts is possible if $\lambda_1 \geq 2/3$. Again, if all TMs care sufficiently about efficiency, full cooperation will arise.

In TAG^{WL}, as in TAG^{LIN}, if $\lambda_1 \geq 0.75$ (and $\delta_1 \geq s\,(1-\lambda_1)/\lambda_1$), there is an equilibrium in which as all TMs contribute their full endowment even if they are completely selfish and rational and the more so if they are other-regarding, and consequently so does the TA, i.e. $c_i = E = 20\ \forall i$, and $d_i = 32\ \forall i$.[23] However, if $\lambda_1 < 0.5$, selfish TMs choose $c_i = 0$, if in the group exists at least one selfish TM and this is common knowledge then all TMs and the TA choose $c_i = 0$, as any contribution would decrease the minimum payoff and lower individual profits. An E=20 is contributed if *all* TMs care sufficiently about efficiency, requiring $\lambda_i \geq 0.625$.[24] If $\lambda_1 \geq 2/3$, partial cooperation can be achieved, however, like before, the contributions of TMs and TAs, would be determined by the individual with TM with the lowest λ_i. Thus, in contrast to Fehr and Schmidt (1999), sufficiently high efficiency concerns by TMs, at least in principle, could explain positive contributions by TMs in TAG^{WL} even if the TA is selfish, but only if such concerns are shared mutually across all TMs.

In TAG^{BS}, if $\lambda_1 \geq 0.75$ and $\delta_1 \geq s\,(1-\lambda_1)/\lambda_1$ and TMs are selfish, there is a unique Nash equilibrium in which only the TA contributes and then redistributes equally between herself and the TMs. However, if the TMs also exhibit other-regarding preferences, then a coordination issue arise as to whom should contribute to the public account. If $\lambda_1 < 0.5$ and $\delta_1 \geq s\,(1-\lambda_1)/\lambda_1$, then TMs have no incentive to contribute if they are self-interested. If all TMs are self-interested, and this is common knowledge, the TA would contribute his full endowment and keep the whole public account. If one TM is sufficiently concerned about efficiency, (e.g., $\delta_i = 0$ and $\lambda_i = 1$) it is possible that he would contribute his full endowment, despite that would reduce the minimum contribution and his profit to zero. In this case, every other member including the TA would contribute zero.

In the VCM^{LIN} treatment, TMs have to care sufficiently for social welfare to have an incentive to contribute to the public account. Note that an increase in the contribution level decreases an TM's own payoff by $1-\gamma/n$, increases the minimum payoff in the team by γ/n and increases the sum of all team members' payoffs by $\gamma - 1$. Hence, contributing positive amounts is optimal if:

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[23] Notice that in this case the TAs contribution, is determined by the TMs lowest contribution.

[24] Notice here that in contrast to TAG^{LIN} where the sum payoffs increase linearly by $\gamma - 1$, at individual contributions, in TAG^{WL} this is achieved only if all TMs contribute. If even one TM contributes less than the others the sum of payoff decreases by -1 for every unit of contribution above the minimum contribution.

$$(1-\lambda_i)\left(1-\frac{\gamma}{n}\right) \leq \lambda_i\delta_i \cdot \frac{\gamma}{n} + \lambda_i(1-\delta_i)(\gamma-1) \Leftrightarrow \delta_i \leq 6-\frac{3}{\lambda_i}$$

For δ_i to be non-negative, this requires $\lambda_i \geq 0.5$. Full cooperation by all group members will therefore only arise if all TMs fulfill $\lambda_i \geq 0.5$ (and δ_i appropriately). In VCM^{WL} it is the dominant strategy, to always contribute the full amount irrespective of whether the TMs exhibit Charness and Rabin preferences or are self-interested. In VCM^{BS}, relative to VCM^{LIN}, an increase in the contribution level would increase the sum of all team members' payoffs by $4\gamma - 1$. Hence, when only one TM exhibits Charness and Rabin preferences contributing positive amounts is optimal if:

$$(1-\lambda_i)\left(1-\frac{\gamma}{n}\right) \leq \lambda_i\delta_i \cdot \frac{\gamma}{n} + \lambda_i(1-\delta_i)(4\gamma-1)$$

Thus, for δ_i to be non-negative, this requires $\lambda_i \geq 0.1$. However, if more than one TM exhibits $\lambda_i \geq 0.1$, then multiple Nash equilibria arise.[25]

Proposition A.2. *With Charness and Rabin (2002) preferences, the TA in TAGs would return positive amounts to TMs if* $\lambda_1 \geq 0.5$ *(and* $\delta_1 \geq s\,(1-\lambda_1)/\lambda_1$*), i.e., if she is sufficiently "maximin"-oriented. However, full payoff equalization can only be achieved if* $\lambda_1 \geq 0.75$ *(and* $\delta_1 \geq s \cdot (1-\lambda_1)/\lambda_1$*). In TAG*^{LIN}*, full cooperation is also possible if all TMs care sufficiently about efficiency. In TAG*^{WL} *TMs cooperation is a necessary condition to generate positive contributions. Specifically, when the TA exhibit,* $\lambda_1 \geq 0.75$ *(and* $\delta_1 \geq s \cdot (1-\lambda_1)/\lambda_1$*), then even selfish TMs would contribute, if we allow for Pareto dominance to act as an additional refinement to equilibrium selection. If* $\lambda_1 < 0.5$*, selfish TMs always choose* $c_i = 0$*. When,* $0.75 < \lambda_1 < 0.5$*, multiple equilibria arise, depending on the TM with the lowest* λ_i*. In TAG*^{BS}*, if* $\lambda_1 \geq 0.75$ *and* $\delta_1 \geq s\,(1-\lambda_1)/\lambda_1$ *and TMs are selfish, there is a unique equilibrium, in which there are no excess contributions. In this equilibrium, the TA contributes her full endowment and then redistributes equally between herself and the TMs. A unique equilibrium also arises, when one TM, is purely concerned for efficiency while every other TM is selfish. However, when the TA and one (or more) TMs are other-regarding the coordinating problem remains. In the* VCM^{LIN} *full cooperation will only arise if all TMs fulfill* $\lambda_i \geq 0.5$*. In contrast, in VCM*^{WL} *it is the optimal strategy to always contribute irrespective of whether the TMs exhibit*

[25] Notice that when a second TM's contribution would decrease the TM's own payoff by -1, would have no impact on the minimum payoff, or increasing the sum of total payoffs.

Charness and Rabin (2002) preferences or are self-interested, if we assume that subjects prefer the Pareto dominant equilibrium. In VCM^{BS}, a unique equilibrium arises if one TM is mildly concerned about efficiency with $\lambda_i \geq 0.1$ and every other TM is selfish. However, when multiple TMs exhibit an $\lambda_i \geq 0.1$. then concerns for efficiency and own payoff maximization, generate a coordination problem,

To sum up, in contrast to the case of standard preferences, both models of other-regarding preferences predict (for appropriate parameter values) that TAs in the TAGs return positive amounts to TMs. Moreover, such behavior can induce full cooperation and payoff equalization within the team, even among purely self-interested TMs. Both models can also explain full cooperation in the VCMs treatments. However, an equilibrium with full cooperation in the VCM^{LIN} and VCM^{WL} requires that *all* TMs have sufficiently strong other-regarding preferences. In contrast, in TAG^{LIN} it is sufficient that the TA has strong enough other-regarding preferences. Whereas, in TAG^{WL} either the TA would need to have strong other-regarding preferences or all the TMs. In TAG^{BS}, even though both models can explain positive contributions from the TA, provide little guidance with regards to coordination, unless in special circumstances.

Appendix B: Additional results

B.1: Evolution of the number of teams with full cooperation across treatments

To get a better idea of the individual group effects of team allocators, we focus on the number of teams with full cooperation over time. This is displayed in Figure B.1. The left cell depicts the VCM and TAG cases for the public good with the weakest-link structure. Whereas the right cell focuses on the VCM and TAG cases for the standard public good. We exclude the Best-shot treatments as we never find any group with full cooperation, neither in Best-shot VCM, nor in Best-shot TAG.

Overall, the figure suggests that the number of fully cooperating teams does not change over time in the VCM treatments of the weakest-link and standard public-good games. Again, it turns that coordination problems seem to be predominant in the weakest-link setting. Consequently, team allocators do not boost cooperation, i.e., the number of fully cooperating teams does not clearly increase in weakest-link TAG. If anything, the figure suggests that the total number of fully cooperating teams is higher in VCM^{WL}.

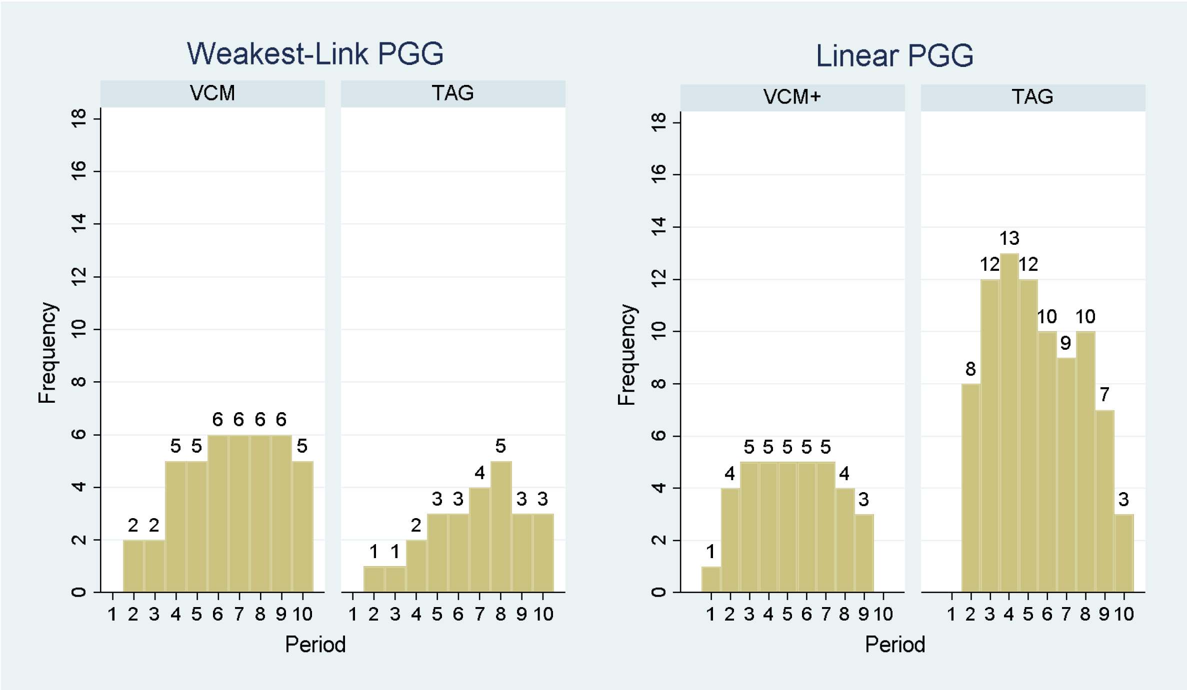

Figure B.1: Evolution of the number of teams with full cooperation across treatments.

However, with linear public-good technology, it is clearly visible that from period two onwards, the number of fully cooperating teams is roughly twice as high in the TAG than in the VCM. This confirms the prediction from the Fehr and Schmidt (1999) model that full cooperation is easier to achieve in the TAG treatment. In fact, up to 2/3 of all teams manage to cooperate completely in intermediate periods of the TAG. Moreover, it turns out that cooperation seems to be very stable over time in the linear TAG setting. We only observe a decrease in the number of teams with full cooperation in the very last period, which is evidence for an end-game effect.

B.2 Average contributions of TMs in VCM and TAG^{LIN} over time by team

Figure B.2 shows the average contributions of TMs in VCM over time by team for the VCM treatment (sessions 4-6). Team "4a" characterizes team "a" in session "4", etc. In this treatment, only five teams (4a, 4d, 4f, 5c, 5f) can be classified as *high contribution* teams. In line with the past literature in standard public goods games, the *low contribution* teams dominate.

Specifically, half of the teams (4e, 5a, 5b, 5d, 5e, 6a, 6b, 6d, 6f) fall into this category. The four remaining teams (4b, 4c, 6c, 6e) form the *mixed contribution* category.

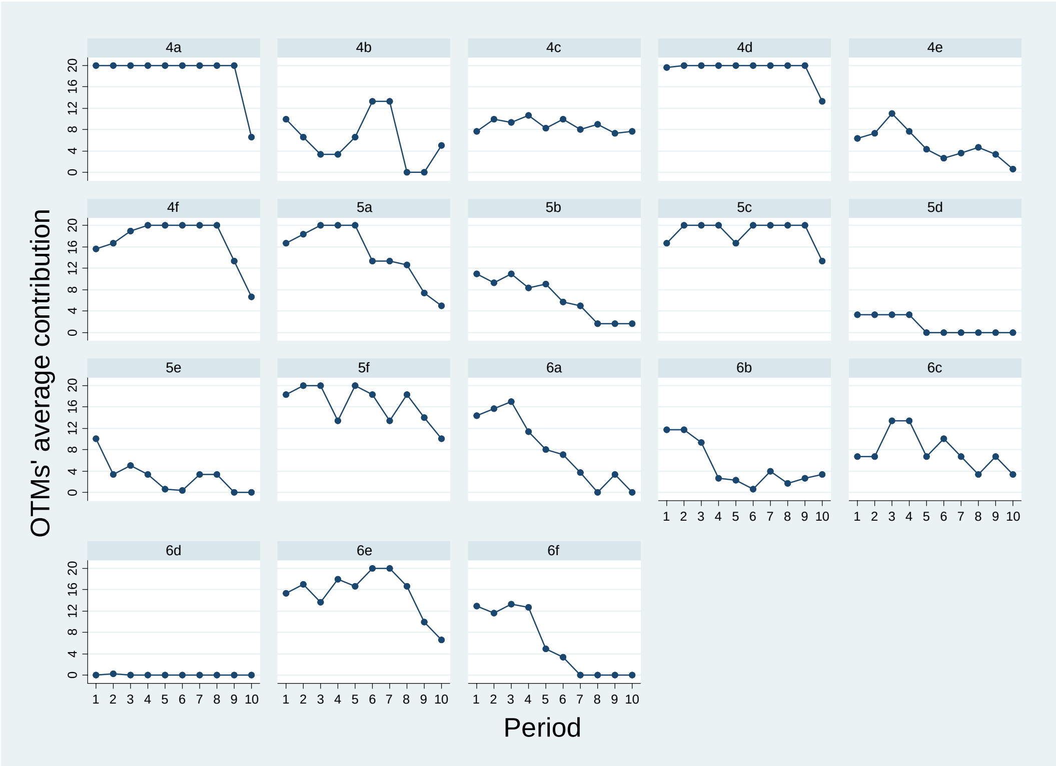

Figure B.2: Average contributions of TMs in VCM over time by team

Table B.1 shows the frequency of categories for the VCM and the TAG treatment. Frequencies in the first two columns are significantly different using a χ^2 test ($p < 0.05$).[26] These results that there is an apparent increase in average contribution in each team that can be safely attributed to a decrease in the number of low contributing teams.

	High contribution	Low contribution	Mixed contribution
TAG	11	4	3
VCM	5	9	4
H0: No difference between *high contribution* and *low contribution* (χ^2 test (p-value))	< 0.05		

Table B.1: Frequency of teams by category and treatment

[26] A Fisher's exact test yields p = 0.06.

Appendix C: Experimental instructions

Experimental instructions (originally in German)[27] TAG^{LIN}

A warm welcome to an experiment on decision making!
Thank you for participating!

During the experiment you and all other participants will be asked to make decisions. Your decisions as well as the decisions of the participants you are matched with determine your earnings from the experiment according to the following rules.

Please stop talking to other participants from now on. If you have any questions after going through the instructions or while the experiment is taking place, please raise your hand, and one of the experimenters will come to you and answer your questions privately. In case the question is relevant for all participants, its answer is repeated aloud.

The whole experiment is computerized and will last approximately **90 minutes**. All your decisions and answers remain anonymous. You will not find out with whom you are matched in each of the experiment's parts and how much each of the other participants earns. We evaluate data from the experiment on aggregate level only and never link names to data from the experiment. At the end of the experiment, you will be asked to sign a receipt for your earnings. This has accounting purposes only.

The experiment consists of **two** parts. At the beginning of each part, you will receive the corresponding instructions for this part. The instructions will be read out loud and you will get time to ask questions. Please, do not hesitate to ask if anything is unclear to you. Your decisions in Part I of the experiment **do not** have any effects on Part II. In the interest of clarity, we will only use male terms in the instructions. They should be interpreted as being gender-neutral. For means of help, you will find a pen on your table.

While taking your decisions at the PC, there will be a clock counting down in the right upper corner of the screen. The clock serves as a guide for how much time you should need. You may

[27] Baseline instructions describe treatment TAG. Differences in VCM are indicated by [**VCM**]. Instructions for the other treatments are analogous and available upon request.

exceed the time. The input screens will **not** be turned off when time has run out. However, the information screens on which no decision is required to be taken will be turned off when time has run out. Once you have taken a decision or have read through a screen, please confirm by clicking on the “OK” button.

Your earnings in the experiment will be calculated in **“points”**. At the end of the experiment, the “points” get converted into euro at the exchange rate announced in the respective part. In addition, you receive 4 euro for your arrival on time. Your total earnings from the experiment will be paid out to you privately and in cash at the end of the experiment.

Part I

In Part I of the experiment all participants are randomly assigned into groups of two. Nobody will find out with whom he forms a group – not during the experiment and not after the experiment either.

You have to take 24 decisions in this part of the experiment. In each decision you can choose between 2 options, A and B. Each option allocates a positive or negative payoff (earning) in points to you and to the other person in your group. The other person answers exactly the same questions. Your total payoff from Part I depends on your decisions *and* on the decisions taken by the other person in your group.

A decision example:

	Option A	Option B
Your payoff	10.00	7.00
Other’s payoff	-5.00	4.00

- If you choose Option A you receive 10 points, and the other person loses 5 points. If the other person also chooses Option A, he, too, receives 10 points and you lose 5 points. In total, you therefore earn 5 points (10 points from your choice minus 5 points from the other person’s choice). The other person earns 5 points (10 points – 5 points), too.

- In case you choose Option B, and the other person chooses Option A, you earn 2 points (7 points from your choice minus 5 points from the other person's decision). The other person earns 14 points (10 points + 4 points).
- The remaining combinations (you choose A, and the other person chooses B, or both persons choose B) are analogous to these two examples.

Overall, you take 24 decisions like the one described above. Your total payoff is computed as follows: The 24 values for "your payoff" are summed up over your decisions. The 24 values for "other's payoff" are summed up over the other person's decisions. The sum of these two sums determines your total payoff from this part and is converted into euro at the end of the experiment as follows: **25 points = 3 euro** (1 point = 12 cent). This exchange rate is valid only for Part I of the experiment.

Note that you are not receiving information on each single decision taken by the other person in your group. Rather, you will find out only the sum of your decisions for "your payoff", the sum of the other person's decisions for "other's payoff" and your total payoff from Part I at the very end of the experiment. Note that you do not get any feedback immediately after Part I.

If there are any questions, please raise your hand now. We will come to you and answer your questions privately.

Part II

The points earned in Part II are converted into euro at the exchange rate of **25 points = 1 euro** (1 point = 4 cent) at the end of the experiment.

At the beginning of Part II, all participants are randomly assigned into groups of four. Nobody will find out with whom he forms a group – not during the experiment and not after the experiment either. Part II consists of **10 identical periods** and you remain matched with the **same persons throughout the entire Part II**.

Each participant is randomly given an **individual name,** which, too, remains the same across all 10 periods, and which allows you to keep track of the behavior of your group members throughout the periods. The names are: Person 1, Person 2, Person 3, and Person 4.

Furthermore, a **member type** is assigned to each group member (A or B). Within each group, there is one group member of type A and three group members of type B. The group members of type A and B differ in their decision possibilities. The type of each group member is publicly announced within the group and remains the same throughout the 10 periods.

The group member of type A is **randomly determined**. The probability of being of type A is 25 % for each group member. The remaining three group members are of type B.

Endowment and alternatives in each period

Each period consists of two stages, a **contribution stage** and a **distribution stage**.

Contribution stage

Each participant receives an initial endowment of **20 points** at the beginning of the contribution stage in each period. The 20 points are allocated to two alternatives, a group account, and a private account, depending on the participant's type:

The group member of type A **is obliged** to put all of the 20 points into the group account. Thus, the group member of type A takes no decision during the contribution stage.
Group members of type B can **freely** choose how many points to contribute to the group account and how many points to contribute to the private account.

The group account

Contributions to the group account from all group members are summed up. The sum is multiplied with 1.6 and distributed among the group members during the distribution stage (s.b.). For example, if the sum of all contributed points to the group account is 60, there are 60*1.6=96 points from the group account to be distributed to the group members in the distribution stage. If the sum of contributed points to the group account is 20, there are 20*1.6=32 points from the group account to be distributed in the distribution stage.

The private account

The contribution of a group member to the private account turns solely and one-to-one into direct earning of the respective individual. For example, if a group member puts 6 points into the private account, he receives exactly 6 points from the private account to his earnings. If the contribution to the private account is 17, the group member earns exactly 17 points from the private account. The other group members do not receive anything in each case.

Distribution stage

During the distribution stage, the group account gets divided among the four group members. The group member of **type A** is in charge of the division**.** He distributes the group account among himself and the other group members. Group members of type B do not have any influence. Values with **at maximum one decimal place** are allowed for the distribution (please use a dot to separate digits).

[**VCM**: The distribution is done **automatically**. Each group member receives 25% of the group account.]

The following table is exemplary and shows several distributions for the case that there are 60 points to be distributed. The first three distribution settings are possible. The fourth one is not possible as there are too few points (29) that are distributed. The fifth setting is not possible, either as there are too many points (120) that are distributed.

	Distribution 1	**Distribution 2**	**Distribution 3**	**Distribution 4**	**Distribution 5**
Person 1	12.6	0	15	5	45
Person 2	10	0	15	8	15
Person 3	21	60	15	2	15
Person 4	16.4	0	15	14	45
	Possible	Possible	Possible	Too few points	Too many points

Naturally, the actual distribution chosen by the group member of type A can look completely different to the exemplary distributions 1–3. Any combination of numbers that adds up to the sum to be distributed is possible.

[**VCM**: The following table is exemplary and shows the distribution for the case that there are 60 points to be distributed.

	Distribution
Person 1	15
Person 2	15
Person 3	15
Person 4	15

]

Earnings in one period

Your earnings per period are the sum of the amount of your private account and the amount allocated to you from the group account.

Procedure

On the first screen you get told about your individual name (Person 1, Person 2, Person 3, or Person 4) and which Person is of type A. The other group members are automatically of type B. Afterwards, all group members of type B get asked about how much of the 20 points they would like to contribute to the group account. The remainder is automatically allocated to the private account. Saving points for later periods is thus not possible. Only integer numbers between 0 and 20 (whereby 0 and 20 are possible choices, too) can be entered. The group member of type A is obliged to contribute 20 points to the group account and, consequently, does not get an input screen.

Afterward, all group members get informed about contributions to the group account of all group members and the resulting sum to be distributed.

The group member of type A is then asked how he wants to divide the group account among the group members. The Windows Calculator can be used to help with calculations. It can be found by clicking on the calculator symbol on the screen.

[**VCM**: Thereafter, the group account is divided among the group members.]

At the end of the period, all group members are informed about the contributions to the group account, the allocation from the group account, the contributions to the private account as well as the earnings of all group members in this period. Subsequently, the next period starts.

This part of the experiment is finished after 10 periods. The results from all periods are summed up and converted into euro.

Afterward, we will ask you to fill in a short questionnaire on the PC. The questions on individual persons relate to the names of Part II. There are reply options given for most of the questions. Free text entry is required by some questions. For free text entry questions, please write your answers in the corresponding blue text box on the PC screen, and confirm your entry by clicking the enter button. Your text will then appear above the blue text box.

You get told your feedback from Part I after you have filled in the questionnaire. After that, payment of your total earnings in the experiment takes place.

If there are any questions, please raise your hand now. We will come to you and answer your questions privately.

Experimental instructions (originally in German) TAG^{WL}

Only differences to TAG^{LIN} reported.

Part II

The points earned in Part II are converted into euro at the exchange rate of **25 points = 1 euro** (1 point = 4 cent) at the end of the experiment.

At the beginning of Part II, all participants are randomly assigned into groups of four. Nobody will find out with whom he forms a group – not during the experiment and not after the experiment either. Part II consists of **10 identical periods** and you remain matched with the **same persons throughout the entire Part II**.

Each participant is randomly given an **individual name,** which, too, remains the same across all 10 periods, and which allows you to keep track of the behavior of your group members throughout the periods. The names are: Person 1, Person 2, Person 3, and Person 4.

Furthermore, a **member type** is assigned to each group member (A or B). Within each group, there is one group member of type A and three group members of type B. The group members of type A and B differ in their decision possibilities. The type of each group member is publicly announced within the group and remains the same throughout the 10 periods.

The group member of type A is **randomly determined**. The probability of being of type A is 25 % for each group member. The remaining three group members are of type B.

Endowment and alternatives in each period

Each period consists of two stages, a **contribution stage** and a **distribution stage**.

Contribution stage

Each participant receives an initial endowment of **20 points** at the beginning of the contribution stage in each period. The 20 points are allocated to two alternatives, a group account, and a private account, depending on the participant's type:

The group member of type A **is obliged** to put all of the 20 points into the group account. Thus, the group member of type A takes no decision during the contribution stage.

[**VCM**: Here, we do not use the sentence that a group member of type A is obliged to contribute 20 points to the group account.]

Group members of type B can **freely** choose how many points to contribute to the group account and how many points to contribute to the private account.

The group account

First, the computer determines the **lowest** contribution. This contribution determines the value of the group account for all group members. The lowest contribution is multiplied by 6.4 and will be distributed in the distribution phase (see below) among the group members.

Formal: Assume that we denote a group member's contribution to the group account with C_i: 6.4 * min{C_i}, whereby "min" denotes the minimum contribution of the four group members.

Example 1: Assume that player 1 chooses 19, player 2 chooses 18, player 3 chooses 15, player 4 chooses 20, then 15 will be determined as lowest contribution. Afterward, 15*6.4 = 96 points will be distributed from the group account among the group members.

Example 2: Assume that player 1 chooses 19, player 2 chooses 10, player 3 chooses 5, player 4 chooses 20, then 5 will be determined as lowest contribution. Afterward, 5*6.4 = 32 points will be distributed from the group account among the group members.

The private account

The contribution of a group member to the private account turns solely and one-to-one into direct earning of the respective individual. For example, if a group member puts 6 points into the private account, he receives exactly 6 points from the private account to his earnings. If the contribution to the private account is 17, the group member earns exactly 17 points from the private account. The other group members do not receive anything in each case.

Distribution stage

During the distribution stage, the group account gets divided among the four group members. The group member of **type A** is in charge of the division**.** He distributes the group account among himself and the other group members. Group members of type B do not have any influence. Values with **at maximum one decimal place** are allowed for the distribution (please use a dot to separate digits).

[**VCM**: The distribution is done **automatically**. Each group member receives 25% of the group account.]

The following table is exemplary and shows several distributions for the case that there are 96 points to be distributed. The first three distribution settings are possible. The fourth one is not possible as there are too few points (29) that are distributed. The fifth setting is not possible, either as there are too many points (120) that are distributed.

	Distribution 1	Distribution 2	Distribution 3	Distribution 4	Distribution 5
Person 1	22.4	0	24	5	45
Person 2	15.6	0	24	8	15
Person 3	33	96	24	2	15
Person 4	25	0	24	14	45
	Possible	Possible	Possible	Too few points	Too many points

Naturally, the actual distribution chosen by the group member of type A can look completely different to the exemplary distributions 1–3. Any combination of numbers that adds up to the sum to be distributed is possible.

[**VCM**: The following table is exemplary and shows the distribution for the case that there are 96 points to be distributed.

	Distribution
Person 1	24
Person 2	24
Person 3	24
Person 4	24

]

Procedure

On the first screen you get told about your individual name (Person 1, Person 2, Person 3, or Person 4) and which Person is of type A. The other group members are automatically of type B. Afterward, all group members of type B get asked about how much of the 20 points they would like to contribute to the group account. The remainder is automatically allocated to the private account. Saving points for later periods is thus not possible. Only integer numbers between 0 and 20 (whereby 0 and 20 are possible choices, too) can be entered. The group member of type A is obliged to contribute 20 points to the group account and, consequently, does not get an input screen.

[**VCM**: Here, we do not use the sentence that a group member of type A is obliged to contribute 20 points to the group account.]

Afterward, all group members get informed about contributions to the group account of all group members and the resulting sum to be distributed.

The group member of type A is then asked how he wants to divide the group account among the group members. The Windows Calculator can be used to help with calculations. It can be found by clicking on the calculator symbol on the screen.

[**VCM**: Thereafter, the group account is divided among the group members.]

At the end of the period, all group members are informed about the contributions to the group account, the minimum contribution to the group account, the resulting allocation from the group account, the contributions to the private account as well as the earnings of all group members in this period. Subsequently, the next period starts.

This part of the experiment is finished after 10 periods. The results from all periods are summed up and converted into euro.

If there are any questions, please raise your hand now. We will come to you and answer your questions privately.

Experimental instructions (originally in German) TAG^{BS}

Only differences to TAG^{LIN} reported.

Part II

The points earned in Part II are converted into euro at the exchange rate of **25 points = 1 euro** (1 point = 4 cent) at the end of the experiment.

At the beginning of Part II, all participants are randomly assigned into groups of four. Nobody will find out with whom he forms a group – not during the experiment and not after the experiment either. Part II consists of **10 identical periods** and you remain matched with the **same persons throughout the entire Part II**.

Each participant is randomly given an **individual name,** which, too, remains the same across all 10 periods, and which allows you to keep track of the behavior of your group members throughout the periods. The names are: Person 1, Person 2, Person 3, and Person 4.

Furthermore, a **member type** is assigned to each group member (A or B). Within each group, there is one group member of type A and three group members of type B. The group members of type A and B differ in their decision possibilities. The type of each group member is publicly announced within the group and remains the same throughout the 10 periods.

The group member of type A is **randomly determined**. The probability of being of type A is 25 % for each group member. The remaining three group members are of type B.

Endowment and alternatives in each period

Each period consists of two stages, a **contribution stage** and a **distribution stage**.

Contribution stage

Each participant receives an initial endowment of **20 points** at the beginning of the contribution stage in each period. The 20 points are allocated to two alternatives, a group account, and a private account, depending on the participant's type:

The group member of type A **is obliged** to put all of the 20 points into the group account. Thus, the group member of type A takes no decision during the contribution stage.

[**VCM**: Here, we do not use the sentence that a group member of type A is obliged to contribute 20 points to the group account.]

Group members of type B can **freely** choose how many points to contribute to the group account and how many points to contribute to the private account.

The group account

First, the computer determines the **highest** contribution. This contribution determines the value of the group account for all group members. The highest contribution is multiplied by 6.4 and will be distributed in the distribution phase (see below) among the group members.

Formal: Assume that we denote the a group member's contribution to the group account with C_i: 6.4 * max{C_i}, whereby "max" denotes the maximum contribution of the four group members.

Example 1: Assume that player 1 chooses 12, player 2 chooses 14, player 3 chooses 15, player 4 chooses 9, then 15 will be determined as highest contribution. Afterward, 15*6.4 = 96 points will be distributed from the group account among the group members.

Example 2: Assume that player 1 chooses 8, player 2 chooses 6, player 3 chooses 11, player 4 chooses 9, then 11 will be determined as highest contribution. Afterward, 11*6.4 = 70.4 points will be distributed from the group account among the group members.

The private account

The contribution of a group member to the private account turns solely and one-to-one into direct earning of the respective individual. For example, if a group member puts 6 points into the private account, he receives exactly 6 points from the private account to his earnings. If the contribution to the private account is 17, the group member earns exactly 17 points from the private account. The other group members do not receive anything in each case.

Distribution stage

During the distribution stage, the group account gets divided among the four group members. The group member of **type A** is in charge of the division**.** He distributes the group account among himself and the other group members. Group members of type B do not have any influence. Values with **at maximum one decimal place** are allowed for the distribution (please use a dot to separate digits).

[**VCM**: The distribution is done **automatically**. Each group member receives 25% of the group account.]

The following table is exemplary and shows several distributions for the case that there are 96 points to be distributed. The first three distribution settings are possible. The fourth one is not possible as there are too few points (29) that are distributed. The fifth setting is not possible, either as there are too many points (120) that are distributed.

	Distribution 1	**Distribution 2**	**Distribution 3**	**Distribution 4**	**Distribution 5**
Person 1	22.4	0	24	5	45
Person 2	15.6	0	24	8	15
Person 3	33	96	24	2	15
Person 4	25	0	24	14	45
	Possible	Possible	Possible	Too few points	Too many points

Naturally, the actual distribution chosen by the group member of type A can look completely different to the exemplary distributions 1–3. Any combination of numbers that adds up to the sum to be distributed is possible.

[**VCM**: The following table is exemplary and shows the distribution for the case that there are 96 points to be distributed.

	Distribution
Person 1	24
Person 2	24
Person 3	24
Person 4	24

]

Procedure

On the first screen you get told about your individual name (Person 1, Person 2, Person 3, or Person 4) and which Person is of type A. The other group members are automatically of type B. Afterwards, all group members of type B get asked about how much of the 20 points they would like to contribute to the group account. The remainder is automatically allocated to the private account. Saving points for later periods is thus not possible. Only integer numbers between 0 and 20 (whereby 0 and 20 are possible choices, too) can be entered. The group member of type A is obliged to contribute 20 points to the group account and, consequently, does not get an input screen.

[**VCM**: Here, we do not use the sentence that a group member of type A is obliged to contribute 20 points to the group account.]

Afterward, all group members get informed about contributions to the group account of all group members and the resulting sum to be distributed.

The group member of type A is then asked how he wants to divide the group account among the group members. The Windows Calculator can be used to help with calculations. It can be found by clicking on the calculator symbol on the screen.

[**VCM**: Thereafter, the group account is divided among the group members.]

At the end of the period, all group members are informed about the contributions to the group account, the maximum contribution to the group account, the resulting allocation from the group account, the contributions to the private account as well as the earnings of all group members in this period. Subsequently, the next period starts.

This part of the experiment is finished after 10 periods. The results from all periods are summed up and converted into euro.

If there are any questions, please raise your hand now. We will come to you and answer your questions privately.

Appendix D: Social value orientation questionnaire (ring test) – mostly taken from Sutter et al. (2010)

The social value orientation questionnaire consists of 24 different allocation tasks. In each task, a subject chooses among two payoff allocations, called options A and B (see Table D.1). Each option allocates money, in experimental currency units, to the subject herself (*own payoff* x) and an anonymous recipient (*other's payoff* y). The recipient stays the same in all 24 tasks and answers herself the same set of questions (thereby, vice versa, influencing the first person's payoff). It is common knowledge that both persons receive the same set of tasks. No feedback about the other person's decisions is given during the task to avoid any strategic considerations.

All used payoff allocations lie, equally distributed, on a circle with radius $r = 15$ that is centered at the origin of an x- y-coordinate system, i.e., $r^2 = 15^2 = x^2 + y^2$ holds. Hence, it is possible to represent allocations by vectors in a Cartesian plane. Tasks are designed such that subjects always decide between two adjacent payoff allocations. By assuming that subjects have a preferred motivational vector $\vec{M}$ somewhere in the Cartesian plane, it is optimal for them to always choose the allocation that is closer to $\vec{M}$.

	Option A		Option B	
Question number	your payoff (x)	other's payoff (y)	your payoff (x)	other's payoff (y)
1	15	0	14.5	-3.9
2	13	7.5	14.5	3.9
3	7.5	-13	3.9	-14.5
4	-13	-7.5	-14.5	-3.9
5	-7.5	13	-3.9	14.5
6	-10.6	-10.6	-13	-7.5
7	3.9	14.5	7.5	13
8	-14.5	-3.9	-15	0
9	10.6	10.6	13	7.5
10	14.5	-3.9	13	-7.5
11	3.9	-14.5	0	-15
12	14.5	3.9	15	0
13	7.5	13	10.6	10.6
14	-14.5	3.9	-13	7.5
15	0	-15	-3.9	-14.5
16	-10.6	10.6	-7.5	13
17	-3.9	-14.5	-7.5	-13
18	13	-7.5	10.6	-10.6
19	0	15	3.9	14.5
20	-15	0	-14.5	3.9
21	-7.5	-13	-10.6	-10.6

22	-13	7.5	-10.6	10.6
23	-3.9	14.5	0	15
24	10.6	-10.6	7.5	-13

Table D.1: The 24 allocation tasks

Adding up subject's x and y separately across all decisions yields a total sum of money allocated to the subject herself (X) and to the recipient (Y). The point (X, Y) determines the vector $\vec{A}$ used to estimate a subject's social orientation. This is done by computing the angle α between $\vec{A}$ and the x-axis using $\tan\alpha = Y/X$. The size of the angle specifies in which out of eight behavioral types a subject is classified (see Figure B.1). Subjects with an angle α between 337.5° and 22.5° are classified as individualistic, subjects with an angle between 22.5° and 67.5° as cooperative. The other categories are altruism (between 67.5° and 112.5°), martyrdom (between 112.5° and 157.5°), masochism (between 157.5° and 202.5°), sadomasochism (between 202.5° and 247.5°), aggression (between 247.5° and 292.5°), and competition (between 292.5° and 337.5°).

Additionally, the length of vector $\vec{A}$ can be used as a consistency measure. If a subject decides consistently over all 24 allocation tasks, the length will be 30, while perfect random choice will result in a vector of zero length. The greater the length of the vector, the more consistent is a subject's decision. The questionnaire is incentivized monetarily, since the subject's earnings are determined by the sum of her decisions for *your payoff* and the sum of the recipient's decisions for *other's payoff*.

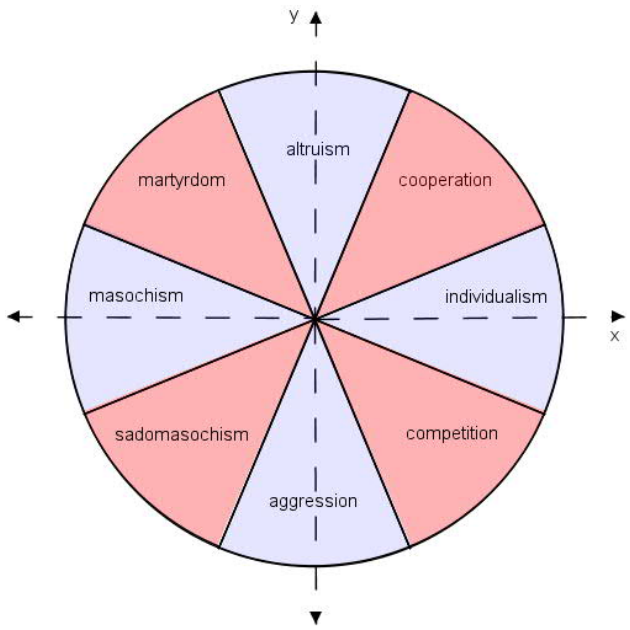

Figure D.1: Classification of behavioral types