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Analysis

Coordinating on good and bad outcomes in threshold games – Evidence from an artefactual field experiment in Cambodia

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ABSTRACT

The tendency to cooperate in social dilemma situations strongly depends on how the decision is framed. Cooperation levels are higher in decisions that involve doing something good to others, rather than avoiding harm. This insight mostly comes from linear public goods games. We conduct a threshold public goods game – framed as a public good or public bad – that requires players to coordinate on a threshold. We find that the level of cooperation and group success in reaching the threshold are higher in a positive than a negative frame. We find the role of beliefs to be salient, as players hold more optimistic beliefs about contributions of others in the negative frame. Generally, contributions exceed the best-response, but are not sufficient to close the gap between the too optimistic beliefs and actual contributions in the negative frame. Hence, contributions and group success are lower in the public bad game.

1. Introduction

Social dilemmas are often sketched as problems of cooperation, where the temptation to free-ride is a looming threat undermining collective action. Yet, most real-world social dilemmas also require coordination, as optimal strategies often depend on what others are doing. For example, when a member of a small-scale community invests in common water infrastructure, relying too much on contributions of others may result in collective failure to provide it. At the same time, investing too much may result in collective overprovision and suboptimal use of resources. For fishing communities, failure to restrain fishing effort may result in wasteful overexploitation and a potential stock collapse, while too little extraction implies foregone revenues, which can be inefficient, too.

The tension between cooperation and coordination can be conceptualized in a threshold public goods game, where all collective contributions below or above a threshold are inefficient (Rocha et al., 2021; Brekke et al., 2017; Brown and Kroll, 2017; Dannenberg et al., 2015; Tavoni et al., 2011; Barrett and Dannenberg, 2014; İriş et al., 2019; Au, 2004). Such threshold games may resemble the coordination towards the provision of a public good or the prevention of a public bad. But are groups better in coordinating towards achieving something good (e.g. water infrastructure) or preventing something bad (e.g. a fish stock collapse)? Ever since the pioneering work of Andreoni (1995), we know that cooperation is more widespread in positively framed public goods games than in negatively framed public bads games (Fujimoto and Park, 2010; Isaksen et al., 2019; Kingsley, 2015; Park, 2000; Abatayo and Li, 2024).[1] However, most of those results come from stylized linear games, where the social optimum (contribute everything to the public good) and Nash equilibrium (contribute nothing) are extreme cases at the lower and higher bound of the strategy space. Indeed, the framing effect does not necessarily carry over to games with non-linear payoffs, where optimal strategies depend on contributions

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[1] There are several ways in which linear public goods have been framed in the literature. First, the above cited papers all follow Andreoni (1995) rather closely, where an individual decides between two investment activities: (i) an individual activity, and a (ii) group activity. In the positive frame, the group activity creates a positive externality, while in the negative frame the private activity creates a negative externality. Second, there is a branch of experiments where the decision is framed as one where an individual (i) takes or (ii) gives tokens to a public account; see for example Khadjavi and Lange (2015), Cox and Stoddard (2015), Sell and Son (1997), Dufwenberg et al. (2011), Messer et al. (2013). Third, there is a class of experiments where the decision is framed as one of (i) maintaining or (ii) providing to the public good (Gächter et al., 2017, 2022). What all these different versions have in common is that the two variants of the game (i.e. the frames) are economically identical in terms of payoffs and consequences, but the decision context is phrased differently.

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of others (Isaksen et al., 2019). Given that framing effects are largely mediated through beliefs of what others do (Fischbacher and Gächter, 2010; Dufwenberg et al., 2011; Fosgaard et al., 2019; Ellingsen et al., 2012), one may hypothesize that such framing effects could be recovered in non-linear games with a clear coordination element, such as the threshold public goods game since thresholds often act as focal points (Cadsby and Maynes, 1999; Bouma et al., 2020; Schill et al., 2015). Yet, it is unclear how framing prevents or enables coordination towards cooperation.

In this paper, we conduct a de-contextualized artefactual field experiment with Cambodian farmers using a threshold public good/bad framing design. We use two treatments, one in which reaching the threshold leads to "gaining a public good" and one in which reaching the threshold leads to "avoiding a public bad". If the threshold is not met, all contributions towards the threshold are lost. Depending on the frame the threshold can act as a target that needs to be reached or one that should not be crossed. While the experimental design resembles daily situations for our population, we refrain from labelling the public good game as a "water infrastructure setting" and the public bad game as a "fisheries setting" to avoid biasing the results by evoking memories of positive or negative experiences in these settings. Since optimal contributions in a threshold game depend on the believed contributions by the other group members, we also elicit beliefs. This allows us to investigate the role of beliefs in achieving success in framed threshold public goods games.

We find that contributions in a threshold public goods game are higher if the game is framed positively. Consequently, the number of groups that were successful in achieving the target is higher in the positive frame. This difference in success is due to two mechanisms that unfold differently in the treatments. First, while the accuracy of beliefs is similar in both treatments, players tend to err on the other side of the spectrum. For the public goods game, players tend to believe that co-players contribute less than they actually do, while the opposite is true for public bad games. Second, players in both treatments contribute more than what would be optimal based on their best-reply. When players are too optimistic (as in the public bad game), this overcontribution is not sufficient to close the gap in beliefs, resulting in failure to reach the target.

We contribute to the literature that investigates how framing of public goods and bads affects cooperation outcomes. By using an artefactual field setting with Cambodian farmers and fishers, we analyse the framing effect in threshold public goods/bads games with a population that is frequently exposed to real-world social dilemmas. We expand the decision space from binary (which so far has been used in framed threshold games) to seven discrete contribution levels. This allows us to capture the elements of cooperation and coordination, including the role of beliefs about other peoples behaviour, that are typical for natural resource management.

2. Literature

Since Andreoni (1995) we know that people act more cooperatively if they are playing a positively framed game compared to a negatively framed one (Khadjavi and Lange, 2015; Fujimoto and Park, 2010; Gächter et al., 2017; Cox and Stoddard, 2015; Kingsley, 2015; Cox, 2015; Isaksen et al., 2019). Yet, these framing effects have been shown in linear games and thus, do not necessarily carry over to strategically more complex nonlinear games. Isaksen et al. (2019) show that framing effects that are observed in linear public goods games, do not carry over to nonlinear public goods games and common pool resource games. Also, Kotani et al. (2008, 2014) do not find a framing effect in their threshold games.

Threshold public goods games – where the provision of a public good depends on reaching a threshold – are well equipped to capture cooperation as well as coordination which are present in many real-world social dilemmas. Most threshold studies use an 'all-or-nothing approach', where the contributions to the public fund are lost if the threshold is not reached (Rocha et al., 2021; Brekke et al., 2017; Brown and Kroll, 2017; Dannenberg et al., 2015; Tavoni et al., 2011; Barrett and Dannenberg, 2014; İriş et al., 2019; Au, 2004).

While the framing effect replicates reliably in linear public goods games, the mechanism causing the effect is somewhat unclear. Different individual preferences, such as value orientation (Park, 2000) or political attitude in combination with cooperative behaviour types (Fosgaard et al., 2019) have been shown to impact framing, while loss aversion does not (Cox, 2015). Contribution levels are often influenced by the beliefs about the partners' contributions (Fischbacher et al., 2001). In linear public goods games it has been shown that beliefs and contributions are positively correlated (Croson, 2007; Fischbacher and Gächter, 2010). The role of beliefs in framed linear public goods games is analysed by Dufwenberg et al. (2011), Cubitt et al. (2011) and Fosgaard et al. (2019). While Cubitt et al. (2011) find only a weak framing effect between two of their four subgroups, Dufwenberg et al. (2011) find that the believed contributions are higher in the public good framing. They find that framing affects beliefs, and beliefs influence cooperation levels and that the framing effect on beliefs is stronger than on contribution levels. Fosgaard et al. (2019) also find that people expect higher contributions from their partners in the public good treatment. Thus, beliefs affect the equilibrium selection (Ellingsen et al., 2012).

It is unclear whether framing effects would also occur in threshold public goods games. The first framed threshold game was carried out by Sonnemans et al. (1998) where cooperation is a binary choice and the game is played for 20 rounds in groups of five. They find that contributions and success is higher in a positive frame, but only after five rounds. This raises the question whether the effect is not just due to dynamics in the game, rather than the frame. They also explore the role of beliefs about the partners' behaviour. Their results are in line with findings of McBride (2010) that people are more likely to cooperate if they believe being pivotal for reaching the threshold, but this behaviour is independent of the treatment. Higher cooperation and success rates for a positive frame is confirmed by Cartwright et al. (2019), while Kotani et al. (2008, 2014) do not find any significant framing effects. In contrast, Iturbe-Ormaetxe et al. (2011) find cooperation to be higher in the negative frame. Therefore, the evidence on framing in threshold public goods game is inconclusive, also because many of the studies used very low sample sizes by today's standards. All of these framed threshold games are laboratory games with a binary choice to contribute or not to contribute, and an all-or-nothing design. The binary setting restricts the choice of the participants considerably which might not be the most realistic outside a lab setting (Cadsby and Maynes, 1999). While threshold games without framing are often continuous (Milinski et al., 2008; Barrett and Dannenberg, 2014; Dannenberg et al., 2015; Tavoni et al., 2011) so far this has not been done in framed experiments. We propose an intermediate step of seven discrete contribution levels which provides a decision space that lets us measure cooperation as well as coordination without causing cognitive overload. By introducing granularity in the decision process we increase the similarity towards decision making in a linear public good game while maintaining the threshold feature. We anticipate that this design increases the likelihood of a framing effect such as that the public good frame elicits higher cooperation than the public bad frame which Andreoni (1995) coined the 'warm glow' effect.

3. Experimental setup

3.1. Study region

We conduct our research in the Kampong Chhnang province in Cambodia. The rural population in Cambodia often lives in small, tight-knit communities that heavily rely on rice farming for their daily income (Nguyen et al., 2015). In addition, fish and non-timber forest products are used as secondary sources of income. In many cases,

Table 1
Relationship between believed contribution, optimal contribution based on beliefs, and success rate.

Believed contributions	Optimal contribution based on beliefs	Deviation from own best-reply function	Errors in beliefs	Threshold reached
$\widetilde{G_i}$,	$g_i^* = T - \widetilde{G_i}$,	$\omega_i = g_i - g_i^*$,	$\zeta_i = \widetilde{G_i} - \sum_{j=1}^{n-1} g_j$,	$\sum_{i=1}^{n} \omega_i \geq \sum_{i=1}^{n} \zeta_i$.

relying on natural resources is a diversification mechanism to cope with economic and climate shocks (Nguyen et al., 2020).

Rice farming requires access to sufficient water for irrigation. Rehabilitating and maintaining the irrigation system and making arrangements how to share water is mainly the responsibility of the local communities and is built to a large extent on informal rules embedded in some local formal institutions (Chou, 2010; Perera, 2006; Nhim et al., 2023). In practice, local rules are made by Farmer Water User Communities (FWUCs) to govern irrigation water. This institution is formally recognized and is designed to enhance collective action in water sharing and irrigation infrastructure maintenance. Data across Cambodia, however, document a mixed picture of its success. Typically, the main challenge is to collect sufficient irrigation service fees to finance its operation and to maintain the infrastructure (Sithirith, 2017; Diepart, 2015). The organization and its farmer members thus have to deal with the social dilemma of ensuring that enough funds are available to ensure maintenance and functioning of irrigation infrastructure. Similarly, rules regarding fishing are also the responsibility of the communities. Akin to water management, formal community-lead 'Community Fishery' institutions are responsible for monitoring the fishing activities and ensuring fair access to the resource (Sreyphea Chap Panha Touch, 2016; Kurien, 2017).

The irrigation infrastructure is a public good which needs to be maintained regularly to ensure functioning. Excluding people from using the infrastructure is difficult, if not impossible, regardless of whether the person contributes to the public good or not. Hence, the irrigation system has the characteristics of a threshold public good, as it requires a critical contribution level for the system to function well and provide sufficient water for everyone. While contribution to infrastructure resembles a public good (achieving the maintenance threshold to ensure functioning of irrigation), extracting water or fishing impose negative externalities on others. Fishers have to refrain from overfishing to ensure that the fish stock does not collapse. In the context of the study region, fishers and their community organization are commonly involved in a collective effort to prevent people from illegal practices, such as fishing in protected areas, fishing during the spawning season, or fishing endangered species (Sreyphea Chap Panha Touch, 2016). The fishers have to contribute cash or labour for monitoring illegal fishing, which can be considered a public good. The overexploitation of a fish stock in general, and illegal fishing in particular, may result in a sudden collapse of the stock. Therefore, preventing fish stocks to pass critical thresholds is of key importance. Hence, the rural population in Cambodia and in this study region is used to handling the uncertainties around water and fishery resources in general, and dealing with non-linear dynamics of the resources within a close community on a day-to-day basis.

3.2. Threshold public goods game

We conduct a threshold public good / bad game with n players and discrete contribution levels. The individual payoff π_i is determined by

$$\pi_i = \begin{cases} (E - g_i) + B & \text{if } G \geq T \\ (E - g_i) & \text{if } G < T \end{cases}$$

where E is the individual endowment for each player, g_i the individual contribution to the public fund, and the collective contribution is defined as $G = \sum_{j=1}^{n} g_j$. B is a lump sum bonus every player gets if the threshold T is reached. In our game, we set $B = E$ and $T = \frac{1}{2}nE$.

The game has two symmetric Nash equilibria: the pure uncooperative strategy (contributions to the public fund being 0) and the symmetric cooperative strategy in which everyone contributes the same to the public fund to exactly match the threshold. The symmetric uncooperative Nash equilibrium is a risk-dominant and the symmetric cooperative Nash equilibrium is a payoff-dominant equilibrium. In this game collective underprovision (and failing to get the bonus) and overprovision (providing more than necessary to get the bonus) are both inefficient. Therefore, the social optimum is reached when the sum of individual contributions to the public good is equal to the threshold which can be either the symmetric Nash equilibrium where everyone contributes equally or asymmetric Nash equilibria. This implies that the threshold game has several social optima. An obvious focal point is the symmetric social optimum which is reached if each group member contributes half of the endowment to the public fund. This optimum is intuitively appealing since it ensures an equal distribution of costs and benefits across group members. Therefore, we refer to this optimum also as the fair social optimum (FSO). We expect the fair social optimum to be a focal point which players can try to coordinate on.

To play the game optimally, individuals need to form beliefs about contributions by the other group members when deciding how much to contribute to the public fund. The best response of individuals is a piecewise function that consists of three regimes. First, if contribution by co-players is so low that the threshold is not reachable, it is optimal to invest zero into the public fund. Second, if the contributions of the co-players is so high that the threshold is already reached, it is also optimal to contribute zero. Third, if the co-players contributions alone are not sufficient to reach the threshold, but the threshold is reachable, it is optimal to contribute so much that the threshold is met. Players i forms beliefs ($\widetilde{G_i}$) about the joint contribution of co-players to the public fund, which is given by $\widetilde{G_i} = \sum_{j=1}^{n-1} \widetilde{g_{ji}}$, where $\widetilde{g_{ji}}$ is the belief of player i about the contribution of group member j that sums over all $j = 1, \ldots, N-1$ for whom $j \neq i$. Formally, the optimal individual contribution is

$$g_i^* = \begin{cases} 0 & \text{if } T - \widetilde{G_i} > E \\ T - \widetilde{G_i} & \text{if } 0 < T - \widetilde{G_i} \leq E \\ 0 & \text{if } T - \widetilde{G_i} \leq 0; \end{cases}$$

see Fig. 1 for a visual presentation for our parametrization.

Whether a threshold is met depends on two factors. First, whether individuals are gauging the actions of their co-players correctly and have accurate beliefs (i.e. $\zeta_i = \widetilde{G_i} - \sum_{j=1}^{n-1} g_j$). Second, whether individuals act in line with their beliefs and contribute in accordance with their-best reply function (i.e. $\omega_i = g_i - g_i^*$). Taken together, a threshold is met if $\sum_{i=1}^{n} \omega_i \geq \sum_{i=1}^{n} \zeta_i$ (see Table 1).

3.3. Parametrization

We set the group size to three to reduce cognitive load, while preserving the features of a threshold public goods game. Each subject receives six bills of 1000 Cambodian Riel (KHR), i.e. 6000 KHR, as an endowment (1000 KHR are equivalent to 25 cents USD). The task is to distribute these 6000 KHR, in discrete steps of 1000 KHR, between a private fund and a public fund. To obtain the bonus, the threshold has to be reached, i.e. a collective contribution of at least 9000 KHR is needed. If the threshold is reached, each group member receives 6000 KHR. Otherwise, no bonus payment is made and all contributions

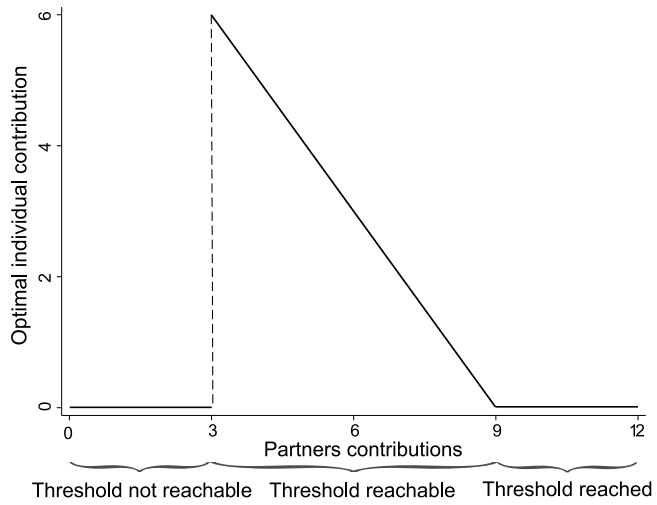

Fig. 1. Optimal contribution strategy depending on the partners' contributions.

towards the public fund are lost. The fair social optimum is reached if every group member contributes 3000 KHR to the public fund. Since the optimal contribution strategy depends on the contributions of the partners, the range of optimal individual contributions ranges from zero to 6000 KHR (see Fig. 1). If the partners contribute jointly less than three bills (threshold not reachable) the optimal contribution strategy is to not contribute anything. If the partners contribute combined nine bills or more (threshold reached) the optimal strategy is also to not contribute anything. Thus, it is only socially optimal to contribute a positive amount if one believes that the partners invest between three and eight bills in the group account and otherwise contribute zero.

3.4. Implementing the framing experiment

We run an artefactual field experiment with Cambodian farmers and fishers. Our subjects are largely illiterate, so we use a setup with banknotes and envelopes. Since the optimal strategy depends on the contribution of the other two players, we also conduct a belief elicitation task where we ask individuals to guess the level of the joint contributions of the two other group members. If the amount is guessed correctly, individuals receive a 1000 KHR bonus. We use a between-subject design to test the public good/bad framing effect. We run one session per village and randomize between treatments. Each session consists of one public good and one public bad treatment.

We provide each participant with six bills of 1000 KHR and two envelopes, one white and one green. We ask each participant to divide these six bills into these two envelopes, white being the private fund and green the public fund. We have two framing treatments. The first setting is 'achieving a public good' and the second is 'avoiding a public bad'. The frames are economically equivalent, but the wording is different. In the public good setting the instructions state that the group fund yields either 6000 KHR or zero KHR, depending how much the three group members combined put into the green envelope. If the joint amount in the green envelopes is 9000 KHR or more, each group member gets 6000 KHR from the group fund. If less than 9000 KHR are in the green envelopes, each group member gets zero KHR from the group fund.[2] In this frame, the participants are cooperating to achieve a threshold which, once reached, will provide a public good to everyone. Cooperation in this treatment corresponds to contributing sufficient amounts to the public fund. In the public bad setting the instructions are changed to state that the group fund yields either 6000 or zero KHR, depending how much the three group members put into the white envelopes. If at most 9000 KHR are in the white envelopes, each group member gets 6000 KHR from the group fund. If the joint amount in the white envelopes is more than 9000 KHR, each group member gets zero from the group fund.[3] In this frame, the participants are cooperating to avoid reaching a threshold, which, once reached, will lead to a public bad affecting everyone. Cooperation in this treatment corresponds to retaining amounts for oneself without triggering the threshold. Further, by making the participants distribute all of the six bills between the two envelopes we ensure that, independent of the framing, the task is always the same between the treatments. Thus, contributions to the public fund as well as keeping the money for oneself is always an active choice. The active distribution of money between the two envelopes ensures that the effect is not driven by loss aversion or an endowment effect.

The belief elicitation is framed just as the threshold game. While the subjects in the public good treatment are asked to indicate how much they think the other two group members will contribute jointly to the public fund,[4] the subjects in the public bad framing are asked to indicate how many bills they think the partners in the group will keep in the private fund.[5] The beliefs are elicited just before the contributions were made which has been shown to provide the highest consistency between the participants beliefs and their actions (Costa-Gomes and Weizsäcker, 2008).

3.5. Experimental procedure

We conducted the experiments in three communes in the Kampong Chhnang province in Cambodia. In Toul Khpos and Kouk Banteay we visited all villages within the commune. In Taing Krasaing, the biggest of the three communes, we randomly selected half of the villages. In total we visited 21 villages, seven in Toul Khpos, six in Taing Krasaing, and eight in Kouk Banteay. Given the cultural setting in Cambodia, the participants were recruited via the commune and village chiefs. We asked them to pick participants from all social spheres within the village. We also required that the participants were at least 18 years old and that they should be able to sit on the floor for around three hours. We restricted the participants to one per household. Our preferred participants were household heads or the spouses of the household heads. Our sample population is not representative of the Cambodian

[2] The actual wording for the public good framing is "The money you want to contribute to the group fund, you put in the green envelope. The amount of money you get from the group fund can change, depending on how much you and the other two group members put into the green envelopes. Each group member either gets zero Riel or 6000 Riels from the group fund. If 9000 Riels or more are in the green envelopes, each group member will get 6000 Riel from the group fund. If less than 9000 Riels are in the green envelopes, each group member will get zero Riel from the group fund".

[3] The actual wording for the public bad framing is "The money you want to contribute to the group fund, you put in the green envelope. The amount of money you get from the group fund can change, depending on how much you and the other two group members put into the white envelopes. Each group member either gets zero Riel or 6000 Riels from the group fund. If 9000 Riels or less are in the white envelopes, each group member will get 6000 Riel from the group fund. If more than 9000 Riels are in the white envelopes, each group member will get zero Riel from the group fund".

[4] The exact wording for the belief elicitation in the public good framing is "We would like to know what you think how much your partners will put in the green envelope. Therefore, we included a paper slip in the green envelope [show the paper slip]. This paper shows you the thirteen options of how much your other two group members could jointly put into the green envelopes".

[5] The exact wording for the belief elicitation in the public bad framing is "We would like to know what you think how much your partners will put in the white envelope. Therefore, we included a paper slip in the white envelope [show the paper slip]. This paper shows you the thirteen options of how much your other two group members could jointly put into the white envelopes".

population. Rather, the selection of the population ensured that the participants show no systematic deviations in their cooperative behaviour based on family ties or other social affiliations.

We play one-shot games to avoid confounding the framing effect with intra-group dynamics such as retaliation. To ensure that participants understand the task we follow Rustagi et al. (2010), who have a similar subject pool, in the way of providing instructions. We use control questions[6] as well as a lot of interactive examples to make sure that everyone understands the design. Further, we encourage questions in front of the whole group to make sure that everyone, including those who are reluctant to ask questions, receives the same information. Based on the comments in the debriefing we are confident that the combination of publicly asked questions and private control questions ensured that participants understood the task and understood that this task was an abstraction of their daily life experiences. Given the shown relevance of individual characteristics on framing effects (see Park, 2000; Kotani et al., 2008, 2014) we elicited preferences regarding risk and cooperation.

We conduct a risk elicitation task following Gneezy and Potters (1997) and play a linear[7] and conditional public goods game with strategy elicitation to classify cooperative types according to Fallucchi et al. (2019); see for details on study design. We always start with eliciting risk preferences, followed by the linear and conditional public goods game before we play the threshold game. We announce at the start of the session that only one of the games will be paid out to the participants. This will be decided randomly at the end of the session. We play all the games without giving feedback about performance and behaviour of partners in any of the games. The participants only learn at the end of the session how much they earned from the game which was chosen to be paid out.

We elicit individual characteristics to be able to control for them when analysing the robustness of the public good/bad treatment effect. Therefore, the experiment is followed by a survey (see appendix for instructions and survey). Each session lasts 3 h including breaks. To account for the time investment we pay each participant a show-up fee of 4000 KHR and another 6000 KHR if they stay till the end of the session. The average payout is around 17000 KHR. This is equivalent to $4.25 which is a sufficient incentive given that the average daily wage of rural Cambodia is 7.8$ per day. All experiments, research ideas, and the survey were assessed by the Social Sciences Ethic Committee of Wageningen University and registered as a pre-analysis plan (see Richter et al. (2020)).

3.6. Research questions and expected results

Previous research on framing in linear public goods games have suggested positive framing to have a positive impact on contributions that does not seem to easily carry over to more complex games with strategic interactions and the question whether positive framing leads to higher cooperation in binary threshold games remains inconclusive. Given the binary decision making (cooperate; do not cooperate) in previous threshold games our setup allows a more nuanced investigation of cooperation. Thus, our first research question investigates whether framing has an impact on contributions in a non-binary threshold game.

Given the strategic uncertainty present in threshold games, an obvious question is how framing affects beliefs about contribution levels in threshold games. Our second research question is whether framing has an impact on beliefs in a threshold game.

Finally, our third research question is whether framing has an impact on collective success in a threshold game. On the one hand, if we observe higher contributions in the positive frame, this may translate in higher collective success. On the other hand, if the threshold acts as a coordination device towards the social optimum, this may override the effect of any framing effect. Here, it will be particularly informative how contribution schemes conditional on beliefs look like.

4. Results

In total we had 303 participants in the experiments of which two did not provide us with valid belief elicitations. For 276 out of the 301 we have complete information (survey and all experiments). Out of the 276 participants, 63 people got at least one control question wrong. We tested whether they differed between treatment groups, which is not the case (table A.1). Given the importance of the interactive examples in comparison to the control questions, we use the full sample for our analysis but report robustness checks in the appendix where appropriate. We asked participants what their main occupation is which indicated that most people consider themselves to be farmers. We also asked whether their household undertook any fishing activity in the previous year. If people answered affirmatively, we consider them to have fishing experience which we will refer to as fishers. Whilst there are socio-economic differences between the participants, they are a very homogeneous group compared to Cambodian society.

We run two-sample t-tests to test that no systematic differences exist between the randomly assigned treatment groups (see table A.1). The tests confirm that the treatment populations do not show systematic differences for our key variables. We analyse first the contribution to the public fund. We are interested whether we see differences in the contribution levels depending on the public good/bad framing treatment. Further, we test whether the framing effect depends on socio-demographics or social preferences followed by an analysis of the believed contribution by the partners to the public fund. The last part of the analysis will focus on the relationship between believed contributions of the partners and the actual contribution level.

4.1. Contribution to the public fund

4.1.1. Treatment effect

To facilitate the analysis, we convert all variables into ‘contribution to the public fund’. This variable runs in discrete steps from zero to six. The average contribution to the public fund is 3.16 (SD 1.2). The most common contribution level is three (the fair social optimum) with 48.19%, followed by four with 22.1% and two with 13.04%. The average contribution in the public good treatment is 3.41 (SD 1.28) and 2.91 (SD 1.07) in the public bad treatment (see Table 4). A Fishers test shows that this difference in means is significant (Pearson χ^2 = 40.4107, p = 0.000). We also run a Mann–Whitney–Wilcoxon rank-sum test which confirms the difference between treatments for contribution levels (z = 4.225, p = 0.0000) and indicates that the contributions are higher in the public good framing (probability of higher contributions in the public good treatment than in the public bad treatment is 63.8%). The Kolmogorov–Smirnov test confirms that the distribution of contribution levels differs across treatments (contribution D = 0.2319, p = 0.001) (see Fig. 2).

We find a clear public good/bad framing treatment effect on contribution levels. We see distinctly higher contributions to the public good than to the public bad. Yet, it is not clear what drives this framing effect. Based on the literature we expect that believed contributions by the partners play a significant role. We also anticipate that socio-demographic factors, as well as daily life experiences dealing with different collective action problems could influence the reaction to the framing. So as a next step we will analyse what impacts contribution levels other than framing.

[6] Given the cultural setting it would have been ill conceived if we had asked participants to leave if they got a control question wrong. We had taken the decision upfront to let people participate in the game, independent of the control questions and to control for these people in the analysis.

[7] The results of the linear public good game are used in to analyse differences in contribution strategies for linear and threshold public good games.

Table 2
Public good/bad framing treatment effect on contribution level.

Dep. Var.: Contribution to public fund	(1)	(2)	(3)	(4)	(5)
Public Bad	−0.498***	−0.401***	−0.393***	−0.368**	−0.477***
	(0.143)	(0.142)	(0.143)	(0.146)	(0.144)
Constant	3.502***	3.473***	3.071***	2.951***	2.761***
	(0.310)	(0.567)	(0.689)	(0.701)	(0.559)
Risk aversion	√	√	√	√	√
Cooperative behaviour type				√	√
Socio-demographics			√	√	√
Fixed Commune Effects	√				√
Fixed Village Effects		√	√	√	
Observations	276	276	276	276	276
R^2	0.043	0.188	0.204	0.229	0.114
Adjusted R^2	0.029	0.117	0.117	0.131	0.070

Clustered standard errors in parentheses, robust. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Estimates of all coefficients of control variables provided in Table A.4.

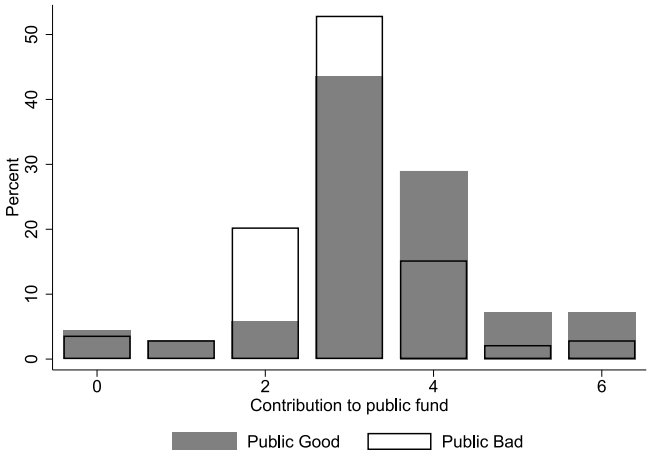

Fig. 2. Contributions to the public fund by treatment.

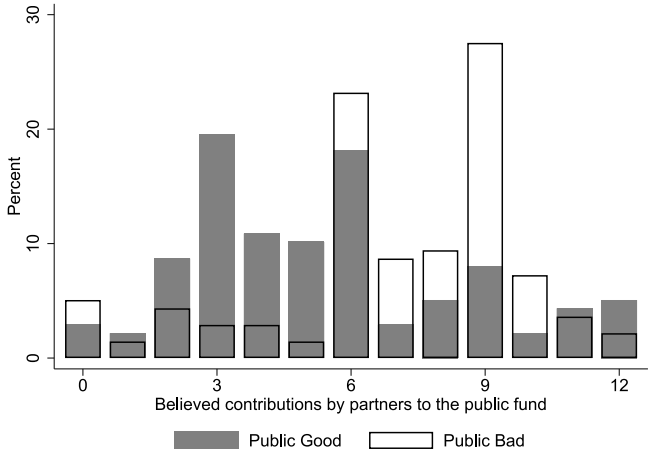

Fig. 3. Belief about the partners joint contributions to the public fund by treatment.

4.1.2. Robustness of treatment effect on contribution levels

We test whether the public good/bad framing treatment effect is influenced by factors such as risk aversion or cooperative behaviour types. We estimate the following OLS model

$$y_i = \alpha + \beta_1 D_i + \boldsymbol{\beta_2} \boldsymbol{X_i} + \epsilon_i, \quad (1)$$

where y_i denotes the contribution to the public fund, D_i captures the treatment effect, $\boldsymbol{X_i}$ encompasses our control variables, and ϵ_i is the error term. We control for commune or village fixed effects, cooperative behaviour type, risk aversion, and socio-demographics (age, education, gender, fishing experience, and number of household members). We include socio-demographics to ensure that the effect is not based on a subpopulation such as people with fishing experience. We use robust standard errors clustered at the village level. We see that the treatment effect is robust and not influenced by social preferences or socio-demographics (Table 2, for robustness checks regarding the control questions see A.2). To ensure that the treatment effect is not driven by the linear public goods game played before, we run the model also whilst controlling for contributions in linear public goods game. We find that the contributions to the public fund in the linear public goods game have an effect on the contributions to the public fund in the threshold game, which is to be expected, the treatment effect persists (table A.3).

4.2. Believed contribution by partners

In regard to believed joint contribution of the two partners we are focusing on two aspects: (i) whether or not we also observe a framing effect in beliefs, and (ii) what determines the believed contribution level?

4.2.1. Treatment effect

The believed total contributions by the other partners range from zero to twelve in discrete steps. As in the case of contributions we convert the variable into believed contribution to the public fund by partners to facilitate the analysis. The believed average contribution to the public fund in the public good treatment is 5.44 (SD 3.04) while the believed average contribution to the public fund in the public bad treatment is 6.99 (SD 2.85) (see Table 4). The difference between the mean beliefs is statistically significant (Pearson $\chi^2 = 27.3149$, p = 0.000). On average, we see that in the public good treatment people believe that the partners contribute less than the fair social optimum to the public fund while in the public bad treatment the subjects believe that the partners contribute more than the fair social optimum. The distribution of the elicited beliefs differs between treatments (Kolmogorov–Smirnov test: D = 0.3623, p = 0.000).

In Fig. 3 we see that the fair social optimum is a focal point in both treatments (in the public bad treatment slightly above 23% and in public good treatment around 18%). Yet, while in the public good treatment the most often chosen option is a joint contribution of three, the option we observe most in the public bad treatment is nine. Overall, we see that the majority of believed contributions in the public bad treatment is six or higher while in the public good treatment the majority of the believed contributions is six or lower. This treatment

Table 3
Treatment effect on believed contributions.

Dep. Var.: Believed Contributions by partners to public fund	(1)	(2)	(3)	(4)	(5)
Public Bad	1.488***	1.421***	1.412***	1.374***	1.474***
	(0.357)	(0.347)	(0.349)	(0.357)	(0.363)
Constant	6.756***	7.318***	6.265***	6.490***	6.720***
	(0.649)	(1.223)	(1.398)	(1.402)	(1.207)
Risk aversion	√	√	√	√	√
Cooperative behaviour type				√	√
Socio-demographics			√	√	√
Fixed Commune Effects	√				√
Fixed Village Effects		√	√	√	
Observations	276	276	276	276	276
R^2	0.083	0.205	0.213	0.220	0.104
Adjusted R^2	0.069	0.136	0.127	0.121	0.060

Clustered standard errors in parentheses, robust. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Estimates for all coefficients of control variables provided in Table A.6.

effect is confirmed by the Kruskal–Wallis test ($\chi^2 = 23.120$, p = 0.0001) and Mann–Whitney–Wilcoxon rank-sum test (z = −4.851, p = 0.0000).

4.2.2. Robustness of treatment effect on believed contributions

As in the case of the contribution level we are interested whether the framing effect persists when we control for social preferences and socio-demographics. We use the same covariates in our OLS as in Eq. (1) to explain what determines the believed contributions (see Table 3, for robustness checks regarding the control questions see A.2)). We do see a clear framing effect of higher believed contributions in the public bad treatment than in the public good treatment whilst controlling for several covariates such as risk aversions, socio-demographics, cooperative behaviour type, and commune or village fixed effect.

4.3. Relationship between believed contribution and contribution levels

So far, we analysed contributions and expected contributions separately (see fig. A.1 for an overview of contributions by believed contributions of the partners per treatment). For both we see clear framing effects: while individuals believe others to contribute more in the public bad treatment, they themselves tend to contribute less in the public bad treatment. In practice, individuals make their contributions conditional on beliefs. The relationship between contributions and believed contributions is expected to be non-linear, and therefore we test whether a linear, quadratic, or any other polynomial relationship explains the data best. We can clearly reject a linear relationship between contributions and believed contributions (p-value = 0.652) but we cannot reject that there is a quadratic relationship (p-value = 0.027). We expand Eq. (1) and include squared beliefs $\widetilde{G_i}^2$ and estimate the interaction effect with the framing treatment to explain contribution levels,

$$y_i = \alpha + \beta_1 D_i + \beta_2 D_i \times \widetilde{G_i} + \beta_3 D_i \times \widetilde{G_i}^2 + \boldsymbol{\beta_4 X_i} + \epsilon_i. \quad (2)$$

We use commune fixed effects and robust standard errors clustered at the village level. The quadratic marginal effects show that the relationship between contributions and beliefs follows an inverted-U shape, with a turning point around the symmetric social optimum six (see Fig. 4).

In Fig. 4 we show that, conditional on beliefs, we have a clear framing effect in contributions. While both framings follow a similar contribution pattern, the contributions for each of the belief levels are higher in the public good framing. Therefore, for a given belief level a public good frame leads to higher contribution levels.

4.3.1. Determinants of success rate in reaching the threshold

Apart from differences in contribution levels and beliefs by treatment, we also find differences in success rates. While 79.71% of the participants in the public good treatment are in a group that manages to reach the threshold, only 57.25% of the participants in the public bad treatment reach the threshold (Table 4).

Whether or not a group reaches the threshold depends fundamentally on two factors. First, whether individuals make contributions that – given their beliefs – ensure reaching the threshold. Second, whether individuals hold correct beliefs in the first place. In practice, people are not able to consistently guess the partners contributions correctly. The error of guessing the others' contributions incorrectly can be costly since it may lead to either failure to reach the threshold or overprovision, which is inefficient. Overprovision could be driven by risk or ambiguity averse people but when testing for the effect of risk aversion on contribution levels we do not find any significant impact table A.4.

Comparing treatments we find that in the public good treatment, on average players contribute 0.63 bills more than the best-reply, while this is 1.57 in the public bad treatment (Kolmogorov–Smirnov test, D= 0.2242, p = 0.002).

We also assess the accuracy of beliefs as 'the errors in beliefs', i.e. the deviation of beliefs from true actions, and find its size to be the same in the two treatments (Kolmogorov–Smirnov test, D = 0.1449, p = 0.110) but the direction of the error differs (Table 4). Fig. 5 shows that contributions of partners in the public bad are often overestimated while they are underestimated in the public good (Kolmogorov–Smirnov test, D = 0.3768, p = 0.000). On average, in the public good treatment, co-players contribute 1.38 bills more than believed, while in the public bad treatment co-players contribute 1.08 bills less (Table 4).

We observe distinct differences between the treatments when analysing the groups reaching the threshold. Looking at the groups which reached the threshold, we find that the average contribution is higher in the public good treatment and the believed contributions are higher in the public bad treatment. Comparing the relative importance of ω (the deviation from own best-reply function) and ζ (the errors in beliefs), we find some interesting differences between treatments (Table 5). First, in successful groups, players tend to contribute more than what would be the best response compared to unsuccessful groups (0.85 vs −0.21 for public good and 2.14 vs 0.81 for public bad). Second, when it comes to errors in beliefs, we find that successful groups are more pessimistic than unsuccessful groups and expect lower contributions (−2.06 vs 1.32 for public good and 0.7 vs 1.59 in public bad). While it was expected that those two mechanisms can be linked to group success, we find that the relative importance of those two mechanisms differ between treatments. In public bad games, an average successful groups contributed more than 2 bills above the best reply,

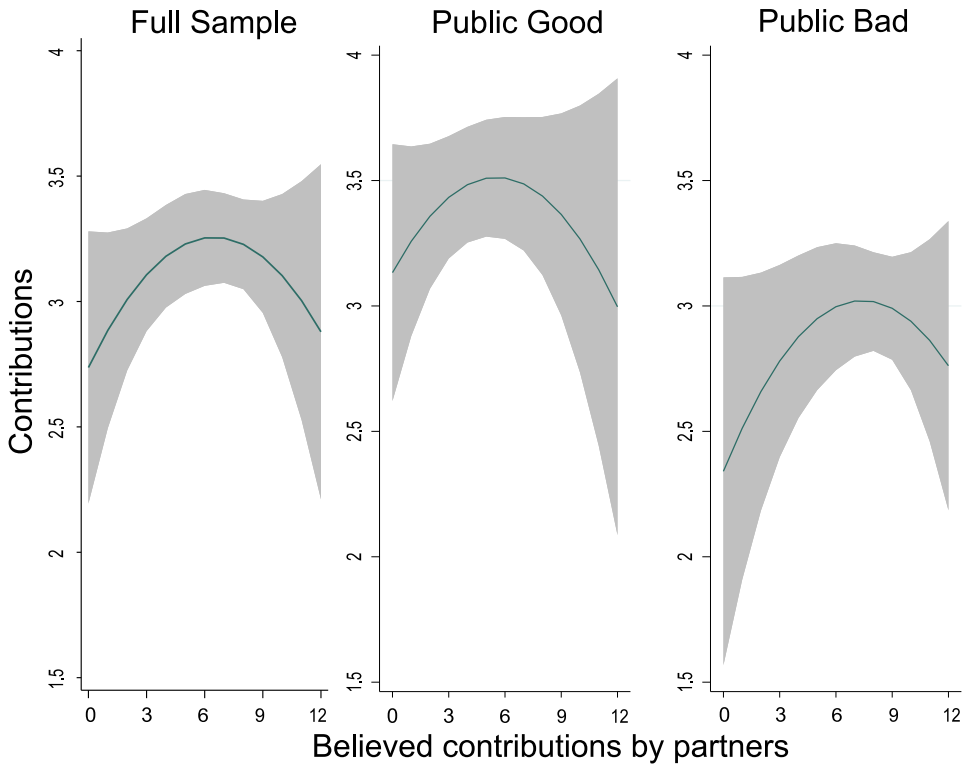

Fig. 4. Quadratic marginal effects by treatment, estimated with interaction effect between treatment and beliefs. Estimates for all coefficients are provided in table A.7.

Table 4
Average contribution, average believed contribution, average deviation from best-reply function, average errors in beliefs, and threshold reached per treatment. Standard deviations are reported in brackets.

Treatment	Contribution	Believed contribution $\widetilde{G_i}$	Deviation from own best-reply function ω_i	Errors in beliefs ζ_i	Threshold reached $\sum_{i=1}^{n}\omega_i \geq \sum_{i=1}^{n}\zeta_i$
Public Good	3.41	5.44	0.63	−1.38	79.71%
N=138	(1.28)	(3.04)	(2.59)	(3.54)	
Public Bad	2.91	6.99	1.57	1.08	57.25%
N=138	(1.07)	(2.85)	(1.93)	(3.04)	

Table 5
The role of different mechanisms linking contributions and beliefs in achieving the threshold separated by framing.

	Threshold reached $\omega \geq \zeta$			Threshold not reached $\omega < \zeta$		
	PG (1)	PB (2)	Fishers test	PG (3)	PB (4)	Fishers test
Mean contribution (g_i)	3.72	3.39	0.005	2.18	2.27	0.363
	(1.07)	(0.85)		(1.33)	(0.1)	
Mean believed contributions ($\sum g_{-i}^{b}$)	5.35	7.53	0.000	5.82	6.27	0.274
	(3.02)	(2.56)		(3.15)	(3.1)	
Mean optimal contribution based on beliefs (g_i^{*b})	2.87	1.25	0.000	2.4	1.46	0.289
	(2.36)	(1.63)		(2.3)	(1.07)	
Deviation from own best-reply function (ω)	0.85	2.14	0.018	−0.21	0.81	0.392
	(2.56)	(1.78)		(2.57)	1.87	
Errors in beliefs (ζ)	−2.06	0.7	0.000	1.32	1.59	0.850
	(3.29)	(2.8)		(3.3)	(3.34)	
N	110	79		28	59	
Percentage	39.86%	28.62%		10.14%	21.38%	

We report the continuity corrected fishers' exact tests. Standard deviation in parenthesis.

while this was only 0.85 bills in successful public good groups. In public goods games, successful groups underestimated contributions by their co-players by 2 bills, while successful public bad groups expected co-players to contribute 0.7 bills more. Hence, in public good games players were more pessimistic about contributions of others, which ensured that their own contributions were sufficient to reach the threshold (for visualization refer to fig. A.2).

5. Discussion

Natural resource use often poses social dilemmas that are frequently studied in linear settings such as a linear public goods games (Rustagi

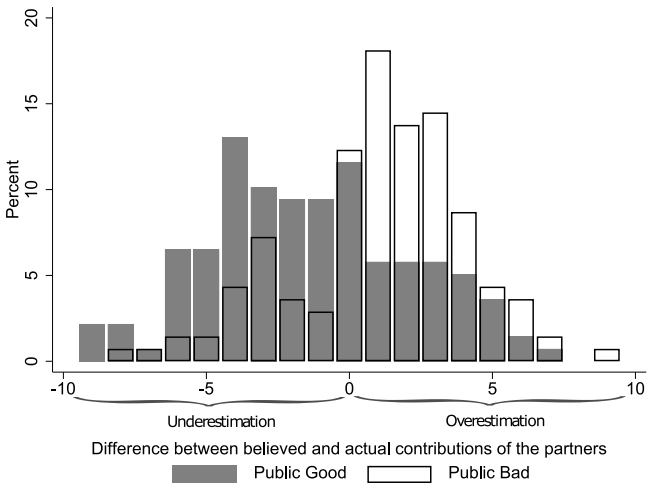

Fig. 5. Histogram of the difference between believed contributions and actual contributions by partners in Public Good and Public Bad treatment.

et al., 2010; Voors et al., 2011; Cárdenas et al., 2011, 2017; Werthmann et al., 2010; Prediger, 2011). Linear public good games have clearly defined strategies on how to achieve a social optimum (contribute all of the endowment) and the Nash equilibrium (contribute nothing) and these strategies are independent of what others are doing. In the context of natural resource use this seems unintuitive, since typically, actions of co-players will influence the privately and socially optimal responses, and call therefore for cooperation as well as coordination.

Here, we use a framed threshold public goods game that requires coordination and cooperation. Our subjects are Cambodian farmers and fishers who co-manage water and fisheries and are therefore very familiar with the tensions that arise around social dilemmas. In our setup, participants make decisions on how to divide money between different envelopes. Thus, our design does not require literacy or acquaintance with electronic devices whilst making the decisions very salient. Overall, extending the threshold public goods game from a binary to a discrete contribution mechanism allows us to analyse cooperative behaviour in more detail. This provides a more nuanced and realistic setting in how people cooperate since we are able to not only assess whether people are willing to cooperate, but also how much they want to contribute, as well as the role the behaviour of others plays in framed threshold games.

We find higher cooperation in the public goods frame than in the public bad frame, which is largely mediated through beliefs, and ultimately leads to higher collective success. This begs the question why we observe higher beliefs about other's contributions (and lower own contributions) in the public bad frame, compared to the public good frame. As shown by previous research, the different frames transport important messages about the collective dilemma at hand which gives cues about what others may do (Ellingsen et al., 2012; Dufwenberg et al., 2011). In our case, the negative frame emphasizes a potential collective loss, potentially invoking a greater sense of urgency, which may lead individuals to believe that others contribute more. This would point to two clear avenues for further research. First, it would be very interesting to see how our finding may carry over to different cultural contexts. From linear public good games we know already that frames evoke different reactions across cultural contexts (Dufwenberg et al., 2011; Ellingsen et al., 2012), so in other parts of the world we may find other, potentially opposite, effects on beliefs. In Cambodia, we find a high sense of community with free-riding being more or less absent () which has clear effects on average contribution levels and average believed contributions. Second, to really understand *why* the two frames evoke different beliefs, using qualitative methods would be every insightful. It is somewhat surprising that this has also not been done to explain why we observe the original framing effect by Andreoni (1995) in linear games. So this would also be an exciting research project for someone using mixed methods, combining economic experiments with a qualitative analysis of verbal expressions of game participants.

To our knowledge, the role of believed contributions has not been studied as extensively as the framing effect on contribution levels. Yet, we see that a systematic over- or underestimation of the contributions made by the partners has strong implications for coordination towards overcoming a social dilemma. At the same time, beliefs are of course also more than just an expectation about the state of the world, and can be motivated and reasoned in light of wider values and identity considerations (Bénabou and Tirole, 2016). Also, while a causal link from beliefs to actions is commonly assumed in economic models, such directionality is not obvious. Therefore, future research could take the next step towards unravelling the role of beliefs, identities, and also actions in various social dilemma situations.

Our work holds certain policy implications. First, our results suggest that voluntary user arrangements are less likely to emerge in situations that need to discipline 'bad' behaviour, e.g., avoiding overfishing in fisheries management, potentially calling for more formal rules in such a case compared to encouraging 'good' behaviour like contributing to the maintenance of the irrigation structure. Second, as we do find beliefs to be an important mechanism, there is an obvious opportunity for local leaders to help coordinating on a good equilibrium (Kosfeld and Rustagi, 2015). The crux of the matter is that simply highlighting 'good behaviour' of others or leading by example – which is conventionally done to stimulate cooperation – may trigger differing responses ranging from relying that others will take care of it, to feeling compelled to do contribute a fair amount to contributing more than necessary. In that sense, threshold games may call for a different set of information due to the complexity of coordination on the social optimum than linear games that can try to leverage the role of conditional cooperators (Fischbacher et al., 2001; Fehr and Fischbacher, 2003; Fischbacher et al., 2012). In regard to Cambodia, the role of Farmer Water User Community and Community Fishery' institutions should not be underestimated. These institutions could support cooperation considerably by e.g., providing guidance on average cooperation level of others to reduce the margin of error on believed contributions, or by announcing fair contribution levels. Previous research indicates that Cambodians values these institutions considerably since they are willing to spend money to ensure they are functioning.

Our experimental design choices are very much motivated by making sure that the game was well understood by our participants. Yet, some of these choices may pose limits towards generalizability. First, each participant played a linear public good game including a strategy elicitation before the threshold game, which might have increased the salience of the strategic elements and the role of beliefs. Second, participants who played the public good framing might experience a lower cognitive load than those playing the public bad framing, because they had played the linear public good before. Randomizing the order of the games would have mitigated this issue, but playing the linear game before the threshold games gives more intuition and understanding to players about how those games work. To counteract these order effects we spend a significant amount of time on explaining the individual games to ensure that people understood the game, even if it might have required more effort for one of the frames. Also, the belief elicitation task asks for the most likely contribution of others. However, this method does not capture the distribution of beliefs. For instance, an individual reporting that she believes that others will contribute eight bills might still consider an investment of 5 bills possible. In the context of risk aversion, it would have been insightful to elicit the distribution of beliefs. Further, our main specification includes village fixed effects, and we do not attempt to explain contributions with socioeconomic factors, either at the individual or village level. While interesting, we feel this should be better done in future research, as we did not specify

any guiding hypotheses in the pre-analysis plan. We did specify in the pre-analysis plan that we would compare the behaviour of fishers with farmers. We hypothesized that fishers are more used to a setting where they try to avoid a public bad (the collapse of a fish stock) and farmers are more used to a setting where they try to achieve a public good (maintaining water infrastructure). Hence, we conjectured that this prior experience leads to more cooperation among fishers in the "public bad" frame compared to fishers, but to less cooperation in the "public good" frame compared to farmers. Yet, in the field we realized that these are not distinct groups, but rather everyone is a farmer, whole some pursue fishing as an additional side activity. Therefore, we did include fishing experience only as a control variable.

6. Conclusion

In this paper, we analyze how the positive and negative framing of threshold games affects contribution of players and group success in an artefactual field experiment in Cambodia. In line with the key finding by Andreoni (1995), we find higher cooperation in the public goods frame than in the public bad frame. While previous results have shown that the framing effect does not easily carry over to more complex non-linear games (Isaksen et al., 2019), our findings suggest that a clear focal point – which is present in threshold games – may recover such framing effect since the thresholds plays a stronger role in the public bad framing. The ability to coordinate crucially depends on beliefs, which we show to be also the key mechanism of the framing effect.

While previous framed threshold games were carried out as binary games, we designed a game with stepwise contribution levels. By allowing for discrete contribution levels, we are able to distinguish two mechanisms that explain group success in threshold games and operate differently in the "achieving a public good" and "avoiding a public bad" frames. First, we find that in both frames players tend to contribute more than what would be optimal based on their beliefs. Intuitively, it makes sense that players try to be on the safe side. Yet, this mechanism is not different across frames. Second, we find players to be much more pessimistic in the public good game, underestimating the contributions of others. In contrast, in the public bad treatment, players are too optimistic about contributions by others. This difference is crucial, because with pessimistic beliefs, contributing according to the best-reply is sufficient to reach the threshold. With optimistic beliefs, it is not, and a much higher contribution is needed to meet the threshold. Hence, collective success is higher in positively framed threshold games.

CRediT authorship contribution statement

Esther Schuch: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Tum Nhim:** Writing – review & editing, Methodology, Conceptualization. **Andries Richter:** Writing – review & editing, Supervision, Project administration, Methodology, Formal analysis, Conceptualization.

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Declaration of competing interest

The authors declare no conflict of interests.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.ecolecon.2025.108547.

Data availability

Data will be made available on request.

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