Journal of Behavioral and Experimental Economics 90 (2021) 101642

Contents lists available at ScienceDirect

Journal of Behavioral and Experimental Economics

journal homepage: www.elsevier.com/locate/jbee

Cooperation under social and strategic uncertainty – The role of risk and social capital in rural Cambodia

Esther Schuch [*,a], Simone Dirks [a], Tum Nhim [a,b], Andries Richter [a,c]

[a] Environmental Economics and Natural Resources group, Wageningen University, P.O. Box 8130, 6700 EW Wageningen The Netherlands
[b] Center for Khmer Studies, 234 Street 450 Tuol Tumpung II, Chamkamorn, Phnom Penh, Cambodia
[c] Centre for Ecological and Evolutionary Synthesis, Department of Biosciences, University of Oslo, Norway

ARTICLE INFO

Keywords:
Cooperation
Social uncertainty
Public good game
Threshold game
Natural resource management
Uncertainty

ABSTRACT

Cooperation in a social dilemma is noble but risky because one is not sheltered against selfish individuals. This "social uncertainty" is essentially captured in the linear public good game, where it is socially optimal to contribute everything to the public good, while it is privately optimal to keep everything for oneself. Many real-world social dilemmas have an additional source of "strategic uncertainty", as socially and privately optimal strategies tend to depend on actions of others. Here, we compare the determinants of cooperation in a linear public good game and a threshold game, where individuals are challenged to guess the contributions of the partners to determine an appropriate investment that aligns with private and collective interest. We combine elicited risk preferences and cooperative attitudes with information from a survey on social capital and demographics to analyse what explains cooperation. Our experiments are carried out with farmers in Cambodia who are exposed to various social dilemmas on a daily basis. We find that risk and social capital explain cooperation in the linear public good game, but not in the threshold game. These findings call for a more careful examination of real world social dilemmas that typically comprise coordination and cooperation elements.

1. Introduction

Cooperation in social dilemma situations has been studied extensively. The linear public good game is the canonical model to analyse cooperative behaviour in a situation where each individual is torn between personal gains and collective welfare. While it is individually optimal to contribute nothing to the public good regardless of what other players are doing, it is socially optimal to contribute everything (Fehr & Fischbacher, 2003; Willinger & Ziegelmeyer, 1999). The social optimum is reached if all players contribute their full endowment to the public good. Yet, the most frequently observed behaviour is neither free riding nor full cooperation but rather contributions around 40-50% of the endowment (Ledyard, 1995; Fehr & Fischbacher, 2003; Burton-Chellew & West, 2013). Fischbacher, Gächter, and Fehr (2001) established that individuals can be classified according to their contribution strategies, such as free riding, conditional cooperation, or unconditional cooperation. The notion of conditional cooperation highlights the role of beliefs about the partners' contributions in how much individuals contribute (Fehr & Fischbacher, 2003; Fischbacher, Gächter, & Quercia, 2012). Intuitively, individuals try to avoid being the "sucker" (Kerr, 1983) who contributes while others take a free ride.

Most real world social dilemmas are more complex than the linear public good game suggests. While in the linear public good game the strategies on how to achieve the social optimum are known this is not necessarily the case in nonlinear public good games. In nonlinear games, the strategy on how to achieve the social optimum depends on the actions of the partners (Isaksen, Brekke, & Richter, 2019; van Soest, Stoop, & Vyrastekova, 2016; Dannenberg, Löschel, Paolacci, Reif, & Tavoni, 2015; Tavoni, Dannenberg, Kallis, & Löschel, 2011). Hence, in linear public good games the socially optimal strategy – contribute everything – is independent of the contributions of partners, but whether the social optimum materializes does depend on the contributions. In contrast, in nonlinear public good games also the socially optimal strategy depends on actions of partners.[1] One example of nonlinear public goods are irrigation systems to which farmers contribute to ensure maintenance. This infrastructure only retains functionality if a minimum amount of

* Corresponding author.
E-mail address: Esther.Schuch@hotmail.de (E. Schuch).

[1] Mathematically, the contribution levels of partners is an argument in the socially optimal contribution level of a nonlinear public good game, but not in a linear public good game.

https://doi.org/10.1016/j.socec.2020.101642
Received 11 May 2020; Received in revised form 5 November 2020; Accepted 9 November 2020
Available online 11 November 2020

contributions is reached. Those nonlinearities can be formalized in threshold public good games, where players contribute jointly to a group account. If the joint contributions are below a threshold, all contributions are lost and the public good is not provided. In this setting, the strategy to achieve the social optimum (reaching the threshold exactly) depends on the partners contributions (Cadsby & Maynes, 1999).[2]

The linear public good game and the threshold game both feature a form of "social uncertainty". Bohnet, Greig, Herrmann, and Zeckhauser (2008) use the term "social risk" "to describe situations where decisions by other human beings are the prime source of uncertainty". While Bohnet et al. (2008) focus on the fear of being taken advantage of, i.e. betrayal aversion, one may generalize the preference to align own behaviour with what others are doings as a form of conditional cooperation (Fischbacher et al., 2001; Fischbacher et al., 2012). Obviously, to act conditionally cooperative one needs to gauge behaviour of others. This uncertainty about the behaviour of others we refer to as "social uncertainty" which is part of the linear as well as the threshold public good game. In the threshold public good game, these consideration may also play a role, but there is the additional source of "strategic uncertainty". As the best response depends on the unknown contributions of others, there is a risk of contributing inefficiently and either failing to reach the threshold or providing more than needed.

In this paper we unbundle the source of uncertainty by distinguishing the fear of deviating from what the social norm is ("social uncertainty") and the difficulty of gauging contributions of others to make a best response ("strategic uncertainty"). We conduct lab in the field experiments with Cambodian farmers. We ask the question how individual factors, such as risk aversion, social capital, or demographic variables affect cooperation under social and strategic uncertainty. A key feature of this subject pool is that the participants are commonly exposed to social dilemmas, such as contributing to irrigation infrastructure, and rely to a large extent on informal rules to manage these. By studying the behaviour of Cambodian farmers we are able to gain some insights in how small communities manage natural resources with the help of social capital (e.g. the level of support for community tasks, being a member of a voluntary association), as well as risk aversion and prosocial preferences.

Our paper contributes to the literature in two ways. First, by investigating the various factors that play a role when individuals engage in social dilemma situations, accounting for the role of social and strategic uncertainty. Second, we explore under which conditions farmers successfully overcome social dilemmas, building upon the social-ecological systems literature pioneered by Ostrom and others (Ostrom, 1990; Janssen, Lindahl, & Murphy, 2015; Schill, Lindahl, & Crépin, 2015; Lade, Tavoni, Levin, & Schlüter, 2013). In particular, risk aversion and social capital (especially trust) can influence contribution levels in linear public good games. Anderson, Mellor, and Milyo (2004) and Kocher, Martinsson, Matzat, and Wollbrant (2015) find that trust increases contribution levels and Charness and Villeval (2009) observe that risk seeking people invest more in the public good than risk averse people. Contrary, Kocher et al. (2015) do not find any significant effect of risk preferences on contribution levels. Cárdenas et al. (2017) run a public good game, where either the return on the public good or the private account is risky. They observe that risk in the public account leads to lower investments in the risky account than risk in the private account. Apart from individual preferences, social norms and community characteristics also influence cooperative actions (Bouma, Bulte, & van Soest, 2008; Ockenfels & Weimann, 1999; Gneezy, Leibbrandt, & List, 2015). Also, being a member of a voluntary association has been observed to have strong positive correlations with higher contributions to the public good (Anderson et al., 2004). The role of risk preferences in threshold games has been explored to a lesser degree and does not show a clear pattern. While İriş et al. (2019) find that risk aversion leads to higher contributions, Gangadharan and Nemes (2009) find no effect. The remainder of the paper is organised as follows: section 2 describes the Cambodian context and methods used, section 3 explains the experimental design, section 4 presents the results, and section 5 concludes.

2. Materials and Methods

2.1. Study population and experimental procedure

In Cambodia, the management of natural resources (water, fisheries, and forestry) is to a large extend organised at community level. While the resource management is decentralised it is still part of a multilevel governance setting (Chou, Nang, Whitehead, Hirsch, & Thompson, 2011). In 1994, the Cambodian government initiated the transfer of the water management from the national level to the communities (Perera, 2006). This process was further formalised in 1999 when the Participatory Irrigation Management and Development program was introduced that created a formal setting in which the irrigation governance is the task of formal user groups. These Farmer Water User Communities (FWUCs) consist of farmers and are responsible for the maintenance, repair, and improvement of the irrigation system, as well as the establishment of equitable and reliable access to water (Chou, 2010; Perera, 2006). While the official guidelines and regulations provided by the state ensure a framework for running the FWUCs, the experiences, expectations, and perceptions within the communes differ widely, depending on social norms and environmental characteristics (Chou et al., 2011).

The experiments were conducted in May/June 2019 in the province Kampong Chhnang, Cambodia. All experiments and research ideas were reviewed by the Social Sciences Ethic Committee of Wageningen University and registered as a pre-analysis plan; see Richter, Schuch, and Nhim (2020). The research took place in 21 villages in three communes: Tuel Phpos, Tank Krasang and Kouk Bonteay (see Fig. 1). The three communes have different levels of access to water and water availability in Tuel Phpos is most stable. While Kouk Banteay is the commune closest to the Tonle Sap lake, which allows for fishing, water availability there is more volatile than in the other communes. Also, water availability does not only depend on location, but also on the quality of the canal system which may be different between villages. In general, the villages within these communes are tight communities (on average 727 inhabitants) sharing not only resources but also ceremonies such as weddings and funerals.

Participants were recruited through the village chief, a respected member of the community. Only one participant per household was allowed to take part, preferably but not necessarily, the household head. Further requirements were that participants should represent all parts of the village's society, had to be 18 years old and healthy enough to sit on the floor for the duration of the experiments (see Table 1 for an overview). An experimental session began with an introduction of the research team. The village chiefs made sure that the chosen members all showed up and once the formalities were settled left the venue for their respective work. The participants were told that the study aims at understanding livelihoods related to farming and were instructed about the duration and the monetary reward for participating. Participants received a show up fee of 4000 Cambodian Riel (KHR)[3] and 6000 KHR for their effort to stay until the end of the meeting. The sessions lasted 3 hours including a break. At the end of the session one of the games was

[2] There is also extensive research on uncertain thresholds and its effect on contribution levels. Generally, contribution levels are lower when the threshold is uncertain (often referred to as "environmental uncertainty") (Wit & Wilke, 1998; Barrett & Dannenberg, 2014; 2016; McBride, 2010; Suleiman, Budescu, & Rapoport, 2001; İriş, Lee, & Tavoni, 2019; Gustafsson, Biel, & Gärling, 2000; Au, 2004), which is not surprising given the additional layer of uncertainty.

[3] 4000 KHR are equivalent to one USD.

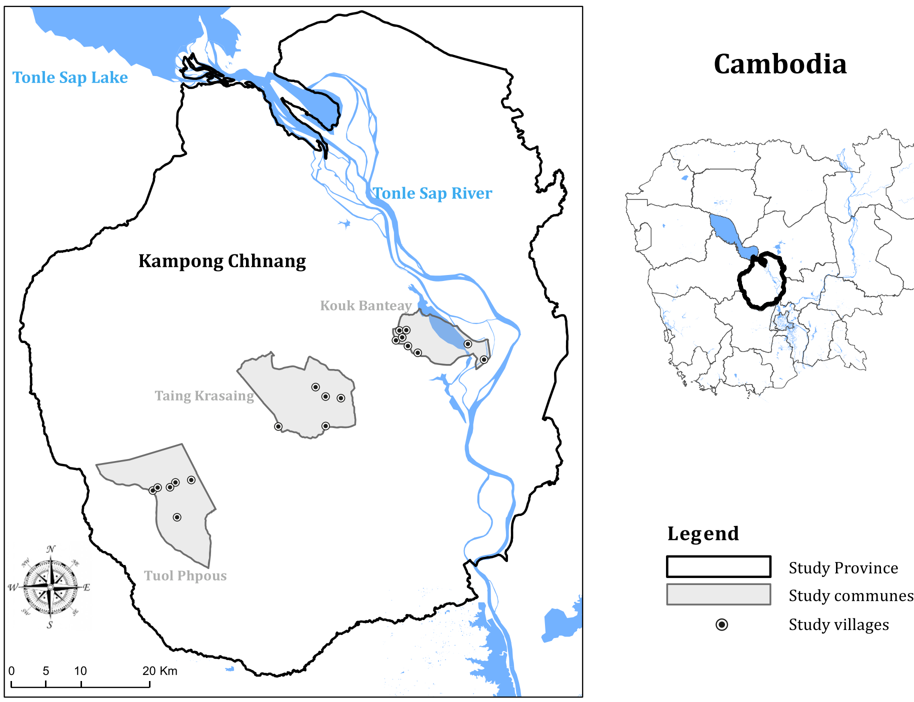

Fig. 1. The study side Kampong Chhnang province with three communes Tuol Phpous, Taing Krasaing, and Kouk Banteay where 21 villages where visited.

Table 1
Overview over sample population

	Household Characteristics
Gender	male (104), female (177), preferred not to say (1)
Age	18 - 80
Years of school attended	0 - 16
Relation to Household head	HH head (128), Spouse (122), Child (2), Parent (25), Other (5)
Primary occupation	Rice farmer (239), Fisher (1), Housewife (12), Other (30)
Household members	1 - 11
Children per Household	0 - 6
Earners per Household	0 - 6
Rice cultivation (2018)	yes (265), no (17)
	Area
Communes	3
Villages	21

chosen randomly to be paid out to each individual.

All instructions were given verbally and aided with posters and examples to ensure understanding in a population with high illiteracy rates (all instructions, visual aids, as well as the survey are available in the appendix). The verbal consent also included information about the confidentiality and anonymity of the decisions and answers given by the participants. Moreover, subjects were made aware that participation is voluntary and that they could leave at any time without negative consequences. Participants were encouraged to ask questions at all times. Once the participants had no further questions, the experimental tasks started. Participants played four economic games in the following order: risk elicitation, linear public good game, conditional linear public good game and the threshold public good game. No feedback was given between these games to avoid confounding behaviour.

The risk elicitation task follows Gneezy and Potters (1997) and the conditional public good game (Fischbacher et al., 2001) with the instructions adapted from Rustagi, Engel, and Kosfeld (2010). The risk elicitation and the conditional public good game are used to measure risk aversion and define cooperative types. For all the games we randomly and anonymously assign new partners. All participants also answered survey questions in regard to socio-demographics and social capital. In 23 cases we have incomplete data which leaves us with 282 full observation sets. Table A.1 in the appendix provides an overview of the summary statistics from the survey as well as the experiments. Finally, subjects are paid their individual payoff privately and in cash.

2.2. *Eliciting risk and social preferences*

To analyse impacts on contribution strategies between games we conducted a risk elicitation task and played a conditional public good game. The risk elicitation task provides us with a measure for risk aversion which runs from zero (highly risk seeking) to six (highly risk averse). We see that the majority of our sample is more or less risk neutral (values from two to four) and only few show extreme risk aversion (value of six) or risk seeking (value of zero) behaviour (Fig. 2). We play a conditional public good game based on Fischbacher et al. (2001) which measures contribution in public goods without any source of social risk. Fischbacher et al. (2001) find that some people free ride independent of how much the other person contributes, others match the contributions of their partners (conditional cooperators), while some match contributions to a certain point from which on they reduce contributions to the public good again (hump-shaped contributions). Rustagi et al. (2010) include further behaviour types such as altruists (unconditional cooperation) and weak conditional cooperators (no exact matching of the contributions, but close). When applying the classification of cooperative behaviour types by Rustagi et al. (2010) we do not explain a lot of the cooperative behaviour in our Cambodian population[4]. This may not be surprising, given that behavioural types are hardly universal, but embedded in cultural contexts (Henrich et al., 2001). For example, there is a strong aversion towards free riding in Cambodia, a behaviour that is entirely absent in our experiment. An alternative way to the standard approach by Fischbacher et al. (2001) is

[4] Based on Rustagi et al. (2010) we classified 8% as unconditional cooperators, 7% as conditional cooperators, 20% as weak conditional cooperators, 0% as free riders, 0% as hump shaped, and 65% as unclassified behaviour.

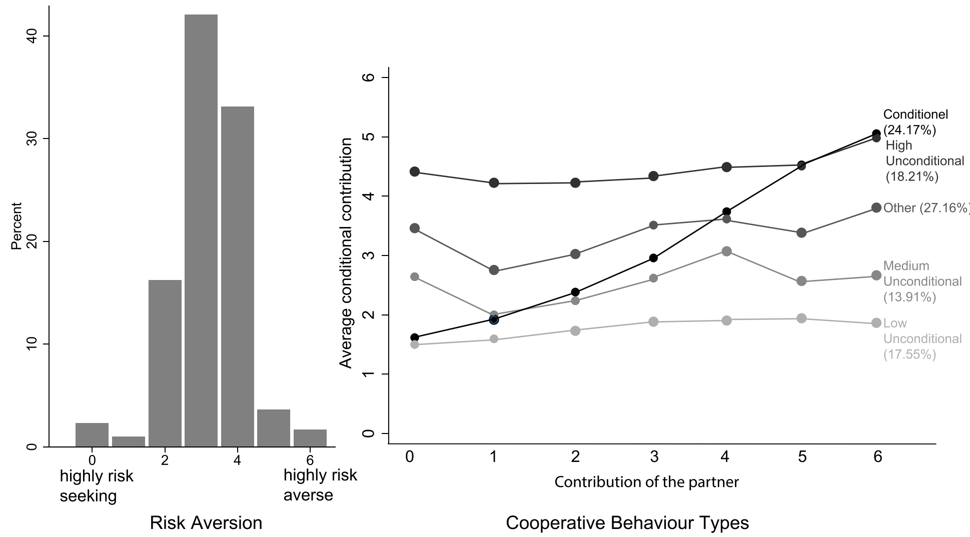

Fig. 2. Degree of risk aversion and cooperative behaviour types based on the hierarchical cluster analysis.

the hierarchical cluster analysis proposed by Fallucchi, Luccasen, and Turocy (2018). Cluster analysis matches variables into groups by analysing their similarities to each other (see appendix appenidx A.2 for details). Fallucchi et al. (2018) show that the hierarchical cluster analysis is able to reproduce the classifications of Fischbacher et al. (2001) if these are the prevalent behaviour types. Yet, the advantage of the hierarchical cluster analysis is that it is also able to detect different contribution patterns. By applying this method to our population we find five behaviour types. A frequent contribution strategy is to contribute more or less the same amount independent of how much the partner contributes, but there are three distinct groups which differ in the level of contributions. Further, we identify a group that can be described best as conditional cooperators and one group that does not seem to match any pattern. Hence, we classify our behavioural types as follows: 18.48% high unconditional cooperators, 24.09% conditional cooperators, 13.86% medium unconditional cooperators, 17.49% low unconditional cooperators, and 26.07% unclassified other behaviour (see Fig. 2). The average contribution in the conditional public good game of a high unconditional cooperator is 4.44 (SD 0.9), 2.54 (SD 0.77) of a medium unconditional cooperator, and 1.78 (SD 0.89) of a low unconditional cooperator. The last group of contributors shows no clear pattern of contributions with an average contribution of 3.37 (SD 1.17) (see table A.1 for summary statistics and fig A.4 for contribution pattern of the five types). Fig. 2 shows that conditional cooperators do increase contributions as the contributions of partners increase, but they do not match them exactly, partially because of a reluctance to contribute zero.

3. Experimental Design

3.1. Linear Public Good Game

We play a standard linear public good game to analyse cooperation under social uncertainty, but without strategic uncertainty. While the payoff for individual i depends on the contributions of the partners, the strategies to achieve the social optimum or maximise individual gains do not. In the linear public good game the group size is set to two and we have the following individual payoff structure

$$\pi_i = E_i - c_i + 0.75 \sum_{j=1}^{n} c_j$$

where π_i is the individual i's payoff, E is the endowment, and c_i the individuals contribution to the public fund. We set $n = 2$ and $E = 6000$ KHR. For every 1000 KHR contributed to the public fund, another 500 KHR are added. Thus, the marginal per capita return is 0.75 and since $0.75 < 1 < 0.75 \times N$, players face a social dilemma. In this game the profit maximising individual will contribute zero ($c_i = 0$) (the Nash equilibrium) and it is socially optimal to contribute everything ($c_i = E_i$) (see Fig. 3). The Nash and socially optimal strategy are independent of the size of the group and the contributions of the partners, but the payoffs clearly depend on the contributions of the partners. Contributions to the public fund are possible in discrete steps of 1000 KHR. The maximum social welfare is 18000 KHR, which is 9000 KHR per person.

3.2. Threshold Public Good Game

The threshold public good game adds strategic uncertainty to the social uncertainty of the linear public good game. The individual payoff π_i in the threshold game is determined by

$$\pi_i = \begin{cases} (E_i - c_i) + B & \text{if } \sum_{j=1}^{n} c_j \geq T \\ (E_i - c_i) & \text{if } \sum_{j=1}^{n} c_j < T \end{cases}$$

where B is a lump sum benefit every player gets if the threshold is reached, c_i the individual contribution to the public good, T denotes the threshold, and E_i the endowment. Note that we set $E = 6000$, $B = 6000$, $T = 9000$ and $N = 3$ so that $E < T < NE$. Thus no individual can reach the threshold by herself and reaching the threshold does not require contributing all of the endowment by everyone.

The game has two symmetric Nash equilibria: the pure uncooperative strategy in which everyone contributes zero to the public fund ($c_i = 0$) which we refer to as symmetric uncooperative Nash equilibrium, and the fair equilibrium strategy in which the threshold is reached via equal contributions by everyone ($c_i = T/N$) which we refer to as symmetric cooperative Nash equilibrium. The symmetric uncooperative Nash equilibrium is a risk-dominant and the symmetric cooperative Nash equilibrium is a payoff-dominant equilibrium. The fair equilibrium only exists if and only if $B \geq T/N$. The symmetric cooperative Nash equilibrium maximises social welfare and distributes it equally among the group. Hence, the fair social optimum is reached. The best response for individual i is T/N if she believes that the others contribute $(N-1)(T/N)$, thus making the individuals contributions just enough to reach the threshold. Contributing zero to the public fund is the individually and socially optimal strategy if the individual believes the partners also contribute zero (see Fig. 3). Apart from those two symmetric equilibria there are also asymmetric equilibria, though symmetric equilibria tend

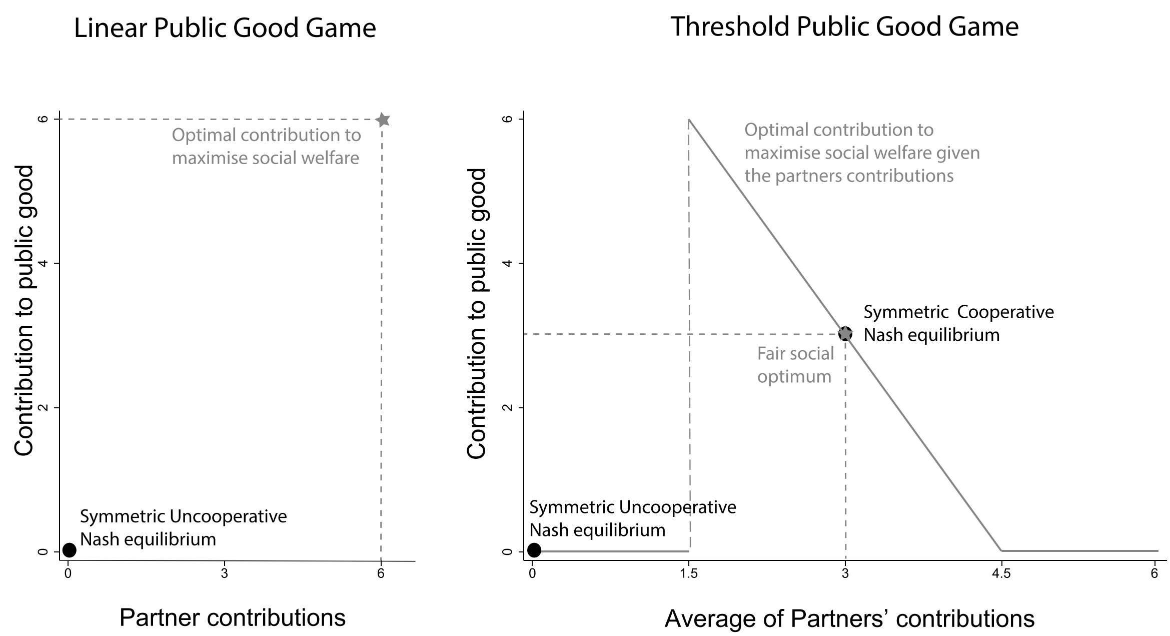

Fig. 3. Optimal contribution strategy and symmetric Nash equilibria in the linear and the threshold public good game.

to act as focal points (Cadsby & Maynes, 1999). The symmetric cooperative equilibrium is often achieved via the equal division rule, or the T/N heuristic (de Kwaadsteniet, van Dijk, Wit, & Cremer, 2008). The requirements for an asymmetric equilibrium are $\sum_{j=1}^{n} c_j = T$ and $c_i \leq B$ for all i. Thus, with every additional partner, the number of asymmetric equilibria increases.

As in the linear public good game the endowment is 6000 KHR, where contributions to the public fund are done in steps of 1000 KHR. The group size is set to three. The maximum social welfare in the threshold public good game is 27000 KHR. Thus, the individual payoff in the fair social optimum (every individual contributes the same amount) in the threshold game is the same as in the social optimum in the linear public good game (9000 KHR). The symmetric cooperative Nash equilibrium is reached if everyone contributes 3000 KHR. As shown by Cadsby and Maynes (1999) the reward of reaching the threshold needs to be sufficiently high to induce cooperation. In our setting, the marginal per capita return in the symmetric cooperative equilibrium is 2 which can be considered sufficiently high.[5] The linear as well as the threshold public good game are played as one-shot games in which we randomly assign new partners for each game to avoid intergroup dynamics such as retaliation.[6]

4. Results

First, we establish the contribution and welfare levels in the linear and the threshold public good games. Second, we analyse how individual preferences, socio-demographics, and social capital influence these contribution levels.

4.1. Public good games

4.1.1. Contribution levels

The average contribution to the public fund in the linear public good game is 3.11 (SD 1.11) and 3.15 (SD 1.18) in the threshold public good game. Fig. 4 shows that in the linear public good game only 3.31% contribute the socially optimal amount of six bills and only 0.33% follow the individual profit maximisation strategy of zero contributions. The most frequent observed contribution is three bills (37.42%). In the threshold game the most frequently observed contribution level is also three bills (48.50%), but the contribution levels zero (3.65%) and six (4.65%) are also observed more often. While the Kolmogorov-Smirnov test confirms the difference of the distributions ($D = 5.9734$, $p = 0.000$), we cannot confirm differences in the mean (paired t test, $p = 0.6242$).

4.1.2. Welfare levels

Comparing the individual payoffs per game, we find that the median payoff is considerably lower in the linear public good game (six) than in the threshold public good game (eight). Also, the range of payoffs is lower in the linear (from four to eight) than in the threshold public good game (from two to twelve) (Fig. 5). When we relate the payoffs to the contribution levels we see a negative relationship between contributions and realised payoffs in both games. This negative relationship is caused by the inherent feature of a social dilemma where contributing less is individually better, but collectively worse. Contributing to the public good often results in payoffs that are even lower than the symmetric uncooperative Nash equilibrium. In Fig. 5 we can clearly see that in the linear public good game the payoffs are distributed around (often below) the Nash equilibrium, while in the threshold game two payoff branches (collective success / failure) are visible. This makes it also intuitively clear why the threshold game features an additional source of risk, as more contribution to the public fund comes at a cost, but reduces the risk of failing to meet the threshold. The symmetric cooperative Nash equilibrium is a popular strategy with a very high chance of success, but also contributing slightly above Nash (four bills) is a strategy with fairly high success rates without having to sacrifice too much of the individual payoff.

[5] Comparing two experiments ideally requires that all key features (endowment, location of Nash equilibrium and social optimum, number of players) are equal. This is not possible in our setting. We keep the endowment as well as individual payoffs in the uncooperative Nash equilibrum and the social optimum the same in both games (0 and 9000) to avoid endowment effects. To do so we increase the number of players in the threshold game to three. In hindsight, we could have played the linear public good game also with 3 players, by choosing a different MPCR, which would have eased comparison across games.

[6] The threshold game is set up as a framing experiment, where the threshold may resemble a public good or a public bad which is analysed in Schuch, Nhim, and Richter (2020). When analysing data, we always control for the framing effect.

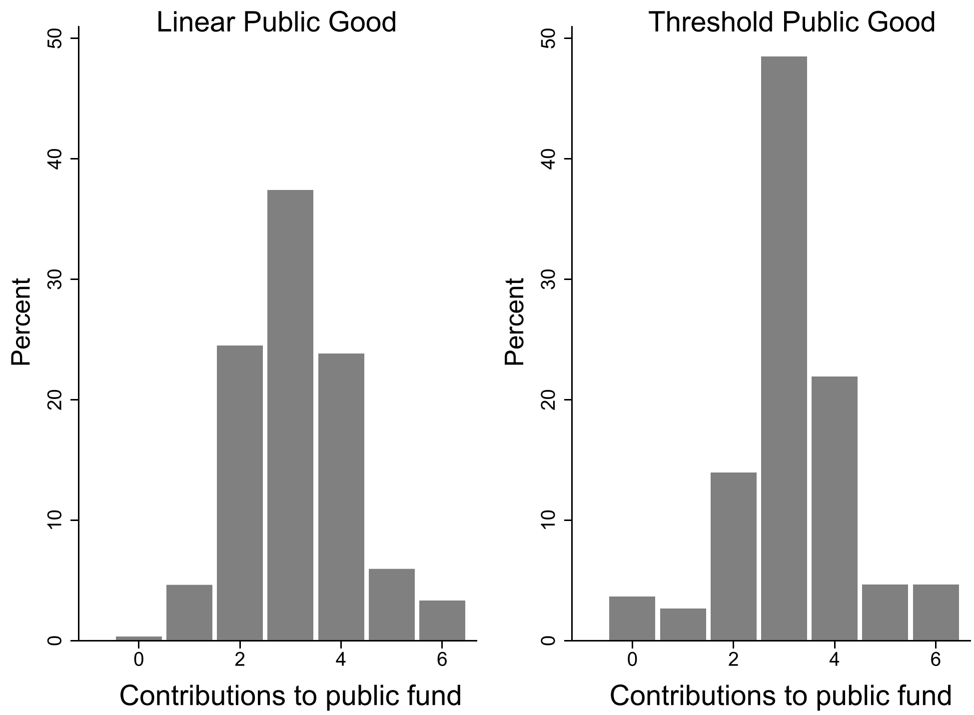

Fig. 4. Contributions to the public fund in the linear public good and the threshold public good game.

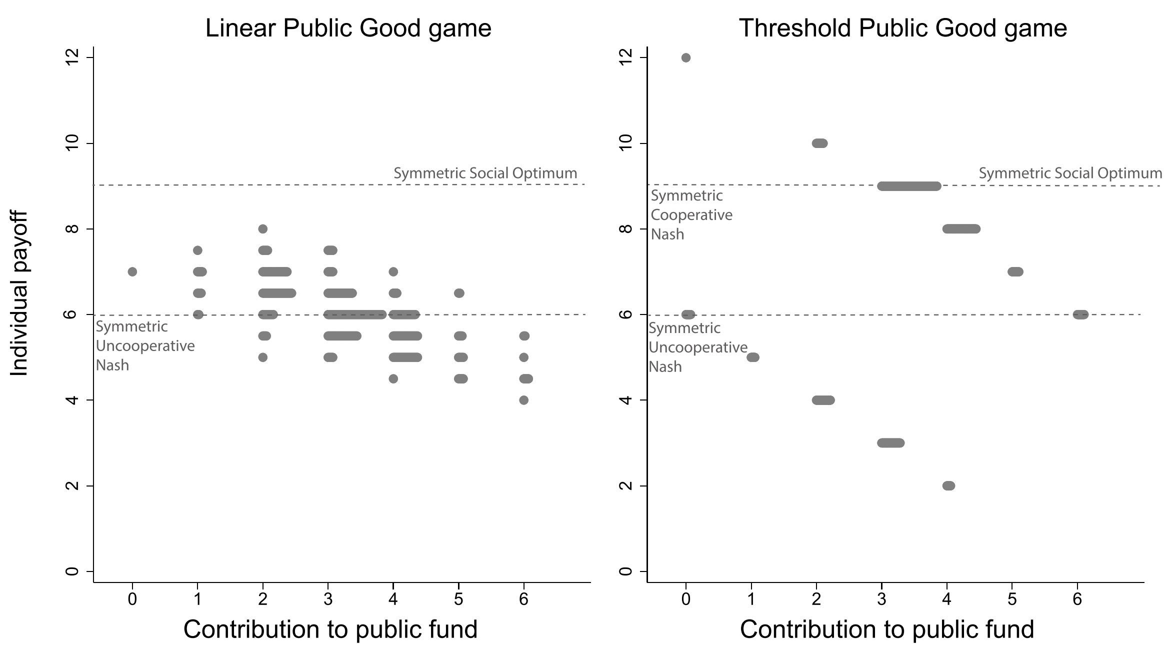

Fig. 5. Individual payoffs depending on contribution level in linear and threshold public good game. The length of the bars indicate the frequency of the observed payoff levels.

4.2. *Determinants of contribution levels*

4.2.1. *Linear Public Good*

We run an OLS regression to explain contribution levels to the public good. We find that risk aversion is negatively correlated with contributions (Table 2; see table A.2 for specific village-fixed effects). This effect persists independent of the covariates included (model (1) to (4) in Table 2). We also see that high unconditional cooperators contribute significantly more than low unconditional cooperators (the base). Also, conditional cooperators contribute more to the public good than low unconditional cooperators but to a lesser extent than high unconditional cooperators. None of the socio-demographics apart from remittances have any significant effect. We do see that a household that receives remittances, which probably belongs to the wealthier part of the population, contributes more to the public good than those households without remittances. Regarding social capital, we do not find any effect of being a member of a voluntary organisation. We measured the

Table 2
Determinants of Contribution level in the linear public good game.

Dep. Var.: Contribution to the public good in linear public good game	(1)	(2)	(3)	(4)
Individual Preferences				
Risk Aversion	-0.201***	-0.224***	-0.230***	-0.217***
	(0.0524)	(0.0538)	(0.0481)	(0.0539)
High Unconditional Cooperators	1.587***	1.270***	1.247***	1.285***
	(0.178)	(0.191)	(0.212)	(0.193)
Conditional Cooperators	0.638***	0.426**	0.417*	0.440**
	(0.165)	(0.199)	(0.208)	(0.192)
Medium Unconditional Cooperators	0.511**	0.238	0.310	0.364
	(0.194)	(0.231)	(0.257)	(0.244)
Other	0.740***	0.514**	0.477**	0.527**
	(0.165)	(0.184)	(0.206)	(0.193)
Socio-demographics				
Male			0.101	0.112
			(0.159)	(0.164)
Age			0.00407	0.00245
			(0.00590)	(0.00567)
Years of schooling completed			0.0204	0.0149
			(0.0201)	(0.0192)
Number of household members			0.0137	0.00810
			(0.0281)	(0.0288)
HH receives remittances			0.343***	0.335***
			(0.110)	(0.113)
Social Capital				
Member in a water and/or fisher association				0.158
				(0.172)
Expected help of neighbours in contributing to community tasks				0.0512*
				(0.0274)
Constant	3.044***	3.411***	2.973***	2.501***
	(0.288)	(0.262)	(0.297)	(0.385)
Village fixed effects		√	√	√
Observations	302	302	281	281
R^2	0.257	0.420	0.446	0.458
Adjusted R^2	0.245	0.367	0.379	0.389

Standard errors in parentheses, clustered on village level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

support for community tasks[7] and find that the higher the support for community tasks is the more people contribute to the public good, even though it is only significant at a 10 % level.

4.2.2. *Threshold Public Good*

We run the same OLS for the contribution level in the threshold public good game and find that risk aversion does not have a significant effect in any specification (Table 3; see table A.3 for specific village-fixed effects). We do find an effect of cooperative types, but the effect is weaker than in the linear public good game. High unconditional cooperators do contribute more than the low unconditional cooperators, but the difference is less than in the linear public good game. In the threshold public good game none of the socio-demographic variables has any significant effect, and the social capital variables are insignificant as well.

Contribution levels in both games are not directly comparable, because the games have different properties. Still, we can look at how contribution levels in both games are correlated and how this depends on risk aversion and social capital; see Figure A.1 and A.2. We find that highly risk averse people have a positive correlation, while people with medium risk aversion show no correlation. People with low risk aversion show a negative correlation (although only the mildly risk averse level 4 correlation of 0.254 is significant at 5%) (Fig. A.1). Regarding social capital, we find that the correlation between the threshold public good and the linear public good game is stronger for individuals with low social capital (Fig. A.2).

Table 3
Determinants of Contribution level in the threshold public good game.

Dep. Var.: Contribution to the public good in the threshold public good game	(1)	(2)	(3)	(4)
Individual Preferences				
Risk Aversion	0.0247	0.0474	0.0503	0.0441
	(0.0716)	(0.0693)	(0.0683)	(0.0677)
High Unconditional Cooperators	0.785***	0.562**	0.542**	0.585**
	(0.222)	(0.248)	(0.256)	(0.261)
Conditional Cooperators	0.417**	0.121	0.0770	0.0858
	(0.148)	(0.213)	(0.224)	(0.222)
Medium Unconditional Cooperators	0.238	0.152	0.164	0.182
	(0.155)	(0.167)	(0.180)	(0.169)
Other	0.633***	0.421*	0.394	0.400
	(0.196)	(0.243)	(0.258)	(0.247)
Socio-demographics				
Male			0.0630	0.0639
			(0.206)	(0.207)
Age			0.000918	0.0000688
			(0.00754)	(0.00703)
Years of schooling completed			0.0474*	0.0454*
			(0.0263)	(0.0262)
Number of household members			0.0166	0.0147
			(0.0629)	(0.0618)
HH receives remittances			-0.0792	-0.0730
			(0.128)	(0.136)
Social Capital				
Member in a water and/or fisher association				0.181
				(0.156)
Expected help of neighbours in contributing to community tasks				-0.0137
				(0.0328)
Constant	2.868***	2.887***	2.545***	2.556***
	(0.322)	(0.289)	(0.478)	(0.608)
Village fixed effects		√	√	√
Framing	√	√	√	√
Observations	301	301	280	280
R^2	0.087	0.206	0.229	0.232
Adjusted R^2	0.069	0.130	0.132	0.129

Standard errors in parentheses, clustered on village level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A potential caveat is of course the very fact that the threshold game is nonlinear and therefore a linear regression may not be the best specification to explain contributions. Therefore, we run alogit logit model where we try to explain whether individuals contribute (i) less than the symmetric cooperative Nash equilibrium (SCNE), (ii) more than the SCNE, and (iii) exactly the SCNE. We code those as dummy variables to test for the impact of risk aversion on those different contribution levels (see table A.4).

We still do not see any effect of risk preferences, but again the cooperative behaviour types are significant. High unconditional cooperators have a higher probability of contributing above the SCNE, conditional cooperators do not have a higher probability of playing one of those strategies and medium unconditional cooperators have a higher probability to play the SCNE. Neither the socio-demographic variables, nor community related variables have any significant effect.

[7] The exact question in the survey was: “Suppose that 10 of your neighbors are invited to help in community activities (e.g. repairing a canal or dam). How many would show up?” The possible answers ranged from 0 to 10.

5. Discussion and Conclusion

A key question in the literature concerns the individual and contextual factors around cooperation in social dilemma situations. An inherent feature of social dilemmas is the fear of being exploited or betrayed by others, which has been coined "social uncertainty". In addition, some games feature an additional source of risk or "strategic uncertainty", as socially and privately optimal strategies depend on actions of others.

The predominant way to analyse social dilemma situations is the use of the linear public good game, where the strategies to achieve the social optimum are independent of behaviour of others and, hence, strategic uncertainty is absent. In this paper we analyse the underlying factors of cooperation in (i) a linear public good game without strategic uncertainty and (ii) a threshold public good game with strategic uncertainty. By running both games we are able to analyse the determinants of contribution levels in light of social and strategic uncertainty.

We find that cooperative behaviour types play a role for contribution levels with and without strategic uncertainty. Yet, the differences between the cooperative behaviour types are less pronounced in the threshold public good game. The symmetric cooperative Nash equilibrium serves as a clear focal point which may put individuals in a mode of coordination, rather than cooperation. Also, our social capital variables explain partially cooperation in the linear public good game, but not in the threshold public good game, lending further support to the idea that the threshold public good game is not necessarily perceived as a game of cooperation only.

While risk aversion plays a role in the linear public good game, we cannot find any impact of risk aversion in the threshold public good game. This finding is somewhat surprising given that the threshold game has a very clear risk component of failing to reach the threshold (the strategic uncertainty), in addition to the social uncertainty of deviating from the social norm of what others are doing. In regard to social capital we find that low social capital leads to higher contributions in the threshold game than in the linear public good game. To some extent, the threshold acts as a focal point which people aim towards and are also prepared to contribute more than their fair share. Thus, the focal point reduces social risk to a certain extent. An obvious follow up experiment would be to explore the role of social risk further, and allow for a treatment where co-players would be computers, rather than humans (Bohnet et al., 2008; Bolton, Feldhaus, & Ockenfels, 2016).

It is worth comparing our results to coordination games, such as the stag hunt game that share some features with threshold public good games. Coordination games have two Nash equilibria, and some studies compared behaviour when one equilibrium has higher payoffs, but also higher risk than the other. It has been shown that social capital variables such as trust do indeed lead to choosing the pay-off dominant option as long as the other person is perceived as trustworthy (Whiteman & Scholz, 2010; Büyükboyacı, 2014; Bosworth, 2013). The effect of risk aversion in stag hunt games is less clear. While a frequent pattern is that risk aversion leads to choosing the risk-dominant option (Girtz, Hill, & Owens, 2017; Whiteman & Scholz, 2010; Bolton et al., 2016), Büyükboyacı (2014) finds that coordination does not depend on the individuals risk preference but on the assumed risk preference of the partner while Al-Ubaydli, Jones, and Weel (2013) find no effect at all.

In both games the most frequently observed contribution level is 50% of the endowment. The tendency to contribute around 50% of the endowment has been observed many times before (Ledyard, 1995; Fehr & Fischbacher, 2003; Burton-Chellew & West, 2013). In a setting where the symmetric cooperative Nash equilibrium corresponds to 50% of the endowment this choice is observed even more frequently. Thus, the observed welfare levels are considerably higher in the threshold public good game than in the linear public good game. While it is generally difficult to compare welfare levels across games, setting the symmetric cooperative Nash equilibrium to 50% probably made coordination easier because it is the point that maximizes social welfare and is also in line with a fairness norm to contribute around 50% of the endowment. Future research could test cooperation in strategic interaction settings where the symmetric cooperative Nash equilibrium differs from the preferred contribution level of 40 - 50% (Hichri, 2004; Willinger & Ziegelmeyer, 1999). One confounding effect in our setup could be that the linear public good game is played with two players while the threshold game is played by three players. This is an important difference in the games, as cooperating with one other person is perhaps less abstract than cooperating with two people. So while we observe that social capital and risk preferences affect behaviour in the linear public goods game, we do not know whether this effect is getting weaker as number of players, and also cognitive load, increases.

Finally, many real world social dilemmas, such as harvesting a renewable resource or contributing to joint infrastructure, resemble a threshold game. However, the linear public good game remains the key device to measure cooperation in most experimental research. Our results suggest that the determining factors in a linear public good game do not necessarily carry over to a threshold game. While our experiments are conducted in a specific Cambodian context and thus may not be generalisable, they do raise the question to what extent results from linear public good games can be used to explain cooperation in the field.

Declaration of Competing Interest

None

Acknowledgements

We are grateful to Francisco Alpizar and Silke Gabbert, as well as the editor and two anonymous reviewers for valuable comments on a previous version of this manuscript.

This work has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 675997 as well as funding from the Center for Khmer Studies, project number 900-185.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.socec.2020.101642.

References

Al-Ubaydli, O., Jones, G., & Weel, J. (2013). Patience, cognitive skill, and coordination in the repeated stag hunt. *Journal of Neuroscience, Psychology, and Economics, 6(2)*, 71–96.

Anderson, L. R., Mellor, J. M., & Milyo, J. (2004). Social capital and contributions in a public-goods experiment. *American Economic Review, 94*(2), 373–376.

Au, W. (2004). Criticality and environmental uncertainty in step-level public goods dilemmas. *Group Dynamics: Theory, Research, and Practice, 8*(1), 40.

Barrett, S., & Dannenberg, A. (2014). Sensitivity of collective action to uncertainty about climate tipping points. *Nature Climate Change, 4*(1), 36.

Barrett, S., & Dannenberg, A. (2016). An experimental investigation into 'pledge and review' in climate negotiations. *Climatic Change, 138*(1-2), 339–351.

Bohnet, I., Greig, F., Herrmann, B., & Zeckhauser, R. (2008). Betrayal aversion: Evidence from Brazil, China, Oman, Switzerland, Turkey, and the United States. *American Economic Review, 98*(1), 294–310.

Bolton, G. E., Feldhaus, C., & Ockenfels, A. (2016). Social interaction promotes risk taking in a stag hunt game. *German Economic Review, 17*(3), 409–423.

Bosworth, S. J. (2013). Social capital and equilibrium selection in stag hunt games. *Journal of economic psychology, 39*, 11–20.

Bouma, J., Bulte, E., & van Soest, D. (2008). Trust and cooperation: Social capital and community resource management. *Journal of Environmental Economics and Management, 56*(2), 155–166.

Burton-Chellew, M. N., & West, S. A. (2013). Prosocial preferences do not explain human cooperation in public-goods games. *Proceedings of the National Academy of Sciences, 110*(1), 216–221.

Büyükboyacı, M. (2014). Risk attitudes and the stag-hunt game. *Economics Letters, 124* (3), 323–325.

Cadsby, C. B., & Maynes, E. (1999). Voluntary provision of threshold public goods with continuous contributions: experimental evidence. *Journal of Public Economics, 71*(1), 53–73.

Cárdenas, J.-C., Janssen, M. A., Ale, M., Bastakoti, R., Bernal, A., Chalermphol, J., , … Wang, Y., et al. (2017). Fragility of the provision of local public goods to private and collective risks. *Proceedings of the National Academy of Sciences, 114*(5), 921–925.

Charness, G., & Villeval, M.-C. (2009). Cooperation and competition in intergenerational experiments in the field and the laboratory. *American Economic Review, 99*(3), 956–978.

Chou, C. (2010). *The local governance of common pool resources: The case of irrigation water in Cambodia*. Cambodia Development Resource Institute Phnom Penh.

Chou, C., Nang, P., Whitehead, I., Hirsch, P., & Thompson, A. (2011). *Decentralised governance of irrigation water in Cambodia: Matching principles to local realities*. CDRI.

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

Fallucchi, F., Luccasen, R. A., & Turocy, T. L. (2018). Identifying discrete behavioural types: A re-analysis of public goods game contributions by hierarchical clustering. *Journal of the Economic Science Association*, 1–17.

Fehr, E., & Fischbacher, U. (2003). The nature of human altruism. *Nature, 425*(6960), 785.

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

Fischbacher, U., Gächter, S., & Quercia, S. (2012). The behavioral validity of the strategy method in public good experiments. *Journal of Economic Psychology, 33*(4), 897–913.

Gangadharan, L., & Nemes, V. (2009). Experimental analysis of risk and uncertainty in provisioning private and public goods. *Economic Inquiry, 47*(1), 146–164.

Girtz, R., Hill, J., & Owens, M. (2017). Risk preferences, responsibility, and self-monitoring in a stag hunt. *Journal of behavioral and experimental economics, 68*, 53–61.

Gneezy, U., Leibbrandt, A., & List, J. A. (2015). Ode to the sea: Workplace organizations and norms of cooperation. *The Economic Journal, 126*(595), 1856–1883.

Gneezy, U., & Potters, J. (1997). An experiment on risk taking and evaluation periods. *The Quarterly Journal of Economics, 112*(2), 631–645.

Gustafsson, M., Biel, A., & Gärling, T. (2000). Egoism bias in social dilemmas with resource uncertainty. *Group Processes & Intergroup Relations, 3*(4), 351–365.

Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H., & McElreath, R. (2001). In search of homo economicus: behavioral experiments in 15 small-scale societies. *American Economic Review, 91*(2), 73–78.

Hichri, W. (2004). Interior collective optimum in a voluntary contribution to a public-goods game. *Applied Economics Letters, 11*(3), 135–140.

İriş, D., Lee, J., & Tavoni, A. (2019). Delegation and public pressure in a threshold public goods game. *Environmental and Resource Economics, 74*(3), 1331–1353.

Isaksen, E. T., Brekke, K. A., & Richter, A. (2019). Positive framing does not solve the tragedy of the commons. *Journal of Environmental Economics and Management, 95*, 45–56.

Janssen, M. A., Lindahl, T., & Murphy, J. J. (2015). Advancing the understanding of behavior in social-ecological systems: results from lab and field experiments. *Ecology and Society, 20(4):34*(4).

Kerr, N. L. (1983). Motivation losses in small groups: A social dilemma analysis. *Journal of Personality and Social Psychology, 45*(4), 819–828.

Kocher, M. G., Martinsson, P., Matzat, D., & Wollbrant, C. (2015). The role of beliefs, trust, and risk in contributions to a public good. *Journal of Economic Psychology, 51*, 236–244.

de Kwaadsteniet, E. W., van Dijk, E., Wit, A., & Cremer, D. D. (2008). ‘How many of us are there?’: Group size uncertainty and social value orientations in common resource dilemmas. *Group Processes & Intergroup Relations, 11*(3), 387–399.

Lade, S. J., Tavoni, A., Levin, S. A., & Schlüter, M. (2013). Regime shifts in a social-ecological system. *Theoretical ecology, 6*(3), 359–372.

Ledyard, J. O. (1995). *Public goods: A survey of experimental research.* In R. A. Kagel, J. (Ed.). Princeton University Press, Princeton.

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

Ockenfels, A., & Weimann, J. (1999). Types and patterns: an experimental East-West-German comparison of cooperation and solidarity. *Journal of Public Economics, 71*(2), 275–287.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press.

Perera, L. (2006). *Factors affecting the formation of FWUCs in institution building for PIMD in Cambodia: Two case studies. 113*. IWMI.

Richter, A., Schuch, E., & Nhim, T. (2020). Pre-analysis plan: Cooperation under uncertainty in natural resource management. *OSF. doi:10.17605/OSF.IO/U3GC8.*

Rustagi, D., Engel, S., & Kosfeld, M. (2010). Conditional cooperation and costly monitoring explain success in forest commons management. *Science, 330*(6006), 961–965.

Schill, C., Lindahl, T., & Crépin, A.-S. (2015). Collective action and the risk of ecosystem regime shifts: insights from a laboratory experiment. *Ecology and Society, 20(1):48* (1).

Schuch, E., Nhim, T., & Richter, A. (2020). A threshold public good game with public good and public bad framing - evidence from farmers and fishers in cambodia. *Working Paper*.

van Soest, D., Stoop, J., & Vyrastekova, J. (2016). Toward a delineation of the circumstances in which cooperation can be sustained in environmental and resource problems. *Journal of Environmental Economics and Management, 77*, 1–13.

Suleiman, R., Budescu, D. V., & Rapoport, A. (2001). Provision of step-level public goods with uncertain provision threshold and continuous contribution. *Group Decision and Negotiation, 10*(3), 253–274.

Tavoni, A., Dannenberg, A., Kallis, G., & Löschel, A. (2011). Inequality, communication, and the avoidance of disastrous climate change in a public goods game. *Proceedings of the National Academy of Sciences, 108*(29), 11825–11829.

Whiteman, M. A., & Scholz, J. T. (2010). Social capital in coordination experiments: Risk, trust and position. *Working Papers*, (Paper 50).

Willinger, M., & Ziegelmeyer, A. (1999). Framing and cooperation in public good games: an experiment with an interior solution. *Economics letters, 65*(3), 323–328.

Wit, A., & Wilke, H. (1998). Public good provision under environmental and social uncertainty. *European Journal of Social Psychology, 28*(2), 249–256.