Centralized common pool management and local community participation*

Jana Vyrastekova and Daan van Soest

Tilburg University

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Abstract. Unrestricted access to common-pool resources leads to individually rational extraction levels that are suboptimally high from a social perspective. In an experimental setting, we analyze to what extent local community participation can enhance the effectivity of a centralized enforcement institution aimed at decreasing aggregate extraction. We hypothesize that, by letting the resource users vote on the incentive structure faced by the enforcement institution, they can communicate their view on the desirability of reduced aggregate extraction. The results are mixed. On the one hand, less than half of all voting outcomes in the local participation treatment are in favor of awarding appropriate policing incentives to the enforcement institution. On the other hand, conditional upon having voted for the appropriate incentive structure, behavior in games with local participation is more cooperative than that in games where the incentives are imposed exogenously on the enforcement institution. These observations can be explained by the presence of subjects with reciprocal preferences in the subject pool, and by their interaction with the enforcement institution's constraints.

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1 Introduction

Biodiversity decreases either directly through overharvesting of a specific species or indirectly through the excessive use of an ecosystem that provides habitat to a variety of species. Typically, even in the absence of positive non-use externalities associated with biodiversity or habitat conservation, privately optimal extraction of a common pool resource (CPR) may result in socially suboptimal conservation levels due to the presence of appropriation externalities, where increased resource extraction by one user reduces the net yield obtained by other users either instantaneously, or over time (Ostrom et al. [8]: 11). And even though CPRs (where access to the resource is limited to members of a community or a well-defined social group) are not necessarily overexploited as local institutions may be sufficiently effective in enforcing extraction and conservation decisions, in practice many of them are under the threat of depletion.

The presence of appropriation externalities implies that there is a need for coordination among resource users, or even cause for government intervention. With respect to the latter, actual results of government intervention in the management of natural resources are mixed. Although many factors can be identified as possible causes of intervention failures, in developing countries the lack of sufficient financial means to adequately monitor the use of (sizable) resources is prominent (Knox and Meinzen-Dick [6]). In addition, moral hazard problems play an important role in the sense that the government institution implementing actual resource management does not always face appropriate incentives to prevent excessive harvesting. In the absence of government intervention, coordination among resource users is also not found to be very successful, at least in economic experiments. In this field, much attention has been devoted to decentralized sanctioning mechanisms, where each individual group member can inflict a pecuniary punishment on other resource users. This type of community self-regulation is observed in reality (see, e.g. Balland and Platteau [2]), but experiments point out that the net effect of decentralized sanctioning is negligible (Ostrom, Gardner and Walker [8], Ostrom, Gardner and Walker [7], Keser and Gardner [5]). Indeed, Ostrom et al. [7] observed that punishment was motivated by emotions such as spite or revenge, and that the aggregate benefits of resource use even turned out to be lower than in the absence of any enforcement mechanisms. Face-to-face communication, however, is found to facilitate cooperation among CPR users, enhancing net efficiency of the resource use (see for example Ostrom, Gardner and Walker [8], Ostrom, Gardner and Walker [7]). These results suggest that efficiency of resource use could be enhanced by introducing a centralized sanctioning institution which allows for an institutionalized form of communication among the resource users, such as voting.

In an experimental setting, we explore the effectiveness of such an institution using a simple CPR game, which embodies the above-mentioned appropriation externalities. We assume perfect information on the part of the users concerning the extraction activities of other users, ignoring thereby the monitoring problems at the local level. The resource users' interaction is modelled as a finitely repeated game, both in order to avoid the complexity of truly dynamic games in the experiment[1] and equilibrium multiplicity.[2] With respect to the principal-agent relationship between the central government and the enforcement institution hinted at above, we assume that the government cannot directly monitor the institution's activities. Therefore, the government can only pay the enforcer a fixed wage, but may provide better sanctioning incentives by allowing the enforcer to keep the enforcement revenues (that is, the fines).

The behavior of human subjects is studied under three institutional variations. First, we analyze a CPR game in the absence of a norm enforcement institution. To induce resource users to focus on discovering the mechanisms of cooperation rather than on finding out the consequences of free-riding behavior, we inform the subjects explicitly about the socially optimal extraction level as well as about the importance of trust and cooperation for sustaining that socially optimal behavior. Next, we expose each subject to one of two alternative environments in which an enforcement institution is present. The institutional element that we vary is the incentive structure of that enforcement institution. In one case, the policy enforcer receives the revenues of his/her enforcement activity, that is the fines collected from resource users who extract more than is socially optimal. In the other case, the incentives of the enforcement institution are not imposed exogenously by the experimenters, but endogenously decided upon by majority voting by the resource users themselves. More specifically, we allow resource users to vote on whether or not the norm enforcer is allowed to keep any fines levied, or not. The voting stage plays two roles. First, it meets the recommendation of many researchers in the field (see for example Agrawal and Yadama [1], and Knox and Meinzen-Dick [6]), that enforcement institutions should be made accountable to the local group in order to avoid dissolution between the incentives of the resource users and the policy maker. In addition, the voting may serve as a means for resource users to communicate their stance with respect to the need to reduce aggregate extraction, and hence play a similar role as the face-to-face communication discussed above (see for a similar argument e.g. Witt [10]).

We hypothesize that the introduction of an enforcement institution may improve the efficiency of resource use, but that the outcome depends on the incentives faced by the enforcer. Further, we hypothesize that efficiency of resource use is higher if the enforcement institution is awarded appropriate sanctioning incentives by the resource users' voting decision rather than if these are imposed exogenously by the central government. Thus, we analyze the role of voting in coordinating extraction behavior among resource users. We try to distinguish between the role of voting as a coordination device and its role of informing resource users about the characteristics of the CPR, thus increasing 'problem awareness'. We create problem awareness by announcing the social norm beforehand. Thus, we can test whether in the presence of perfect problem awareness, there is still a specific role for community participation (for example via voting), or whether simply a

[1] Herr et al. [4] compare behavior of experienced subjects in a static repated common-pool game and in a truly dynamic common-pool game. In the repeated game, symmetric subgame perfect Nash equilibrium is a better predictor of behavior than the efficient extraction. In the dynamic game, the extractions are closer to the myopic prediction (calculated by ignoring the today's extraction effect on tomorrow's costs) than to the symmetric subgame perfect Nash Equilibrium. To eliminate the forward-looking and learning problems in our experiment, we choose to study a static repeated game.

[2] Refereing to Folk theorem for infinitely repeated games, any individually rational payoff vector can be obtained as equilibrium outcome.

clear statement by the government with respect to the CPR's functioning can effectively replace local community participation.

The set-up of the paper is as follows. In section 2 we present the common pool game and discuss the game-theoretic predictions of the game without any enforcement (in the experiments referred to as Base treatment), and the two centralized enforcement games, one with exogenous incentives for the enforcement institution (in the experiments referred to as Transfer treatment), and a second with endogenous incentives, established by majority voting (in the experiments referred to as Vote treatment). In section 3 we formulate our game-theoretic and behavioral hypotheses and in section 4 we present the experiment design. The experimental data are analyzed in section 5, and section 6 concludes.

2 The model

The management of a natural resource by a group of individuals is modelled as follows. There is a finite number of members of a community (hereafter referred to as "users"), $N > 1$, who have access to a common pool resource (CPR). Each user has the same endowment of effort, e, that he/she can allocate between CPR extraction activities and an alternative type of activity, the outside option. All N users are assumed to be identical with respect to their preferences over the resource consumption and the alternative. Extraction effort exerted by user $i = 1, ..., N$ is denoted by x_i, and hence user i's effort devoted to the outside option is $(e - x_i)$. The outside option yields a fixed per-unit wage rate, w, and extraction costs are assumed to be linear in effort with constant marginal cost equal to c. In line with earlier work on CPRs (see for example Ostrom et al. [8]), we assume that total revenues obtained from resource extraction in period t, R_t, depend on the aggregate amount of harvesting effort, $X_t = \sum_{i=1}^{N} x_{it}$, according to the following equation:

$$R(X_t) = AX_t - BX_t^2. \tag{1}$$

We assume the game to be static (in the sense that revenues in one period only depend on the (aggregate) amount of extraction effort exercised in that period), and therefore we drop time subscripts in the rest of this section.

As all individual resource users are assumed to be identical, each user's revenues r_i are proportional to his/her share in total extraction effort:

$$r(x_i, X) = \frac{x_i}{X} R(X) = x_i [A - BX] \tag{2}$$

and hence user i's objective can be written as:

$$\max_{x_i \in [0,e]} \pi_i(x_i, X) \tag{3}$$

$$\text{where } \pi_i(x_i, X) = w(e - x_i) + \frac{x_i}{X}\left[AX - BX^2\right] - cx_i. \tag{4}$$

Social welfare (measured as the unweighted sum of users' payoffs) is maximized if aggregate extraction X is equal to X^*,

$$X^* = \frac{A - c - w}{2B}; \tag{5}$$

we assume that $A - c - w > 0$. While the socially optimal resource use does not exclude asymmetric distributions of payoffs among the users, our benchmark is the equitable extraction level x^*:

$$x^* = \frac{A - c - w}{2NB}. \tag{6}$$

In the absence of sidepayments, this extraction leads to both efficient resource extraction and an equitable payoff distribution among the resource users.

2.1 Resource use in the absence of enforcement

Let us denote the CPR game in the absence of enforcement by G_0. In this game, user i maximizes (3) taking the aggregate extraction of all other users $X_{-i} = \sum_{j \neq i} x_j$ as given. The necessary (and sufficient) condition that determines user i's optimal extraction is given by:

$$\frac{\partial \pi_i(x_i, X_{-i})}{\partial x_i} = A - c - w - B(x_i + X_{-i}) - Bx_i = 0. \tag{7}$$

Hence, user i's best response function is given by:

$$x_i(X_{-i}) = \frac{A - c - w}{2B} - \frac{X_{-i}}{2}. \tag{8}$$

The symmetric Nash equilibrium extraction x^{NE} in the absence of any enforcement institution in the common pool problem is then equal to:

$$x^{NE} = \frac{A - c - w}{B(N + 1)}. \tag{9}$$

Comparing (9) to (6), it is obvious that $x^{NE} > x^*$ since $N > 1$.

For a graphical illustration of the symmetric Nash equilibrium, see Figure 1. In this figure, the weakly downward-sloping line is the best-response function of user i given the aggregate extraction of all other users, X_{-i}. The solid upward-sloping line represents the symmetric extraction function (where each user extracts the same amount of the resource). The intersection of these two lines denotes the symmetric Nash equilibrium. The figure is drawn for the actual parameter values that were used in the experiment.

2.2 Resource use in the presence of enforcement

The fact that each individual user has an incentive to extract more than is socially optimal implies that there may be a case for government intervention. The government can announce an extraction norm and establish an institution overseeing and enforcing the

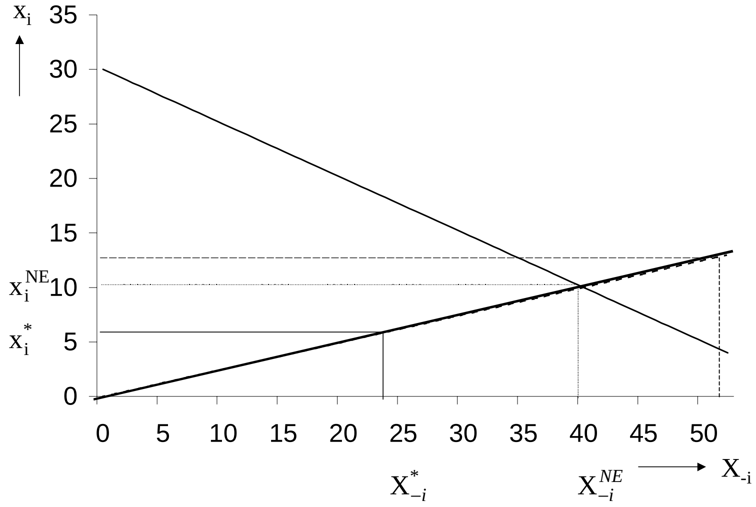

Figure 1: Best response function of user i in game G_0 for parameter values: $N = 5$, $A = 11.5$, $B = 0.15$, $c = 2$, $w = 0.5$, $e = 13$. Dotted upward-sloping line: combinations of x_i and X_{-i} that reflect equal extraction levels among resource users.

norm. Suppose that this is the case. The government announces the norm equal to the socially optimal extraction level x^* as defined in (6). Moreover, the government establishes an institution that is entrusted with the enforcement of this norm. Let us refer to this institution as the police officer. The police officer has the right to take to court all users who extract more from the resource more than is prescribed by the norm. We assume that the central government faces information constraints with respect to norm enforcement: it cannot directly monitor the behavior of resource users, nor the enforcement activity of the police officer. Together, these information constraints imply that the government can at best pay a fixed wage to the police officer. The lack of rewards connected to the police officer's performance gives rise to severe moral hazard problems leading to inactivity of the enforcement institution, which may be solved by allowing the police officer to keep any fines collected. The fines themselves however, are subject to approval by the court to avoid corruption problems. The evidence collected may not always be sufficient for a conviction, and hence the court outcome is uncertain.

This view of the world is translated into a game as follows. The common pool game with centralized enforcement and the (probabilistic) transfer of the fines to the police officer is denoted by G_T. In this game, there are N resource users and one additional player, a police officer. The users choose their extraction levels. We assume that the police officer has perfect information with respect to individual extraction decisions, but has to incur costs when taking norm violators to court. More specifically, we assume that the cost of filing a 'law suit' equals K ($K > 0$), independent of the number of resource users violating the norm. This cost may be understood as the cost the police officer's time spent at work, and the fact that it is lump-sum reflects the existence of substantial economies of scale with respect to the enforcement activity. In addition, the outcome of the law suit is assumed to be probabilistic, where each of the norm violators faces a probability p $(0 < p < 1)$ that he/she will be convicted and be forced to pay a fine.

The objective function of user i, equation (3), needs to be adjusted to incorporate (expected) fines in case his/her extraction level exceed norm x^*. Hence, user i's objective function reads as:

$$\max_{x_i \in [0,e]} \quad \hat{\pi}_i(x_i, X) \tag{10}$$

$$\text{where } \hat{\pi}_i(x_i, X) = w(e - x_i) + \frac{x_i}{X}\left[AX - BX^2\right] - cx_i - Mpf \max\{(x_i - x^*), 0\} \tag{11}$$

where f is the fine levied for each unit of x_i in excess of the norm x^*, M is an indicator function that denotes whether the police officer decides to take norm violators to court ($M = 1$) or not ($M = 0$), and p is the probability that norm violators are convicted when taken to court. Here, p is assumed to be given, but M is a choice variable of the police officer.

The police officer appointed by the government receives a fixed wage W as well as all fines collected in court. The police officer observes extraction levels of all users, and decides whether to start the law suit procedure ($M = 1$), or not ($M = 0$). Starting the procedure implies incurring a fixed cost K, and the expected benefits are equal to $\sum_{i=1}^{N} \max\{0, pf(x_i - x^*)\}$. Depending on the parameter values p and f, the introduction of this enforcement type does not necessarily implement the social optimum. The parameter p can be seen as exogenous characteristics of the environment (the success rate of collecting evidence of a law suit may depend on how accessible the monitored area is etc.), and parameter f as policy device of the government (the "strictness" of the law). Because of various reasons (the fine has to fit the crime etc.) it may be unfeasible to increase the expected fine to a level where the Nash equilibrium coincides with the social optimum. Therefore, we fix the experimental parametrization values such that game G_T does improve upon game G_0 in terms of efficiency, but is not expected to achieve the first best. This set-up allows us to distinguish between equilibrium behavior (partial improvement upon G_0) from disequilibrium behavior (full improvement upon G_0).

We look for a symmetric equilibrium where all resource users choose the same extraction $\hat{x}$ which is such that $x^* < \hat{x} < x_{NE}$. The police officer is expected to take norm violators to court if the net expected benefits of doing so are positive. In symmetric equilibrium, the police officer will set $M = 1$ if:

$$Npf(\hat{x} - x^*) > K, \tag{12}$$

Therefore, if all users choose $\hat{x} = x^* + (K/Npf)$, the police officer is indifferent between taking and not taking the group to court.[3] Symmetric equilibrium extraction will be higher (i) the higher the costs of filing a law suit K, (ii) the smaller the group N (due to the fixed-costs nature of taking any number of norm violators to court), (iii) the smaller the

[3] Oberve that the social optimum can be implemented if the costs of filing a law suit are zero, in which case all group members choose x^* and the police officer's income equals W.

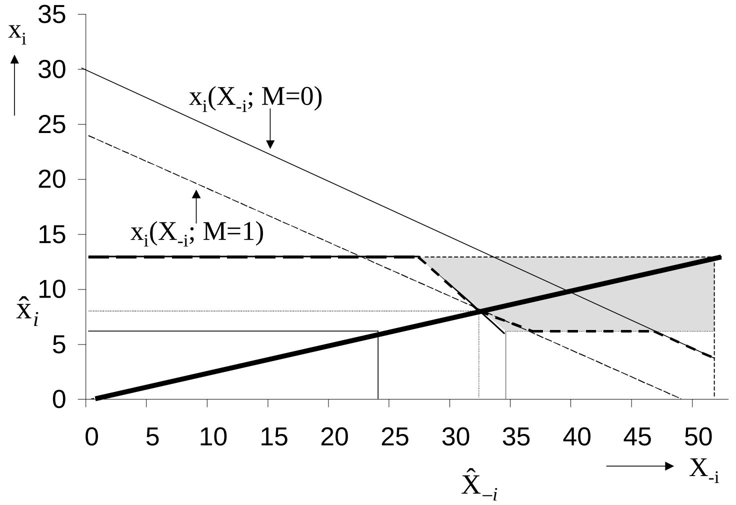

Figure 2: Best response function (striped line) of user i in game G_V for parameter values: $N = 5$, $A = 11.5$, $B = 0.15$, $c = 2$, $w = 0.5$, $e = 13$. Thick upward sloping line: combinations of x_i and X_{-i} that reflect equal extraction levels among resource users.

likelihood of being convicted p and (iv) the lower the fine per unit of excessive extraction f.

In Figure 2, the grey region indicates the combinations of x_i and X_{-i} for which user i expects to be taken to court, given the experiment parametrization. This figure shows that, for sufficiently low levels of X_{-i}, user i can put in all his effort endowment into extraction activities ($x_i = e$) without triggering the police officer to become active. However, for sufficiently high X_{-i}, extracting more than the social optimum ($x_i > x_i^*$) would render user i vulnerable to a fine. The downward sloping part of the no-enforcement region denotes the combinations of x_i and X_{-i} for which the ex-ante revenues of enforcement just fall one extraction unit short of being equal to the fixed costs of enforcement, K.

The best-response function of a resource user i, given the constraint (12), now depends on whether the aggregate extraction triggers the police officer to be active, or not. User i 's best response function equals:

$$x_i\,(X_{-i}, M) = \frac{1}{2B}(A - c - w - BX_{-i} - Mpf)$$

where $M = 0$ if $\sum_j \max\{0, (x_j - x^*)\} < \frac{K}{pf}$ and $M = 1$ if $\sum_j \max\{0, (x_j - x^*)\} > \frac{K}{pf}$. Note that user i's decision may result in the police officer becoming active, or not active, given the actions of the other group members, X_{-i}. The equilibria of the game depend on the parameter values chosen.

For the parameterization chosen in the experiment, user i's best response function is represented by the dotted line in Figure 2. If the other users devote almost all their effort endowment into resource extraction, user i's best response is to extract less than the social norm, which implies that he/she is not eligible to be fined; the appropriate best-response function is equation (8), which is represented by the line $x_i(X_{-i}; M = 0)$.[4] For slightly lower levels of X_{-i} user i would extract more than the social norm if that decision would not trigger the police officer to become active. However, for the parameter values fixed in the experiment, the police officer will be triggered to take user i to court (along with the other norm violators), and hence the best-response function in case the police officer is active ($x_i(X_{-i}; M = 1)$), now becomes relevant. For even lower levels of X_{-i}, the best-response function traces the region where, in expectation, it is not profitable for the police officer to take the norm violators to court. The symmetric Nash equilibrium in the game with enforcement G_T leading to extraction by any user i, $x_i = \hat{x}$, is such that each user puts in so much effort that it is not profitable for the police officer to take the group to court, but only just so.

2.3 Enforcement with local community participation

In this subsection, we introduce the game in which prior to choosing extraction levels, the users vote on the police officer's incentives. In particular, the users attain the power to vote on the allocation of the enforcement revenues, and majority rule determines whether the fines are transferred to the enforcement institution, or not; in the latter case, the fines can be considered to be 'burned'. The game is as the previous game G_T in all respects except for the presence of a voting stage prior to the resource extraction stage. The consequences for the resource extraction decisions depend on the voting outcome, and hence this treatment allows us to analyze whether delegation of the power over the police officer's incentives to the resource users improves the behavior as compared to the games discussed above. Let us denote this CPR game by G_V.

The decision-making in one round of game G_V is as follows. In the first stage, the voting stage, all N users vote whether the money collected as fines in court stage (stage three) shall be transferred to the police officer, or not. In the second stage, the extraction stage, all players (including the police officer) observe the voting outcome. Next, the users choose independently and simultaneously their extraction levels. In the third stage, the court stage, all players observe the extraction decisions of all resource users, and the police officer decides whether to take the norm violators to court, or not. Any fines collected are either transferred to the police officer, or burned, depending on the voting outcome in the voting stage. Before proceeding to the next round, the users are informed whether the police officer took the group to court or not. The users as well as the police officer learn the final payoffs (including any fines) of all users.

In the voting stage, user i submits a vote $v_i \in \{0, 1\}$,where $v_i = 1$ (0) signifies that user i is in favor (not in favor) of transferring any fines levied in the current period to the police officer. The outcome of the voting is decided by a majority rule.

Consider first the subgame which arises when the voting outcome is such that the fines (if any) are not transferred to the police officer but flow into the central government's

[4] Note that the police officer will be active as the exoected value of taking the norm violators to court, is positive. However, user i is not eligible to be fined as his/her extraction level is less than or equal to the social norm.

treasury and hence, from the viewpoint of this game, can be considered as burned. Given that taking norm violators to court is costly for the police officer, there is no incentive for her to enforce the social norm in this case. Indeed, her payoff equals $W - K$ in case she takes one or more norm violators to court, and W if she does not enforce the norm. A money-maximizing police officer, therefore, will set $M = 0$ with probability 1 in equation (10), and the privately optimal extraction level for each resource user will be x^{NE}.

Consider now the subgame which arises when the voting outcome is such that any fines collected are transferred to the police officer. As discussed in subsection 2.2, the strategy choices by the police officer and the users depend on the particular parametrization of the game. For the parametrization used in the experiment (see section 2.2), the symmetric equilibrium extraction level $\hat{x}$ is such that the expected revenues of taking the group to court just fall short of the fixed costs of filing a law suit, and hence the police officer decides not to take the group to the court.

Clearly, the equilibria where the police officer is voted not to receive the fines are payoff-dominated by the equilibria where the police officer is voted to receive the fines. Nevertheless, from a purely game-theoretic viewpoint, this is not sufficient for disqualifying them immediately. Payoff dominance is a very attractive property, but there is evidence in the literature that other aspects of a game (e.g. riskiness of an equilibrium) can affect the propensity of players to choose such an equilibrium. From this viewpoint, we test experimentally (i) whether the payoff-dominant equilibrium is chosen invariantly in this game, and (ii) whether voting serves as a device signalling the intentions to decrease extraction levels among the group members, having an impact on actual extraction behavior.

3 Hypotheses

Assuming that subjects maximize their own payoffs, we can formulate Nash equilibrium hypotheses with respect to (i) the resource user's extraction behavior, and (ii) the police officer's enforcement behavior. Besides these Nash equilibrium hypotheses, we add two hypotheses not stemming from the game-theoretic analysis. One is the awareness hypothesis (iii) with respect to the role of public announcements of the socially optimal (but individually irrational) extraction level in game G_0. The second is the local participation hypothesis (iv) with respect to the role of voting as a belief-aggregating and communication device (and hence refers to the equilibrium selection problem in game G_V).

Let us discuss the four types of hypotheses in a little more detail, starting with the Nash equilibrium hypotheses on the behavior of resource users.

Nash equilibrium extraction hypothesis A resource user behaves as a rational, own-payoff maximizing agent, and expects that other players are also motivated exclusively by own material outcomes. This holds for the user's expectations with respect to the behavior of other resource users in all three games, but also for the behavior of the police officer in games G_T and G_V. On the basis of these expectations, each user chooses extraction x equal to the Nash equilibrium extraction level, i.e. (i) in game G_0, he/she chooses $x = x_{NE}$, (ii) in game G_T, he/she chooses $x = \hat{x}$, and (iii) in game G_V, he/she chooses $x = \hat{x}$ if $M = 1$ and $x = x_{NE}$ if $M = 0$.

According to this hypothesis, the extraction levels will be highest in game G_0 and lowest in game G_T. If we denote a representative user's extraction (payoff) in game $g \in \{0, V, T\}$ by x^g (π^g), we can rank the equilibrium extractions (payoffs) as follows: $x^0 \geq x^V \geq x^T$ ($\pi^0 \leq \pi^V \leq \pi^T$). The weak inequality signs refer to the fact that at this moment, we do not make any assumptions with respect to the voting outcomes in game G_V; in any round, the majority of the resource users may vote against transferring the fines to the police officer (in which case $M = 0$ and $x^V = x^0 = x_{NE}$), or in favor (in which case $M = 1$ and $x^V = x^T = \hat{x}$).

Before elaborating on the Nash equilibrium hypothesis regarding the police officer's behavior, we state the alternative hypothesis (iii) for game G_0, where no enforcement takes place. In the experiment, we induce problem awareness in game G_0 as follows. Before starting the game, we informed the experiment participants collectively (during the instruction reading) about the symmetric socially optimal extraction level. Moreover, we also pointed out the risks of other resource users free-riding at the socially optimal extraction choice, and we stressed the importance of trust and compliance with the norm for achieving the socially optimal outcome. Publicly announcing these two pieces of information allows us to obtain insight into what renders face-to-face communication so effective, as has been observed by Ostrom et al. ([7], [8]). Is it the fact that face-to-face communication allows players to exchange information about the (individually as well as socially) optimal mode of behavior in the game, thus not only improving each individual player's understanding of the game, but also decreasing the uncertainty faced by each resource user with respect to the extent to which other players of the game have understood the problem? Or is it that communication serves as a social commitment device, which prevent us from breaking promises and intention statements as to our future behavior? In our experiment we test for the first role of communication. If we find that announcing the social norm does not result in improved efficiency of resource use, we are able to reject the hypothesis that face-to-face communication is effective because it facilitates solving some of the problems associated with obtaining cooperation. We formulate the following

Awareness hypothesis In game G_0, users are informed about the socially optimal extraction levels, thus overcoming the problem of calculating these individually. The awareness problem is absent. Due to the public announcement of the socially optimal mode of behavior, all resource users are informed that the other members of their groups understand which extraction level maximizes aggregate pay-off. Thus, the awareness-creating role of face-to-face communication is effectively substituted by the public announcement, and resources users choose the socially optimal level x^* in every round.

Now let us have a look at the game-theoretic predictions with respect to the police officer's behavior.

Nash equilibrium enforcement hypothesis The police officer behaves as a rational, individual payoff maximizing individual. In game G_T, the police officer will take the group to court ($M = 1$) in any round in which $\sum_i \max(x_i - x^*, 0) > \frac{K}{pf}$. In game G_V, the police officer will not take the group to court in any round in which the voting outcome is that any fines levied should be burned (that is, if $\sum_j v_j < \frac{N}{2} - 1$), while the police officer will take the group to court in any round in which the voting outcome is such that he/she is allowed to keep all fines collected (that is, if $\sum_j v_j > \frac{N}{2}$), provided that $\sum_i \max(x_i - x^*, 0) > \frac{K}{pf}$.

This hypothesis takes into account that the resource users may not necessarily behave according to the Nash equilibrium prediction.

Unambiguously ordering the three treatments on the basis of efficiency of resource use is impossible without making assumptions about the voting behavior. We now present a hypothesis that addresses the voting behavior of individuals and thereby the equilibrium selection problem in game G_V. In particular, the hypothesis asserts that there is an additional role of voting in the game, namely that of coordinating users' beliefs about other users' intentions and desires. We have in mind that the voting outcome that is in favor of transferring the fines to the police officer does not only inform the resource users that there are pecuniary incentives to reduce the resource extraction, but also that a majority of the group recognizes the value of reducing aggregate extractions, and therefore votes for the fine transfer. Alternatively, if more than half of the resource users vote against transferring fines to the police officer, this conveys the information that the majority does not prefer to be subject to punishment by the police officer. In light of other results on face-to-face communication, we state the following:

Local participation hypothesis In game G_V, the resource users vote for the transfer of fines to the police officer, and choose the extraction level $\hat{x}$ in every round. Moreover, any learning which might take place in game G_V, and any search for the optimal second best extraction level, is faster than in game G_T due to the voting outcome, which informs the resource users about the intentions to decrease extractions by the majority of the group.

In other words, voting facilitates coordination among resource users as it enables them to communicate their willingness to reduce extraction.

4 Experiment design

In the Spring semester of 2002, we ran six experimental sessions at Tilburg University. In total, 115 economics, law and business students participated. The language of the experiments was English. The experiments were fully computerized, and the program was written using z-Tree experiment toolbox designed by U. Fischbacher.

In the experiment, we framed the subject's decision situation in the common pool game as a division of an endowment of hypothetical experimental units called tokens, into two "markets": one in which the payoff depends on one's own actions as well as on those of the other group members (the market with externalities) and another in which the payoff depends purely on one's own activities. We described the player representing the norm enforcement institution as a "police officer" and explicitly pointed out to the participants the symmetric socially optimal extraction level. The relevant part of the instructions reads:

> We would like to draw your attention to the fact that you and the other group members together can earn the maximum number of points together if each group member puts 6 tokens into Market I. Note, however, that if each other group member puts 6 tokens into Market I, that means that if the others put together 4 times 6 = 24 tokens into Market I, it is best for you to put all your 13 tokens into Market I. Please, verify this in the table now. Therefore we remind you that you and the other group members can earn the maximum number of points in any round only by putting 6 tokens into Market I *and* trusting that the others do the same.

Upon arrival at a session, 20 participants were randomly seated at computer cubicles separated by blinds.[5] Any communication during the experiment was prohibited; a rule that was well-obeyed in all sessions. In each session, the participants first received instructions for the common pool game without any enforcement institution, game G_0 (see Appendix 1). We refer to this game played in the experiment as the "Base treatment". Further, subjects obtained the payoff table (see Table 4) and an instruction sheet describing the screens of the computer program. The instructions were read aloud by the experimenter. Before making any choices in the experiment, each participant answered four computerized questions testing his/her understanding of the payoff table. All participants answered the questions correctly without further instructions.

Next, the experiment participants were randomly matched by computer into groups consisting of five members, and played 15 rounds of the Base treatment. Upon finishing this first experiment, we informed them that a second experiment would take place, but only for 18 of them.[6] Those who were requested to leave, were randomly drawn from the pool and were paid out anonymously. Meanwhile, the remaining subjected received instructions for the second experiment. We ran three sessions implementing game G_{T}, and three sessions implementing game G_{V}. In the following, we refer to these games as the "Transfer treatment" and "Vote treatment", respectively. The instructions (see Appendix) were again read aloud by the experimenter.

Subjects were subsequently informed that this second experiment is the last one, after which they would be paid out. They were randomly re-matched into groups consisting of six subjects, five resource users and one police officer, and played 15 rounds of the Vote or Transfer treatment. Thus, each subject participated first in the common pool game without any enforcement institution (in which the socially optimal extraction strategy was announced; the Base treatment), and subsequently either in a game with centralized enforcement with exogenous incentives for the police officer (Transfer treatment) or with endogenous incentives for the police officer (Vote treatment). The schedule of the sessions is given in Table 1.

In the two treatments with centralized enforcement, we asked the subjects in each round of the experiment to make guesses about the decisions of the other group members.

[5] In one session, only 15 participants participated due to no shows.

[6] Or, in case of the one session with 15 participants, for only 12 of them.

Session (Date)	Second treatment	Participants	Base treatment	Second treatment
V1 (March 26, 2002)	Vote	20	4 groups	3 groups
T1(April 11, 2002)	Transfer	15	3 groups	2 groups
T2 (April 16, 2002)	Transfer	20	4 groups	3 groups
V2 (April 25, 2002)	Vote	20	4 groups	3 groups
V3 (May 1, 2002)	Vote	20	4 groups	3 groups
T3 (May 7, 2002)	Transfer	20	4 groups	3 groups

Table 1: Experimental sessions

To induce careful consideration, correct guesses were rewarded financially. The maximum amount of money that could be earned by guessing correctly was 5 Euro's, and subjects received a share of that amount depending on the fraction of guesses that were correct. Resource users were asked to guess whether or not the police officer would take the group to court (given the group's extraction decisions), and the police officers were asked to guess the voting outcome (in Vote treatment) and the presence of excessive extraction among users (both in Vote and Transfer treatment). These guesses provide us with additional information on subjects' motivations in the experiment.

In the experiment, all payoffs were in points, and experiment participants were informed about the exchange rate to real money: 1000 points were worth 15 Euro's. At the end of the experiment, participants were anonymously paid out a participation fee of 5 Euro's, plus money for points collected in the first experiment (Base treatment), plus money for points collected in the second experiment (Transfer or Vote treatment). On average participants earned 17.50 Euro's.

5 Data analysis and discussion

In this section, we address the hypotheses formulated in section 3, that is the Nash equilibrium hypotheses with respect to extraction behavior and enforcement, the awareness hypothesis as an alternative to the Base treatment Nash equilibrium extraction hypothesis, and the local participation hypothesis on the role of voting in selecting the payoff dominant equilibrium in the Vote treatment.

5.1 The Nash equilibrium extraction hypothesis

The Nash equilibrium extraction hypothesis derived in section 3 provides us with comparative statics of extraction levels with respect to the centralized enforcement. Here we test whether indeed the hypothesis holds, and hence wether the three treatments can be ranked unambiguously in terms of efficiency of CPR use. Taking into account learning, occasional mistakes and experimenting, which are never fully absent in experimental data, we would consider the predictions of the Nash extraction hypothesis at least partially fulfilled if the ranking of the data corresponds to the one spelled out in the hypothesis, i.e. $x^{\mathsf{0}} \geq x^{\mathsf{V}} \geq x^{\mathsf{T}}$.

For each treatment, Table 2 presents the averages and their standard deviations of

	Base	Transfer	Vote
Average extraction (St.Dev.)	10.16 (2.36)	9.44 (2.61)	9.49 (2.46)
Nash equilibrium extraction	10	8	[8,10]
Symmetric social optimum	6	6	6
Average gross payoff (St.Dev.)	19.42 (8.14)	23.50 (7.71)	23.00 (8.16)
Average net payoff (St.Dev.)	19.42 (8.14)	19.20 (10.87)	20.83 (9.64)
Nash equilibrium payoff	21.00	30.50	25.88*
Social optimum payoff	33.50	33.50	33.50
Average net payoff / Social opt.payoff	58%	57%	62%
Average net payoff / Nash eq.payoff	93%	63%	81%

* Based on actual voting outcomes in Vote treatment.

Table 2: Treatment descriptives

(i) the extraction levels, (ii) the gross payoffs from resource use (before sanctioning takes place) and (iii) the net payoffs as obtained by the users (that is, after fines have been subtracted). Furthermore, the table contains the Nash equilibrium benchmarks for the parametrization used in the experiment, as well as net efficiency (calculated as the ratio of the actually obtained net average payoff and the socially optimal payoff).

First of all, we find that the average extraction is lowest in the Transfer treatment and highest in the Base treatment, in accordance with the Nash extraction hypothesis; see Table 2. However, the differences are small. Also, whereas the gross payoffs are highest in the Transfer treatment, the costs associated with punishing are such that on average the Vote treatment yields higher net average payoffs than the Transfer treatment. More remarkably, resource users' net payoffs are even higher in the absence of any enforcement institution than in case the enforcement institution is imposed exogenously; average net payoffs in the Base treatment exceed those in the Transfer treatment. Although these differences are small and insignificant at conventional levels[7], they indicate that the net efficiency gain arising from the introduction of a centralized enforcement institution is, if anything, not overwhelming.

In addition, in all three treatments the average gross payoffs are below the Nash equilibrium prediction, which corresponds to a payoff of 21.6 in Base treatment, and to a payoff of 30.5 in Transfer treatment. The average equilibrium payoff in Transfer treatment depends on the voting outcome distribution in the experiment and is between these two benchmarks.

Observation 1: Average extractions and payoffs *On average*, extractions rank as predicted in the Nash equilibrium hypothesis, but exceed the point predictions in every treatment. The average payoffs obtained in the treatments, however, do not support the hypothesis. In particular, the net payoffs do not differ significantly in the absence or presence of an enforcement institution.

[7]For the average net payoffs for each group over all 15 rounds, the relevant p-values of the Mann-Whitney U Test for pairwise comparison of treatments are $p = 0.877$ for the Base-Transfer comparison, and $p = 0.386$ for the Base-Vote comparison.

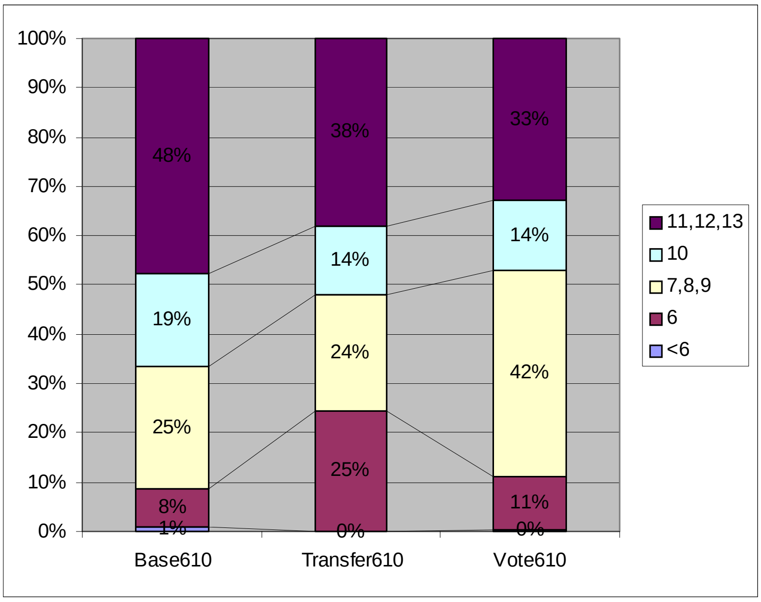

Figure 3: Average frequency of effort choice in rounds 6 to 10 across treatments.

It appears that the net treatment effect of the centralized enforcement institution is small if any. So, the question arises whether the averaging out of individual data hides some important underlying effects of the enforcement.

In this respect, the first point to make is that the standard deviations of the gross average payoffs (that only reflect extraction behavior, and hence do not take into account the financial impact of fines) at the group level do differ significantly among the treatments. Taking as a unit of observation the average gross payoff of a group, the p-values of a Mann-Whitney U test for pairwise comparisons are $p = 0.000$ for the Base-Transfer comparison and $p = 0.046$ for the Base-Vote comparison.

These differences in behavior volatility suggest that the three treatments may differ after all in terms of actual individual extraction behavior, and additional insight can be obtained by taking a closer look at the frequency with which various extraction levels are chosen in the three treatments. To control for learning effects and end-game affects, we present the frequency of effort choices using data from rounds 6-10 only; see Figure 3.

The first insight that can be obtained from Figure 3 is the high frequency with which extraction levels above Nash equilibrium prediction are chosen, and the fairly low frequency with which the socially optimal extraction level ($x^* = 6$) is selected. This is remarkable as we explicitly informed the players that this extraction level maximizes the payoff to the group. Our mere appeal to the social optimum was not sufficient for its implementation. This even holds for extractions in the first round: in all 23 Base games, each constituting an independent observation, only 28% of the subjects chose the socially optimal extraction level in the first period. Nevertheless, the average extraction was 8.55 in that round, which is significantly lower that the extraction level 10 predicted by the Nash equilibrium (and hence also lower than the average over all 15 rounds as presented in Table 1). This leads to the following observation:

Observation 2: Problem awareness *Announcing the socially optimal extraction level* prior the common pool game in the absence of any enforcement does not lead, on average, to extractions improving upon the Nash equilibrium predictions. In round 1 the incidence of the socially optimal extraction is higher than the average frequency over all 15 rounds of the game, but it deteriorates in later rounds.

Second, Figure 3 shows that the introduction of an enforcement institution does affect the frequency with which the socially optimal extraction level was chosen, as can be seen by comparing the Base and Transfer treatments. However, choosing the socially optimal extraction level is not an equilibrium strategy in the Transfer treatment (as was explained in section 2): the parameter values were chosen such that the enforcement institution is not able to fully implement the first best. The entire efficiency gain arising from the presence of the enforcement institution is due to *disequilibrium behavior*. The importance of disequilibrium behavior is also reflected by the high frequency with which the maximum extraction level was chosen.

These remarks can be summarized in the following observation, which is found to hold for not just rounds 6-10, but also in the other rounds (see Appendix 2 for the aggregate frequencies of strategy choices per group over all rounds):

Observation 3: Individual extractions Although on average, the treatments yield the same net payoffs, subjects' behavior is more volatile in the presence of an enforcement institution than in its absence. The symmetric *Nash equilibrium* extraction level does poorly as a point predictor of individual behavior. Introducing *a centralized enforcement mechanism* (in the Vote and Transfer treatments) which induces lower extractions in equilibrium than in the Base treatment without any enforcement does not affect the likelihood by which the Nash equilibrium extraction level is chosen by individual subjects, nor how often the maximum free-riding behavior is observed. However, it *does affect the propensity to choose the socially optimal extraction*. In particular, subjects choose more often the socially optimal extraction level in the Transfer treatment than in the other two treatments.

Furthermore, we observe that individual behavior does not seem to convergence towards higher efficiency and lower resource use over time; aggregate group extraction displays a pulsing pattern of high and occasionally lower extractions over time.

To understand the lack of convergence, it is illuminating to analyze individual behavior in order to identify the factors determining the response of individual resource users to changes in aggregate extraction. In the game-theoretic literature, the relevance of an equilibrium analysis is sometimes justified by quasi-dynamic approaches, according to which in a repeated interaction, players take myopic best responses to other players' behavior as observed in the previous round. As we have shown before (see the best response functions in section 2), each user will decrease his/her own extraction level in response to an increase in the other group members' aggregate extraction, and vice versa. Hence, in the common pool game, the myopic best response updating model is consistent with a negative correlation between user's extraction and the aggregate extraction of the remaining group members in the previous round.

	Game	% subjects in game	Significant at $\alpha < 0.1$
$\gamma > 0.25$	Base	46/115 (40%)	21/115 (18%)
	Transfer	12/40 (30%)	9/40 (22%)
	Vote	21/45 (47%)	14/45 (31%)
$\gamma < -0.25$	Base	20/115 (17%)	12/115 (10%)
	Transfer	11/40 (28%)	6/40 (15%)
	Vote	7/45 (16%)	4/45 (9%)

Table 3: Correlation between subject's extraction and previous roundaggregate extraction of other group members

However, there is abundant evidence in the experimental literature (Fehr et al.[3]) that individuals often behave reciprocally rather than following their own pure self interest. In the common pool game, such reciprocal behavior would mean high extractions if the remaining users extracted large amounts in the previous round and vice versa. In other words, reciprocal behavior is consistent with a positive correlation between a user's extraction and the aggregate extraction of the remaining group members in the previous round.

To test the presence of these two types of behavior in our data pool, we calculate for each user i a nonparametric measure of association, the Gamma coefficient γ_i. This Gamma $\gamma_i \in [-1, 1]$ is calculated for paired data observations consisting of user i's extraction choice in period t, x_i^t, and the aggregate extraction of the other four group members in the previous period $(t-1)$, X_{-i}^{t-1}. For each user we analyze his/her extraction behavior in rounds 2-15. In addition, we omit all observations in which extraction is at its maximum level because at that level, positive correlation is not feasible. If user i updates his/her extraction levels myopically but in accordance with the individual payoff maximization as assumed in the game-theoretic analysis, we should find $\gamma_i < 0$; if subjects display reciprocal behavior, we expect $\gamma_i > 0$.

In Table 3, one finds the fraction of individuals with a gamma coefficient which is at least 0.25 or at most -0.25. These cut-off values are arbitrary but enlightening; the higher the absolute value of the cut-off points, the smaller is the share of individuals for which the correlation coefficients are significant at the 10% level. In all treatments, the 'reciprocal' behavioral pattern occurs more frequently than the 'myopic best response' one. The smallest asymmetry with respect to the behavioral types is found in the Transfer treatment, which may be the result of the users' inclination to avoid punishment. In this treatment, reciprocating to free riding behavior implies to be exposed to the police officer's punishment.

Observation 4: Individual extraction dynamics The most frequent pattern of users' dynamics with respect to the previous round group extraction is positive correlation, which suggest that there is a nonnegligible fraction of users who behave reciprocally in their extraction choices, extracting large amounts as a response to excessive resource extraction by the other users, and vice versa.

Punishment is ex-ante profitable	Police officer does not take the group to court	takes the group to court	Total
no	60	25	85
yes	135	380	515
Total	195	405	600

Table 4: Court decisions and eligibility to be punished in Transfer treatment

Punishment is ex-ante profitable	Police officer does not take the group to court	takes the group to court	Total
no	13	2	15
yes	9	29	38
Total	22	31	53

Table 5: Court decisions and eligibility in Vote treatment: cases where policeman will receive the fines

5.2 The Nash equilibrium enforcement hypothesis

According to the Nash equilibrium enforcement hypothesis presented in Section 3, taking norm violators to court should take place only if it is ex-ante profitable. This is observed to a large extent in the experiment: taking the group to court is significantly more likely when it is ex-ante profitable than when it is not. Considering first the Transfer treatment, one can find in Table 4 that taking the group to court is ex ante profitable in 86% (515/600) of the cases, and the police officer actually starts a law suit in 74% (380/515) of these cases. Of the 85 cases in which taking norm violators to court was *not* ex ante profitable, the police officer decided to enforce the norm in 25 of them, that is in 30% of these cases.

Similar observations are made in the Vote treatment. However, in this treatment, ex ante profitability depends crucially on the voting outcome as well as on the amount of excess extraction. The decisions of the police officer in the Vote treatment are therefore presented in two tables, Table 5 and Table 6. First, Table 5 summarizes the police officer's decision in those cases in which he/she was allowed to keep the fines. The decision actually taken was found to be rational in 79% (42/53) of the cases, including ex-ante profitable cases (29) when the group was taken to the court, and ex-ante unprofitable cases (13) when the group was not taken to court. Similarly, the police officer correctly decided not to take the group to court in 90% (74/82) of the cases in which he/she was not allowed to keep the fines, see Table 6.

These observations can be summarized in the following:

Observation 5: Enforcement behavior The police officers behave fairly consistent with the enforcement hypothesis, assuming own payoff maximizing behavior. The decision to take the group to court is mostly made when this is ex ante profitable.

Risk aversion may explain why some profitable enforcement opportunities were not captured by the police officers. Due to the probabilistic outcome of the court, risk averse

Punishment is ex-ante profitable	Police officer: does not take the group to court	takes the group to court	Total
no	7	1	8
yes	59	15	74
Total	66	16	82

Table 6: Court decisions and eligibility in Vote treatment: cases where policeman will not receive the fines

police officers take the group to court under higher amounts of excess extraction than risk neutral police officers. In the presence of risk averse police officers, the higher is the excess extraction, the more likely it is that a police officer will take the group to court. Indeed, for both the Vote treatment and the Transfer treatment the probability of the police officer being active depends positively and significantly on the amount of excess extraction *even* in the range where enforcement is *ex ante* profitable $\left(\sum_j \max\{0, (x_j - x^*)\} > 10\right)$.[8] Furthermore, emotions such as spite do not seem to have played an important role in the police officers's decision making given the low number of cases in which enforcement was undertaken even though ex ante net benefits were negative.

5.3 The local participation hypothesis

The information presented in the two previous subsections sheds doubt on the validity of the hypothesis that voting (with respect to whether the police officer receives the fines or not) serves as an effective communication channel by which individual's behavior is coordinated towards cooperative behavior and increased efficiency. In section 5.1, the average gross earnings in the Transfer and Vote treatments were not found to differ significantly, and the incidence of socially optimal extraction choices is lower in Vote treatment than in Transfer treatment (see Figure 3). Both of these observations discredit the hypothesis that users will use the voting in order to signal their willingness to cooperate. In addition, section 5.2 shows that these results cannot be explained by erratic behavior on the part of the police officer, who was found to behave consistently with the game-theoretic predictions in the majority of the cases. However, from Tables 5 and 6 it can be inferred that resource users do not vote too often for the police officer to receive the fines in the Vote treatment; indeed, this voting outcome was surprisingly achieved in only 39% of the cases.

Observation 6: Voting outcomes Only in 39% of cases, the voting outcome in Vote

[8]If risk-aversion does not play a role, the probability of taking the group to court should be equal to 1 in the range where the expected value of enforcement is positive, and hence should not depend on the amount of excess extraction.

The police officer is expected to take the group to court if (i) excess extraction exceeds 10 units and (ii) the police officer is allowed to keep the fines. Selecting all observations that meet these criteria, we find that the probability that the police officer does take the group to court, is an increasing function of the amount of excess extraction. More specifically, the coefficients on excess extraction in the probit regression are positive and significant at $p = 0.065$ and $p = 0.0193$ for the Transfer and Vote treatment respectively.

Session / Group	% rounds fines are transfered (M=1)	Average extraction
V2 / 1	0%	10.43
V1 / 3	0%	10.05
V1 / 2	0%	9.44
V3 / 3	7%	10.42
V3 / 1	40%	8.63
V1 / 1	60%	9.95
V2 / 3	67%	9.24
V2 / 2	80%	8.60
V3 / 2	100%	8.69

Table 7: Vote treatment: Average extraction in groups by frequency of voting yes for fine transfer to police officer

treatment is in favor of incentives for the police officer that select the more efficient equilibrium with respect to the extraction behavior.

Is low frequency of the payoff dominant equilibrium selection a consequence of users not adjusting their behavior to the police officer's incentives established by voting? Table 7 presents group level data on average extractions and incidence of voting outcomes in favor of the fine transfer. We observe remarkable group asymmetry: there are groups where the police officer is often voted to receive the fines, and groups for which this is hardly ever the case. Also, we find a significant negative correlation between how often the police officer is voted to receive the fines, and the average extraction in that group. As expected, in groups where the majority is in favor of transferring the fines is more frequent, average extraction is lower, and consequently, efficiency is higher.[9]

Having determined that the institutional arrangement does indeed matter at the group level, we now analyze individual decision making. Clearly, in the Voting treatment it is only the actual voting outcome that should matter for a rational user when deciding how much to extract. Table 8 contains the average extractions across all individuals as a function of the voting outcome and the voting behavior. In the line with rational behavior, the average extraction is always lower (higher) when the police officer is voted to receive (not to receive) the fines, supporting the idea that subjects choose their own extraction *taking into account* the police officer's incentives, i.e. design of the institution. Consequently, when the police officer is voted to receive the fines, subjects' (now irrelevant) choice in the voting stage does not affect their subsequent extraction choices. In particular, independent of the vote cast, users choose significantly lower extractions when the voting outcome is actually in favor of the fine transfer, than when the police officer is voted not to receive the fines.[10]

[9]This negative correlation is confirmed by a nonparametric Mann-Whithey U test performed on pairs of observations consisting ofthe average group extraction and average group voting outcome, for which a p-value of 0.008 was obtained. In addition, the Pearson's correlation coeffcient between these group variables is -0.724, which is significant at the 3% level.

[10]For users voting against the fine transfer, the difference between average extractions in case the voting outcome is in favor of transfer (8.922) and in case the voting outcome is against the transfer (10.141) is

	vote		
Voting implies	no	yes	t-test
police officer receives the fines	8.9	8.6	p=0.290
police officer does not receive the fines	10.1	9.7	p=0.095

Table 8: Average extraction effort by vote and voting outcome

The interaction between voting outcome and the extraction choices can be therefore summarized as follows:

Observation 7: Voting outcomes and extractions In the Vote treatment, behavior at the individual and group level is sensitive to the institutional arrangement established by the voting. The more often it is the case that majority voting is in favor of giving appropriate enforcement incentives to the police officer, the higher, on average, is the efficiency gain. Also, if voting is against transferring fines to the police officer, average extraction is higher than if the majority is in favor of transferring fines.

In the Vote treatment, the two possible voting outcomes lead to different Nash equilibrium extraction levels, the first one achieving a relatively high efficiency in the resource use, and the second one achieving a lower efficiency. This raises two questions: (i) how can we explain the relatively low number of cases in which a majority of the votes supports the efficiency improving institution, and (ii) does the procedure in which the institutional arrangement is established, by voting, or exogenously by design, affect the resource use at individual level?

An individual user's voting behavior might depend on several factors, among which the user's past behavior, the group's past behavior, and the police officer's past behavior. The regression results of the probit analysis are presented in Table 9, which shows that (i) own voting behavior in the previous period and (ii) own previous round's extractions levels explain (at least to some extent) current voting behavior. With respect to own past voting behavior, the coefficient is positive and significant at the 7% level, implying that individuals have a tendency to either vote or not vote for the police officer, a tendency that is fairly immune to what other group members decide to do. The coefficient connected to own past extraction is also significant, but negative in sign. In addition, we find no evidence that the voting decision does depend on whether the police officer was active in the previous round, or whether the voter was punished in the previous round. Surprisingly, we did not find evidence that individual voting behavior is determined by the aggregate extraction behavior of the other group members ($X_{-i,t-1}$).

The idiosyncratic element explaining voting behavior is one (though not fully satisfactory) answer to the first question posed above. It would imply that the overall rather low frequency of the voting outcomes in favor of transferring the fines is the outcome of

significant by Mann-Whitney U test at $p = 0.000$.

Similarly, for users voting against the fine transfer, the difference between average extractions in case the voting outcome is in favor of transfer (8.606) and in case the voting outcome is against the transfer (9.689) is significant by Mann-Whitney U test at $p = 0.000$.

ML- Binary Logit: Dependent variable - Vote				
Variable	Coefficient	Std.Error	z-Statistics	Prob.
constant	-0.944	0.714	-1.321	0.1423
$x_{i,t-1}$	-0.076	0.042	-1.821	0.068
$v_{i,t-1}$	2.534	0.199	12.698	0.0000
M_{t-1}	0.257	0.224	1.148	0.251
$X_{-i,t-1}$	0.008	0.017	0.499	0.618
$fined_{t-1}$	-0.102	0.273	-0.375	0.708

Table 9: Factors determining voting behavior in the Vote treatment

too few individuals who find the presence of the enforcement institution to be a favorable arrangement. But, one has to ask, why would users prefer the institutional arrangement without proper incentives for the police officer that yields, in equilibrium, lower expected payoffs? There are two possible answers: on the one hand, myopic users interested in free riding on the group prefer that the police officer's incentives do not motivate him or her for taking the group to court. On the other hand, since the punishment in the court is only probabilistic, a group member extracting large amounts is left unpunished with positive probability even if the group is taken to court which may sometimes result in very inequitable, and unfair, outcomes. There is, however, another way to punish free riders, namely by extracting large amounts as well, but in the absence of the police officer (in order to prevent own punishment). This might be another (spiteful) motivation for some individuals to vote against the fine transfer to the police officer. We remind that a nonnegligible share of subjects was described by positive correlation between past extraction of the other group members and own current extraction, which reflects reciprocal motivations. If reciprocal users do not like free-riders to go unpunished, they might reciprocate by switching to voting against the police officer's incentives and punishing the free-riders by own excessive extraction of the resource.

Observation 8: Individual voting behavior Individual voting behavior is best explained by individual differences and is (surprisingly) independent of the past behavior of group members.

Having established some possible motivations for the users' voting behavior, we now turn to the question how does the Vote treatment compare to the Transfer treatment in cases when they share the same institutional arrangement, i.e. the voting outcome is such that the police officer receives the fines. This amounts to comparing extractions in the Vote treatment in those cases where the police officer was voted to receive the fines, to the extractions in Transfer treatment. In the first case, average extraction is 9.4 units, and in the second case, average extraction is 8.7 units. This difference is statistically significant at the 1% significance level, a result which is confirmed by a Mann-Whitney U test. Hence, when the incentives for the enforcement institution are obtained endogenously, by the decision of the game participants, rather than exogenously, the experiment design, the behavior is more cooperative in that it is described by lower average extractions.

Observation 9: Local participation When users can vote on the enforcement's institution, they choose for the effective enforcement by voting for appropriate incentives only in 39% of all cases. However, conditional upon voting for the transfer of fines, the average extraction level is closer to the social optimum in the Vote treatment than in the Transfer treatment, where the incentives are exogenously given. This difference is statistically significant.

To summarize, we hypothesized that the presence of the voting will improve the group's ability to coordinate on efficiency improving behavior. We observe that in most of the cases, the majority of a group is not willing to establish proper incentives for the police officer, a result which is both interesting and a cause for concern. In cases when the group agreed upon transferring fines to the police officer (hence re-enforcing the institution's incentives), aggregate extraction was lower than in the Transfer treatment, where the fines were always transferred to the police officer.

6 Conclusions

In this paper, we experimentally investigate centralized enforcement of policies targeted towards the preservation of natural resources that are of intrinsic value and/or serve as irreplacable habitat for species under threat of extinction. We model the resource characteristics as a common pool game, in which every individual's extraction activity decreases the return on extraction activities of all other resources users, and where the negative externality is not internalized in the decision making of the resource users. In such cases, government intervention is called for in many instances, and the question arises in which way the government's policy goal - efficient use of the natural resource (which implies preventing excess resource depletion) - can be achieved under the constraints faced by the government.

In particular, we explicitly account for the fact that (i) the policy maker desires to design a self-enforcing institution, but cannot offer outcome-targeted reward schemes to the police officer due to informational constraints, and (ii) the enforcement institution is not always successful in sanctioning excess resource use.

We show that for the parameter configuration chosen in the experimental study, the presence of the enforcement institution (a police officer) does improve the extraction behavior in equilibrium and brings it closer to the efficient extraction level. We hypothesize that the policy maker may use local resource user participation to establish the policy officer's incentives. The local participation is introduced by resource users voting on whether the policy officer is allowed to keep the revenues from the enforcement activity (i.e., the fines), or not. The game including such a voting stage has multiple equilibria, which are characterized by the voting outcome and by the group's resource use. In one type of equilibria, the police officer's incentives are strengthened by the transfer of fines, and the efficiency is as in a game where the fines are always transferred to the police officer. In the second type of equilibria, money collected in the court dissipates and the extraction level is as in the absence of enforcement. We pose a behavioral hypothesis that the additional role of voting, namely that of communicating private incentives of resource users to cooperate in sustaining the socially optimal mode of behavior, will yield more cooperative outcomes than in the presence of enforcement without voting.

Furthermore, we also introduced in the experiment the problem awareness by informing the subjects about the exact socially optimal extraction level. In this way, we filter out one of the reasons why face-to-face communication enhances cooperation in dilemma games, namely that via communication users inform each other about the characteristics of the problem, and obtain public knowledge on others being informed about the problem.

We implement three experiment treatments of the common pool game, one representing the resource management problem without any enforcement but including a public knowledge of the social optimum (Base treatment), one with an enforcement institution that faces exogenously imposed incentives (Transfer treatment), and one with an enforcement institution whose incentives are determined by majority voting by the resource users (Vote treatment).

We find that on average the comparative statics of extraction levels are described by Nash equilibrium predictions, but that the differences are not statistically significant. Moreover, extractions always exceed the point Nash equilibrium predictions. Instructing the resource users about the socially optimal extraction level in the experiment did not significantly affect behavior. At the individual level, differences among experiment participants are observed. Despite the presence of individuals extracting (on average) lower amounts that those predicted by Nash equilibrium, their "conservationist" strategy is outweighed by excessive resource use by the other group members. Furthermore, a significant fraction of the population displays a positive correlation between own choices and the choices of the other group members, in contrast to the game-theoretic prediction of a negative correlation (as extraction decisions should be strategic substitutes rather than complements): cooperation is rewarded by cooperation, and but free-riding with more aggressive behavior.

Surprisingly, the introduction of the voting stage which might have served as a social coordination device did not result in an unambiguous increase in efficiency when compared to the treatment with enforcement established without voting. From a theoretical viewpoint, the equilibrium in which the police officer does not receive the fines is payoff-dominated by the equilibrium in which she does receive the fines. However, in only 39% of all cases, the voting outcome is such that the police officer is allowed to pocket the revenues of norm enforcement, thus giving her appropriate incentives to take norm violators to court. In the remaining cases, the strategic situation of the resource users was as in a full absence of enforcement institution, leading to correspondingly aggressive extraction behavior. Nevertheless, in those cases where appropriate incentives for the police officer to enforce the norm were established by voting, the extraction behavior was indeed more cooperative than in the treatment where the police officer's incentives were established without voting.

On the basis of these observations, we would like to draw attention to the desirability of centralized enforcement with local community participation as a uniform remedy to reduce excessive extraction among common property resource users. The starting conditions of such local decision making have to be prepared properly, allowing for thorough understanding of the community's norms, rules, and history. Speaking in game-theoretical terms, if the past record of cooperation is missing in the group, unprepared exposing to self-governance is very likely to result in the "wrong" equilibrium of the game, as we observed experimentally.

7 Appendix 1

7.1 Instructions for participants (Base treatment)

Introduction

You will now participate in an experiment on economic decision-making. The experiment will last approximately 1.5 hours. You will be paid after the experiment. No other experiment participant will learn how much you earned. You will be paid 5 Euro's for your participation PLUS any additional earnings you will make in the experiment. How much you earn crucially depends on your decisions in the experiment.

During the whole experiment, you are not allowed to talk to other participants. Disobeying this rule results in your exclusion from the experiment.

In the following experiment, you will participate in a game consisting of 15 rounds. After the experiment, you will be paid all what you earned in the 15 rounds of the game. In the game, you will be in a group with four other participants of the experiment. You will not learn the identity of the other members of your group.

Game description

The game has 15 rounds. At the beginning of every round, you will receive 13 tokens. In every round, you will be asked to divide these 13 tokens between two markets: Market I and Market II. Observe that you have to divide all your 13 tokens. Therefore if you put X tokens into Market I, you put automatically 13 - X tokens into Market II. In the experiment, therefore, you will be asked to make one choice: the choice how many tokens you put into Market I. It is then automatic that you put 13 – X tokens into Market II.

You will earn points for the tokens you put into Market I and Market II. Your earning in one round is the sum of the points you earn into Market I and Market II. Your earning in the game is the sum of all the points you earn in the 15 rounds of the game. During the experiment, all your earnings are in points. At the end of the experiment, you will be paid real money for the points you earned in the game. The exchange rate is: 10 points = 15 cents, 1000 points = 15 Euro's.

Earnings

Now, we will explain how you earn points for the tokens you put into Market I and Market II.

Earnings in Market I

The number of points you earn for the tokens you put into Market I depends on how many tokens you put into Market I and how many tokens the other four group members put into Market I. For every token you put into Market I, you receive 9 points. You also have to pay costs when using Market I. The costs depend on how many tokens in total all group members (including you) put into Market I: for every token into Market I, whether put in by you or by somebody else, you have to pay a cost of 0.15 points.

Your total earnings in Market I, if you put X tokens into Market I, and the other four group members put together Y tokens into Market I, are $9*X - 0.15*(X+Y)$.

Earnings in Market II

The number of points you earn for the tokens you put into Market II depends only on how many tokens you put into Market II. For every token you put into Market II you receive 0.5 points. There are no costs for using Market II. Your total point earnings in Market II, if you put X tokens into Market I, are $0.5*(13 - X)$.

Total earnings in one round

The total number of points you earn in one round is the sum of points earned in Market I and Market II, that means

9*X – 0.15*(X+Y) +0.5*(13 – X).

EARNINGS TABLE

When making your decisions, you can refer to the table in front of you. The table contains the number of points you earn in total in Market I and Market II for different combinations of the number of tokens you put into Market I and the other four group members put into Market I. Please, have a look at the table 4 now.

POINTS EARNED IN MARKET I AND MARKET II

	Total number of tokens put in Market I by the other FOUR group members													
Tokens put in Market I by me	0	4	8	12	16	20	24	28	32	36	40	44	48	52
0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
1	15.4	14.8	14.2	13.6	13	12.4	11.8	11.2	10.6	10	9.4	8.8	8.2	7.6
2	23.9	22.7	21.5	20.3	19.1	17.9	16.7	15.5	14.3	13.1	11.9	10.7	9.5	8.3
3	32.2	30.4	28.6	26.8	25	23.2	21.4	19.6	17.8	16	14.2	12.4	10.6	8.8
4	40.1	37.7	35.3	32.9	30.5	28.1	25.7	23.3	20.9	18.5	16.1	13.7	11.3	8.9
5	47.8	44.8	41.8	38.8	35.8	32.8	29.8	26.8	23.8	20.8	17.8	14.8	11.8	8.8
6	55.1	51.5	47.9	44.3	40.7	37.1	33.5	29.9	26.3	22.7	19.1	15.5	11.9	8.3
7	62.2	58	53.8	49.6	45.4	41.2	37	32.8	28.6	24.4	20.2	16	11.8	7.6
8	68.9	64.1	59.3	54.5	49.7	44.9	40.1	35.3	30.5	25.7	20.9	16.1	11.3	6.5
9	75.4	70	64.6	59.2	53.8	48.4	43	37.6	32.2	26.8	21.4	16	10.6	5.2
10	81.5	75.5	69.5	63.5	57.5	51.5	45.5	39.5	33.5	27.5	21.5	15.5	9.5	3.5
11	87.4	80.8	74.2	67.6	61	54.4	47.8	41.2	34.6	28	21.4	14.8	8.2	1.5
12	92.9	85.7	78.5	71.3	64.1	56.9	49.7	42.5	35.3	28.1	20.9	13.7	6.5	-0.7
13	98.2	90.4	82.6	74.8	67	59.2	51.4	43.6	35.8	28	20.2	12.4	4.6	-3.3

Figure 4: Payoff table distributed to the experiment participants.

In the first column (in grey color), you find all possible numbers of tokens you may put into Market I. In the experiment, you can choose any integer number from 0 to 13, that means numbers 0,1,. . . 12, 13. Suppose, for example, you decide to put 4 tokens into Market I.

In the first row (in grey color), you see the numbers of tokens the other four members of your group may put into Market I. Suppose, for example, you think that the other four group members will put in total 12 tokens into Market I.

Look in the table for the intersection of the chosen line (4 tokens) and column (12 tokens). You find that if you put 4 tokens into Market I and the other four members put in total 12 tokens into Market I, you earn in Market I and Market II together 32.9 points.

Observe in the table the following. You can always make sure to earn 6.5 points in any round by putting no tokens into Market I. You can, however, potentially earn more points if you put some tokens into Market I. How many points you earn, however, depends crucially on the behavior of the other members of your group. If, for example, you put all your 13 tokens into Market I, you may earn 98.2 points, if the other group members do not put any tokens into Market I. On the other hand, you loose 3.3 points, if the other group members behave the way you do, and put all their tokens into Market I. Other group members affect how many points you earn, and you affect how many points others earn. We would like to draw your attention to the fact that you and the other group members can earn the maximum number of points together if each group member puts 6 tokens into Market I. Note, however, that if each other group member puts 6 tokens into Market I, that means that the others put together 4 times 6 = 24 tokens into Market I, it is best for you to put all your 13 tokens into Market I. Please, verify this in the table now. Therefore we remind you that you and the other group members can earn the maximum possible number of points in any round only by putting 6 tokens into Market I and trusting that the others do the same.

Note that in the experiment, you and the other four members of your group will decide on the division of the tokens at the same time. Therefore, you will not know at the moment of your decision how many tokens the other members of your group put into Market I. You can only make a guess.

After all group members made their decisions, you will find out how many tokens each group member has put into Market I in this round. You will also find out how many points each group member earned.

COMPUTER SCREENS

We will now explain how you will make your choices on the computer. Have a look at Figure "Screen 1".

Here you will decide how many tokens you put into Market I. Use the keyboard to type in one of the numbers 0, 1,...,12, 13 in the active field, and then confirm your choice by pressing OK. Warning: Before pressing OK, make sure your choice is correct. You cannot change your decision after you press OK.

After having pressed OK, you will be asked to wait till all experiment participants are finished. The experiment continues only after all experiment participants pressed OK, therefore we kindly ask you not to delay your decision too much. For every decision, time indication of one minute is shown in the header. After this time expires, you are repeatedly asked to submit your decision, or press the OK button.

For your information, you will see two history tables in the lower part of Screen 1. The history tables contain information on how many tokens each group member has put into Market I and how many points he/she has earned in the previous rounds. In round 1, these fields will be empty. Information about yourself is always in the second column of the table, denoted "me". In the columns three to six, you find information about the remaining four group members. For anonymity reasons, the columns are denoted x, xx, xxx, and xxxx only. Note that these labels remain the same for each group member over the whole game. For example in the column denoted "xx", you will always find information about one and the same group member, but you will not learn his/her identity.

After you have pressed OK, a waiting screen will appear. After all experiment participants have pressed OK, Screen 2 will appear.

Have a look at Figure "Screen 2".

Here you will find a table with information on how many tokens each group member has put into Market I in this round and how many points he/she earned. Press OK, when you are ready to continue. The experiment continues only after all experiment participants pressed OK, therefore we kindly ask you not to delay it too much.

Please, raise your hand if you have questions at this moment. Note however that we do not answer questions of the type "what shall I do in the experiment?" - it is your own decision. We, however, are happy to answer questions about the way your points are calculated or how the computer program works.

The experiment will now begin with a short test to make sure that everybody understands how the points are earned. Use your tables to answer the following questions. After all experiment participants answered all questions correctly, the experiment will begin.

7.2 Instructions for participants (Transfer treatment)

You will now continue in this experimental session. In this second experiment, you will make similar decisions as in the first experiment. You will also make some guesses, as we explain later. After this experiment, today's experimental session is finished and you will be paid out.

YOUR TOTAL EARNINGS IN TODAY'S EXPERIMENTAL SESSION will be 5 Euro's participation fee, PLUS all your earnings in the first experiment, PLUS plus all your earnings in this second experiment, plus a premium for the fraction of guesses that were correct.

In this experiment, you will be in a group with five other participants of the experiment. These are not the same participants as before. You will not learn the identity of the other members of your group. Again, you will participate in a game, this time consisting of 15 rounds. In this game, you will be either a police officer or a group member for the whole game. You will find out whether you are a police officer or a group member at the beginning of the experiment.

You will make DECISIONS and GUESSES in this experiment. DECISIONS determine how many points you earn in the markets. You will make GUESSES about the decisions by the other group members. The total number of correct guesses divided by the number of all your guesses determines the percentage of the correctness premium you will receive. The correctness premium is 5 Euro's. For example, if 50% of all your guesses are correct, you will receive at the end of the experiment 50% of the correctness premium of 5 Euro's, that means 2.5 Euro's. Note: In each screen at the computer where you make decision, you can find out whether you are making a GUESS or a DECISION in the title of the screen.

The role of group members

The role of the group members is the same as before: at the beginning of each round, each group member receives 13 tokens and is asked to divide them between two markets: Market I and Market II. The way group members earn points in the markets is the same as in the previous experiment and you can use the same earnings table as before.

The role of the police officer

There is one police officer for every five group members. He/she also receives 13 tokens in every round. However, he/she cannot put any tokens into Market I or Market II. All tokens of the police officer go to Market III. The police officer receives 2 points for every token into Market III, that means that he/she receives 13*2=26 points at the beginning of every round.

The police officer observes how many tokens each group member put into Market I. The police officer may then decide to take the group members to court, or not. If the police officer decides to take the group to court, he/she has to pay a cost of 19 points. In that case, each group member who put more than 6 tokens into Market I in that round, faces a possibility to be fined. The computer "flips a coin" for every group member who put more than 6 tokens into Market I. Those group members for whom "heads" is the outcome, what happens with probability one half, will have to pay a fine of 3.6 points for every token put into Market I by that group member above 6 tokens. For example, if a group member has put 8 tokens into Market I, and the police officer takes the group to the court, and the coin flip is "heads", then this group member has to pay the fine of (8-6) times 3.6 points, that means 7.2 points. These points are subtracted from the earnings of that group member.

Note, that even if the police officer chooses to go to court, he/she may succeed in collecting fines from some group members who put more than 6 tokens into Market I, but not necessarily of all such group members. What happens with the fines collected by the police officer depends on the decision of the group members. This decision takes place BEFORE the police officer makes any decision, as we explain below. The police officer either keeps the fines collected, or he/she does not keep the fines.

We now describe one round in sequence.

One round

One round of a game consists of two stages.

1. DIVIDING TOKENS: The group members decide how many tokens to put into Market I.
2. COURT: The police officer decides whether or not to take the group to court.

1. DIVIDING TOKENS: decision of the group members

See Figure "Screen 1 – Group members". The group members are asked to divide 13 tokens between Market I and Market II. This takes place in the same way as in the previous experiment.

1. DIVIDING TOKENS: guess by the police officer

See Figure "Screen 1 – Police officer". While the group members divide the tokens between Market I and Market II, the police officer guesses whether or not any of the group members will put more than 6 tokens into Market I. This guess does not affect the payoff of the group members, only the police officer's correctness premium received at the end of the experiment.

2. COURT: guess by the group members

See Figure "Screen 2 – Group members". The group members guess whether the police officer will take the group to court. This guess does not affect the payoff of the police officer, only the group members' correctness premium received at the end of the experiment.

2. COURT: decision by the police officer

See Figure "Screen 2 – Police officer" The police officer observes how each group member divided his/her tokens between Markets I and II. The police officer then decides to take the group to court or not. If the police officer does not take the group court, no fines are collected. If the police officer does take the group to court, he/she has to pay the cost of 19 points. The computer then flips separately a coin for every group member who has put more than 6 tokens into Market I in that round. Those, for whom "heads" is the outcome, have to pay the fine of 3.6 points for every token above 6 tokens into Market I.

Payoffs

The payoff for the police officer depends on the voting in stage 1 and whether he/she decides to take the group to court. The police officer earns: 26 points into Market III, minus 19 points if he/she take the group to court plus fines if he/she does take the group to court.

The payoff for the group member is: points earned in Market I and Market II, minus the fine of 3.6 points for every token above 6 tokens in Market I, if the police officer takes the group to court and computer coin flip is "heads".

Please, raise your hand if you have any questions at the moment.

7.3 Instructions for participants (Vote treatment)

You will now continue in this experimental session. In this second experiment, you will make similar decisions as in the first experiment. You will also make some guesses, as we explain later. After this experiment, today's experimental session is finished and you will be paid out.

YOUR TOTAL EARNINGS IN TODAY'S EXPERIMENTAL SESSION will be 5 Euro's participation fee, PLUS all your earnings in the first experiment, PLUS plus all your earnings in this second experiment, plus a premium for the fraction of guesses that were correct.

In this experiment, you will be in a group with five other participants of the experiment. These are not the same participants as before. You will not learn the identity of the other members of your group. Again, you will participate in a game, this time consisting of 15 rounds. In this game, you will be either a police officer or a group member for the whole game. You will find out whether you are a police officer or a group member at the beginning of the experiment.

You will make DECISIONS and GUESSES in this experiment. DECISIONS determine how many points you earn in the markets. You will make GUESSES about the decisions by the other group members. The total number of correct guesses divided by the number of all your guesses determines the percentage of the correctness premium you will receive. The correctness premium is 5 Euro's. For example, if 50% of all your guesses are correct, you will receive at the end of the experiment 50% of the correctness premium of 5 Euro's, that means 2.5 Euro's. Note: In each screen at the computer where you make decision, you can find out whether you are making a GUESS or a DECISION in the title of the screen.

The role of group members

The role of the group members is the same as before: at the beginning of each round, each group member receives 13 tokens and is asked to divide them between two markets: Market I and Market II. The way group members earn points in the markets is the same as in the previous experiment and you can use the same earnings table as before.

The role of the police officer

There is one police officer for every five group members. He/she also receives 13 tokens in every round. However, he/she cannot put any tokens into Market I or Market II. All tokens of the police officer go to Market III. The police officer receives 2 points for every token into Market III, that means that he/she receives 13*2=26 points at the beginning of every round.

The police officer observes how many tokens each group member put into Market I. The police officer may then decide to take the group members to court, or not. If the police officer decides to take the group to court, he/she has to pay a cost of 19 points. In that case, each group member who put more than 6 tokens into Market I in that round, faces a possibility to be fined. The computer "flips a coin" for every group member who put more than 6 tokens into Market I. Those group members for whom "heads" is the outcome, what happens with probability one half, will have to pay a fine of 3.6 points for every token put into Market I by that group member above 6 tokens. For example, if a group member has put 8 tokens into Market I, and the police officer takes the group to the court, and the coin flip is "heads", then this group member has to pay the fine of (8-6) times 3.6 points, that means 7.2 points. These points are subtracted from the earnings of that group member.

Note, that even if the police officer chooses to go to court, he/she may succeed in collecting fines from some group members who put more than 6 tokens into Market I, but not necessarily of all such group members. What happens with the fines collected by the police officer depends on the decision of the group members. This decision takes place BEFORE the police officer makes any decision, as we explain below. The police officer either keeps the fines collected, or he/she does not keep the fines.

We now describe one round in sequence.

One round

One round of a game consists of three stages.

1.VOTING: The group members vote what happens with the fines collected in stage 3, the court stage.

2. DIVIDING TOKENS: The group members decide how many tokens to put into Market I.

3. COURT: The police officer decides whether or not to take the group to court.

1. VOTING: decision of the group members

See Figure "Screen 1 – Group members". The group members vote by pushing the button "yes" or the button "no" at the screen. If a majority of the group, that is 3, 4, or 5 group members vote "yes" in some round then if the police officer decides to go to the court in stage 3, he/she keeps any fines collected in stage 3. If a majority of the group, that is 3, 4, or 5 group members vote "no" in some round then the if the police officer decides to go to the court in stage 3, he/she does not keeps any fines collected in stage 3.

1. VOTING: guess of the police officer

See Figure "Screen 1 – Police officer". While the group members make voting decision, the police officer guesses the outcome result of the voting. This guess does not affect the payoff of the group members, only the police officer's correctness premium received at the end of the experiment.

2. DIVIDING TOKENS: decision of the group members

See Figure "Screen 2 – Group members". The group members are asked to divide 13 tokens between Market I and Market II. This takes place in the same way as in the previous experiment.

2. DIVIDING TOKENS: guess by the police officer

See Figure "Screen 2 – Police officer". While the group members divide the tokens between Market I and Market II, the police officer guesses whether or not any of the group members will put more than 6 tokens into Market I. This guess does not affect the payoff of the group members, only the police officer's correctness premium received at the end of the experiment.

3. COURT: guess by the group members

See Figure "Screen 3 – Group members". The group members guess whether the police officer will take the group to court. This guess does not affect the payoff of the police officer, only the group members' correctness premium received at the end of the experiment.

3. COURT: decision by the police officer

See Figure "Screen 3 – Police officer" The police officer observes how each group member divided his/her tokens between Markets I and II. The police officer then decides to take the group to court or not. If the police officer does not take the group court, no fines are collected. If the police officer does take the group to court, he/she has to pay the cost of 19 points. The computer then flips separately a coin for every group member who has put more than 6 tokens into Market I in that round. Those, for whom "heads" is the outcome, have to pay the fine of 3.6 points for every token above 6 tokens into Market I.

Payoffs

The payoff for the police officer depends on the voting in stage 1 and whether he/she decides to take the group to court. The police officer earns: 26 points into Market III, minus 19 points if he/she take the group to court plus fines if he/she does take the group to court and voting determined that he/she is allowed to keep them.

The payoff for the group member is: points earned in Market I and Market II, minus the fine of 3.6 points for every token above 6 tokens in Market I, if the police officer takes the group to court and computer coin flip is "heads".

Please, raise your hand if you have any questions at the moment.

8 Appendix 2 - Experiment data

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Treatment	Group #										
Base	21	22	23	31	32	33	34	61	62	63	64
<6	0%	1%	3%	1%	0%	3%	0%	1%	1%	1%	0%
6	6%	1%	13%	1%	8%	9%	1%	9%	1%	24%	4%
7,8,9	31%	24%	16%	33%	17%	28%	32%	23%	31%	20%	45%
10	20%	16%	22%	21%	17%	20%	16%	8%	28%	13%	30%
11,12	9%	17%	9%	11%	39%	19%	35%	28%	21%	20%	8%
13	34%	40%	38%	32%	19%	21%	16%	31%	17%	21%	14%

Transfer	21	22	31	32	33	61	62	63
<6	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	36%	0%	18%	18%
7,8,9	0%	77%	50%	62%	27%	50%	45%	45%
10	0%	8%	50%	31%	18%	17%	0%	0%
11,12	17%	0%	0%	8%	9%	0%	27%	9%
13	83%	15%	0%	0%	9%	33%	9%	27%

Base	11	12	13	14	41	42	43	44	51	52	53	54
<6	1%	1%	1%	1%	0%	0%	0%	4%	1%	1%	1%	0%
6	12%	3%	9%	0%	7%	20%	8%	11%	9%	1%	24%	4%
7,8,9	12%	28%	33%	41%	24%	13%	33%	11%	23%	31%	20%	45%
10	19%	12%	13%	16%	20%	41%	13%	13%	8%	28%	13%	30%
11,12	21%	35%	25%	19%	11%	13%	29%	19%	28%	21%	20%	8%
13	35%	21%	17%	23%	39%	12%	16%	43%	31%	17%	21%	14%

Vote	11	12	13	41	42	43	51	52	53
<6	5%	0%	0%	0%	0%	1%	1%	0%	0%
6	8%	25%	17%	5%	15%	29%	4%	11%	9%
7,8,9	27%	32%	27%	23%	56%	21%	73%	67%	24%
10	15%	7%	7%	21%	9%	13%	15%	11%	13%
11,12	20%	4%	13%	25%	15%	5%	4%	3%	31%
13	25%	32%	36%	25%	5%	29%	3%	9%	23%

Figure 5: Experimental data per group.

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