Ours, Not Yours: Property Rights, Poaching and Deterrence in Common-Pool Resources

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Abstract

Governments allocate property rights in different ways to protect common-pool resources (CPR) from over-harvesting, but this can generate conflict between those with access ("insiders") and those without ("outsiders"). We use a laboratory experiment to determine how mechanisms to allocate property rights influence the decentralized management and defense of a CPR. We use a 2×2 design that varies whether access to the CPR is earned (as opposed to being randomly assigned) and whether insiders have the ability to use punishment to deter outsiders from poaching the resource. We find that insiders who earned the property right were more likely to defend the CPR and impose significantly more deterrence, leading to a significant reduction in extreme poaching. However, lower levels of poaching often went unpunished under both earned and assigned rights. While earned property rights can improve the coordinated deterrence of outsiders, they are insufficient to completely eliminate poaching, and conflict between rights-holders and poachers.

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1 Introduction

Property-rights are frequently used by governments to decentralize the management of common-pool resources (CPRs) (Isaksen and Richter, 2019). For instance, Nepal relies on Forest User Groups (FUGs) to manage forests, and Chile relies on Territorial User Rights Fisheries (TURFs) to manage fisheries. The first step in creating a FUG, TURF or something similar is to establish "well-defined boundaries", the first of Ostrom's eight principles of collective management (Ostrom, 1990). This creates a group of "insiders" whose exclusive access to the CPR encourages them to coordinate rather than compete over the resource. However, property rights also create outsiders, and since the allocation of rights alone does not change an outsider's material incentives to poach the resource, there is often conflict between insiders and outsiders. FUGs in Nepal have clashed with illegal loggers (Timilsina and Heinen, 2008), while violent conflict has erupted between Chilean TURFs and poachers (Chávez et al., 2010; Gelcich et al., 2010, 2009).[1]

There are various methods (both formal and informal) available to governments to allocate CPR property rights. One example is historical access. In Nepal, rights are allocated to communities that have a traditional claim to the forest (Bartlett and Malla, 1992; Timilsina and Heinen, 2008). Similarly, Afflerbach et al. (2014) survey TURFs from ten countries and find various instances of rights distributed according to historical access and local traditions.[2] A second way is to ensure access to the CPR is *earned* by competitively allocating rights. In Chile for example, a group of fishermen interested in forming a TURF must submit an application detailing their management plan (Chávez et al., 2018).

However, it is unclear whether one method to allocate property rights is better suited than another to both collectively manage scarce environmental resources and reduce conflict. There is some evidence from simple two-person experiments that earned property rights are more aggressively defended than randomly-assigned property rights (Danková and Servátka, 2015). At the same time, since property rights do not explicitly change an outsider's incentives, the outsider will continue to poach so long as the benefits exceed the costs (Santis and Chávez, 2015; Ali and Abdullah, 2010; Kuperan and Sutinen, 1998). Moreover, non-compliance may compound when an outsider perceives the property right as illegitimate (Quynh et al., 2017). This raises the pressure on insiders to effectively coordinate the deterrence of outsiders.

In this paper we examine whether the mechanism to allocate property rights a) induces outsiders to respect the insiders' property right in the absence of costly punishment, and b) increases insider coordination (on both harvests and deterrence decisions) with costly punishment. To do so, we use a laboratory experiment that enables us to control the property right's allocation method and the

[1]Poaching is a major concern of Chilean fishermen (Gelcich et al., 2017). Chávez et al. (2018) note that the protocol for TURF members who catch a poacher is to hand them over to authorities for prosecution. However, some TURF members opt to personally enforce their boundaries. Enforcement includes physical confrontations that may result in the murder of poachers. The local media refer to these events as "La Guerra del Loco" or the war of the abalone ("loco" is the colloquial name for abalone in Chile). Conflict due to poaching has also been documented in TURFs in South Africa and Malaysia (Raemaekers et al., 2011; Ali and Abdullah, 2010).

[2]The problem of introducing external regulations in CPRs without accounting for local context is well-documented. See for example Ostrom (2008).

insiders' ability to punish outsiders.[3] We build on the CPR-with-poaching design from De Geest and Stranlund (2019) by first varying whether property rights were randomly assigned (*Assigned*) or earned (*Earned*). In half our treatments, a subject was randomly assigned to be either an insider with exclusive access to the CPR, or an outsider who could poach from the CPR. In the other half, subjects became insiders or outsiders based on their performance in a real-effort task. Insiders could communicate in both property-rights settings, while outsiders could neither communicate with each other nor with insiders.

Unambiguous property rights are crucial to treatments where subjects earn the right to be an insider. Accordingly, we chose the slider task by Gill and Prowse (2012). The slider task is well suited for our need. It is (i) easy for subjects to understand, (ii) does not favor certain subjects over others (unlike a general knowledge quiz or a math quiz), and (iii) provides little to no scope for guessing or randomness.[4] Other studies have used the slider to allocate rights. Gee et al. (2017) find it induces a strong sense of earned property rights in a redistribution game, and Faillo et al. (2019) find that when endowments are earned, dictators take (marginally) less in a taking versus giving symmetric dictator game.

However, the drawback to the Gill and Prowse (2012) slider task is its coarser, integer scoring rule. This can lead to ties that need to be broken by the experimenter, cutting down the salience of earned property rights. Therefore we augmented the slider task with a novel, continuous scoring rule that allowed us to clearly delineate property rights to subjects.[5] There were no slider task ties in any of our sessions, and subjects were informed of this fact.

We also vary whether insiders could use punishment to self-govern their use of the CPR and deter outsiders. Thus, we have four treatments (*Assigned-No Punishment*, *Assigned-Punishment*, *Earned-No Punishment*, and *Earned-Punishment*). In treatments with punishment, insiders could pay to impose monetary sanctions on insiders and outsiders. Assuming that an outsider weighs the benefits of poaching against the costs of punishment, poaching will be deterred when the expected costs outweigh the expected gains (Ali and Abdullah, 2010). Accordingly, we estimate the probability of punishment and the intensity of punishment, and then combine our estimates to construct an expected cost curve that describes the expected level of punishment an outsider would face for any level of poaching. Calculating the outsider's expected costs of poaching gives us a detailed look at how insiders coordinated to deter outsiders at various levels of poaching.[6]

The existing literature on CPR with poaching games shows that insiders succeed at coordinating

[3] Quynh et al. (2017) point out that it is difficult to collect field data on both poaching and deterrence, making lab experiments an appropriate method to study this topic.

[4] Gill and Prowse (2019) highlight a number of studies that now use the Gill and Prowse (2012) slider task. We counted about 54 papers since 2012.

[5] The effort task in Danková and Servátka (2015) – cutting posters with scissors – also satisfies these criteria, although it offers less granular effort-scoring.

[6] Chávez et al. (2018) also look at expected punishments to outsiders. However, unlike our study, insiders could only choose the probability of punishment. When an outsider was caught, they were fined by the experimenters, akin to how a poacher might be handed over to prosecutors if caught by TURF members. In our study, insiders could choose whether to punish an outsider or not (after observing his or her level of poaching), as well as the magnitude of punishment (by choosing how many tokens to allocate towards sanctioning).

their harvests (usually close to the socially optimal level) but fail at coordinating the deterrence of poachers (De Geest and Stranlund, 2019; Chávez et al., 2018; De Geest et al., 2017). Similarly, we find insiders without punishment tend to harvest near the social optimum, and the introduction of punishment pushed aggregate harvests even closer to the social optimum in both *Earned-Punishment* and *Assigned-Punishment*.

However, we do find that earned property rights significantly increased coordination on deterrence. Poaching decreased significantly when insiders earned the right to be an insider and had the ability to punish. Our results suggest that this reduction is not driven by outsiders respecting the property-rights, but by insiders in *Earned-Punishment* who were significantly more likely to punish outsiders relative to insider in *Assigned-Punishment* and imposed significantly higher expected costs on outsiders for higher levels of poaching.

Despite the higher punishment levels in *Earned-Punishment*, we also find that insiders did not commit enough punishment to deter outsiders. The expected costs of poaching in both *Earned-Punishment* and *Assigned-Punishment* were well below theoretical deterrent levels. Moreover, insiders in both treatments largely ignored lower levels of poaching.

We believe our paper contributes to various strands of literature. First, we contribute to the growing experimental literature on CPR conflicts. A common thread in this literature is the under-deterrence of outsiders.[7] Several papers using laboratory and field experiments that vary punishment and monitoring technologies suggest that insiders do too little to deter poachers (De Geest et al., 2017; Chávez et al., 2018; De Geest and Stranlund, 2019). Our findings show that earned property rights can increase coordinated deterrence, but they are not enough to completely deter outsiders.

Second, we contribute to the experimental literature on earned property rights. To the best of our knowledge we are the first to study earned property rights in a CPR experiment with conflict over access to the resource. The literature on earned endowments has primarily focused on simple two player games and finds that subjects behave in a more self-interested manner when they earn the endowment. For instance, earned endowments tend to lead to more selfish behavior in Dictator games (Korenok et al., 2017; Oxoby and Spraggon, 2008; Cherry et al., 2002; Hoffman et al., 1994), Ultimatum games (Barber IV and English, 2019), Nash demand games (Gächter and Riedl, 2005), Trust games (Cox and Hall, 2010; Fahr and Irlenbusch, 2000) and redistribution games (Gee et al., 2017). However, there is mixed evidence about the effect of earned endowments in public goods games (Antinyan et al., 2015; Balafoutas et al., 2013; Spraggon and Oxoby, 2009; Harrison, 2007; Cherry et al., 2005; Clark, 2002). We find that earned property rights alone do not dramatically influence insider harvests and outsider poaching, but they do do encourage higher deterrence levels from insiders.

Our results also dovetail with findings in simple dyadic games with theft. For example, Danková and Servátka (2015) study a two-player game where a second-mover either earns or receives an endowment, the property right, which a first-mover can steal. If the first-mover steals the endowment,

[7] TURFs are also found to under-provide deterrence (Davis et al., 2017), particularly when poachers can retaliate. Insiders in our experiment were safeguarded from retaliatory punishment by outsiders.

the second-mover can retaliate with monetary punishment. Like us, the authors find that earned endowments are significantly more likely to be protected. Together, the findings from Danková and Servátka (2015) and this paper suggest that an earned property right is more salient and so its theft is more egregious. This is likely why subjects who earned the right to be an insider did a better job at coordinating deterrence. Nevertheless, a heightened sense of ownership of the CPR was not enough to motivate insiders to fully deter outsiders. In other words, the free-rider problem in enforcement is present even under an earned property-rights regime.

Similarly, our findings on poaching in the absence of punishment relate to the literature on "taking aversion". Theory suggests an innate sense of property can create moral costs that deter theft (Eswaran and Neary, 2014), though Faillo et al. (2019) note that the experimental evidence from simple bargaining games with a fixed surplus is mixed. Faillo et al. (2019) augment the symmetric dictator game of List (2007) to address a number of potential confounders, including the effect of assigned versus earned property. They find that most dictators are not averse to taking (i.e., they take the other player's property), but they take less than they could, and less still when property is earned, although the effect of earned property is marginal. We find that in the absence of punishment, average poaching of an endogenous surplus (insider harvests) was slightly below predicted levels. However, many outsiders poached around the maximum amount, and outsiders were not more or less averse to poaching when the insiders' property rights were earned.

Moreover, our results show that outsiders did not seem to respond differently to property rights in the punishment conditions (*Assigned-Punishment* and *Earned-Punishment*). This is consistent with studies showing that compliance in CPRs tends to be higher when agents are involved in the design or enforcement of a regulation (Ali and Abdullah, 2010; Basurto, 2005). Abatayo and Lynham (2016) show that while "top-down" enforcement does not crowd-out intrinsic motivations to conserve the CPR, it performs worse than "bottom-up" enforcement *with* communication. This also helps explain why insiders in our study coordinate harvests quite well despite low expected costs to non-compliance: punishments between insiders may serve primarily as a signal that one is violating a group norm and thus need not exactly eliminate the gains from non-compliance. Furthermore, it is plausible that pitting insiders against outsiders helps their coordination efforts. Even an arbitrary or minimal group will coordinate against an equally arbitrary rival (Beekman et al., 2017; Chang et al., 2016; Ahmed, 2007; Tajfel et al., 1979). If the threat (or even just the presence) of outsiders influences the in-group's norms, it may also sharpen the importance of norm-compliance to insiders. By contrast, outsiders are not involved in the creation or enforcement of the rules that govern the use of the CPR, making it more likely that the only way insiders can stop poaching is by setting deterrent penalties. While we find that that insiders in *Earned-Punishment* set higher expected penalties to poaching than insiders in *Assigned-Punishment*, these penalties are still below deterrent levels, which helps explain why outsiders did not respond differently to punishment across treatments.

CPR rights-holders and the authorities overseeing them may need to explore alternative mechanisms beyond the standard crime-and-punishment approaches to property rights enforcement. In particular, our results reinforce the findings of Abatayo and Lynham (2016), who highlight the importance of communication in mitigating negative CPR outcomes. Rather than only "communicating" with outsiders through punishment, future research can explore whether insiders could benefit from direct communication with outsiders. For example, communication could allow insiders to threaten enforcement, give context to enforcement, or even bargain over access to the CPR.

The rest of this paper is organized as follows. Section 2 summarizes our theoretical benchmarks and our experiment design, including a detailed description of our scoring rule for the slider task used to allocate property rights. In Section 3 we present our results. Section 4 discusses our results and possible directions for future research.

2 Design and procedures

2.1 Theory and experimental benchmarks

Our design is based on the theoretical set-up from De Geest and Stranlund (2019), which extends Apesteguia and Maier-Rigaud (2006) to model a group of insiders with rights to a CPR coordinating their harvests from the CPR and sanctions to deter poachers. The payoff to individual h who is an insider i is

$$\pi_{hi} = c(e - g_{hi}) + \frac{g_{hi}}{\sum_{h=1}^{n_i} g_{hi}} V(G_i) \tag{1}$$

where e is the insider's endowment, g_{hi} is the insider's harvest of the CPR, c is the return to a private good, $V(G_i)$ is the surplus defined by $V(G_i) = a\sum_{h=1}^{n_i} g_{hi} - b(\sum_{h=1}^{n_i} g_{hi})^2$, and n_i is the number of insiders. In the absence of outsiders this model is simply the same simultaneous non-linear CPR as Ostrom et al. (1992) (and many others) with a socially optimal harvest and a Nash equilibrium harvest above the social optimum.

When outsiders are introduced, the model has two-stages. First, insiders choose their harvests and generate surplus $V(G_i)$. Outsiders then observe the surplus and choose how much of it to poach. The payoff to individual h who is an outsider o is

$$\pi_{ho} = c(e - x_{ho}) + f(x_{ho}, V(G_i)) \tag{2}$$

where e is the outsider's endowment and $f(x_{ho}, V(G_i)) = x_{ho}wV(G_i)$ are the returns to effort x_{ho} exerted towards poaching, with $w \in (0, 1)$.

The key point about outsider payoffs in this model is that they are linear in poaching, meaning an outsider spends either all or none of their endowment on poaching. Moreover, it can be shown that outsiders only poach when insiders harvest above a threshold level of harvest G_i^0 (a full derivation of the model benchmarks is available in Section A of the appendix). This implies that one way insiders can deter outsiders is by choosing a low-enough level of harvest and generating a small surplus $V(G_i^0)$ that disincentives poaching. And since the insider who unilaterally increases their harvest above this threshold loses it to poaching, this method of deterrence can be sustained as a

Nash equilibrium.

However, this form of deterrence, in which insiders strategically generate a small surplus, is payoff dominated by the other form of deterrence that involves insiders generating a large surplus and then coordinating the use of monetary sanctions to disincentive poaching. Suppose insiders have a technology θ that converts individual sanctions s_{hi} into monetary punishments. These could be fines, or more severe punishments such as those seen in the field (e.g., damaging boats). Assuming insiders can perfectly monitor outsiders, poaching is deterred when

$$\theta \sum_h s_{hi} \geq ewV(G_i)$$

or when the sum of individual contributions towards deterrence ($\theta \sum_h s_{hi}$) is at least equal to the total gains to outsiders from poaching ($ewV(G_i)$). When insiders establish a credible threat, outsiders are deterred (they know whatever they gain from poaching will be lost in punishment), and insiders need never actually punish outsiders.

Importantly, deterring outsiders through the coordinated use of sanctions allows insiders to increase their payoffs by generating a larger surplus. However, this form of deterrence cannot be sustained as an equilibrium, since punishment in a repeated game with a known end period is not credible. This is because deterrence is a second-order public good, meaning each insider has an incentive to free-ride and withhold sanctions. In the absence of a mechanism that ensures insiders contribute towards deterrence, the subgame perfect equilibrium sees insiders not deterring and outsiders poaching. Therefore, one of the main questions we ask in this paper is whether earned property rights can serve as such a mechanism. While earned property do not affect incentives in our model, evidence from other, simpler experiments suggest that subjects will exert more effort to defend earned versus assigned property rights (Danková and Servátka, 2015).[8]

Table 1 reports our experimental benchmarks. Like De Geest and Stranlund (2019) we set $a = 6, b = 0.025, c = 1, e_{hi} = e_{ho} = 50, n_i = 4$ and $w = 0.01$ (to satisfy $1 - e_o w > 0$).[9] The benchmarks are expressed in terms of aggregate harvest G_i. For instance, G_i^0 is the Nash equilibrium harvest that deters poaching by generating a small surplus, $G_i^{S,D}$ is the socially-optimal aggregate harvest when outsiders deter outsiders with sanctions, $G_i^{S,ND}$ is the socially-optimal aggregate harvest when outsiders do not deter outsiders with sanctions ("ND" for "non-deterrence")

[8] Insiders in our experiment could also communicate with each other to facilitate coordination. A number of studies have shown that communication increases coordination in CPR experiments (Cason and Gangadharan, 2015; Cardenas et al., 2000; Cardenas, 2000; Ostrom et al., 1992). However, there is no evidence that insider communication correlates with outsider deterrence in the CPR-with-poaching experiments by De Geest and Stranlund (2019), Chávez et al. (2018) and De Geest et al. (2017). In a different environment, Morgan et al. (2019) explore how private (one-way) communication with a rule-maker who establishes a non-binding minimum contribution rule affects public goods provision. The authors find that comments help but are insufficient to sustain high contribution levels. However, the introduction of an exogenous punishment mechanism (which punishes individuals who contribute less that the minimum contribution rule) does increase contributions to the public good and reduces non-compliant behavior. In our study, insiders could communicate in all treatments and had the ability to punish one another in half of our treatments.

[9] The parameters in De Geest and Stranlund (2019) are based on Kingsley and Liu (2014) who study a non-linear CPR with no outsiders.

and so on. The column "Insider payoff" is the surplus $V(G_i)$ generated by an aggregate harvest benchmark and split across n_i insiders.

Table 1: Benchmarks and payoffs to insiders and outsiders.

	Benchmark	Aggregate harvest	Individual harvest	Insider payoff	Outsider payoff
(1)	Non-cooperative harvest/ Deterrence ($\boldsymbol{G_i^0}$)	18	4.5	70	50
(2)	Non-cooperative harvest/ Deterrence ($\boldsymbol{G_i^{N,D}}$)	160	40	90	50
(3)	Non-cooperative harvest/ Non-deterrence ($\boldsymbol{G_i^{N,ND}}$)	170	42.5	45	136.85
(4)	Cooperative harvest/ Deterrence ($\boldsymbol{G_i^{S,D}}$)	100	25	112.5	50
(5)	Cooperative harvest/ Non-deterrence ($\boldsymbol{G_i^{S,ND}}$)	80	20	70	160

It is clear from Table 1 that it is better to hold the property right and have a shot at deterring outsiders than to be an outsider, as the majority of benchmarks favor the insiders. This is important because it creates an incentive for subjects in our experiment to compete for the property right in the effort task. In the model, insiders have two margins of coordination: harvest and deterrence. Payoffs to insiders are maximized when they coordinate on both margins (Benchmark 4). If they can only coordinate on one margin, they are better off coordinating on deterrence (Benchmark 2) than harvests (Benchmark 5). When insiders cannot deter outsiders their payoffs are equivalent at the socially optimal surplus (Benchmark 5) and at the threshold G_i^0 (Benchmark 1).

Outsider poaching is linear: either they poach all of the insiders' surplus or they poach none. If insiders collectively harvest above the threshold G_i^0, and do not commit to deterrence, then outsiders poach the entire surplus (Benchmarks 3 and 5). If insiders harvest below the threshold, *or* if insiders harvest above the threshold and commit to deterrence, then outsiders invest their entire endowment into the private good with fixed return of 50 EDs (Benchmarks 1, 2 and 3).

2.2 Experimental procedure

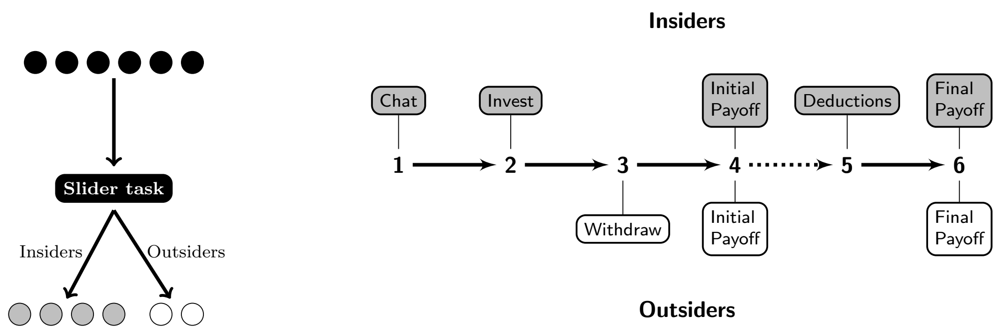
Our experiment is similar to De Geest and Stranlund (2019) but with two key differences.[10] First, we introduce earned property rights to the CPR. Second, we allow insiders to sanction not only outsiders but also fellow insiders.

We use a 2×2 between-subject design in which a subject participates in one of the four experimental conditions. The conditions are identical except for the manner in which the property rights are allocated (*Assigned* vs. *Earned*) and whether a sanctioning technology is present (*No Punishment* or *Punishment*). We therefore have four experimental treatments: *Assigned-No Punishment*, *Assigned-Punishment*, *Earned-No Punishment*, and *Earned-Punishment*. The treatments without punishment allow us to isolate how earned versus assigned property rights alone influence outsider poaching. The mechanism to allocate rights does not affect the theoretical outcomes for insiders and outsiders. Nevertheless, if outsiders in our experiment were to respect the insiders' claim in *Earned-No Punishment*, we should see less poaching than in *Assigned-No Punishment*. Introducing

[10] Beekman et al. (2017) also study competition between groups. One major difference between our study and theirs is that outsiders in our design can poach the surplus created by insiders.

punishment allows us to isolate how mechanisms to allocate rights affect insiders' ability to coordinate the use of sanctions to deter outsiders. While insider incentives are unchanged by any such mechanism, earned rights tend to be more salient and defended more aggressively (Danková and Servátka, 2015), so it is possible that insiders will do a better job of coordinating deterrence in *Earned-Punishment* than *Assigned-Punishment*.

Figure 1 summarizes our design. At the beginning of each session, subjects were randomly placed together into groups of six as shown in Panel (a). (Groups remained fixed for the entire session.) Next, we distributed property rights. Subjects with the property rights were told they were members of Type 1, while the rest were Type 2. In the *Assigned* treatments, property rights were randomly distributed, similar to De Geest et al. (2017) and De Geest and Stranlund (2019). In the *Earned* treatments, property rights were distributed based on the outcome of the real-effort task, which we explain below. After distributing property rights, subjects went through stages 1 - 6 as shown in Panel (b). Completion of all stages constituted one round. There were a total of fifteen rounds in the experiment. (The instructions to our experiment are available in the appendix.)



(a) Sorting. **(b)** Stages.

Figure 1: Experiment design. Insiders are in gray, outsiders in white. Insiders held the property rights to the CPR. In the *Assigned* treatments, insiders were chosen randomly by the software. In the *Earned* treatments, the four best performers in the slider task were selected to be insiders. Stage 4 represents the last stage in the No Punishment condition. The dotted line depicts the additional stages in the Punishment condition.

At the start of the experiment, the experimenter read out-loud the full set of instructions for both parts of the experiment, the slider task and the CPR game. The subjects were also provided with their own copies of the instructions. After going through the instructions, the subjects undertook a detailed comprehension quiz. The subjects proceeded to the experiment only after answering the questions correctly. Thus, at the very outset the experiment, subjects were aware of: i) whether they would become Type 1 or 2 players by random assignment or by earning it through their performance in the slider task; ii) that Type 1 players were first-movers, and only they could communicate and punish; iii) the payoffs to Type 1 and 2 players.[11]

[11] Ioannou et al. (2015) show that in simple bargaining games, displaying group payoffs can generate intergroup biases.

2.2.1 Allocating property rights with a real-effort task

As previously noted, the benchmarks in Table 1 show that it is generally better to be an insider than an outsider in our design. Before the effort task, subjects were trained on the payoff functions to both insiders and outsiders, and had to answer a set of comprehension questions to ensure they understood the differences between the two. After reading the instructions and correctly answering the comprehension quiz, subjects participated in a modified version of the slider task by Gill and Prowse (2012). There are many advantages to the slider task over other real-effort tasks as documented in Gill and Prowse (2019).[12] It is easy for subjects to understand, consistent (each slider is the same), and reduces noise by leaving no room for guessing. Moreover, results from Gee et al. (2017) suggest that the slider task is an appropriate method to allocate property rights in our design.[13] Gee et al. (2017) study income redistribution and find that when income is earned from the Gill and Prowse (2012) slider task, subjects are less willing to redistribute their income to others, compared to when incomes are randomly assigned. The authors argue that this is because subjects who earn their income from the slider task believe that they deserve it.

However, for our purposes, the scoring rule of Gill and Prowse (2012) is too coarse. Sliders have a minimum value of zero and maximum value of 100, and subjects earn a point only when they move a slider to exactly 50. Since a subject is awarded points only when he or she reaches exactly 50, there is a higher chance of ties, and ties must be broken randomly by the experimenter. This poses a problem for our design. Ties broken randomly may weaken the sense of "earning" the property right.

Therefore, we modified the Gill and Prowse (2012) slider task by introducing a finer scoring rule. Let i be the integer position of slider q between 0 and 100. A subject's total effort score was calculated as

$$\left(\frac{\sum_{i=1}^{N} |q_i - 50| - 50}{50} \right) \times -100 + \mathcal{U}(0.001, 0.009) \tag{3}$$

which equals the subject's average absolute deviation from the maximum score. This rule made it so subjects could earn points in smaller amounts. Specifically, subjects earned points as they moved each slider closer to 50. When a slider was positioned at zero or 100, the score was zero. Each step closer to 50 from either direction increased the slider score by 0.04 points. Moving the slider to 25 or 75 resulted in a score of one. When a slider was placed exactly on 50, the score was two, the highest possible. There were fifty sliders on the screen, so subjects could earn a maximum of 100 points. Effort scores were added to total payoffs at the end of the experiment with a conversion rate of 1 point = \$0.02, with a maximum payoff of \$2.00 (100 points).

Our scoring rule preserves the original scoring rule in the Gill and Prowse (2012) slider task:

[12] A criticism of the slider task is that effort does not vary with incentives (Araujo et al., 2016). But that is not a concern for us, because we are using the slider task to simply rank subjects, and not to assess the impact of incentives on performance.

[13] One subject who was an insider in *Earned-Punishment* wrote: "we won the slider game so we get more". Coupled with the higher use of punishment by insiders to deter outsiders observed in the data, this statement provides some evidence in favor of the notion that subjects felt a claim to the right and also grasped the value of being an insider with access to the right.

subjects who placed more sliders at exactly 50 earn more points. The adjustment we made further enabled subjects to be rewarded for their general efforts, as each slider they moved closer to 50 earned them points. Since points were awarded in steps of 0.04, subject scores could range from any number with two decimals between 0.00 and 100.00, reducing the likelihood of ties. Of course, ties were still possible, so a tiny random number drawn uniformly between 0.001 and 0.009 was added to each score in the event of a tie. However, there were no ties in any of our sessions. Scores in the real-effort task did not vary significantly across treatments.[14]

Subjects in both *Assigned* and *Earned* completed our slider task to maintain consistency across treatments (Feltovich, 2019). Subjects participated in this task for two minutes. Total effort scores were shown at the top of their screens and updated in real time. At the end of the task, subjects were informed of their total effort score, their earnings from the task, whether they were made a Type 1 member (meaning they were the insiders and shared the property rights) or a Type 2 member (the outsiders), and their corresponding ID (a Type 1 ID was 1, 2, 3 or 4; a Type 2 ID was 1 or 2). These IDs stayed the same throughout the session, allowing subjects to identify each other. Subjects were also informed whether there were any effort score ties within their group. As previously noted, there were no ties in any of the treatments.

2.2.2 Experiment stages

At the start of each round, all insiders and outsiders received an identical endowment of 50 Experimental Dollars (EDs).[15] Insiders began with a 60-second communication stage in which they could exchange messages in a chat room. Then the insiders individually chose how much of their endowment to invest in a shared account ("The Account") or to keep for themselves. Outsiders next viewed the value of The Account and decided how much they wanted to withdraw to their personal account. Like De Geest and Stranlund (2019), each outsider could withdraw at most 25% of The Account. Thus, the maximum loss to insiders was 50%, ensuring that insiders would always have an incentive to invest in The Account. Outsiders had a calculator on their decision screen that let them calculate how their payoff could vary for different withdrawals, holding the value of The Account constant. Likewise, insiders had a calculator that showed how their payoffs would change if they changed their investment and/or if the other insiders changed their investment decisions. Before starting a session, we ran a detailed comprehension stage. Subjects were introduced to the software and learned how to use both calculators to ensure they understood the decisions made by insiders and outsiders.

After outsiders chose their withdrawals from The Account, insiders and outsiders viewed their initial payoffs, as well as the value of The Account and the total investment by insiders and withdrawal by outsiders. In the *No Punishment* conditions, the experiment continued to the next round. In the *Punishment* conditions, insiders could levy sanctions on outsiders and other insiders. Sanctions were referred to as "Deductions" in the instructions. We used the standard 1:3 sanctions

[14]See Figure A1 in the appendix.

[15]The conversion rate was set at 1 Experimental Dollar = 0.01 US Dollar.

technology in which a subject can pay one experimental dollar to reduce another subject's payoffs by three experimental dollars (De Geest and Stranlund, 2019; Chaudhuri, 2011). An insider's budget for sanctions was their initial payoff. Both insiders and outsiders then observed their final payoffs for that round (initial payoffs less sanctions sent or received) and their cumulative payoffs across rounds.

2.2.3 Implementation

Data was collected in Spring 2019 at the University of Massachusetts Amherst Cleve E. Willis Experimental Economics Laboratory. Subjects were recruited from the undergraduate population at the University of Massachusetts Amherst using ORSEE (Greiner, 2015) A total of seven sessions were conducted with a total of 168 subjects (which is in line with the number of subjects used in similar studies: 96 subjects in De Geest et al. (2017), 120 subjects in De Geest and Stranlund (2019), and 200 subjects in Chávez et al. (2018)). We collected eight groups for *Assigned-No Punishment*; six groups for *Assigned-Punishment*; six groups for *Earned-No Punishment*; and eight groups for *Earned-Punishment*. The average session lasted approximately one hour and thirty minutes. Subjects earned an average of $17.31 ($17.37 for insiders, $17.19 for outsiders), with a standard deviation of $1.83 ($1.70 for insiders, $2.07 for outsiders). The experiment was implemented in z-Tree (Fischbacher, 2007).

3 Results

We divide our results into two sections.[16] First we look at insider harvest and then outsider poaching in our four experiment conditions. Insiders tended to harvest around the social optimum, while outsiders poached regardless of how property rights were allocated. However, outsiders reduced their poaching when they were hit with more severe punishment.

The next section of our results focuses on the use of punishment across *Earned-Punishment* and *Assigned-Punishment*. We calculate the expected punishments to insiders and outsiders across treatments by combining estimates of the extensive margin (the probability of punishment) and the intensive margin (the intensity of punishment). We find that when insiders earned the property right to the CPR, they were significantly more likely to punish outsiders and impose higher expected punishments. However, the gains from poaching were not completely eliminated by insiders in neither *Earned* or *Assigned*.

3.1 Harvest and poaching

Table 2 summarizes average harvests and poaching levels, as well as average payoffs across treatments. Insider harvests were consistently around 25 (the social optimum with deterrence) in both treatments. We find no significant difference in insider harvests between *Earned-No Punishment*

[16] The code and data to replicate our results can be found online at https://github.com/lrdegeest/OursNotYours.

and *Assigned-No Punishment* ($\chi^2 = 0.00, p = 0.96$) nor between *Earned-Punishment* and *Assigned-Punishment* ($\chi^2 = 0.62, p = 0.43$).[17] Insiders payoffs were also consistent across treatments, with payoffs increasing only marginally in the punishment condition.

Table 2: Average harvest/poaching and payoff across treatments. Standard deviations are shown in parentheses.

(a) Insiders

	Assigned		**Earned**	
	No Punishment	*Punishment*	*No Punishment*	*Punishment*
Harvest	29.74	28.07	29.59	26.50
	(16.35)	(15.12)	(12.97)	(15.44)
Payoff	67.83	69.31	69.01	70.29
	(34.17)	(37.07)	(30.82)	(38.23)

(b) Outsiders

	Assigned		**Earned**	
	No Punishment	*Punishment*	*No Punishment*	*Punishment*
Poaching	38.63	34.28	42.06	33.15
	(16.37)	(16.70)	(13.10)	(16.64)
Payoff	74.56	61.73	78.75	57.90
	(13.74)	(17.33)	(11.89)	(19.17)

Figure 2 provides a more detailed look at each treatment. Harvest and poaching distributions across all periods are shown in the left-hand panels, while the right-hand panels show average harvest and poaching over time. Most harvest decisions appear to cluster around the social optimum with deterrence (25, the dashed line), less around the Nash with deterrence (40, the solid line) and least around the threshold G_i^0 (4.5, the dotted line). In *No Punishment* treatments the density is higher for *Earned*, though we see no major gaps in the time series. Overall, insiders appeared to coordinate effectively on harvests regardless of how property rights were allocated but introducing seems to further improve that coordination. We have some mixed evidence that average insider harvests are significantly different from the social optimum across our treatments without punishments. A t-test reveals that the average insider group harvest is not statistically different from the social

[17] We report Chi-squared tests of average treatment effects estimated from the linear model $x_{htk} = \alpha + \beta T + \mu_h + \nu_k + \varepsilon_{htk}$, where x_{htk} is the harvest or poaching decision by subject h in group k in period t, T is the treatment indicator ($T = 0$: *Assigned*, $T = 1$: *Earned*), μ_h is the individual random effect and ν_k is the group random effect. Standard errors are clustered at group level. Separate models were estimated for insiders and outsiders, with and without punishment. De Geest and Stranlund (2019) and De Geest et al. (2017) use a similar approach to estimate treatment effects.

optimum in *Assigned-No Punishment* ($t = 1.97, p = 0.09$), but it is statistically different in *Earned-No Punishment* ($t = 3.04, p = 0.03$). By introducing punishment, and thereby giving insiders the ability to deter outsiders (as well as a credible threat to punish insiders), average group harvests are no longer statistically different from the social optimum across treatments (*Assigned-Punishment*: $t = 1.64, p = 0.16$, *Earned-Punishment*: $t = 0.69, p = 0.51$).

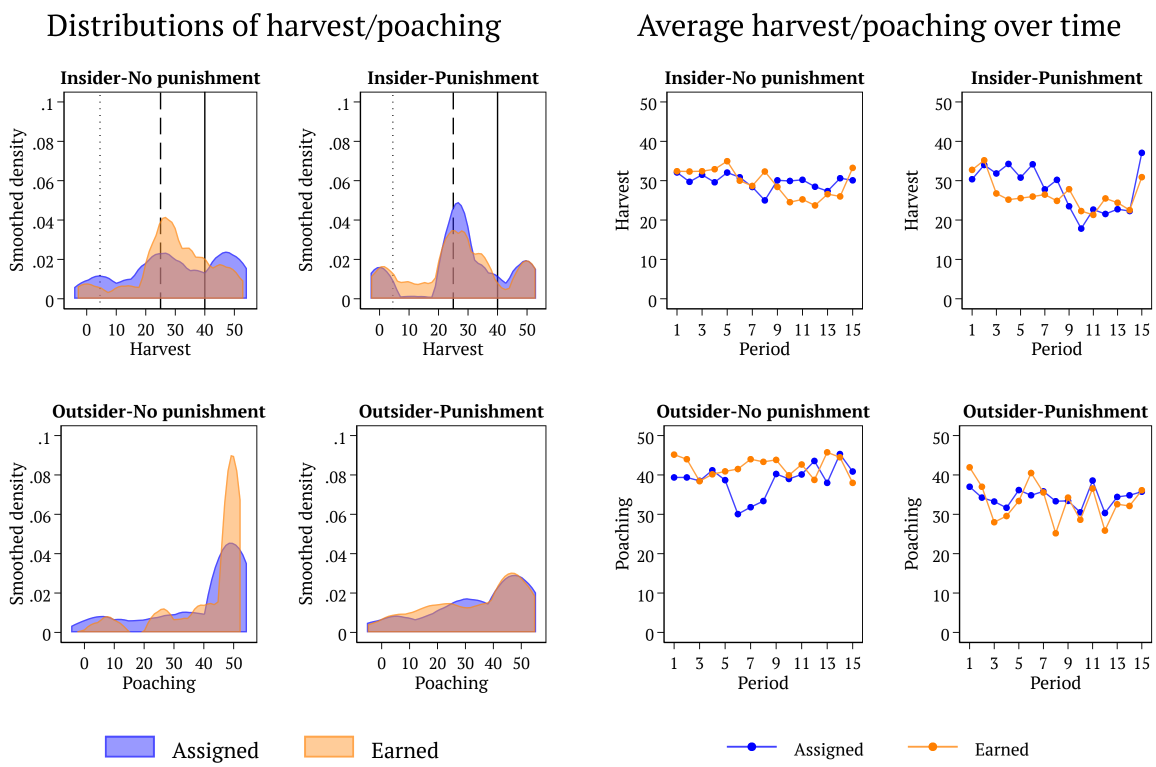


Figure 2: Summary of insider harvest and outsider poaching. The four panels on the left show distributions of harvest/poaching across treatments and over all periods. Black lines indicate theoretical benchmarks in Table 1. Dotted line: G_i^0 (threshold harvest). Dashed line: social optimum with deterrence. Solid line: Nash harvest with deterrence. The four panels on the right show averages for each period.

Turning to the outsiders, we see that average poaching and average payoffs were also steady across *Earned* and *Assigned* treatments. In both conditions there was a decrease in average poaching and payoffs when punishment was introduced. Interestingly, in both property rights conditions without punishment, average poaching was below 50 (theoretical poaching), and since average insider harvest was above the threshold G_i^0 (the aggregate harvest that is too low to incentivize poaching), it seems outsiders may have had some respect for the insiders' property rights, regardless of the allocation method. However, as evidenced in Figure 2, most poaching decisions skewed towards 50. While outsider poaching was lowest in the *Earned* treatments, we do not find a treatment effect for earned property rights (*Assigned-No punishment* vs *Earned-No punishment*: $\chi^2 = 0.62, p = 0.43$; *Assigned-Punishment* vs *Earned-Punishment*: $\chi^2 = 0.04, p = 0.84$).

However, we do see a significant decline in poaching in *Earned* when insiders can punish outsiders. The bottom left panel of Figure 2 shows the distributions of outsider poaching across treatments and conditions. In *Earned-No Punishment* we observe a sharp peak in the density at high levels of poaching (from around 40 to 50) that flattens out in *Earned-Punishment*, and we find a significant difference between the two treatments ($\chi^2 = 3.94, p = 0.05$). This in turn led to a significant drop in payoffs to outsiders in *Earned-Punishment* relative to outsider payoffs in *Earned-No Punishment* ($\chi^2 = 11.41, p < 0.01$). By contrast, there is no significant decline in poaching within *Assigned-No Punishment* and *Assigned-Punishment* ($\chi^2 = 0.65, p = 0.42$). While outsiders payoffs also fell on average by about \$13 EDs across *Assigned-No Punishment* and *Assigned-Punishment* ($\chi^2 = 9.26, p < 0.01$), the effect was larger in *Earned-Punishment*, where outsider payoffs fell about \$21 EDs, and the difference is also significant ($\chi^2 = 11.41, p < 0.01$).

To summarize our results so far, insiders tended to harvest close to the social optimum in both *Earned* and *Assigned* without punishment, suggesting that simply holding the property right – regardless of how it was allocated– helped insiders coordinate their harvests. Peer punishment had a modest effect on insider harvest coordination by centering the harvest around the social optimum of harvests around the social optimum. So it is plausible that the presence of outsiders alone helps insiders coordinate their harvest decisions. But the same may not hold for coordinated deterrence. Indeed, the significant drop in poaching within *Earned* when punishment is introduced suggests that earned property rights help insiders better coordinate deterrence. We now turn to our punishment data to explore this result in more detail.

3.2 Punishment and deterrence

Figure 3 summarizes average punishment received across treatments for insiders and outsiders. The left-hand panel shows average punishment over all observations (zero and positive punishment), and the center panel shows average punishment just for sanctions greater than zero. Punishments to outsiders were larger than punishments to insiders when looking at all observations, but the gap narrows when we look only at positive sanctions. This suggests that outsiders did not receive larger sanctions, but instead were punished more often. The rightmost panel in Figure 3 shows the proportion of gains from poaching removed by sanctions. Insiders in *Earned* appeared to deter more of the gains from poaching than in *Assigned*. But after controlling for individual and group random effects the difference is not significant (all punishment: $\chi^2 = 0.21, p = 0.65$; punishment greater than zero: $\chi^2 = 0.01, p = 0.93$).

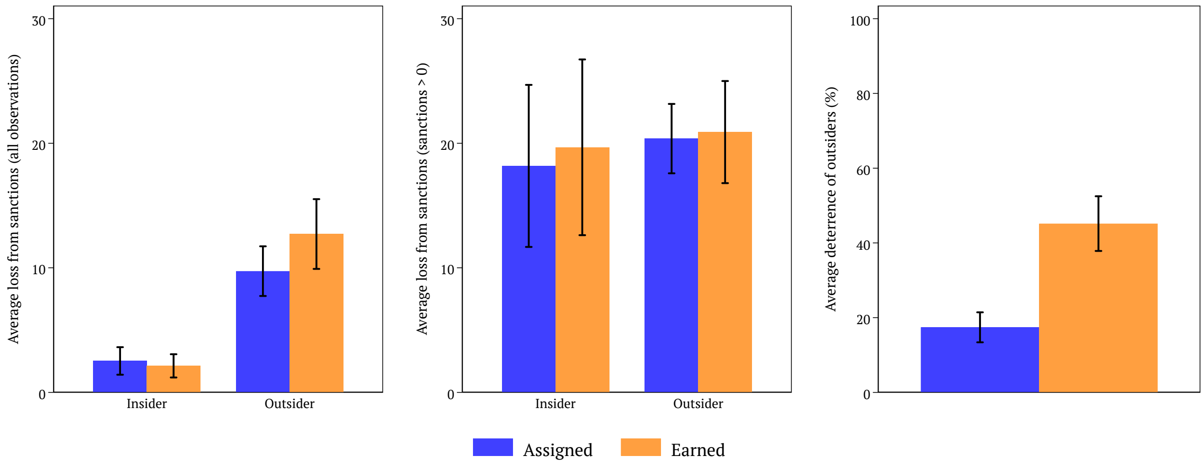


Figure 3: Average cost of sanctions received: all observations (left) and all positive sanctions (center). Average deterrence of poaching (the percent of the gains from poaching removed with punishment) is show on the right. The 95% confidence intervals are shown in black.

However, average punishment and deterrence obscure two important points. First, from the point of view of a target, punishment is probabilistic. Therefore we need to consider the expected punishment: the intensity of punishment weighted by the probability of punishment.[18] Second, expected punishments may be non-linear. For example, De Geest et al. (2017) show that insiders aggressively punish high levels of poaching but effectively ignore low levels of poaching (although the authors do not account for the probabilistic nature of punishment).

To calculate expected punishments we separately estimate the probability of punishment and the intensity of punishment, and then combine them. A probit model estimates the probability of punishment, and a Poisson model estimates the intensity of punishment. Our full specification is

$$P(\text{sanction})_{ijkt} = \Phi(\beta_0 + \beta_1 g_{ikt} + \beta_2 g_{jkt} + \beta_3 \sum_j^{n_k} s_{ijk,t-1} + \mu_i + \epsilon_{ikt}) \tag{4a}$$

$$\mathbb{E}[\text{sanction}|\text{sanction} > 0]_{ijkt} = \exp(\alpha_0 + \alpha_1 g_{ikt} + \alpha_2 g_{jkt} + \alpha_3 \sum_j^{n_k} s_{ijk,t-1} + \nu_i + \varepsilon_{ikt}) \tag{4b}$$

where g_{ikt} is the harvest of subject i in group k and period t, g_{jkt} is the harvest or poaching of a target j, $\sum_j^{n_k} s_{ijk,t-1}$ is the total amount of punishment sent by i in the previous round, $\mu_i(\nu_i)$ are individual random effects, and $\epsilon_{ikt}(\varepsilon_{ikt})$ is the idiosyncratic error.

After estimating the parameters in Equation 4 we plugged them back in and calculated the derivatives for each level of harvest and poaching between zero (the minimum) and fifty (the maximum). This gave us the predicted probability of punishment for a given level of harvest and poaching, and the predicted intensity of punishment for those same levels of harvest and poaching.

[18]This is also true in the field. For instance, TURF members cannot ensure perfect monitoring when patrolling their TURF boundary (e.g., Gelcich et al., 2017).

Multiplying each probability with the corresponding magnitude gave us the expected punishment from the average insider. Multiplying this number by four gave us the total expected punishment to an outsider from the entire group of insiders.

We take our expected punishment calculation to describe insider coordination. Each expected punishment curve is a proxy for how well insiders coordinated self-governance (behavior within their group) and deterrence (behavior outside their group). If they coordinated well, then the expected punishment for a given level of harvest beyond the social optimum should cancel out the benefits to noncooperation. Similarly, the expected punishment for poaching – at any level – should cancel out the gains to the poacher and make them indifferent about poaching.

Figure 4 shows our estimates of the expected punishments to insiders and outsiders across treatments. Insiders faced nearly identical expected punishments in *Assigned* and *Earned*, and these punishments were quite low. Outsiders, by contrast, faced much higher expected punishments. Consistent with our earlier finding of a significant decrease in extreme poaching by outsiders in *Earned-Punishment*, we see that insiders who earn the right to be an insider more effectively coordinated than insiders who were randomly assigned the right. While there is a lot of overlap in the expected punishments for low levels of poaching, the confidence interval is much tighter for *Earned*. For higher levels of poaching, we begin to see a significant difference between treatments as seen by the gap in expected punishments. After poaching of around 30, we see insiders in *Earned* imposing significantly higher expected punishments. At poaching of 50, the expected punishment in *Earned* is almost double that of *Assigned*.

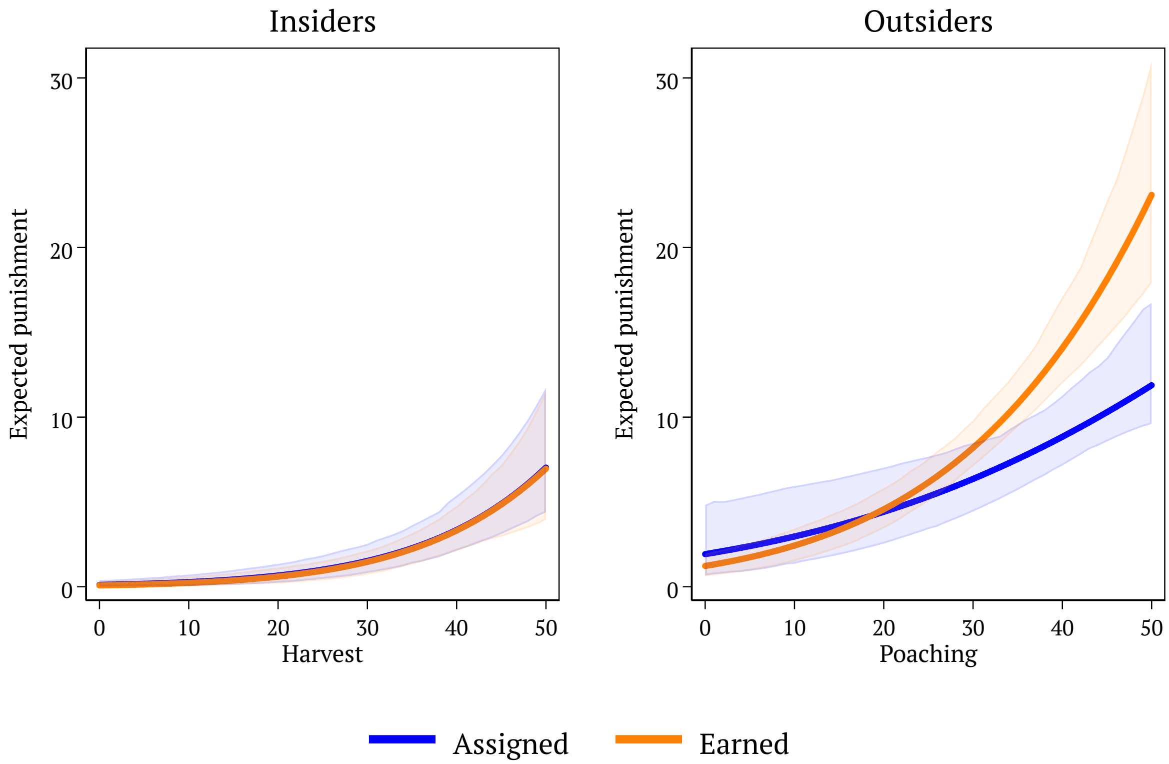


Figure 4: Expected punishments (predicted probability of punishment times the predicted magnitude of punishment). Shaded are the bootstrapped, bias-corrected 95% confidence intervals from 1000 simulations.

To put these expected punishments into sharper relief, we calculated how much a representative insider or outsider could gain from non-compliance in Figure 5. The left-hand panel assumes $n_i - 1$ insiders are harvesting the social optimum ($g_{hi} = 25$) and calculates the gains from defection to the remaining insider $-i$ net the expected punishments in *Earned* and *Assigned*. The black line shows the gains from defection with no punishment. What stands out is the modesty of enforcement among insiders. Net expected payoffs with punishment are very close to payoffs without punishment, meaning defections from the social optimum were not aggressively targeted. Yet, as previously discussed, most insider harvests in both treatments were close to the social optimum. In other words, insiders coordinated their harvests with very little punishment.

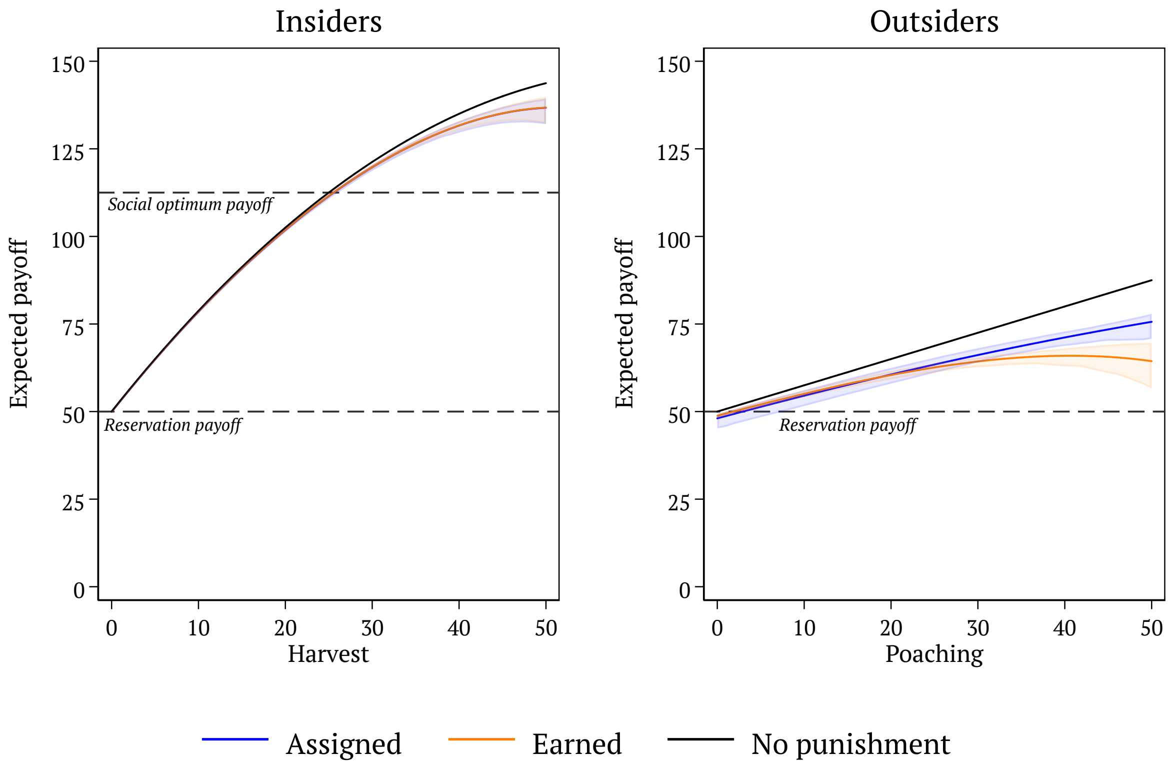


Figure 5: Expected benefits to non-compliance. In the left-hand panel we assume $n_i - 1$ insiders are harvesting the social optimum and calculate the gains from defection to the remaining insider net the expected costs of punishment. In the right-hand panel we assume n_i insiders harvest the social optimum and calculate the gains to poaching for an outsider net the expected costs of punishment. Each panel shows the reservation payoff to the representative insider or outsider who does not harvest or poach.

The right-hand panel of Figure 5 shows the expected payoffs to poaching by a representative outsider when all the insiders harvest the social optimum. As before, the black line shows payoffs without punishment. At higher levels of poaching we see the divergence in the two treatments, as expected payoffs fall more in *Earned* than *Assigned*. Had insiders achieved total deterrence then the expected payoffs to any level of poaching would lie on the reservation payoff line (50). While total deterrence clearly did not happen, it is notable that in *Earned* the expected payoff to extreme poaching is closer to the reservation payoff. We interpret this as evidence that insiders in *Earned* did a better job of coordinating deterrence, at least for extreme poaching.

Of course, it is possible that individual differences and not group coordination are behind the gap in expected punishments. We test this by re-estimating Equation 4 with a treatment indicator interacted with each explanatory variable and then calculated the average marginal effects. Results are shown in Table 3.

Table 3: Average marginal treatment effects of punishment behavior. Each value shows the average marginal effect of an explanatory variable calculated as the average difference between *Earned* and *Assigned*. Standard errors are shown in parentheses and are clustered at the group level.

	Insiders		Outsiders	
	(1)	(2)	(3)	(4)
	P(sanction)	E[sanction]	P(sanction)	E[sanction]
Target harvest/poaching	0.002***	0.026**	0.007***	0.018***
	(0.00)	(0.01)	(0.00)	(0.00)
Own harvest	-0.000	-0.010	0.000	-0.000
	(0.00)	(0.01)	(0.00)	(0.01)
Sanctions in t-1	0.001	0.025	0.007**	0.009
	(0.00)	(0.03)	(0.00)	(0.01)
Observations	2352	108	1568	388

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In each regression, positive and statistically significant effects are seen for Target Harvest/Poaching, indicating that insiders in *Earned* were significantly more likely to both participate in enforcement and to contribute more sanctions than in *Assigned*. Moreover, we see very few treatment differences on the covariates that describe the average insider, with one exception: insiders in *Earned* were more likely to participate in deterring outsiders if they had contributed deterrence in the previous round. Given this evidence, it is unlikely that the method of allocating property rights affected insiders at the individual level. However, it appears that earned property rights do encourage insiders to defend their property right, even if they fail to eliminate all the gains from poaching.

4 Discussion

In this paper we studied two different methods of allocating property rights to CPRs. In half our treatments (*Earned*), subjects earned access to the CPR by scoring highly on a real-effort task. In the other half (*Assigned*), subjects were randomly assigned access to the CPR. We also varied whether subjects with access to the CPR-insiders- could levy sanctions (*No Punishment* and *Punishment*). While insiders in both *Assigned* and *Earned* treatments coordinated equally well on harvest, insiders who earned access to the CPR did a better job at coordinating on deterrence. Specifically, insiders who earned the right to be an insider were more likely to punish outsiders and to impose higher expected punishments. This finding in a complex, multi-player game with inter-group conflict is consistent with findings from simple two-player games studies that suggest earned endowments or property rights are more salient and thus defended more aggressively (Danková and Servátka, 2015).

Nevertheless, and consistent with previous studies, insiders in both *Assigned-Punishment* and

Earned-Punishment tended to tolerate a certain amount of poaching (De Geest and Stranlund, 2019; Chávez et al., 2018; De Geest et al., 2017). Evidence from insider communication suggests this was a deliberate choice. Poring over the chat logs, we find that groups often started off with a back-and-forth about whether to punish outsiders at all. Some insiders saw punishing outsiders as wasteful and held onto this view, while others adjusted their opinion as they observed poaching. Still others proposed the idea of creating less surplus for outsiders to poach in the first place, an idea keeping with one of our theoretical benchmarks (the threshold surplus at which outsiders are indifferent about poaching).

In many ways, our results reinforce the importance of communication. The ability for groups to verbally coordinate their decisions has been shown time and again to promote socially optimal CPR management (Abatayo and Lynham, 2016; Cason and Gangadharan, 2015; Cardenas et al., 2000; Cardenas, 2000; Ostrom et al., 1992). This may help explain why insiders coordinated on harvests near the social optimum in both treatments, despite setting the expected costs of non-cooperation (among insiders) far below their theoretically deterrent levels. Similarly, simply holding the property right – just being "insiders" – may instill a shared identity that was further developed through communication as groups discussed norms and the costs of non-compliance. Nearly all groups used the chat box to discuss how much to collectively harvest, and then coordinated to punish group members who did not "follow the plan" or "broke trust".

Moreover, the inability to deter poachers is hard to attribute to the insiders feeling no claim to the property right. Insiders in both the *Earned-No Punishment* and *Earned-Punishment* treatments regarded outsiders as "stealing" or "taking too much". Indeed, outsiders stirred up strong reactions among insiders. In some groups the insiders hated the outsiders with a passion. One subject even said they felt the experiment made them "racist" against outsiders.

While extreme, such sentiments are not uncommon in settings of inter-group conflict between minimal groups (Beekman et al., 2017; **?**; Tajfel et al., 1979). But if communication helps insiders feel a legitimate claim to the CPR, then the absence of communication between outsiders and insiders may have reinforced any feelings outsiders had about the illegitimacy (or irrelevance) of the property rights. This would help explain why insiders enforced themselves with minimal punishment, but needed stiffer sanctions to deter outsiders.

An open question is how our results would change if insiders could communicate with outsiders. It happens regularly in the field – poachers and TURF members often hail from the same community – but it is unclear what might result from inter-group communication. In all the laboratory studies so far on TURF management, punishment is the only way insiders can "communicate" with outsiders. The message to outsiders seems to be: go ahead and poach, but not too much. What if insiders could communicate an intent to deter poaching? They would still need a mechanism (e.g., punishment) to ensure the threat is credible, and poachers might try their luck anyway. Still, communicated threats might give outsiders something to think about before poaching, and they might also help insiders formulate better deterrence plans and stick to them.

In addition, insiders could use communication to signal information about the resource. TURFs in Chile are required to provide yearly evaluations of their stock, so they likely have more knowledge than outsiders. Insiders could exploit their private information and create uncertainty for outsiders about the resource, since uncertainty can change how fishers make decisions (Chávez et al., 2018).

Another key aspect in our study is that insiders had to make simultaneous decisions–they simultaneously chose their harvest, then observed the level of poaching by outsiders, and subsequently simultaneously chose their deterrence. Future work could explore the potential benefits of sequential decision making. Boyce and Bruner (2017) use a simple Tullock contest (only insiders) to show that sequential decisions to invest in the collective defense of private resources (e.g., investments to hire a police force) can reduce conflict between insiders. Sequential decision making among insiders may result in higher provision of deterrence if their decisions were sequential rather than simultaneous (as they are in our design). Moreover, the value of sequential decisions could be compounded if groups have a leader who is able to spur contributions to mutual defense (Loerakker and van Winden, 2017).

At the same time, it could be that deterrence efforts are too much stick and not enough carrot. Perhaps there are other ways for insiders to defend their property right that do not involve punishment. For instance, insiders could Coasean bargain with outsiders over the property right, or even develop a process by which to enable outsiders to become insiders. Alternatively, there is some evidence that simple messages extolling the importance of cooperation can increase it (Chaudhuri and Paichayontvijit, 2017). Insiders could use communication to appeal to the social or environmental preferences of outsiders and simply ask them not to poach, though outsiders may not listen to such messages if any such preferences are crowded-out by being forced out of the CPR in the first place. The broader point is that while insider-outsider communication could offer new channels towards resolving CPR conflicts, exactly how such communication should be structured, and what that communication should entail, is unclear. This is a promising avenue for future study.

References

Abatayo, A. L. and J. Lynham (2016). Endogenous vs. exogenous regulations in the commons. *Journal of Environmental Economics and Management 76*, 51–66.

Afflerbach, J. C., S. E. Lester, D. T. Dougherty, and S. E. Poon (2014). A global survey of "TURF-reserves", Territorial Use Rights for Fisheries coupled with marine reserves. *Global Ecology and Conservation 2*, 97–106.

Ahmed, A. M. (2007). Group identity, social distance and intergroup bias. *Journal of Economic Psychology 28*(3), 324–337.

Ali, J. and H. Abdullah (2010). Impact of enforcement and co-management on compliance behavior of fishermen. *International Journal of Economics and Finance 2*(4), 113–121.

Antinyan, A., L. Corazzini, and D. Neururer (2015). Public good provision, punishment, and the endowment origin: Experimental evidence. *Journal of Behavioral and Experimental Economics 56*, 72–77.

Apesteguia, J. and F. P. Maier-Rigaud (2006). The role of rivalry: public goods versus common-pool resources. *Journal of Conflict Resolution 50*(5), 646–663.

Araujo, F. A., E. Carbone, L. Conell-Price, M. W. Dunietz, A. Jaroszewicz, R. Landsman, D. Lamé, L. Vesterlund, S. W. Wang, and A. J. Wilson (2016). The slider task: an example of restricted inference on incentive effects. *Journal of the Economic Science Association 2*(1), 1–12.

Balafoutas, L., M. G. Kocher, L. Putterman, and M. Sutter (2013). Equality, equity and incentives: An experiment. *European Economic Review 60*, 32–51.

Barber IV, B. S. and W. English (2019). The origin of wealth matters: Equity norms trump equality norms in the ultimatum game with earned endowments. *Journal of Economic Behavior & Organization 158*, 33–43.

Bartlett, A. and Y. Malla (1992). Local forest management and forest policy in nepal. *Journal of World Forest Resource Management 6*, 99–99.

Basurto, X. (2005). How locally designed access and use controls can prevent the tragedy of the commons in a mexican small-scale fishing community. *Society and Natural Resources 18*(7), 643–659.

Beekman, G., S. L. Cheung, and I. Levely (2017). The effect of conflict history on cooperation within and between groups: Evidence from a laboratory experiment. *Journal of Economic Psychology 63*, 168–183.

Boyce, J. R. and D. M. Bruner (2017). Conflict resolution through voluntary provision of property protection. *Journal of Economic Psychology 63*, 199–215.

Cardenas, J.-C. (2000). How do groups solve local commons dilemmas? Lessons from experimental economics in the field. *Environment, development and sustainability 2*(3-4), 305–322.

Cardenas, J. C., J. Stranlund, and C. Willis (2000). Local environmental control and institutional crowding-out. *World Development 28*(10), 1719–1733.

Cason, T. N. and L. Gangadharan (2015). Promoting cooperation in nonlinear social dilemmas through peer punishment. *Experimental Economics 18*(1), 66–88.

Chang, L. W., A. R. Krosch, and M. Cikara (2016). Effects of intergroup threat on mind, brain, and behavior. *Current Opinion in Psychology 11*, 69–73.

Chaudhuri, A. (2011). Sustaining cooperation in laboratory public goods experiments: a selective survey of the literature. *Experimental Economics 14*(1), 47–83.

Chaudhuri, A. and T. Paichayontvijit (2017). On the long-run efficacy of punishments and recommendations in a laboratory public goods game. *Scientific reports 7*(1), 12286.

Chávez, C., J. Dresdner, M. Quiroga, M. Baquedano, N. González, and R. Castro (2010). Evaluación socio-económica de la pesquería del recurso loco asociada al régimen de áreas de manejo, como elemento de decisión para la administración pesquera. *Proyecto FIP 31*.

Chávez, C. A., J. J. Murphy, and J. K. Stranlund (2018). Managing and defending the commons: Experimental evidence from TURFs in Chile. *Journal of Environmental Economics and Management 91*, 229–246.

Cherry, T. L., P. Frykblom, and J. F. Shogren (2002). Hardnose the dictator. *American Economic Review 92*(4), 1218–1221.

Cherry, T. L., S. Kroll, and J. F. Shogren (2005). The impact of endowment heterogeneity and origin on public good contributions: evidence from the lab. *Journal of Economic Behavior & Organization 57*(3), 357–365.

Clark, J. (2002). House money effects in public good experiments. *Experimental Economics 5*(3), 223–231.

Cox, J. C. and D. T. Hall (2010). Trust with private and common property: Effects of stronger property right entitlements. *Games 1*(4), 527–550.

Danková, K. and M. Servátka (2015). The house money effect and negative reciprocity. *Journal of Economic Psychology 48*, 60–71.

Davis, K. J., M. E. Kragt, S. Gelcich, M. Burton, S. Schilizzi, and D. J. Pannell (2017). Why are fishers not enforcing their marine user rights? *Environmental and Resource Economics 67*(4), 661–681.

De Geest, L. R. and J. K. Stranlund (2019). Defending public goods and common-pool resources. *Journal of Behavioral and Experimental Economics 79*, 143–154.

De Geest, L. R., J. K. Stranlund, and J. M. Spraggon (2017). Deterring poaching of a common pool resource. *Journal of Economic Behavior & Organization 141*(C), 254–276.

Eswaran, M. and H. M. Neary (2014). An economic theory of the evolutionary emergence of property rights. *American Economic Journal: Microeconomics 6*(3), 203–26.

Fahr, R. and B. Irlenbusch (2000). Fairness as a constraint on trust in reciprocity: earned property rights in a reciprocal exchange experiment. *Economics Letters 66*(3), 275–282.

Faillo, M., M. Rizzolli, and S. Tontrup (2019). Thou shalt not steal: Taking aversion with legal property claims. *Journal of Economic Psychology 71*, 88–101.

Feltovich, N. (2019). Is earned bargaining power more fully exploited? *Journal of Economic Behavior & Organization 167*, 152–180.

Fischbacher, U. (2007). z-tree: Zurich toolbox for ready-made economic experiments. *Experimental economics 10*(2), 171–178.

Gächter, S. and A. Riedl (2005). Moral property rights in bargaining with infeasible claims. *Management Science 51*(2), 249–263.

Gee, L. K., M. Migueis, and S. Parsa (2017). Redistributive choices and increasing income inequality: experimental evidence for income as a signal of deservingness. *Experimental Economics 20*(4), 894–923.

Gelcich, S., J. Cinner, C. J. Donlan, S. Tapia-Lewin, N. Godoy, and J. Castilla (2017). Fishers' perceptions on the Chilean coastal TURF system after two decades: problems, benefits, and emerging needs. *Bulletin of Marine Science 93*(1), 53–67.

Gelcich, S., N. Godoy, and J. C. Castilla (2009). Artisanal fishers' perceptions regarding coastal co-management policies in Chile and their potentials to scale-up marine biodiversity conservation. *Ocean & Coastal Management 52*(8), 424–432.

Gelcich, S., T. P. Hughes, P. Olsson, C. Folke, O. Defeo, M. Fernández, S. Foale, L. H. Gunderson, C. Rodríguez-Sickert, M. Scheffer, et al. (2010). Navigating transformations in governance of Chilean marine coastal resources. *Proceedings of the National Academy of Sciences 107*(39), 16794–16799.

Gill, D. and V. Prowse (2012). A structural analysis of disappointment aversion in a real effort competition. *American Economic Review 102*(1), 469–503.

Gill, D. and V. Prowse (2019). Measuring costly effort using the slider task. *Journal of Behavioral and Experimental Finance 21*, 1–9.

Greiner, B. (2015). Subject pool recruitment procedures: organizing experiments with orsee. *Journal of the Economic Science Association 1*(1), 114–125.

Harrison, G. W. (2007). House money effects in public good experiments: Comment. *Experimental Economics 10*(4), 429–437.

Hoffman, E., K. McCabe, K. Shachat, and V. Smith (1994). Preferences, property rights, and anonymity in bargaining games. *Games and Economic behavior 7*(3), 346–380.

Ioannou, C. A., S. Qi, and A. Rustichini (2015). Group payoffs as public signals. *Journal of Economic Psychology 48*, 89–105.

Isaksen, E. T. and A. Richter (2019). Tragedy, property rights, and the commons: investigating the causal relationship from institutions to ecosystem collapse. *Journal of the Association of Environmental and Resource Economists 6*(4), 741–781.

Kingsley, D. C. and B. Liu (2014). Cooperation across payoff equivalent public good and common pool resource experiments. *Journal of Behavioral and Experimental Economics 51*, 79–84.

Korenok, O., E. Millner, L. Razzolini, et al. (2017). Feelings of ownership in dictator games. *J. Econ. Psychol 61*, 145–151.

Kuperan, K. and J. G. Sutinen (1998). Blue water crime: deterrence, legitimacy, and compliance in fisheries. *Law and Society Review*, 309–338.

List, J. A. (2007). On the interpretation of giving in dictator games. *Journal of Political economy 115*(3), 482–493.

Loerakker, B. and F. van Winden (2017). Emotional leadership in an intergroup conflict game experiment. *Journal of Economic Psychology 63*, 143–167.

Morgan, S. N., N. M. Mason, and R. S. Shupp (2019). The effects of voice with (out) punishment: Public goods provision and rule compliance. *Journal of Economic Psychology 74*, 102190.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action.* Cambridge university press.

Ostrom, E. (2008). Institutions and the environment. *Economic affairs 28*(3), 24–31.

Ostrom, E., J. Walker, and R. Gardner (1992). Covenants with and without a sword: Self-governance is possible. *American Political Science Review 86*(02), 404–417.

Oxoby, R. J. and J. Spraggon (2008). Mine and yours: Property rights in dictator games. *Journal of Economic Behavior & Organization 65*(3-4), 703–713.

Quynh, C. N. T., S. Schilizzi, A. Hailu, and S. Iftekhar (2017). Territorial Use Rights for Fisheries (TURFs): State of the art and the road ahead. *Marine Policy 75*, 41–52.

Raemaekers, S., M. Hauck, M. Bürgener, A. Mackenzie, G. Maharaj, É. E. Plagányi, and P. J. Britz (2011). Review of the causes of the rise of the illegal south african abalone fishery and consequent closure of the rights-based fishery. *Ocean & Coastal Management 54*(6), 433–445.

Santis, O. and C. Chávez (2015). Quota compliance in territorial use rights in fisheries: an experimental analysis of formal and informal enforcement with changes in abundance. *Ecol. Econ. 120.*

Spraggon, J. and R. J. Oxoby (2009). An experimental investigation of endowment source heterogeneity in two-person public good games. *Economics letters 104*(2), 102–105.

Tajfel, H., J. C. Turner, W. G. Austin, and S. Worchel (1979). An integrative theory of intergroup conflict. *Organizational identity: A reader 56*(65), 9780203505984–16.

Timilsina, N. and J. T. Heinen (2008). Forest structure under different management regimes in the western lowlands of nepal. *Journal of Sustainable Forestry 26*(2), 112–131.

A Derivations of insider and outsider theoretical benchmarks

Recall the payoff to individual h who is an insider i be

$$\pi_{hi} = c(e - g_{hi}) + \frac{g_{hi}}{\sum_{h=1}^{n_i} g_{hi}} V(G_i) \tag{5}$$

where e is the insider's endowment, g_{hi} is the insider's harvest of the CPR, c is the return to a private good, $V(G_i)$ is the surplus defined by $V(G_i) = a\sum_{h=1}^{n_i} g_{hi} - b(\sum_{h=1}^{n_i} g_{hi})^2$, and n_i is the number of insiders. Each insiders chooses how much of e to use towards harvesting the CPR or investing in the private good. For $a > c > b$ and $0 < b < 1$ this is a social dilemma similar to the one introduced by Ostrom et al. (1992). Where there are no outsiders, or equivalently when outsiders are deterred (D) the aggregate Nash harvest (N) by insiders is

$$G_i^{N,D} = \frac{n_i(a-c)}{b(n_i+1)}, \tag{6}$$

and the aggregate socially optimally harvest (S) is

$$G_i^{S,D} = \frac{a-c}{2b}. \tag{7}$$

where $G_i^{N,D} > G_i^{S,D}$.

Next, recall the payoff to individual h who is an outsider o is

$$\pi_{ho} = c(e - x_{ho}) + f(x_{ho}, V(G_i)) \tag{8}$$

where e is the outsider's endowment and $f(x_{ho}, V(G_i)) = x_{ho} w V(G_i)$ are the returns to effort x_{ho} exerted towards poaching, with $w \in (0,1)$. Outsiders payoffs are linear in poaching, so they spend either all or none of their endowment on poaching. The outsider's first-order condition is

$$-c + w(aG_i - bG_i^2) \begin{cases} \geq 0, \text{ if } > 0, \text{ then} & x_{ho} = e \\ \leq 0, \text{ if } < 0, \text{ then} & x_{ho} = 0. \end{cases} \tag{9}$$

with a two-root solution in G_i:

$$G_i^0 = \frac{a}{2b} - \frac{\sqrt{w\left(a^2w - 4bc\right)}}{2bw},\ G_i^1 = \frac{a}{2b} + \frac{\sqrt{w\left(a^2w - 4bc\right)}}{2bw}. \tag{10}$$

Our experiment parameters ensure $G_i^0 > 0$. And since $\text{argmax}_G V(G_i) = \frac{a}{2b} > G^{S,D}$, we assume insiders choose total harvest such that $G_i \leq G^{S,D}$. Therefore, we can write the outsider's decision rule as

$$x_{ho} = \begin{cases} 0, & \text{if } G_i \leq G_i^0 \\ e_o, & \text{if } G_i > G_i^0, \end{cases} \tag{11}$$

with payoffs

$$\pi_{ho} = \begin{cases} ce_o, & \text{if } G_i \leq G_i^0 \\ e_o w(aG_i - bG_i^2), & \text{if } G_i > G_i^0. \end{cases} \tag{12}$$

Thus, outsiders only poach when insiders choose a level of harvest above the threshold G_i^0. Next we consider insider benchmarks under non-deterrence of outsiders and deterrence.

A.0.1 Deterrence

Recall there are two ways the insiders can deter outsiders.

The first is for insiders to choose a level of harvest that does not induce poaching. When $G_i \leq G_i^0$, outsiders do not gain anything by poaching, and thus outsiders are deterred. Moreover, if an insider unilaterally deviates by increasing their harvest, they are worse off because they trigger poaching. Therefore, the threshold level of harvest G_i^0 can be sustained as a Nash equilibrium.

Alternatively, insiders can choose the level of sanctions that eliminates the outsider's gains from poaching. Recall that with technology θ that converts individual sanctions s_{hi} into monetary punishments, and assuming perfect monitoring of outsiders, poaching is deterred when

$$\theta \sum_h s_{hi} \geq ewV(G_i)$$

or when the sum of individual contributions towards deterrence ($\theta \sum_h s_{hi}$) is at least equal to the total gains to outsiders from poaching ($ewV(G_i)$). When insiders establish a credible threat, outsiders are deterred (they know whatever they gain from poaching will be lost in punishment), and insiders need never actually punish outsiders. However, deterrence by punishment cannot be sustained as an equilibrium, since punishment in a repeated game with a known end period is not credible. This is because deterrence is a second-order public good, meaning each insider has an incentive to free-ride and withhold sanctions. In the absence of a mechanism that ensures insiders contribute towards deterrence, the subgame perfect equilibrium sees insiders not deterring and outsiders poaching.

A.0.2 Non-deterrence

Suppose losses from poaching ($e_o wV(G_i)$) are sustained and split equally among insiders. When insiders do not cooperate on harvests and do not deter outsiders, their payoffs net of losses from poaching are

$$\max_{g_{hi}} \ \pi_{hi} = \begin{cases} c(e_i - g_{hi}) + \frac{g_{hi}}{G_i} V(G_i), & \text{if } G_i \leq G_i^0 \\ c(e_i - g_{hi}) + \frac{g_{hi}}{G_i} V(G_i) - \frac{1}{n_i} e_o w V(G_i), & \text{if } G_i > G_i^0, \end{cases} \tag{13}$$

and aggregate harvests under Nash strategies are

$$G_i^{N,ND} = \frac{n_i a(1 - \frac{1}{n_i} e_o w) - c}{b(n_i + 1 - 2e_o w)} > G_i^{N,D}. \tag{14}$$

When insiders do cooperate on harvests but do not deter outsiders, their payoffs are

$$\sum_i \pi_{hi} = \begin{cases} n_i c e_i - cG_i + V(G_i), & \text{if } G_i \leq G_i^0 \\ n_i c e_i - cG_i + V(G_i) - e_o w V(G_i), & \text{if } G_i > G_i^0. \end{cases} \tag{15}$$

and aggregate harvests are

$$G_i^{S,ND} = \frac{a(1 - ew) - c}{2b(1 - ew)} < G_i^{S,D}. \tag{16}$$

B Effort task results

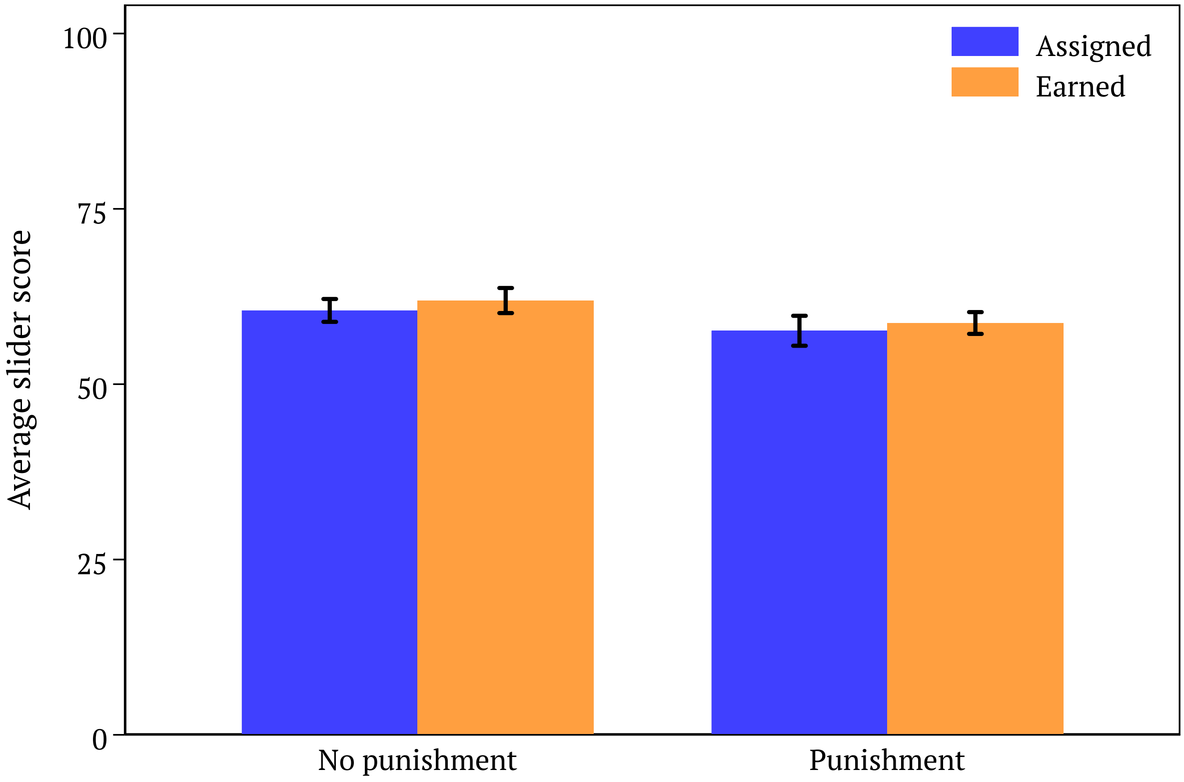


Figure A1: Average slider scores across treatments and punishment conditions with 95% confidence intervals.

C Experiment instructions

Attached are the experiment instructions for the treatment *Earned-Punishment*. The instructions are identical for *Assigned-Punishment* with the exception of the Sorting stage. In *Assigned-Punishment* and *Assigned-No Punishment* this section read:

> After the slider task, you will then be **randomly** split within your group of 6 between two types, Type 1 (4 members) or Type 2 (2 members). You will then receive a corresponding group ID. Your group, type and group ID will remain the same throughout the experiment. At no point during this experiment will the other members of your group be known to you.
>
> **Please note your performance on the slider task has no effect on your group or type assignment.** However, a higher score will earn you a higher payoff at the end of the experiment.

Finally, the instructions for the treatments without punishment are identical to the treatments with punishment, except they do not include Stages 4 and 5.

1 # Experiment instructions

(ER_P)

Welcome to the experiment. From now on and until the end of the experiment any verbal or written communication with other participants is not permitted, except through the software interface as explained below. Please follow along as these instructions are read. This information packet will describe the experiment, the decisions you make at various stages of the experiment, and how your decisions, and the decisions of others, can affect your individual earnings. You will be compensated, privately and in cash, at the end of the experiment. The conversion rate for your earnings will be 1 Experimental Dollar ED = $0.01. The experiment will consist of 15 periods, each lasting about 4-5 minutes. The experiment will last approximately 90 minutes.

Slider task

At the beginning of the experiment, the software will group you and 5 other participants into groups of 6. Each subject in each group will then perform a slider task. After the slider task, you will be assigned to either Type 1 or Type 2 within your group. **Your type will depend on your performance in the slider task.**

The task will consist of a screen with 50 sliders. Each slider is initially positioned at 0 and can be moved as far as 100. Your objective is to move as many sliders as close to 50 as possible. Each slider has a number to its right showing its current position. Use the mouse to move each slider. You can re-adjust the position of each slider as many times as you wish. You will have 120 seconds to complete this task.

At the top of your screen you will see your current score. Each slider is worth a maximum of two points. The minimum score is 0 points and the maximum score is 100 points. You will earn $0.04 for each correct point, paid out at the end of the experiment.

Sorting

Once everyone has completed the slider task, your "points score" will be compared to those of the other members in your group. *The subjects with the four highest scores will be Type 1, and the subjects with the lowest two scores will be Type 2.* The screen will display whether there were any ties. In the event there are ties between subjects, those ties will be broken randomly by the software.

You will then received a unique group ID. Your group, type and group ID will remain the same throughout the experiment. At no point during this experiment will your personal identity be revealed to the other members of your group.

Stage 1: Communication (Type 1)

In this stage, members of Type 1 can communicate with each other using a chat box. Each Type 1 member will be able to send, and see, messages from other Type 1 members in his or her group. To send a message, type your text in the entry box and then press "Enter" on your keyboard. Your message will be visible on the computer screen of each member of Type 1, with your ID next to it. Please restrict your conversation to topics concerning the experiment. The stage will last for 60 seconds. Once the timer in the upper right corner reaches zero, the stage will end, and you will advance to the next stage. If you finish chatting before the time is up, click *Continue*.

Stage 2: Decision (Type 1)

At the beginning of each period every Type 1 member in a group will receive an endowment of 50 Experimental Dollars (EDs). Each Type 1 member will independently decide how many EDs to allocate to a shared account called The Account. Individual payoffs from The Account depend on total investment in The Account and how much Type 2 members *withdraw* from The Account. Note that Type 2 members will chose how much to withdraw from The Account *after* you and the other three Type 1 members have invested in The Account.

How are your payoffs calculated?

Type 1 initial payoffs *per period* are the sum of payoffs from The Account and private payoffs , *minus the amount withdrawn from The Account by Type 2*. (Note that any withdrawals by Type 2 members will be equally shared among all four Type 1 members.) Additional payoffs can be accumulated each period.

The value of The Account depends on your investment (X) *plus* the investment of the other three Type 1 members of that group in The Account (Y):

$$\textbf{\textit{The Account value}} = \left[6(X+Y) - 0.025(X+Y)^2\right]$$

Your share of The Account is then calculated as

$$\textbf{\textit{Your payoffs from The Account}} = \frac{X}{X+Y} \times [\text{The Account value}]$$

and whatever you do not invest in The Account will go towards your private payoffs, which are calculated as

Private Payoffs = 50 EDs - (investment in The Account)

So, if you are Type 1, your initial payoffs, *before the decisions from Type 2*, are the sum of your private payoffs and your payoffs from The Account.

$$\textbf{\textit{Your payoffs = Your Private Payoffs + Your Payoffs from The Account}} - \frac{\textbf{\textit{Type 2 withdrawal}}}{\textbf{\textit{4}}}$$

In Table 1, you will see your payoffs calculated for different values of X (your investment) and Y (all other Type 1 investments) in 5 ED increments.

In addition, your screen will show a calculator. Before you make your investment decision, you can calculate your expected payoff for different values of X and Y.

Finally, please note that your payoffs from The Account will also depend on the decisions of Type 2. After Type 1 makes it investment decisions, Type 2 will have an opportunity to withdraw from The Account. We will discuss this shortly.

Example 1

Please follow along with the example on your screen.

Comprehension 1

Please answer the comprehension questions on your screen. Use the on-screen calculator to help you answer the questions.

Stage 3: Decision (Type 2)

At the beginning of each Period, Type 2 members will receive an endowment of 50 Experimental Dollars (ED). Type 2 members will decide how many of their 50 ED they will use to withdraw from the value of The Account.

By using some or all of their endowment, Type 2 members can transfer payoffs from The Account to themselves.

How are your payoffs calculated?

Payoffs from The Account depend on your withdrawal and the value of The Account:

$$\textbf{\textit{Payoffs from The Account}} = (0.005) \times (\text{Withdrawal}) \times [\text{Value of The Account}]$$

Recall the value of The Account is calculated as

$$6(\text{Total Investment in The Account}) - 0.025(\text{Total Investment in The Account})^2.$$

Whatever is left of your endowment will go towards your private payoffs, calculated as

Private Payoffs = 50 - (withdrawal from The Account)

So, if you are Type 2, your initial payoffs are the sum of of your payoffs from withdrawing from The Account and your private payoffs:

Your payoffs = Your Private Payoffs + Your Payoffs from The Account

In Table 2, you will see your payoffs calculated for different values of X (your take) and P (the Account Value).

Your screen will show a calculator. Before you make your withdraw decision, you can calculate the payoff to different withdrawals.

Example 2

Please follow along with the example on your screen.

Comprehension 2

Please answer the comprehension questions on your screen. Use the on-screen calculator to help you answer the questions.

Stage 4: Initial Payoffs (Type 1 & Type 2)

- **Type 1.** In this stage you will view: (1) your individual investment decision, (2) the sum of all investments in The Account (including yours), (3) the value of The Account, (4) the total withdrawal by Type 2, (5) your individual losses due to withdrawals from The Account by Type 2, (6) your payoff from The Account, (7) your private payoff, (8) your total payoff and (9) your accumulated payoff up to this point in the experiment.
- **Type 2.** In this stage you will view: (1) the Value of The Account, (2) your withdrawal from the value of The Account, (3) your payoff from The Account, (4) your private payoff, (4) your total payoff and (6) your accumulated payoffs up to this point in the experiment.

Stage 5: Deductions (Type 1 & Type 2)

In this stage, Type 1 members can decrease the payoffs of Type 1 and/or Type 2 members by assigning deduction points. Subjects who are Type 1 may enter a number of deduction points for each Type 1 or Type 2 member. If you do not wish to decrease somebody's payoffs, then you must enter "0". Only Type 1 members can assign deduction points.

Assigning deductions: Type 1

You will incur costs from assigning deduction points. Each deduction point you assign will cost you $1ED and cost the receiver $3EDs.

For example, if you assign 2 deduction points to another player, this costs you $2ED and it costs $6ED to that player. If you assign another 4 deduction points to a different player, this costs you an additional $4ED and it costs $12ED to that player. In this example you will have assigned 6 deduction points, costing you $6ED.

To view the cost of your assigned deductions, click the button *Cost*. Your deduction assignment cost is calculated as:

$$\textit{Total cost of assigned deductions} = 1 \times \textit{Total assigned deduction points}$$

You can change your decision as long as you have not left the stage. To recalculate the costs after changing your assigned points, simply click *Cost* again.

Please note your cost of assigned deductions cannot exceed your initial payoff.

Receiving deductions: Type 1 and Type 2

If you receive one deduction point, your payoff will be decreased by $3ED. If you receive 2 deduction points, your payoff will be decreased by $6ED, and so on. Your loss from received deductions are calculated as:

$$\textit{Total cost of received deductions} = 3 \times \textit{Total received deduction points}$$

Note that your cost of received deductions cannot exceed your initial payoff.

Stage 6: Final Payoffs (Type 1 & Type 2)

- **Type 1.** In this stage you will view: (1) the number of deduction points you assigned, (2) the number of deductions points you received, (3) your loss from deductions, (4) your initial payoff for the current period, (5) your total payoff for the current period, and (6) your cumulative payoffs for all periods.
- **Type 2.** In this stage you will view: (1) the number of deductions points you received, (2) your loss from deductions, (3) your initial payoff for the current period, (4) your total payoff for the current period, and (5) your cumulative payoffs for all periods.

1 Payoff table: Type 1

TABLE 1: Your investment X is on the horizontal axis. The total investment of everyone else in Type 1 Y is on the vertical axis. Each table value shows your payoff if you choose X and everyone else chooses Y.

Y/X	0	5	10	15	20	25	30	35	40	45	50
0	50.00	74.38	97.50	119.38	140.00	159.38	177.50	194.38	210.00	224.38	237.50
5	50.00	73.75	96.25	117.50	137.50	156.25	173.75	190.00	205.00	218.75	231.25
10	50.00	73.12	95.00	115.62	135.00	153.12	170.00	185.62	200.00	213.12	225.00
15	50.00	72.50	93.75	113.75	132.50	150.00	166.25	181.25	195.00	207.50	218.75
20	50.00	71.88	92.50	111.88	130.00	146.88	162.50	176.88	190.00	201.88	212.50
25	50.00	71.25	91.25	110.00	127.50	143.75	158.75	172.50	185.00	196.25	206.25
30	50.00	70.62	90.00	108.12	125.00	140.62	155.00	168.12	180.00	190.62	200.00
35	50.00	70.00	88.75	106.25	122.50	137.50	151.25	163.75	175.00	185.00	193.75
40	50.00	69.38	87.50	104.38	120.00	134.38	147.50	159.38	170.00	179.38	187.50
45	50.00	68.75	86.25	102.50	117.50	131.25	143.75	155.00	165.00	173.75	181.25
50	50.00	68.12	85.00	100.62	115.00	128.12	140.00	150.62	160.00	168.12	175.00
55	50.00	67.50	83.75	98.75	112.50	125.00	136.25	146.25	155.00	162.50	168.75
60	50.00	66.88	82.50	96.88	110.00	121.88	132.50	141.88	150.00	156.88	162.50
65	50.00	66.25	81.25	95.00	107.50	118.75	128.75	137.50	145.00	151.25	156.25
70	50.00	65.62	80.00	93.12	105.00	115.62	125.00	133.12	140.00	145.62	150.00
75	50.00	65.00	78.75	91.25	102.50	112.50	121.25	128.75	135.00	140.00	143.75
80	50.00	64.38	77.50	89.38	100.00	109.38	117.50	124.38	130.00	134.38	137.50
85	50.00	63.75	76.25	87.50	97.50	106.25	113.75	120.00	125.00	128.75	131.25
90	50.00	63.12	75.00	85.62	95.00	103.12	110.00	115.63	120.00	123.12	125.00
95	50.00	62.50	73.75	83.75	92.50	100.00	106.25	111.25	115.00	117.50	118.75
100	50.00	61.88	72.50	81.88	90.00	96.88	102.50	106.88	110.00	111.88	112.50
105	50.00	61.25	71.25	80.00	87.50	93.75	98.75	102.50	105.00	106.25	106.25
110	50.00	60.62	70.00	78.12	85.00	90.62	95.00	98.12	100.00	100.62	100.00
115	50.00	60.00	68.75	76.25	82.50	87.50	91.25	93.75	95.00	95.00	93.75
120	50.00	59.38	67.50	74.38	80.00	84.38	87.50	89.38	90.00	89.38	87.50
125	50.00	58.75	66.25	72.50	77.50	81.25	83.75	85.00	85.00	83.75	81.25
130	50.00	58.12	65.00	70.62	75.00	78.12	80.00	80.62	80.00	78.12	75.00
135	50.00	57.50	63.75	68.75	72.50	75.00	76.25	76.25	75.00	72.50	68.75
140	50.00	56.88	62.50	66.88	70.00	71.88	72.50	71.88	70.00	66.88	62.50
145	50.00	56.25	61.25	65.00	67.50	68.75	68.75	67.50	65.00	61.25	56.25
150	50.00	55.62	60.00	63.12	65.00	65.62	65.00	63.12	60.00	55.62	50.00

If you are a member of Type 1, the formula for your payoffs is

$$\text{Total Individual Payoff} = \underbrace{\frac{X}{X+Y}\left[6(X+Y) - 0.025(X+Y)^2\right]}_{\text{The Account Payoff}} + \underbrace{(50-X)}_{\text{Private Payoff}}$$

where X is your investment in The Account, and Y is the total investment by all other members of Type 1.

Payoff table: Type 2

TABLE 2: Your withdrawal X is on the horizontal axis. The value of The Account P is on the vertical axis. Each table value shows your payoff if the value of The Account is P and your withdrawal X.

P/X	0	5	10	15	20	25	30	35	40	45	50
0	50.00	45.00	40.00	35.00	30.00	25.00	20.00	15.00	10.00	5.00	0.00
10	50.00	45.25	40.50	35.75	31.00	26.25	21.50	16.75	12.00	7.25	2.50
20	50.00	45.50	41.00	36.50	32.00	27.50	23.00	18.50	14.00	9.50	5.00
30	50.00	45.75	41.50	37.25	33.00	28.75	24.50	20.25	16.00	11.75	7.50
40	50.00	46.00	42.00	38.00	34.00	30.00	26.00	22.00	18.00	14.00	10.00
50	50.00	46.25	42.50	38.75	35.00	31.25	27.50	23.75	20.00	16.25	12.50
60	50.00	46.50	43.00	39.50	36.00	32.50	29.00	25.50	22.00	18.50	15.00
70	50.00	46.75	43.50	40.25	37.00	33.75	30.50	27.25	24.00	20.75	17.50
80	50.00	47.00	44.00	41.00	38.00	35.00	32.00	29.00	26.00	23.00	20.00
90	50.00	47.25	44.50	41.75	39.00	36.25	33.50	30.75	28.00	25.25	22.50
100	50.00	47.50	45.00	42.50	40.00	37.50	35.00	32.50	30.00	27.50	25.00
110	50.00	47.75	45.50	43.25	41.00	38.75	36.50	34.25	32.00	29.75	27.50
120	50.00	48.00	46.00	44.00	42.00	40.00	38.00	36.00	34.00	32.00	30.00
130	50.00	48.25	46.50	44.75	43.00	41.25	39.50	37.75	36.00	34.25	32.50
140	50.00	48.50	47.00	45.50	44.00	42.50	41.00	39.50	38.00	36.50	35.00
150	50.00	48.75	47.50	46.25	45.00	43.75	42.50	41.25	40.00	38.75	37.50
160	50.00	49.00	48.00	47.00	46.00	45.00	44.00	43.00	42.00	41.00	40.00
170	50.00	49.25	48.50	47.75	47.00	46.25	45.50	44.75	44.00	43.25	42.50
180	50.00	49.50	49.00	48.50	48.00	47.50	47.00	46.50	46.00	45.50	45.00
190	50.00	49.75	49.50	49.25	49.00	48.75	48.50	48.25	48.00	47.75	47.50
200	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
210	50.00	50.25	50.50	50.75	51.00	51.25	51.50	51.75	52.00	52.25	52.50
220	50.00	50.50	51.00	51.50	52.00	52.50	53.00	53.50	54.00	54.50	55.00
230	50.00	50.75	51.50	52.25	53.00	53.75	54.50	55.25	56.00	56.75	57.50
240	50.00	51.00	52.00	53.00	54.00	55.00	56.00	57.00	58.00	59.00	60.00
250	50.00	51.25	52.50	53.75	55.00	56.25	57.50	58.75	60.00	61.25	62.50
260	50.00	51.50	53.00	54.50	56.00	57.50	59.00	60.50	62.00	63.50	65.00
270	50.00	51.75	53.50	55.25	57.00	58.75	60.50	62.25	64.00	65.75	67.50
280	50.00	52.00	54.00	56.00	58.00	60.00	62.00	64.00	66.00	68.00	70.00
290	50.00	52.25	54.50	56.75	59.00	61.25	63.50	65.75	68.00	70.25	72.50
300	50.00	52.50	55.00	57.50	60.00	62.50	65.00	67.50	70.00	72.50	75.00
310	50.00	52.75	55.50	58.25	61.00	63.75	66.50	69.25	72.00	74.75	77.50
320	50.00	53.00	56.00	59.00	62.00	65.00	68.00	71.00	74.00	77.00	80.00
330	50.00	53.25	56.50	59.75	63.00	66.25	69.50	72.75	76.00	79.25	82.50
340	50.00	53.50	57.00	60.50	64.00	67.50	71.00	74.50	78.00	81.50	85.00
350	50.00	53.75	57.50	61.25	65.00	68.75	72.50	76.25	80.00	83.75	87.50
360	50.00	54.00	58.00	62.00	66.00	70.00	74.00	78.00	82.00	86.00	90.00

The formula for payoffs to Type 2 is

$$\text{Total Individual Payoff} = \underbrace{(X)(0.005)(P)}_{\text{withdrawal from The Account}} + \underbrace{(50-X)}_{\text{Private Payoff}},$$

where X is your withdrawal from The Account and P is the value of The Account ($P = 6$(The Account Investment)$-$ 0.025(The Account Investment)^2).