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Negative Emission Technologies and Climate Cooperation

Abstract

Negative Emissions Technologies (NETs) — a range of methods to remove carbon dioxide from the atmosphere— are a crucial innovation in meeting temperature targets set by international climate agreements. However, mechanisms which undo the adverse consequences of short-sighted actions (as NETs) can fuel substitution effects and crowd out virtuous behaviors (e.g., mitigation efforts). For this reason, the impact of NETs on environmental preservation is an open question among scientists and policy-makers. We model this problem through a novel *restorable common-pool resource game* and use a laboratory experiment to exogenously manipulate key features of NETs and assess their consequences. We show that crowding out only emerges when NETs are surely available and cheap. The availability of NETs does not allow experimental communities to either conserve the common resource for longer or accrue higher earnings and makes the earnings distribution more unequal.

JEL-Codes: C920, H410, Q550.

Keywords: climate crisis, environmental sustainability, carbon dioxide removal, common-pool resource, free-rider problem, laboratory experiment.

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1 Introduction

To stabilize global temperature within safe limits, we must reach net zero global carbon emissions.[1] Meeting this target will require extensive mitigation efforts in most sectors. It will also require deploying carbon dioxide removal (or negative emission) technologies to compensate for emissions from hard-to-abate sectors and developing countries that might need more time to transition to clean technologies. In the short term, mitigation efforts will play a major role, with negative emission technologies serving only as a residual and complementary instrument to compensate the toughest to decarbonize sectors and geographical areas. In the medium term, however, when economies will be mostly decarbonized, negative emissions technologies will be crucial. Their potential significance lies in their capacity to counteract past excessive cumulative emissions. Indeed, achieving net negative (rather than simply net zero) global emissions may be eventually necessary to offset the accumulation of excessive emissions in the atmosphere (Riahi et al. 2022).

Negative Emissions Technologies (NETs) include various biological, chemical, and geochemical processes capable of removing carbon dioxide from the atmosphere and storing it in soils, materials, geological formations, and oceans. These methods range from long-time known and widely used nature-based practices, such as afforestation and reforestation, to less mature and more ambitious solutions relying on enhanced natural processes or carbon capture and storage technologies, which operate either directly from the air or at plants producing electricity with biomass.

While NETs' role will be critical in solving the climate change crisis, their significance is conditional on a series of factors. First, the feasibility of their large-scale deployment is still debated within the scientific community (IPCC 2022, Minx et al. 2018, Fuss et al.

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[1] See Lacis et al. 2010 on the relationship between greenhouse gas concentration in the atmosphere (especially carbon dioxide) and global temperatures over history; Pachauri et al. 2014 and Mann et al. 2017 on anthropogenic climate change; Field et al. 2014 on the severe negative consequences of a changing climate on humans and their economic activities. In 2015, 196 countries pledged to hold the increase in the global average temperature to well below 2°C compared to pre-industrial levels through the legally binding Paris Climate Agreement. To achieve this goal, emissions need to be urgently and drastically reduced and reach the net zero target early in the second half of the century (Rogelj et al. 2018).

2018). Depending on the chosen technologies, several issues and (unanticipated) side effects may arise. For example, forest-based methods are considered among the most cost-effective carbon dioxide removal methods to be deployed at a large scale, yet — due to the changing climate — their potential could be drastically reduced in the future due to lower forest resilience as forests approach critical resilience thresholds, especially close to biomass hotspots like the Amazon, and increasing forest disturbances, as fires, windfall, and pests become more widespread (Windisch et al. 2023). More generally, the effectiveness of these technologies is not independent of the status of the Earth system and its climate. Second, monitoring and verifying the long-term carbon dioxide sequestration also poses a governance challenge, as institutions must be created to guarantee the long-term permanence of these stocks (Sovacool et al. 2023). Third, carbon dioxide removals might not be able to entirely undo the effect of past carbon emissions if the temporary excess of emissions and the resulting overshooting of temperatures has triggered a tipping point, kick-starting an irreversible natural process (Drouet et al. 2021).

Finally, and most importantly from the social sciences perspective, negative emissions technologies may generate a relevant moral hazard problem. If instead of being perceived as a complement to aggressive and immediate emission reductions, they are considered a substitute for these economic and politically costly short-term efforts, they could ultimately delay or crowd out current emissions abatement efforts. This *mitigation deterrence risk* represents a critical threat to our chances to limit global warming, even if we had full knowledge of the costs and potentials of carbon removal technologies because delaying emissions reduction efforts could generate irreversible damage due to late action. The severity of such mitigation deterrence risk becomes paramount in light of the technical and implementation limitations discussed above. Indeed, failing to account for the uncertainty in future removal technologies' availability and to separate the role of removal technologies and emission reduction policies as two independent and additive climate strategies — erroneously considering them as substitutable tools — could cost us the opportunity to reduce end-of-century warming by up to 0.5°C (Grant et al. 2021). Similarly, failing to account for both substitution effects and other side-effects arising from the large-scale deployment of such technologies could lead us to underestimate the need for further carbon dioxide (CO2) mitigation efforts and cause unanticipated net additions of CO2 to the atmosphere equivalent to a further temperature rise of up to 1.4°C (McLaren 2020).

In this paper, we aim to investigate the role of, and the risks associated with, introducing such fail-safe mechanisms that can reverse the consequences of our previous hazardous actions. To this aim, we model the NETs' substitution problem through a modified version of the infinite-horizon Common Pool Resource (CPR) game. CPR games are often employed to study natural resources' use and conservation problems. The mapping between the real-world problem and the theoretical setup is straightforward: over-exploiting natural resources and fostering excessive high-emissions activities is economically advantageous in the short run but detrimental to our wellbeing and subsistence in the medium-long run. Committing to conservative exploitation behaviors and low-emissions targets would instead be less profitable to individuals in the short run but benefit the whole community and its subsistence in the medium-long run if all members agreed on and stuck to a coordinated virtuous action pattern.

In a classic infinite-horizon CPR game, a group of agents has access to the same shared resource, which they can repeatedly harvest to their benefit over an indefinite number of periods. In each period, if total harvesting is not too high, what is left of the resource can fully regrow to its initial level so that the same group of players can harvest it again in the next period. The resource is irreversibly exhausted if total harvesting exceeds a threshold, causing the game to end. Agents' welfare equals total harvesting over all periods played; hence, it is a function of both the harvesting level and the number of periods the resource survives.

We modify the standard version of the infinite-horizon CPR game, introducing a backup restoration technology that is able to reverse resource exhaustion. When collective harvesting turns out to be excessive, the restoration technology essentially reverses resource exhaustion — and hence the sudden game end — as long as agents' collective restoration investment is high enough, reaching the minimum level needed to make the investment effective. In addition to a Baseline condition in which restoration technologies are never available, we investigate four treatments, manipulating the cost (High versus Low) and certainty of restoration availability (Certain versus Uncertain) with a factorial design.

Our experimental results show that heavy reliance on restoration, which crowds out sustainable harvesting strategies, occurs only when restoration technologies are cheap and available with certainty. In all other cases, players tend not to deviate from the behavioral pattern observed in the Baseline, where the majority of groups succeed in coordinating on a virtuous feasible harvesting equilibrium. In addition, the presence of restoration technologies neither allows groups to conserve the resource longer nor accrue higher earnings- net of short-term effects. Rather, it contributes to exacerbating earnings inequality within groups.

This evidence suggests that concerns about the risk of crowding out on short-term mitigation efforts are well-founded if fail-safe mechanisms to tackle the climate crisis — like NETs — are (possibly mistakenly) perceived as low-cost and readily available.[2] Interestingly, our experimental results also indicate that this undesirable effect vanishes when agents learn that the cost to revert their previous hazardous actions is considerable, and/or that the possibility to make their actions reversible is not guaranteed.

Our paper is related to the experimental literature studying what mechanisms can foster cooperation in games that mimic the main features at the roots of the climate change dilemma, such as dynamic Public Good (PG) games or threshold Common Pool Resource (CPR) games. A relevant share of papers from this literature, accounting for the inter-

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[2] Evidence of stark promotion efforts in favor of carbon capture and storage (CSS) technologies by fossil fuel and other high-pollution industries is widespread (`https://www.theguardian.com/environment/2023/dec/08/at-least-475-carbon-capture-lobbyists-attending-cop28`). Both online and offline — during official events such as the COP28 — interested stakeholders advertise such technologies, over-promising the capacity and effectiveness of their CSS projects, and pushing for their adoption as an opportunity to license themselves to keep their business and production plans unchanged, refraining from taking concrete actions to reduce their emissions

generational dimension of the climate change problem, focuses on the evolution of behavior in games in which a different group of agents takes action in each period of a repeated game, introducing inter-generational dependence. From a standard game-theoretical perspective, no cooperation should be observed, as it would be in a static decision environment since the utility of groups acting before or after in the sequence should not enter the decision-maker utility function. Consistently with this prediction, very low levels of cooperation are usually observed in these settings. However, both institutions introducing voting (as opposed to decentralized decision-making) and peer punishment prove to be effective in increasing cooperation rates (Hauser et al. 2014, Lohse and Waichman 2020, Nockur et al. 2020). Similarly to these papers, we rely on a dynamic threshold CPR game, where excessive resource exploitation leads to immediate resource exhaustion. Differently from these papers, we focus on how the behavior of the same group of agents, who play together repeatedly over time, evolves, and we introduce choice reversibility through restoration.

We also contribute to the economic literature studying intra-generational cooperation in dynamic games: in these papers, the focus is on the behavior of the same group of players facing the same PG or CPR stage game repeatedly, either for an infinite or finite number of times. Players in each group are called to make their choice simultaneously and independently in a single game stage per period, knowing that their choices will affect both their own and their groupmates' future outcomes, hence payoffs. This literature analyzes how the evolution of the durable public good or shared resource and/or the equilibrium selection is affected by changing some key parameters of the game, such as the number of players in the group (Battaglini et al. 2016), the degree of persistence of own actions on future outcomes (Calzolari et al. 2018), the possibility of refund options for contributions, the action space, or the resource stock (Tasneem et al. 2017, Cason and Zubrickas 2019, Vespa 2020). Indeed, when interactions evolve over an indefinite number of periods, as in our case, and players are sufficiently patient, multiple equilibria arise: in this context, the main interest lies in understanding what factors contribute to move players towards more cooperative and efficient equilibria.

The key innovation of our design is introducing a second game stage, the "restoration stage", in which players have the opportunity, by paying a cost, to revert their previous (excessively) hazardous behavior, which would otherwise lead the game to end. To the best of our knowledge, this is the first time a dynamic threshold CPR game has been modified to incorporate a second stage that makes first-stage choices essentially reversible. The most closely related paper to ours in this aspect is Battaglini et al. (2016): although with a different design, under certain treatments, they study the accumulation of a durable PG in an infinite horizon game in which contributions can also be negative, thus undoing a previous virtuous action (rather than, as in our framework, a previous selfish and hazardous action). They find that, in the presence of reversibility, the steady-state levels of the public good are lower, the accumulation is inefficiently slow and the under-provision problem remains unsolved, just like in the benchmark case with only non-negative contributions.

2 Theoretical Framework

To study the role of negative emission technologies, we model the climate mitigation problem as an infinite-horizon common-pool resource game. Our main research question is whether introducing a technology that allows restoration of the resource after its exhaustion affects group members' extraction behavior, group members' earnings, and the chance that the common-pool resource is irreversibly depleted or conserved. To this purpose, we develop and investigate a novel game: the *restorable common-pool resource* game.

2.1 The Restorable Common Pool Resource Game

Consider the following common-pool resource game with an infinite horizon and a community of $n \geq 2$ homogenous individuals who discount future payoffs with a factor $\delta \in [0, 1]$. Each game period is divided into the *Extraction Phase* and the *Restoration Phase*.

In every period t, the game starts with the **Extraction Phase** where

- The common pool resource counts $K > 0$ units
- Each player i receives an endowment $w_{it} = W/n$ where $W > 0$
- Each player i makes simultaneously an individual extraction choice $e_{it} \in \left[0, \frac{K}{n}\right]$
- The group extraction is given by $E_t = \sum e_{it}$

At the end of the Extraction Phase:

- If $E_t \leq T_E$, the resource is conserved, and the game continues to another period
- If, instead, $E_t > T_E$, the game continues to the Conservation phase with probability $\rho \in [0, 1]$; the resource is exhausted and the game ends with probability $(1 - \rho)$

In the **Restoration Phase** (if reached):

- Each player makes simultaneously an individual restoration choice $r_{it} \in [0, w_{it}]$
- The group restoration is given by $R_t = \sum r_{it}$

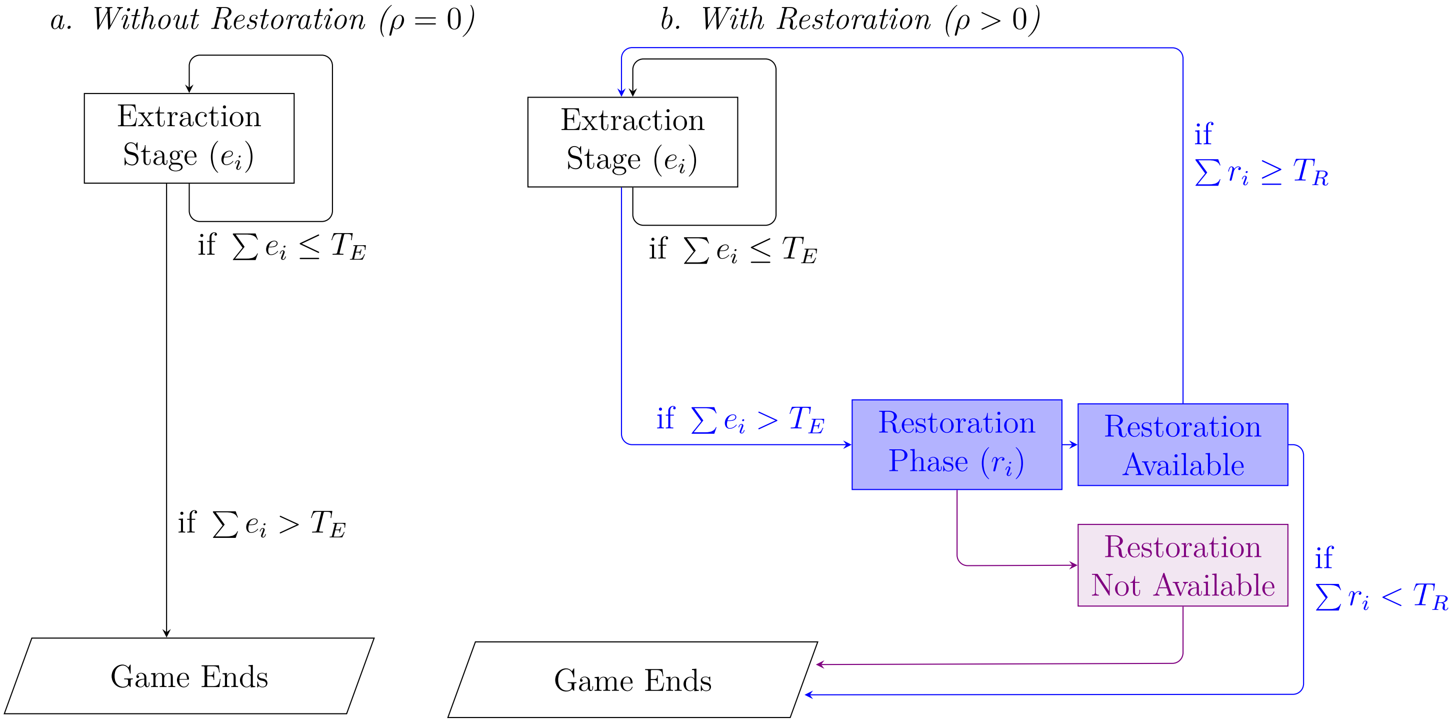
At the end of the Restoration Phase:

- If $R_t \geq T_R > 0$, the resource is restored, and the game continues to another period
- If, instead, $R_t < T_R$, the resource is exhausted and the game ends

Player i's utility in period t is given by $u_{it} = w_{it} + e_{it} - r_{it}$, where w_{it} is the initial endowment, e_{it} is the individual benefit from extraction, r_{it} is the individual cost from restoration. Assuming $r_{it} \leq w_{it}$ guarantees $u_{it} \geq 0$, which is useful for the experimental implementation.

Figure 1 summarizes the timing of a single period in the game.

Figure 1: Recap of Experimental Game Timing and Rules



Panel a: In the absence of restoration technologies, the game only counts one action stage — the Extraction Stage — in which each group member makes an extraction choice (e_i); if total extractions do not exceed the threshold ($\sum e_i \leq T_E$) the game continues for another round, reaching a new Extraction Stage; otherwise, the game ends immediately. *Panel b:* In the presence of restoration technologies, the game counts two action stages: the Extraction Stage and the Restoration Stage. In the latter, each group member makes a restoration choice (r_i) that is relevant only if total extractions exceed the threshold and restoration is available; if Restoration is available and aggregate restoration is high enough ($\sum r_i \geq T_R$), players suffer the cost of their restoration choice and the game continues for another round, reaching a new Extraction Stage; if instead, Restoration is available but aggregate restoration is not high enough ($\sum r_i < T_R$), players suffer the choice of their restoration and the game nevertheless ends; if Restoration is not available and total extractions exceeded the threshold, the game ends as in the case without restoration.

Table 1: Treatments

Treatment	ρ	T_E	T_R	No. Sessions	No. Subjects	No. groups
T1 - No Restoration (Baseline)	0	50	–	6	120	312
T2 - Uncertain / Low	0.5	50	25	6	120	216
T3 - Certain / Low	1	50	25	6	120	184
T4 - Uncertain / High	0.5	50	75	6	120	208
T5 - Certain / High	1	50	75	6	120	196

Notes. ρ denotes the probability restoration is available; T_E and T_R denote threshold values for group total extraction and restoration choices, respectively. The total number of groups varies across treatments due to the different number of supergames played per session. See Table 12 in Appendix G for descriptive statistics about the total number of supergames played per treatment.

Assumption 1 (No Unilateral Conservation) *We assume that* $\left(\frac{n-1}{n}\right) K > T_E > 0$*, that is, a single group member cannot unilaterally conserve the resource in the Extraction Phase if everybody else is extracting maximally.*

Assumption 2 (No Unilateral Restoration) *We assume that* $K > T_R > \frac{W}{n}$*, that is, a single group member cannot unilaterally restore the resource in the Restoration Phase if everybody else makes no restoration effort.*

2.2 Equilibrium Analysis

We focus on symmetric and stationary subgame perfect Nash equilibria (SPNEs) of the game. Note that payoffs in a period are strictly increasing in individual extraction levels and that transition probabilities across periods and across phases within a period are discontinuous in group extraction and group restoration levels (in particular, they are sensitive to marginal changes in E_t only when $E_t = T_E$, and in marginal changes in R_t only when $R_t = T_R$). It follows that, in any period of any symmetric and stationary SPNE of the game, players choose either $e_{it} = \frac{K}{n}$ (i.e., maximal extraction) or $e_{it} = \frac{T_E}{n}$ (i.e., the largest symmetric extraction which ensures conservation) in the Extraction Phase. They choose either $r_{it} = 0$ (i.e., no restoration effort) or $r_{it} = \frac{T_R}{n}$ (i.e., the minimal symmetric restoration effort which avoids exhaustion) in the Restoration Phase.

This means that there can only be (at most) four symmetric and stationary SNPEs:

1. (*Extract, Don't Restore*) where, in each period, $e_i^\star = \frac{K}{n}$ and $r_i^\star = 0$
2. (*Conserve, Don't Restore*) where, in each period, $e_i^\star = \frac{T_E}{n}$ and $r_i^\star = 0$
3. (*Extract, Restore*) where, in each period, $e_i^\star = \frac{K}{n}$ and $r_i^\star = \frac{T_R}{n}$
4. (*Conserve, Restore*) where, in each period, $e_i^\star = \frac{T_E}{n}$ and $r_i^\star = \frac{T_R}{n}$

No other strategy can be part of a symmetric and stationary equilibrium because, if that were the case, each player could unilaterally deviate and extract marginally more (thus increasing the payoff in the current period) without changing the transition between periods or between phases within the same period (thus, leaving the continuation value of the game unchanged). Below, we characterize conditions on the game's parameters for each of these four potential equilibria to exist. All proofs are in Appendix A.

Proposition 1 (Extract, Don't Restore) *An equilibrium of the game where, in each period, $e_i^\star = \frac{K}{n}$ and $r_i^\star = 0$ exists for any $\delta \in [0, 1]$. In this equilibrium, the resource is exhausted in a single period and the value of the game is $V_1^{EQ} = \frac{W+K}{n}$.*

Proposition 2 (Conserve, Don't Restore) *An equilibrium of the game where, in each period, $e_i^\star = \frac{T_E}{n}$ and $r_i^\star = 0$ exists if and only if $\delta \geq \frac{K-T_E}{W+K}$. In this equilibrium, the resource is never exhausted and the value of the game is $V_2^{EQ} = \frac{W+T_E}{n(1-\delta)}$.*

Proposition 3 (Extract, Restore) *Assume $\rho > 0$. An equilibrium of the game where, in each period, $e_i^\star = \frac{K}{n}$ and $r_i^\star = \frac{T_R}{n}$ exists if and only if $\delta > \frac{T_R}{W+K}$. In this equilibrium, the resource is exhausted when the game does not reach the Restoration Phase in a period. Thus, at the beginning of every period, the expected number of periods until the resource is exhausted equals $1/(1-\rho)$. The value of the game is $V_3^{EQ} = \frac{W+K-\rho T_R}{(1-\delta\rho)n}$.*

Proposition 4 (Conserve, Restore with Uncertain Restoration Technology) *Assume $\rho \in (0, 1)$. An equilibrium of the game where, in each period, $e_i^\star = \frac{T_E}{n}$ and $r_i^\star = \frac{T_R}{n}$ exists* *if and only if* $\delta \geq \max\left\{\frac{K-\rho T_R-T_E}{W+K-\rho(W+T_E+T_R)}, \frac{T_R}{W+T_E+T_R}\right\}$*. In this equilibrium, the resource is never exhausted and the value of the game is* $V_4^{EQ} = V_2^{EQ} = \frac{W+T_E}{n(1-\delta)}$*.*

Proposition 5 (Conserve, Restore with Certain Restoration Technology) *Assume* $\rho = 1$*. An equilibrium of the game where, in each period,* $e_i^\star = \frac{T_E}{n}$ *and* $r_i^\star = \frac{T_R}{n}$ *exists if and only if* $T_R \geq K - T_E$ *and* $\delta \geq \frac{T_R}{W+T_E+T_R}$*. In this equilibrium, the resource is never exhausted and the value of the game is* $V_5^{EQ} = V_2^{EQ} = \frac{W+T_E}{n(1-\delta)}$*.*

The (Extract, Don't Restore) equilibrium exists for any degree of patience because, according to Assumptions 1 and 2, if a player believes others are extracting as much as they can and investing as little as they can in restoration, there is nothing he can unilaterally do to conserve or restore the resource and behaving selfishly in both stages is the best response. When, instead, players believe others are cooperating, an equilibrium with (perpetual or temporary) resource preservation is feasible as long as players are sufficiently patient to give up the immediate gratification of greater resource exploitation and smaller restoration investment for the delayed benefit of longer resource life. As the sustainable level of extraction (T_E) grows, the players' degree of patience needed to support the equilibrium (Conserve, Don't Restore) decreases. On the other hand, as the investment required for restoration (T_R) grows, the players' degree of patience needed to support the (Extract, Restore) equilibrium increases. We also highlight that while the outcomes on the equilibrium path and the efficiency of the (Conserve, Restore) equilibrium are the same as in the (Conserve, Don't Restore) equilibrium, the equilibrium with restoration off the equilibrium path (which only exists when restoration is available) can be harder to sustain in terms of players' degree of patience (and, indeed, this will be the case with our experimental parameters). This is due to the moral hazard or mitigation deterrence risk discussed in the Introduction.

Multiple equilibria coexist for a wide range of parameters (and in our experimental implementation). While equilibrium selection is one of our main research questions (and, thus, experimental parameters were purposefully chosen to ensure equilibrium multiplicity in all treatments), one criterion that can be used to refine predictions and select one equilibrium ex-ante is the efficiency of equilibrium outcomes (in a utilitarian sense). First, when the (Conserve, Don't Restore) equilibrium exists (that is, when the condition in the statement of Proposition 2 is satisfied), it Pareto dominates the (Extract, Don't Restore) equilibrium. Second, when the (Extract, Restore) equilibrium exists (that is, when the condition in the statement Proposition 3 is satisfied), the value of the game under this equilibrium is strictly increasing in ρ and is strictly greater than V_1^{EQ} as long as $\rho > 0$. When $\rho = 1$ (and, thus, restoration is available with certainty), the (Extract, Restore) equilibrium is more efficient than the (Conserve, Don't Restore) equilibrium if and only if $K - T_R > T_E$, that is, depending on what equilibrium leads to a greater aggregate per period consumption.

3 The Experiment

3.1 Experimental Design

We ran the experimental sessions at the Bocconi Experimental Laboratory for the Social Sciences between May and June 2023 with students from Bocconi University recruited from a database of volunteers.[3] Each session lasted approximately 90 minutes and participants earned, on average, €27.6, including a €7.5 show-up fee.

Treatments. We used a between-subject design to implement five treatments, manipulating restoration technologies' availability and cost. In all treatments, we use a neutral framing, without mentioning the climate or the environment; groups are composed of $n = 5$ members; at the beginning of each period, the resource counts $K = 100$ units; in each period, each group member receives an endowment of $w_{it} = 20$ units and chooses simultaneously and independently how much to extract from the resource, between a minimum of 0 and a maximum of $\frac{K}{n} = 20$ units; if the total extraction in a period exceeds $T_E = \frac{K}{2} = 50$, the

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[3] The experimental protocol was approved by the Bocconi University Ethics Committee on February 20, 2023 (FA000565) and pre-registered on AsPredicted on May 22, 2023 (#133060). The pre-registration is available at `https://aspredicted.org/ZS8_3Q5`. The experimental instructions are available in Appendix B.

resource is depleted (irreversibly so when restoration is unavailable); if, instead, the total extraction in a period is less than T_E, the resource regenerates and the game continues for another period; the discount factor is $\delta = 0.8$ and is implemented through a block random termination rule protocol (Fréchette and Yuksel 2017).[4]

The ***Baseline*** treatment is a standard infinite-horizon common-pool resource game. No restoration technologies are available; thus, if the total extraction in a period exceeds $T_E = 50$, the resource is irreversibly depleted and the game ends. We introduce restoration technologies in four additional treatments where, using a factorial design, we manipulate:

1. whether the ability to restore is ***Certain*** ($\rho = 1$) or ***Uncertain*** ($\rho = 0.5$);
2. whether the cost of restoration, that is, the minimum total effort needed for restoration to undo depletion successfully, is ***High*** ($T_R = 75$) or ***Low*** ($T_R = 25$).

Choices and Beliefs. We elicit restoration choices using the strategy method, in which a respondent makes conditional decisions for each possible information set (Brandts and Charness 2011; Fischbacher et al. 2012). In our environment, this means that participants make restoration choices after they make their extraction choices but before they learn whether the restoration stage is actually reached, that is, before they learn whether total group extraction was excessive and, in treatments with uncertain restoration, before they learn whether restoration technologies are available. While restoration choices are elicited in every period, they are payoff relevant only when the restoration stage is reached. We opt for this method (rather than to the direct response method) to obtain observations at both stages of our game, regardless of the frequency at which the second stage would be reached in the actual course of play. At the end of each period, subjects learn the status of the resource and receive comprehensive feedback on total group extraction and restoration (if

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[4] Participants play in blocks of 5 rounds, as long as the resource is conserved (as determined by total extraction in a period). At the end of each block, participants learn the realizations of the random number determining whether the game continued or not at the end of each period in the block, how many rounds in the block mattered for their earnings, and if the game continues to another block.

available) levels reached, including a breakdown detailing the choices made by each group member. The experiment is divided into two parts: Part 1 includes the first 6 supergames played; Part 2 includes all supergames played from the 7^{th} supergame onwards. In Part 2, we also elicit participants' beliefs about the sum of the other group members' extraction and restoration choices. We do this at the end of each period before participants receive the end-of-period feedback.

Supergames. All sessions count 20 participants. At the beginning of each *supergame* (a repetition of the infinite-horizon game), we form four groups of five members. We use a partner matching protocol within supergames and a stranger matching protocol across supergames. A supergame ends when either (i) the random termination rule decides so or (ii) the resource is depleted and not restored in the round. Participants play all supergames started within 60 minutes from the beginning of the first supergame.[5] To reduce concerns related to the chance that the realized length of early supergames affects participants' behavior in later supergames, possibly interacting with or confounding the effect of our treatments, we control for supergames' realized length across treatments (Mengel et al. 2022).[6]

Earnings. Participants are paid for their cumulative payoff in one randomly selected supergame form Part 1 and in one randomly selected supergame form Part 2. In addition, we select one round of a different supergame played in Part 2 and pay a fixed prize to participants whose reported belief about the sum of the other group members' extraction or restoration choices is accurate.[7]

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[5] After reading the instructions and before the first supergame, subjects answer 3 comprehension questions and have up to two attempts to answer them correctly. If they fail, subjects are not excluded from the session but can continue only after a debriefing session with the experimenter. This ensures all subjects understand the instructions well before playing the first supergame.

[6] In particular, we use the following procedure: i) we organize experimental sessions in batches of 5 sessions each, in which one session per each treatment condition is included; ii) within each batch, we let the software randomly determine the length of all (potential) super-games to be played for the first session (in which participants are assigned to the Baseline treatment); the same realizations are used to determine the length of all (potential) super-games to be played in all other sessions belonging to the same batch.

[7] Both beliefs we elicit can range between 0 and 80. As in Aoyagi et al. (2022), we randomly draw two numbers from $[0; 80]$ and the belief is considered to be accurate if the distance between the actual value and

Sample Size. We recruited 600 participants and split them equally across the five treatments, resulting in 120 participants per treatment. This sample size is based on the behavior we observed in two pilot sessions we conducted in March 2023 with 20 participants in the Baseline treatment and 20 participants in the Certain Restoration/Low Cost treatment.[8] Table 1 summarizes the experimental design.

3.2 Theoretical Predictions for Experimental Treatments

Our careful choice of experimental parameters was meant to achieve the following goals: in all treatments, there exist equilibria with immediate depletion and equilibria with longer resource life; the introduction of restoration expands the set of equilibria with respect to the Baseline treatment; the equilibria that emerge when restoration is available require either less or more patience than the conservative equilibrium without restoration (depending on the cost of restoration); these equilibria are either more or less efficient than the conservative equilibrium without restoration (depending on the likelihood of restoration availability). More specifically, given our experimental parameters:

(a) the (Extract, Don't Restore) equilibrium exists in all treatments, regardless of δ;

(b) the (Conserve, Don't Restore) equilibrium exists in all treatments as long as $\delta \geq 1/4$;

(c) the (Extract, Restore) equilibrium exists in all treatments but the Baseline; the patience needed for equilibrium existence depends on the restoration costs: it is higher

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participants' stated belief is smaller than the distance between the actual value and any of the two randomly extracted numbers.

[8] The goal of these sessions was to check participants' comprehension of the instructions and to make distributional assumptions for power calculations. Using standard values for significance level ($\alpha = 0.05$) and statistical power ($\beta = 0.80$), the sample size we settled on would allow us to detect a minimum treatment effect size of 0.3 standard deviations on average Round 1 individual extraction choices in cross-sectional analyses. This corresponds to a variation of approximately one unit in individual extraction behavior, which is the smallest yet economically relevant variation in the outcome of interest. This sample size would allow us to reach a minimum detectable effect size of approximately the same size also in the presence of mild intra-correlation within clusters (experimental sessions). After these pilot sessions, we slightly modified the experimental protocol and software interface (to increase understanding of the block random termination rule and to measure beliefs about the behavior of others in a subset of infinite-horizon games). We do not use data from these pilot sessions in the analyses.

Table 2: Conditions for Existence of Equilibria with Restoration in Treatments with $\rho > 0$

	High Cost ($T_R = 75$)	**Low Cost** ($T_R = 25$)
Certain Restoration ($\rho = 1$)	(Extract, Restore): $\delta \geq 3/8$ (Conserve, Restore): $\delta \geq 1/3$	(Extract, Restore): $\delta \geq 1/8$ (Conserve, Restore): NO
Uncertain Restoration ($\rho = 0.5$)	(Extract, Restore): $\delta \geq 3/8$ (Conserve, Restore): $\delta \geq 1/3$	(Extract, Restore): $\delta \geq 1/8$ (Conserve, Restore): $\delta \geq 1/3$

(lower) than in (Conserve, Don't Restore) with high (low) costs; the efficiency of this equilibrium depends on the likelihood of restoration availability: it is less (more) efficient than (Conserve, Don't Restore) when $\rho = 0.5$ ($\rho = 1$);

(d) the (Conserve, Restore) equilibrium exists in all treatments but the Baseline and (Certain Restoration, Low Cost); this equilibrium is as efficient as (Conserve, Don't Restore), but its existence requires more patience than (Conserve, Don't Restore);

(e) the conditions for the existence of (Extract, Restore) and (Conserve, Restore) equilibria in the 4 treatments where restoration is available ($\rho > 0$) are summarized in Table 2.

At least for the interesting case where group members are sufficiently patient and conservation is a potential equilibrium outcome (as is the case in all experimental treatments), the theoretical predictions are indeterminate: even when restricting attention to symmetric and stationary subgame-perfect Nash equilibria, both the game with restoration technology and the game without restoration technology have multiple equilibria, some with (immediate) resource depletion and some with (perpetual) resource conservation. At the same time, the game with restoration technology has a larger set of equilibria since conservation can be achieved either through limited extraction and no need for restoration or through exploitation followed by restorative efforts. Thus, the experiment is meant to provide evidence of participants' coordination on particular equilibria and of how their behavior might change as a function of the availability and the cost of the restoration technology, affecting resource conservation efforts, resource life length, and participants' payoffs.

One way to assess whether, theoretically, the feasibility of restoration improves the sustainability of the common pool resource is to consider whether introducing the restoration technology (that is, going from $\rho = 0$ to $\rho > 0$) generates an equilibrium where the resource is sustained for longer than a period and which requires a discount factor smaller than 1/4 (i.e., the discount factor required for conservation in the absence of restoration). Interestingly, this is the case (for both the treatment with certain and the treatment with uncertain restoration) only if the cost of restoration (T_R) is sufficiently small, that is, in the Low Cost treatments, where the (Extract, Restore) equilibrium exists if $\delta \geq 1/8$). If we assume that the experimenter cannot perfectly control the participants' discount factor with the random termination rule and that experimental subjects might bring to the laboratory their idiosyncratic degree of patience, this suggests that sustainability is easier to achieve in the Low Cost treatments and that this will occur with coordination on the (Extract, Restore) treatment.

Another way to make sharper theoretical predictions is to focus on the most efficient SPNE, an equilibrium refinement commonly used in the literature on dynamic games (see, for example, Dixit et al. 2000). Given our experimental parameters, the SPNEs which deliver the largest sum of discounted utilities at the beginning of the game are (Conserve, Restore) and (Conserve, Don't Restore) in all but one treatment. The exception is the treatment with Certain Restoration ($\rho = 1$) and Low Cost ($T_R = 25$) where the efficient equilibrium prescribes maximal extraction followed by restoration.

4 Results

Results reported in this section refer to the behavior of "experienced" participants, that is starting from the 4^{th} supergame onwards, as pre-registered.[9] When presenting results about beliefs, we use data starting from the 7^{th} supergame, in which beliefs are first elicited. When discussing results about choices and beliefs, we focus on the first round of a supergame. This

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[9] In Appendix C, we show that the results presented in this Section are qualitatively unchanged when we expand the analyses to the whole sample. We compare subjects' behavior in early (1 to 3) vs. late (4-onwards) supergames in Appendix D.

is standard practice for the analysis of experimental data from infinitely repeated games and simplifies the analysis by i) minimizing the impact of history on behavior, as history may differ across subjects/groups starting from the second round; and ii) increasing comparability, as the length of each supergame may differ across subjects/groups due to the combined effect of their choices and of the random termination rule. For the same reasons, we focus on the first block (rounds 1-5) of a supergame when discussing resource life length and cumulative earnings results.[10]

4.1 Extraction and Restoration Choices

In the Baseline condition, in the absence of restoration, participants tend to extract a sustainable amount, allowing the resource to survive, on average, for 4 periods.[11] As a result, participants' payoffs are close to the efficient levels that can be achieved through sustained cooperation, and payoff dispersion is low. Overall, results show that the availability of restoration technologies neither allows participants to conserve the common resource longer nor to accrue higher payoffs than in the Baseline.

In the presence of restoration, it is only when the restoration technology is certain and cheap (T3) that players converge — and consistently stick — to the profitable actions' pattern in which the resource is first exhausted due to high extraction levels and then replenished through restoration technologies (see Figure 2 reporting evidence on Round 1 choices).[12] Interestingly, while participants invest the amount needed to make restoration successful from the beginning, they only learn over time to extract the resource to the full extent before replenishing it, fully exploiting the strategic substitutability.

When the restoration technology is cheap but uncertain (T2), most players tend to play conservatively on extractions, consuming virtually the same amount of units from the com-

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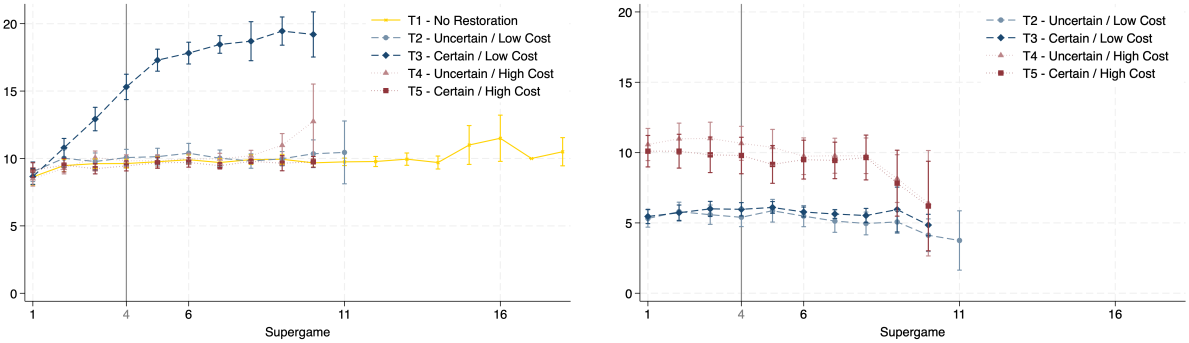
[10] In Appendix E, we show that results are qualitatively unchanged if we relax these constraints and include data from all rounds and all supergames.

[11] Note that with a continuation probability of $\delta = 0.8$ the expected duration of the game is 5 periods.

[12] See Figure 7 in Appendix H for descriptive statistics and results of non-parametric tests on overall Extraction and Restoration choices by experienced subjects in Round 1 (pooling observations from all supergames), and Table 14 in Appendix G for ATEs on individual Extraction and Restoration levels.

Figure 2: Mean Individual Extraction and Restoration Choices, Round 1



Notes: Whiskers denote 95% confidence intervals. *Left panel*: Extraction; *Right panel*: Restoration.

mon pool as in the Baseline. However, similarly to what we observe in the companion treatment with cheap restoration (available with certainty, T3), participants also choose to invest, on average, the amount needed to make restoration technologies effective despite the uncertainty about their actual availability.

When restoration technologies are expensive, irrespective of whether their availability is certain (T5) or uncertain (T4), players tend to play conservatively on extraction choices, just as in the Baseline, in which no restoration option is available. At the same time, although their conservative extraction conduct rarely makes restorative interventions needed, participants also tend to engage, on average, in positive restoration efforts.

RESULT 1: *The only condition in which restoration technologies are consistently employed, in combination with exploitative extraction actions, is when they are certain and cheap.*

4.1.1 Group and Individual Heterogeneity

To investigate heterogeneity at the group level, we classify each group with the equilibrium profile that most closely describes their observed aggregate group action (i.e., total extraction and total restoration) in Round 1. In the Baseline condition, individual extraction choices exhibit low variability when no restoration option is available. Looking at aggregate group behavior, we observe that in the majority of cases, action patterns compatible with what the conservative and most efficient equilibrium *"Conserve, Don't Restore"* would prescribe emerge, and only a minority of all groups exceeds the extraction threshold, exhausting the resource in the first round of play (see Figure 3).[13]

When restoration is certain and cheap (T3), both extraction levels and variability in individual extraction choices are higher, while relatively little heterogeneity is observed in restoration choices, whose value fluctuates around the (symmetrical) due level. As a result, in this treatment, most groups coordinate on extraction and restoration actions compatible with the most profitable (and efficient) equilibrium *"Extract, Restore"*.

When restoration is cheap but uncertain (T2), the average amount of units extracted from the resource is not statistically different than in the Baseline, while the average restoration effort mirrors the level reached in the companion treatment with cheap but certain restoration technologies (T3). However, due to a composition effect driven by the higher variability in individual extraction choices, aggregate group extraction levels exceed the threshold more often than in the Baseline.[14] Similarly, while the average restoration effort is high enough to reach the threshold needed at the group level in the majority of cases, the higher variability in individual restoration choices makes group restoration efforts sufficient less often than in T3.[15] Looking at aggregate group behavior, we observe that the conservative equilibrium *"Conserve, Restore"* — in which a limited amount of resource units is extracted and, simultaneously, efforts needed to make restoration effective are met — emerges as the most frequent. The other two equilibria *"Conserve, Don't Restore"* and *"Extract, Restore"* follow with almost equal frequency (see Figure 3), and similarly to what we observe in the Baseline and in T3, only a minority of groups coordinate on the defective and inefficient equilibrium

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[13] See Figure 8 in Appendix H for further descriptive evidence on the dispersion in Round 1 extraction and restoration choices.

[14] See Table 14 in Appendix G for ATEs on the probability excessive extraction and sufficient restoration effort is observed at the group level.

[15] In addition, as shown in Table 15 in Appendix G, reporting summary statistics on the resource restoration dynamics, the restoration technology proves successful in counteracting resource exhaustion only around 1/3 of the time due to the randomness in the availability of the restoration technology.

"Extract, Don't Restore".

When restoration technologies are expensive, irrespective of whether their availability is certain (T5) or uncertain (T4), we observe a slightly higher variability in extraction choices compared to the Baseline, similar to when cheap but uncertain restoration is available. At the same time, starkly higher variation in individuals' restoration investment choices emerges: while some participants decide not to invest at all, Others decide instead to invest the due amount needed to make costly restoration actions successful: in most cases, such uncoordinated restoration efforts lead to insufficient investment levels, causing groups to fail to reach the restoration threshold. As a result, the majority of groups coordinate on the *"Conserve, Don't Restore"* equilibrium, as in the Baseline, and only a minor share of all groups coordinate (and successfully persist) on extraction and restoration paths compatible with equilibria in which the resource survival relies on coordinated restoration efforts.

To further investigate heterogeneity in individual choices within and across treatments, we analyze participants' behavior in treatments where restoration technologies are available through a *k-means clustering* analysis.[16] We analyse participants' behavior in low- vs. high-cost restoration treatments separately: each observation represents a participant, who is identified with a two-dimensional vector describing her average extraction and restoration choices in Round 1 across all supergames played from the 4^{th} onwards. Results, shown in Figure 4, show that within each cost condition, participants' behavior can be parsimoniously classified into three clusters. However, clusters' classification differs substantially across the two conditions: while in the low-cost scenarios, most of the heterogeneity across individuals arises from differences in average extraction choices, when restoration costs are high, clusters differ mostly only along the average restoration choice dimension. In low-cost

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[16] K-means clustering is a common unsupervised learning technique used to group observations based on their similarity in a multidimensional space of observable characteristics (see MacQueen 1967, Hartigan 1975, Hastie et al. 2005, and Murphy 2012; for a recent use in experimental economics, see Fréchette et al. 2022). The process involves the random selection of k points as cluster centers within the observable characteristic space. Each observation is then linked to its nearest center, and the center positions are iteratively adjusted to minimize within-cluster variance. This process is repeated 10 times with 10 different random cluster centers, and the algorithm selects the best result if the final clusters differ. Determining the initial number of clusters is a necessary step, and we followed the customary practice of using the elbow method.

restoration treatments, the majority of participants can be classified within one of the two clusters characterized by average extraction and restoration actions compatible with what the two equilibria *"Extract, Restore"* and *"Conserve, Restore"* would prescribe, which are the two modal equilibria in T2 and T3, respectively, based on aggregate group actions. Only a minority of participants are classified within a residual cluster characterized by conservative extraction choices and a generous restoration propensity, which is not predicted by any of the symmetrical and stationary equilibria analyzed yet could — in principle — identify participants with strong identity preferences for resource preservation, less sensitive to strategic substitutability. When restoration is expensive, clusters only differ, instead, in terms of average restoration propensity. As in the previous cost scenario, most of the participants can be classified within one of the two clusters compatible with what the two equilibria *"Conserve, Restore"* and *"Conserve, Don't Restore"* would prescribe, and only a minor share of participants are classified within a residual cluster characterized by relatively high but insufficient restoration efforts, which is not predicted by any of the symmetrical and stationary equilibria analyzed.

4.2 Resource Life

Thanks to the implementation of the block random termination rule, all players can — in principle — play for up to five rounds, irrespective of (and prior to being informed about) the random realizations of the parameter determining game continuation. Looking at players' behavior in the first five rounds of each supergame — Block 1 — we observe that the resource survives for, on average, approximately 4 periods.[17]

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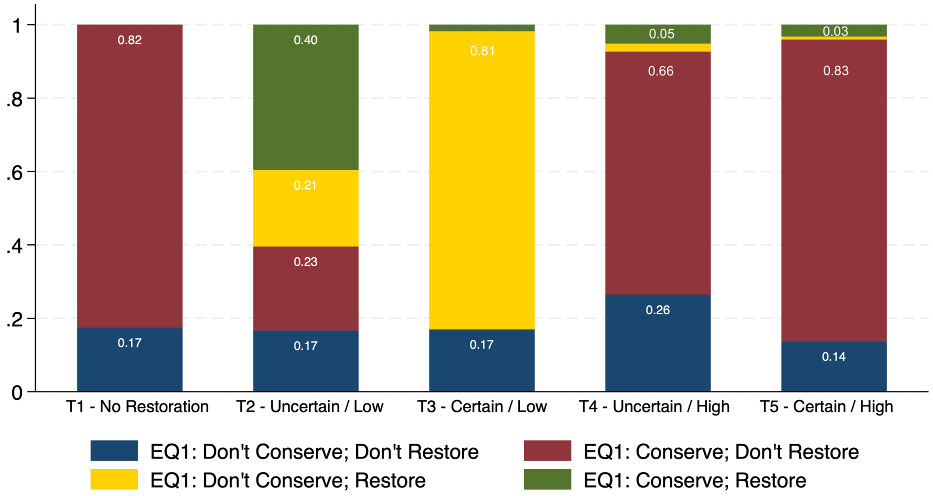
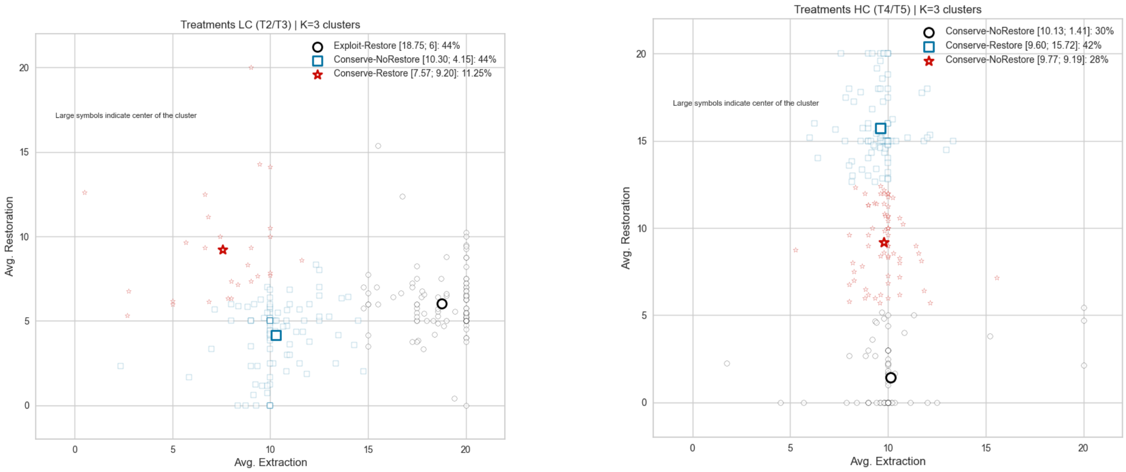
[17] Due to some minor and unexpected technical issues occurred at the end of a few sessions conducted during the first week of data collection, we exclude observations from N=6 groups in total from the analysis on Block 1 behavior: groups 1,3 from session 3 (T2); group 1 from session 4 (T3); groups 1,2,3 from session 5 (T4). During those sessions, a subset of groups experienced a glitch while taking their choices in the last supergame — at different game stages — preventing them from completing to play. The glitch never occurred while subjects were making Round 1 choices; hence no observation is excluded from the analysis of Round 1 behavior.

Figure 3: Distribution of Group Types Across Treatments, Round 1



Notes. Group types are defined based on aggregate group extraction and restoration actions: groups are classified with the equilibrium profile that most closely describes their observed overall group action pattern. Percentage values reported inside the bars represent the frequency of the types within each treatment condition (labels are printed only for percentage values above 0.02). *EQ1:* if $E_t = \sum e_{it} > T_E$ and (if available) $R_t = \sum r_{it} < T_R$; *EQ2:* if $E_t = \sum e_{it} \leq T_E$ and (if available) $R_t = \sum r_{it} < T_R$; *EQ3:* if $E_t = \sum e_{it} > T_E$ and (if available) $R_t = \sum r_{it} \geq T_R$; *EQ4:* if $E_t = \sum e_{it} \leq T_E$ and (if available) $R_t = \sum r_{it} \geq T_R$.

Figure 4: Cluster Analysis



Notes: Left Panel: Low-cost restoration treatments, pooled (T2 and T3); High-cost restoration treatments, pooled (T4 and T5).

The presence of restoration technologies does not improve prospects of resource life length, compared to the Baseline, not even when restoration technologies are largely employed to counteract excessively exploitative extraction behaviors, such as in T3 when restoration is certain and low cost (see Table 3).[18]

RESULT 2: *On average, the resource survives for about 4 periods, and introducing restoration technologies does not improve its life length.*

Table 3: Resource Life & Payoffs (Block 1), Statistical Tests for ATEs

	Pr(Resource Conserved)	Resource Life Length	Round Payoff	Cumulative Payoff
T2 - Uncertain / Low	-0.070	-0.545	-0.504***	-17.021*
	(0.054)	(0.338)	(0.135)	(9.918)
T3 - Certain / Low	-0.005	-0.044	2.865***	11.844
	(0.051)	(0.306)	(0.374)	(9.115)
T4 - Uncertain / High	-0.068	-0.558	-0.728***	-16.276
	(0.080)	(0.488)	(0.196)	(14.104)
T5 - Certain / High	-0.026	-0.049	-1.365***	-4.289
	(0.048)	(0.329)	(0.245)	(10.292)
Constant	0.866***	4.017***	29.996***	118.942***
	(0.044)	(0.258)	(0.079)	(7.900)
Observations	2867	750	14335	3750

Notes. Column 1 reports Average Marginal Effects for the Logit-RE model: an observation is a group in a round of a supergame; Column 2 reports OLS Estimates: an observation is a group in a supergame; Column 3 reports GLS-RE Estimates: an observation is a subject in a round of a supergame; Column 4 reports GLS-RE Estimates: an observation is a subject in a supergame. In each column, the dependent variable is: (1) Dummy variable equal to one if the group manages to conserve the resource, either by not exceeding the extraction threshold or by successful restoration; (2) Number of rounds the resource was conserved in; (3) Individual round payoff; (4) Individual cumulative payoff accrued over Rounds 1-5. The baseline treatment is T1. Standard errors clustered at the session level.

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[18] Resource life length is measured as the number of rounds actually played by each group out of the first block of five rounds. See Figure 9 in Appendix H for descriptive statistics and results of non-parametric tests on resource life.

4.3 Welfare

To evaluate the welfare effects of introducing restoration technologies, we primarily look at cumulative payoffs accrued over the first five rounds of a supergame — Block 1 — which are affected both by individuals' (extraction and restoration) actions in each round and by groups' ability to maximize the resource lifespan.

Overall, the presence of restoration technologies does not lead to any significant improvement in the level of cumulative payoffs, with respect to the Baseline (see Table 3, and Figure 6). Looking at round payoffs, the only condition in which a positive effect is observed is when restoration is cheap and certain (T3): in all other conditions, the presence of restoration technologies leads to lower round payoffs compared to the baseline in which no restoration option is available (see Figure 5).

The availability of restoration technologies also intensifies within-group dispersion in round and cumulative payoffs (see Figures 5 and 6). The strongest and most sizeable effect emerges in the presence of certain and low-cost restoration technologies (T3) and is led by sizeable within-group dispersion in both extraction and restoration choices, with the latter being almost always payoff-relevant, due to players' exploitative actions and technological readiness. Although smaller in size, a significant positive effect on cumulative payoffs' dispersion also emerges when restoration technologies are low-cost but uncertain (T2) or certain and high-cost (T5). In all cases, most of the payoff dispersion observed is driven by the dispersion in extraction choices, as restoration investments — when possible — do not always lead to payoff-relevant consequences, and even when this is the case, display lower variability (see Table 4).[19, 20]

RESULT 3: *Restoration technologies do not prove to be payoff-enhancing, not even when*

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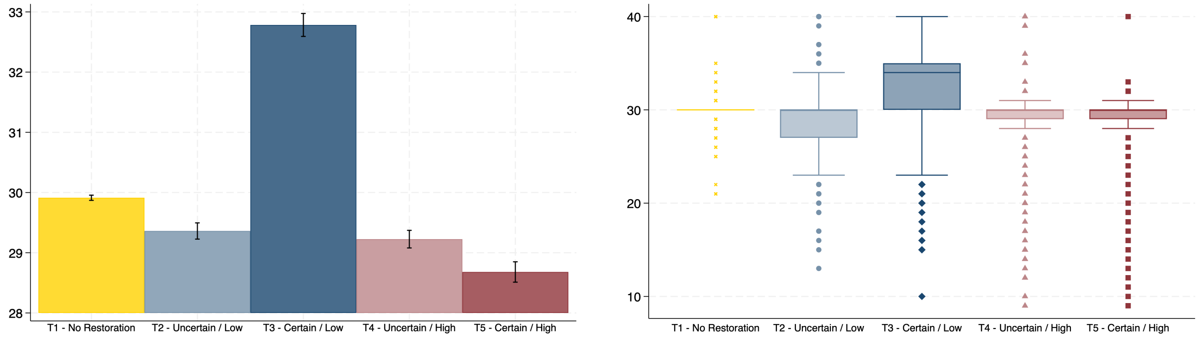
[19] We measure dispersion looking at the standard deviation. We replicate the analysis relying on an alternative measure of dispersion - the Gini index - in Appendix G.

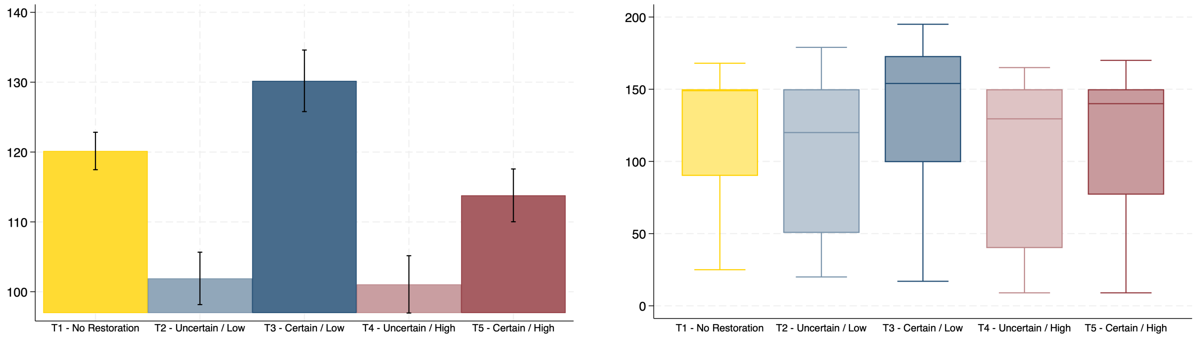
[20] See Figure 10 in Appendix H) for descriptive evidence on the dispersion in cumulative extraction and (payoff-relevant) restoration choices in Block 1, and Table 15 in Appendix G for summary statistics on the resource restoration dynamics.

Figure 5: Individual Round Payoffs in Block 1 (Rounds 1-5): Means & Box Plots



Notes. In the left-hand side panel, whiskers at the top of bars denote 95% confidence intervals. Mann-Whitney-Wilcoxon test statistics on equality of medians (p-values): *T1 vs. T2* z-stat=6.341 (0.000); *T1 vs. T3* z-stat=-48.026 (0.000); *T1 vs. T4* z-stat=6.342 (0.000); *T1 vs. T5* z-stat=10.837 (0.000). Kolgomorov-Smirnov test statistics on equality of distributions (p-values): *T1 vs. T2* D=0.1544 (0.000); *T1 vs. T3* D=0.7575 (0.000); *T1 vs. T4* D=0.0636 (0.000); *T1 vs. T5* D=0.1460 (0.000).

Figure 6: Cumulative Payoffs in Block 1 (Rounds 1-5): Means & Box Plots



Notes. In the left-hand side panel, whiskers denote 95% confidence intervals. Mann-Whitney-Wilcoxon test statistics on equality of medians (p-values): *T1 vs. T2* z-stat=9.232 (0.000); *T1 vs. T3* z-stat=-9.400 (0.000); *T1 vs. T4* z-stat=9.306 (0.000); *T1 vs. T5* z-stat=5.002 (0.000). Kolgomorov-Smirnov test statistics on equality of distributions (p-values): *T1 vs. T2* D=0.2731 (0.000); *T1 vs. T3* D=0.4757 (0.000); *T1 vs. T4* D=0.2214 (0.000); *T1 vs. T5* D=0.2107 (0.000).

available with certainty and at a low cost; The introduction of restoration technologies also triggers negative effects on cumulative payoffs' dispersion within groups, mostly due to a higher dispersion in players' cumulative extraction choices.

Table 4: Analysis of Payoffs Dispersion (Block 1), Statistical Tests for ATEs

	Round Payoff *SD*	Cumulative Payoff *SD*	Cumulative Extraction *SD*	Cumulative Restoration^{PR} *SD*	Cumulative Payoff *SD*
T2 - Uncertain / Low	1.649**	4.117***	3.651**	-4.095***	
	(0.665)	(1.470)	(1.451)	(0.752)	
T3 - Certain / Low	2.212***	8.361***	6.285***		
	(0.430)	(1.747)	(1.459)		
T4 - Uncertain / High	1.307	1.798	0.475	-3.661***	
	(0.902)	(1.062)	(0.782)	(0.914)	
T5 - Certain / High	1.674***	4.873***	2.191**	-1.593*	
	(0.443)	(0.812)	(0.921)	(0.899)	
Cum. Extraction *SD*					0.884***
					(0.028)
Cum. Restoration^{PR} *SD*					0.631***
					(0.101)
Constant	1.081***	2.624***	2.624***	5.527***	0.311
	(0.298)	(0.564)	(0.564)	(0.681)	(0.277)
Observations	2867	750	750	510	510

Notes. SD: Within Group Standard Deviation. Column 1 reports GLS-RE Estimates: an observation is a group in a round of a supergame; Columns 2-5 report OLS Estimates: an observation is a group in a supergame. In each column, the dependent variable is: Dispersion, measured through within-group standard deviation, in (1) Round Payoffs in Block 1; (2,5) Cumulative Payoffs in Block 1; (3) Cumulative Extraction choices in Block 1; (4) Cumulative Payoff-Relevant Restoration choices in Block 1: restoration choices are payoff-relevant only if restoration is needed, because the extraction threshold is exceeded, and available – and otherwise valued as zero. Standard errors clustered at the session level.

4.4 Beliefs

Participants tend to hold correct beliefs about their groupmates' total extraction choices in the Baseline (see Table 5), correctly approximating that their groupmates' total extraction will fluctuate around the level that would enable coordinated conservative action. Almost the same picture emerges when uncertain and expensive restoration technologies are introduced (T4). When uncertain but cheap (T2) or certain and expensive (T5) restoration technologies are available, participants expect their groupmates to extract globally slightly more of

Table 5: Beliefs about Others' Choices (Round 1), Statistical Tests for ATEs

	Others' Extraction		Others' Restoration	
	Belief	*Bias*	Belief	*Bias*
T2 - Uncertain / Low	3.234**	2.973**	-2.557*	0.276
	(1.260)	(1.238)	(1.503)	(0.765)
T3 - Certain / Low	32.586***	-1.847*		
	(1.839)	(1.006)		
T4 - Uncertain / High	2.426*	1.009	16.648***	0.962
	(1.341)	(0.835)	(3.843)	(1.478)
T5 - Certain / High	1.424***	2.893***	14.840***	1.005
	(0.501)	(0.901)	(1.923)	(1.554)
Constant	40.446***	0.863	24.863***	2.358***
	(0.164)	(0.655)	(0.835)	(0.640)
Observations	1980	1980	1140	1140

Notes. GLS-RE Estimates: an observation is a subject in a round of a supergame. In each column, the dependent variable is: (1) Beliefs on the sum of other groupmembers' total extraction choices; (2) Distance between beliefs and actual levels for other groupmembers' total extraction choices; (3) Beliefs on the sum of other groupmembers' restoration choices; (4) Distance between beliefs and actual levels for other groupmembers' restoration choices. Standard errors clustered at the session level.

what would be the level ensuring resource conservation, although such slightly pessimistic beliefs do not match their groupmates' actual extraction patterns. In stark contrast, when restoration technologies are certain and cheap (T3), participants do correctly anticipate that their groupmates' total extraction will be well above the conservative level.

When asked to guess about their groupmates' restoration choices (see Table 5), participants correctly anticipate that their groupmates will be willing to commit to roughly sufficient investments when the cost of restoration is low (T2 and T3) but not when the cost of restoration is high (T4 and T5), when they predict that total investment will largely lag behind the level needed, irrespective of whether the availability of the technology is certain or uncertain. Net of differences in predicted restoration effort levels, across all conditions, participants tend to hold slightly optimistic beliefs about their group mates' willingness to invest in restoration technologies.

RESULT 4: *Participants form correct beliefs about their groupmates' extraction choices in most treatments, correctly anticipating exploitative behavior will steadily emerge only when restoration is cheap and certain; instead, they tend to slightly over-estimate others' willingness to invest in restoration in all conditions despite correctly capturing level effects across different cost dimensions.*

5 Discussion

Like any simplified setting, our laboratory experiment has advantages and disadvantages. The simplicity of the set-up, where all players share accurate information about restoration technologies' presence, availability, and cost, provides a controlled environment for studying coordination behaviours, offering a foundational understanding of individual choices. The changes explored in the various treatments allow us to investigate how real-world unknowns, such as cost and availability for massive implementation of these technologies, may influence the perceived substitutability between mitigation and restoration. Moreover, in our setting, relying on restoration implies a higher degree of governance complexity, reflecting the challenge posed by the need for a dedicated institution for facilitating, implementing, and monitoring negative emissions — just as it would in real life. In our experiment, we rely on a Common Pool Resource game where resource (full) conservation or exhaustion is dichotomously determined by how collective actions relate to some known and deterministic thresholds: failure to respect such thresholds leads to sudden and "extreme" changes in the resource status, irrespective of the size of deviations. This simplification emphasizes one fundamental aspect of climate change damages (Barrett and Dannenberg 2012), yet portrays a somewhat imprecise picture of how human actions can affect climate preservation, as in the real world also the extent of deviations from thresholds can matter, possibly triggering gradual climate transformations. Despite this partial inaccuracy, we find reassurance in recent experimental evidence supporting threshold thinking in climate change problems (Semken 2023): although scientifically inaccurate this threshold setting is the one most people have in mind when thinking about the problem that inspired our study. The choice to allow for complete reversibility of adverse consequences of previous hazardous actions, inherent in our design, is another simplification that makes our experimental setup different from the real-world problem, where irreversible tipping points pose substantial challenges. If anything, introducing incomplete reversibility in resource extraction would strengthen our results. Our findings indicate that strategic substitutability is fully exploited only when restoration is certain and low-cost (T3). When restoration is low-cost but uncertain, most individuals keep betting on conservation as their strategy, and only a small fraction of individuals shift to a substitution strategy. When the restoration cost is high, the behavior remains similar to that in the Baseline. Contrary to expectations, restoration technologies neither extend the resource life horizon nor result in higher cumulative payoffs. The impact on round payoffs varies, with positive effects observed when restoration is cheap and certain and negative effects when restoration is cheap and uncertain or certain and expensive. The introduction of restoration technologies contributes to increased cumulative payoffs' dispersion within groups, primarily driven by higher extraction choice dispersion. This suggests that restoration technologies amplify variations in individual behaviors, influencing cumulative outcomes within groups. Participants demonstrated a decent ability to predict groupmates' behaviors and consistently adjusted their actions accordingly.[21] Notably, there was a tendency towards slightly pessimistic beliefs about others' willingness to act conservatively in treatments involving low-cost and uncertain restoration or expensive and certain restoration.

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[21] Despite the varying degrees of complexity in the choice environment faced in different treatments, participants also showed a good level of understanding of experimental instructions, as documented by their performance in the comprehension questions. Looking at the number of correctly answered CQs (Appendix G - Table 13 it emerges that subjects initially do understand CQs a bit worse in treatments with restoration as the decision environment gets more complex, especially when restoration is available with uncertainty, but differences vanish after they re-read the instructions and answer the CQs for the second time, before moving to the game stage.

6 Conclusion

Our study provides crucial insights into the role of Negative Emission Technologies (NETs) as potential deterrents to mitigation efforts. The equilibrium where mitigation is entirely substituted by restoration emerges only when individuals perceive these technologies as a sure low-cost option. However, short-term mitigation decisions are influenced when these technologies are available in all scenarios. Realistic presentations of removal technologies, characterized by high costs and uncertainty, result in negative short-term effects. These include decreased payoffs, heightened inequality, and increased coordination challenges, particularly amplifying the impact of defectors and free riders. Even under the most optimistic scenario, carbon removal technologies prove ineffective in prolonging the lifespan of the resource. Our findings raise concerns about the risks of portraying Negative Emission Technologies as fail-safe and low-cost mechanisms, as this would shift the focus away from the required short-term mitigation. More generally, our results underscore the pivotal role of communication. Policymakers and communicators must navigate the narrative surrounding the affordability and reliability of restoration technologies with care. In conclusion, our study sheds light on the complexities surrounding integrating restoration technologies in the context of climate change negotiations. Recognizing the limited positive impact on resource longevity and earnings and the critical influence of cost considerations and acknowledging the possibility of irreversible climate change is essential for formulating effective policies and communication strategies. As the global community strives for sustainable solutions, these findings contribute valuable insights to inform future decision-making and action in pursuing a resilient and climate-conscious society.

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A Proofs

Proof of Proposition 1

There is no profitable deviation in either phase because, by Assumptions 1 and 2, a player cannot unilaterally avoid the transition to the Restoration Phase when everybody else extracts the largest feasible amount (in the Extraction Phase) and a player cannot unilaterally avoid resource depletion when nobody else makes any restoration effort (in the Restoration Phase).

Proof of Proposition 2

In the Extraction Phase, there is no profitable deviation if and only if:

$$\begin{aligned} V^{EQ} = \frac{W + T_E}{n(1-\delta)} &\geq \frac{W+K}{n} \\ W + T_E &\geq (W+K)(1-\delta) \\ T_E &\geq K - \delta(W+K) \\ \delta &\geq \frac{K - T_E}{W+K} \end{aligned}$$

In the Restoration Phase, there is no profitable deviation because, by Assumptions 2, a player cannot unilaterally avoid resource depletion when nobody else makes any restoration effort.

Proof of Proposition 3

In the Extraction Phase, there is no profitable deviation because, by Assumptions 1, a player cannot unilaterally avoid the transition to the Restoration Phase when everybody else extracts the largest feasible amount. In the Restoration Phase, there is no profitable deviation if and only if:

$$\begin{aligned} -\frac{T_R}{n} + \delta V^{EQ} &\geq 0 \\ \delta V^{EQ} &\geq \frac{T_R}{n} \end{aligned}$$

Since the continuation value of the game under equilibrium strategies is equal to $V^{EQ} = \frac{(W+K)}{n} - \rho\frac{T_R}{n} + \rho\delta V^{EQ}$, we have $V^{EQ} = \frac{(W+K)-\rho T_R}{(1-\delta\rho)n}$ and the condition above becomes

$$\begin{aligned}
\delta\frac{(W+K)-\rho T_R}{(1-\delta\rho)n} &\geq \frac{T_R}{n}\\
\delta(W+K-\rho T_R) &\geq T_R(1-\delta\rho)\\
\delta(W+K) &\geq T_R\\
\delta &\geq \frac{T_R}{(W+K)}
\end{aligned}$$

Proof of Propositions 4 and 5

In the Extraction Phase, there is no profitable deviation if and only if:

$$\begin{aligned}
V^{EQ} &\geq \frac{W+K}{n}-\rho\frac{T_R}{n}+\rho\delta V^{EQ}\\
(1-\rho\delta)V^{EQ} &\geq \frac{W+K}{n}-\rho\frac{T_R}{n}
\end{aligned}$$

Since the continuation value of the game under equilibrium strategies is given by $V^{EQ} = \frac{W+T_E}{n(1-\delta)}$, the condition above becomes

$$\begin{aligned}
(1-\delta\rho)\frac{W+T_E}{n(1-\delta)} &\geq \frac{W+K}{n}-\rho\frac{T_R}{n}\\
\frac{1-\delta\rho}{1-\delta} &\geq \frac{W+K-\rho T_R}{W+T_E}
\end{aligned}$$

When $\rho = 1$, the condition above becomes $T_E \geq K - T_R$.

When $\rho \in (0,1)$, the condition above becomes:

$$\frac{(1-\delta\rho)(W+T_E)-(W+K-\rho T_R)(1-\delta)}{(1-\delta)(W+T_E)} \geq 0$$

Since the denominator of the LHS is always positive, this condition reduces to checking whether the numerator of the LHS is positive, that is,

$$\begin{aligned}
(1-\delta\rho)(W+T_E)-(W+K-\rho T_R)(1-\delta) &\geq 0 \\
W+T_E-\delta\rho(W+T_E)-W-K+\rho T_R+\delta(W+K-\rho T_R) &\geq 0 \\
-\delta\rho(W+T_E)+\delta(W+K-\rho T_R) &\geq K-\rho T_R-T_E \\
\delta(W+K-\rho(W+T_E+T_R)) &\geq K-\rho T_R-T_E \\
\delta &\geq \frac{K-\rho T_R-T_E}{W+K-\rho(W+T_E+T_R)}
\end{aligned}$$

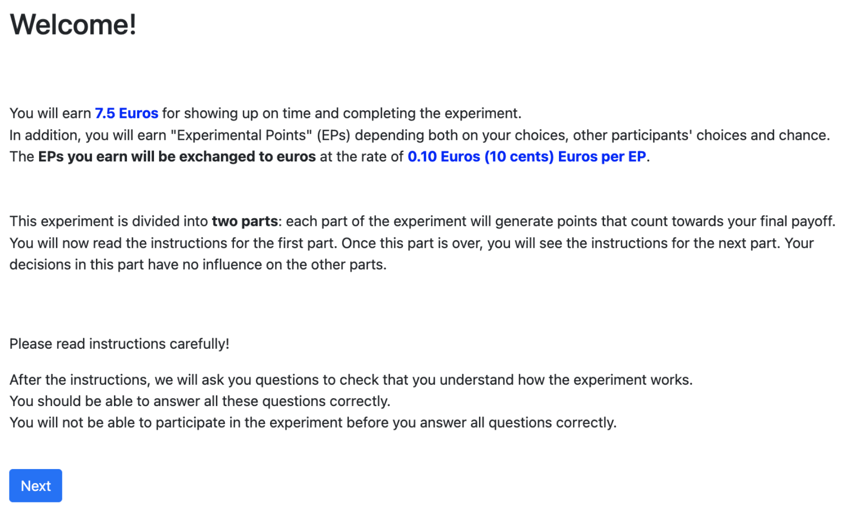
Since the RHS is strictly less than 1, there exists a value of $\delta \in [0,1]$ such that this holds. Thus, when $\rho \in (0,1)$, the condition for no profitable deviation in the Extraction Phase becomes $\delta \geq \frac{K-\rho T_R-T_E}{W+K-\rho(W+T_E+T_R)}$.

In the Restoration Phase, there is no profitable deviation if and only if:

$$\begin{aligned}
-\frac{T_R}{n}+\delta V^{EQ} &\geq 0 \\
-\frac{T_R}{n}+\delta\frac{W+T_E}{n(1-\delta)} &\geq 0 \\
\delta &\geq \frac{T_R}{W+T_E+T_R}
\end{aligned}$$

Since the RHS is strictly less than 1, there exists a value of $\delta \in [0,1]$ such that this holds.

B Experimental Instructions



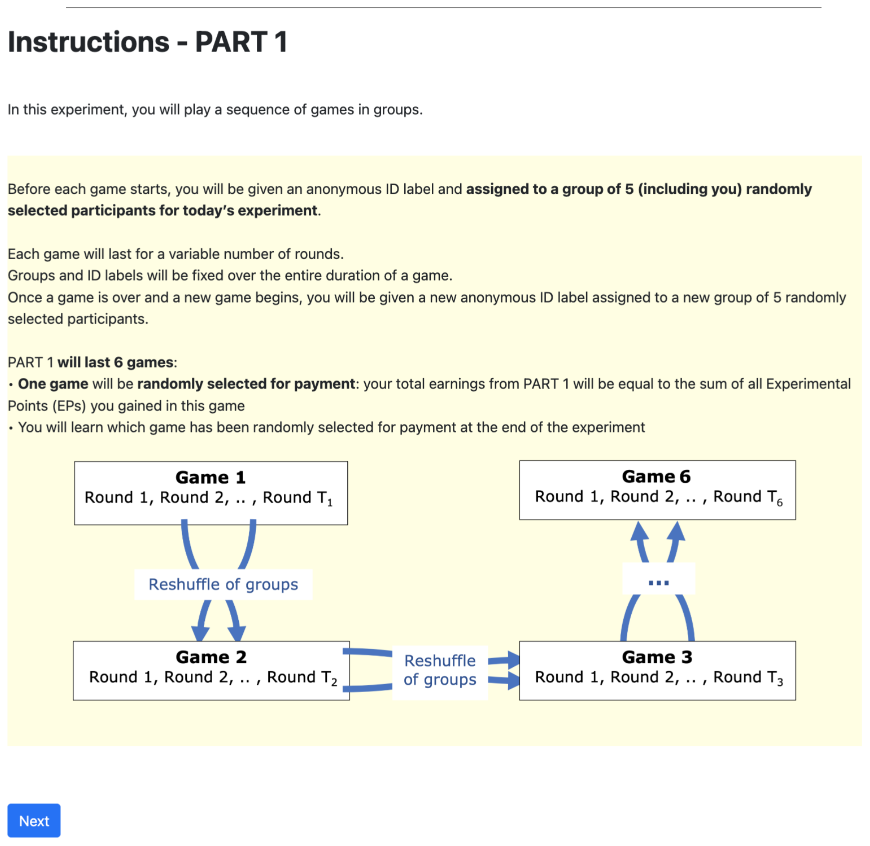
Welcome!

You will earn **7.5 Euros** for showing up on time and completing the experiment.
In addition, you will earn "Experimental Points" (EPs) depending both on your choices, other participants' choices and chance.
The **EPs you earn will be exchanged to euros** at the rate of **0.10 Euros (10 cents) Euros per EP**.

This experiment is divided into **two parts**: each part of the experiment will generate points that count towards your final payoff. You will now read the instructions for the first part. Once this part is over, you will see the instructions for the next part. Your decisions in this part have no influence on the other parts.

Please read instructions carefully!

After the instructions, we will ask you questions to check that you understand how the experiment works.
You should be able to answer all these questions correctly.
You will not be able to participate in the experiment before you answer all questions correctly.



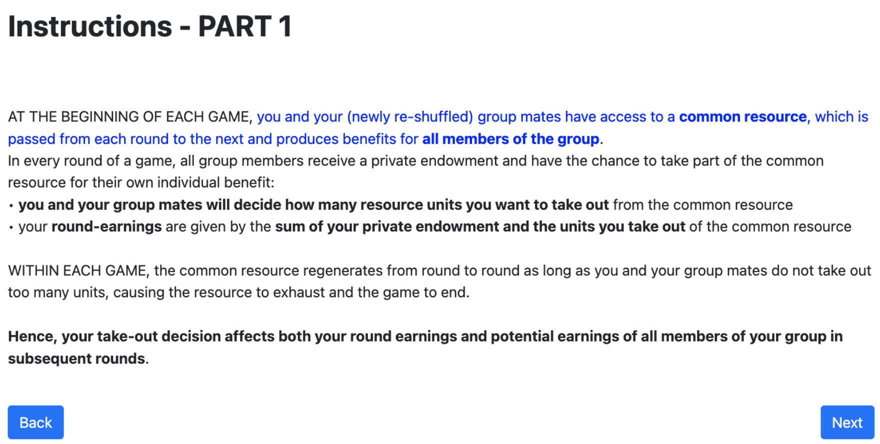
Instructions - PART 1

In this experiment, you will play a sequence of games in groups.

Before each game starts, you will be given an anonymous ID label and **assigned to a group of 5 (including you) randomly selected participants for today's experiment**.

Each game will last for a variable number of rounds.
Groups and ID labels will be fixed over the entire duration of a game.
Once a game is over and a new game begins, you will be given a new anonymous ID label assigned to a new group of 5 randomly selected participants.

PART 1 **will last 6 games**:
- **One game** will be **randomly selected for payment**: your total earnings from PART 1 will be equal to the sum of all Experimental Points (EPs) you gained in this game
- You will learn which game has been randomly selected for payment at the end of the experiment



Instructions - PART 1

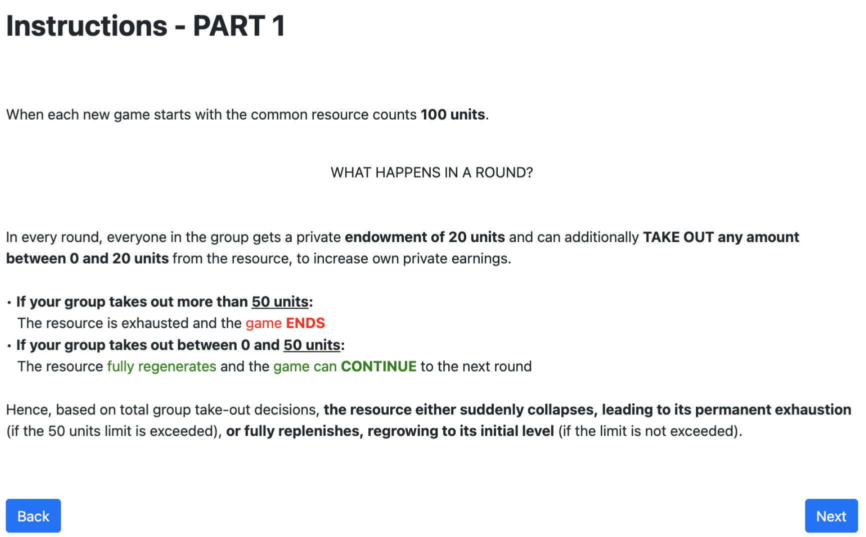
AT THE BEGINNING OF EACH GAME, you and your (newly re-shuffled) group mates have access to a **common resource**, which is passed from each round to the next and produces benefits for **all members of the group**.
In every round of a game, all group members receive a private endowment and have the chance to take part of the common resource for their own individual benefit:

- **you and your group mates will decide how many resource units you want to take out** from the common resource
- your **round-earnings** are given by the **sum of your private endowment and the units you take out** of the common resource

WITHIN EACH GAME, the common resource regenerates from round to round as long as you and your group mates do not take out too many units, causing the resource to exhaust and the game to end.

Hence, your take-out decision affects both your round earnings and potential earnings of all members of your group in subsequent rounds.

Treatment T1: No Restoration



Instructions - PART 1

When each new game starts with the common resource counts **100 units**.

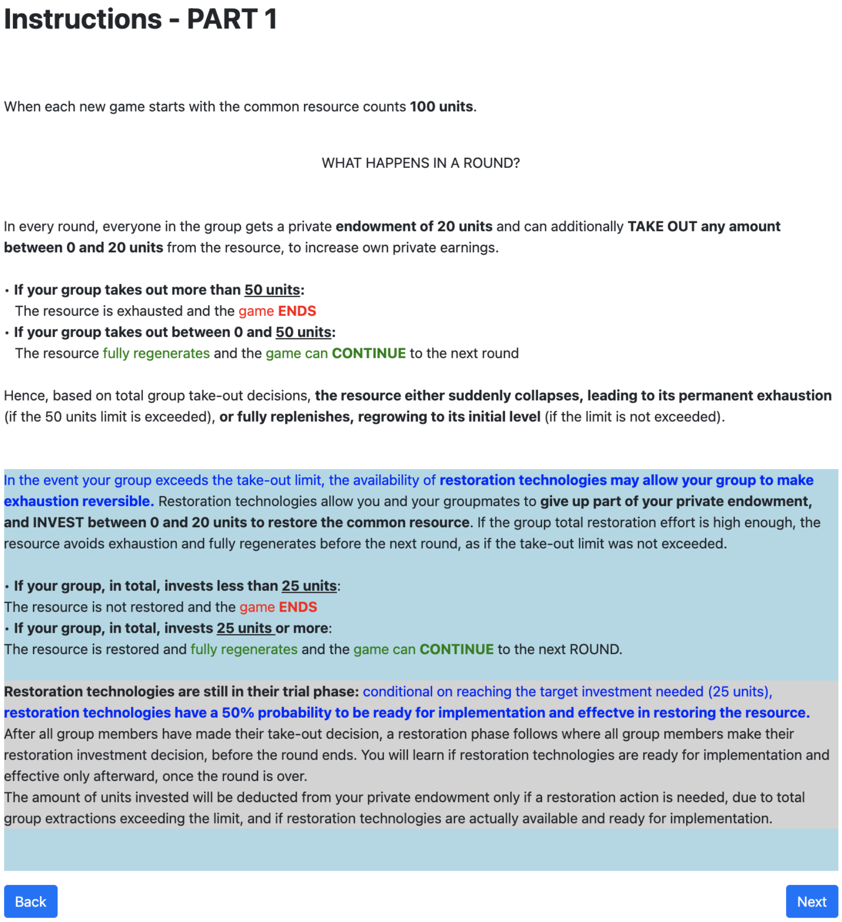
WHAT HAPPENS IN A ROUND?

In every round, everyone in the group gets a private **endowment of 20 units** and can additionally **TAKE OUT any amount between 0 and 20 units** from the resource, to increase own private earnings.

- **If your group takes out more than 50 units:**
  The resource is exhausted and the game **ENDS**
- **If your group takes out between 0 and 50 units:**
  The resource fully regenerates and the game can **CONTINUE** to the next round

Hence, based on total group take-out decisions, **the resource either suddenly collapses, leading to its permanent exhaustion** (if the 50 units limit is exceeded), **or fully replenishes, regrowing to its initial level** (if the limit is not exceeded).

Treatment T2: Uncertain & Low-Cost Restoration



Instructions - PART 1

When each new game starts with the common resource counts **100 units**.

WHAT HAPPENS IN A ROUND?

In every round, everyone in the group gets a private **endowment of 20 units** and can additionally **TAKE OUT any amount between 0 and 20 units** from the resource, to increase own private earnings.

- **If your group takes out more than 50 units:**
  The resource is exhausted and the game **ENDS**
- **If your group takes out between 0 and 50 units:**
  The resource fully regenerates and the game can **CONTINUE** to the next round

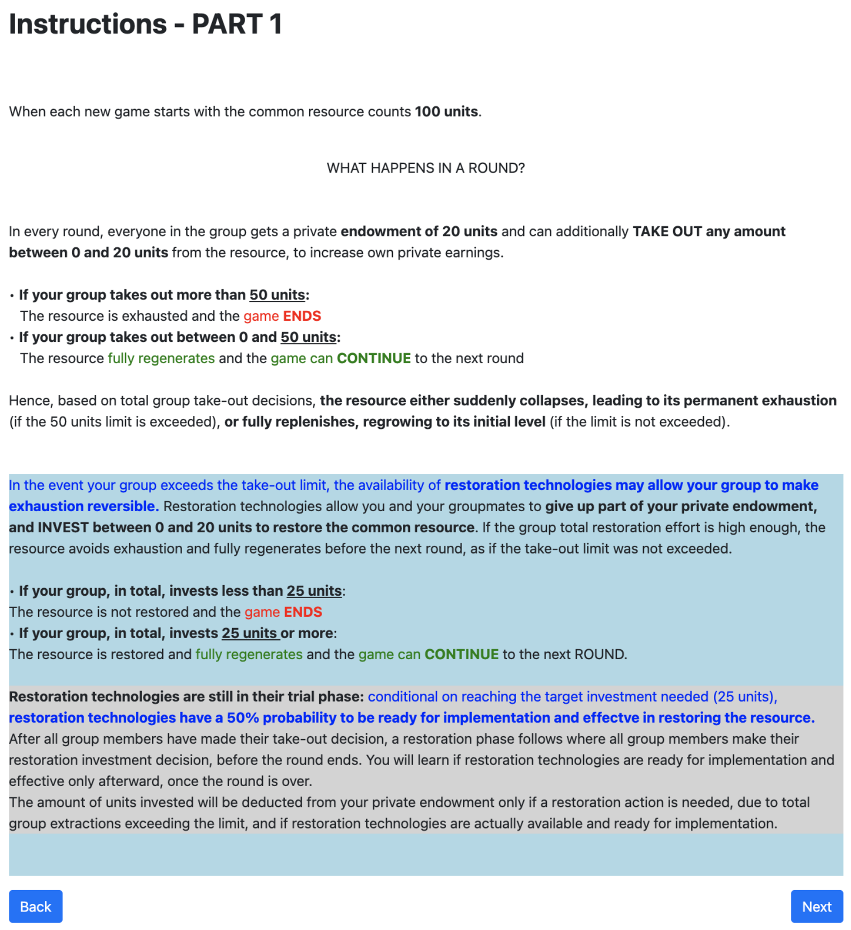
Hence, based on total group take-out decisions, **the resource either suddenly collapses, leading to its permanent exhaustion** (if the 50 units limit is exceeded), **or fully replenishes, regrowing to its initial level** (if the limit is not exceeded).

In the event your group exceeds the take-out limit, the availability of **restoration technologies may allow your group to make exhaustion reversible.** Restoration technologies allow you and your groupmates to **give up part of your private endowment, and INVEST between 0 and 20 units to restore the common resource**. If the group total restoration effort is high enough, the resource avoids exhaustion and fully regenerates before the next round, as if the take-out limit was not exceeded.

- **If your group, in total, invests less than 25 units**:
  The resource is not restored and the game **ENDS**
- **If your group, in total, invests 25 units or more**:
  The resource is restored and fully regenerates and the game can **CONTINUE** to the next ROUND.

Restoration technologies are still in their trial phase: conditional on reaching the target investment needed (25 units), **restoration technologies have a 50% probability to be ready for implementation and effectve in restoring the resource.**
After all group members have made their take-out decision, a restoration phase follows where all group members make their restoration investment decision, before the round ends. You will learn if restoration technologies are ready for implementation and effective only afterward, once the round is over.
The amount of units invested will be deducted from your private endowment only if a restoration action is needed, due to total group extractions exceeding the limit, and if restoration technologies are actually available and ready for implementation.

Treatment T3: Certain & Low-Cost Restoration



Instructions - PART 1

When each new game starts with the common resource counts **100 units**.

WHAT HAPPENS IN A ROUND?

In every round, everyone in the group gets a private **endowment of 20 units** and can additionally **TAKE OUT any amount between 0 and 20 units** from the resource, to increase own private earnings.

- **If your group takes out more than 50 units:**
  The resource is exhausted and the game **ENDS**
- **If your group takes out between 0 and 50 units:**
  The resource fully regenerates and the game can **CONTINUE** to the next round

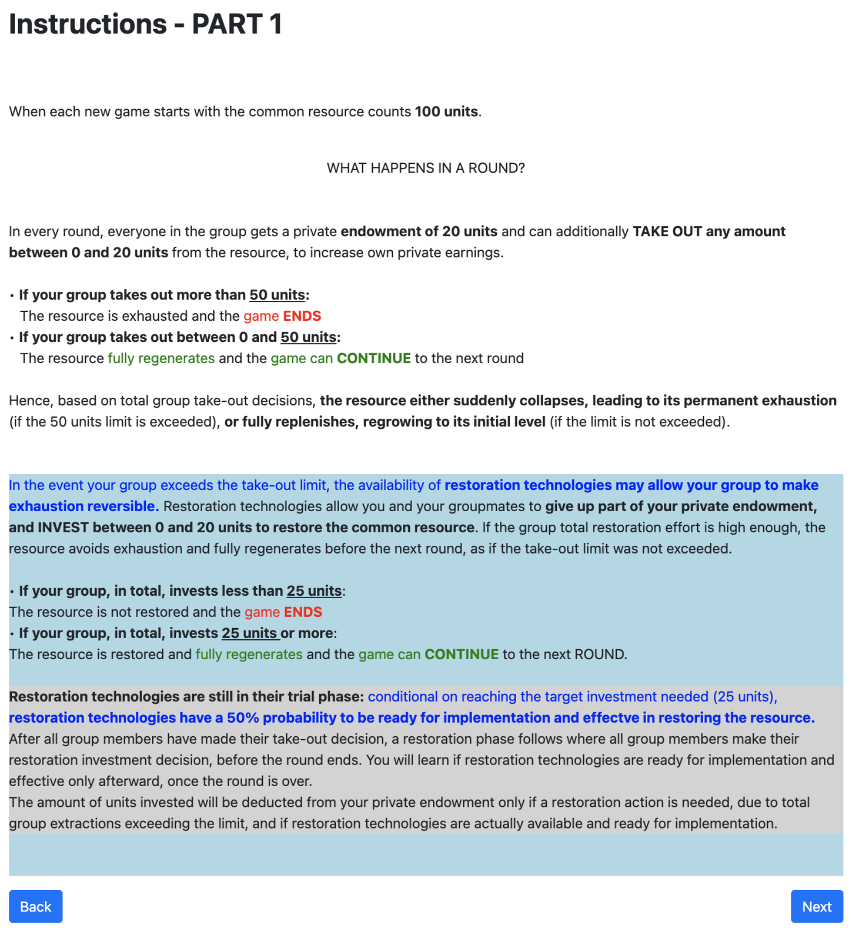
Hence, based on total group take-out decisions, **the resource either suddenly collapses, leading to its permanent exhaustion** (if the 50 units limit is exceeded), **or fully replenishes, regrowing to its initial level** (if the limit is not exceeded).

In the event your group exceeds the take-out limit, the availability of **restoration technologies may allow your group to make exhaustion reversible.** Restoration technologies allow you and your groupmates to **give up part of your private endowment, and INVEST between 0 and 20 units to restore the common resource**. If the group total restoration effort is high enough, the resource avoids exhaustion and fully regenerates before the next round, as if the take-out limit was not exceeded.

- **If your group, in total, invests less than 25 units:**
  The resource is not restored and the game **ENDS**
- **If your group, in total, invests 25 units or more:**
  The resource is restored and fully regenerates and the game can **CONTINUE** to the next ROUND.

Restoration technologies are still in their trial phase: conditional on reaching the target investment needed (25 units), **restoration technologies have a 50% probability to be ready for implementation and effectve in restoring the resource.**
After all group members have made their take-out decision, a restoration phase follows where all group members make their restoration investment decision, before the round ends. You will learn if restoration technologies are ready for implementation and effective only afterward, once the round is over.
The amount of units invested will be deducted from your private endowment only if a restoration action is needed, due to total group extractions exceeding the limit, and if restoration technologies are actually available and ready for implementation.

Treatment T4: Uncertain & High-Cost Restoration



Instructions - PART 1

When each new game starts with the common resource counts **100 units**.

WHAT HAPPENS IN A ROUND?

In every round, everyone in the group gets a private **endowment of 20 units** and can additionally **TAKE OUT any amount between 0 and 20 units** from the resource, to increase own private earnings.

- **If your group takes out more than 50 units:**
  The resource is exhausted and the game **ENDS**
- **If your group takes out between 0 and 50 units:**
  The resource fully regenerates and the game can **CONTINUE** to the next round

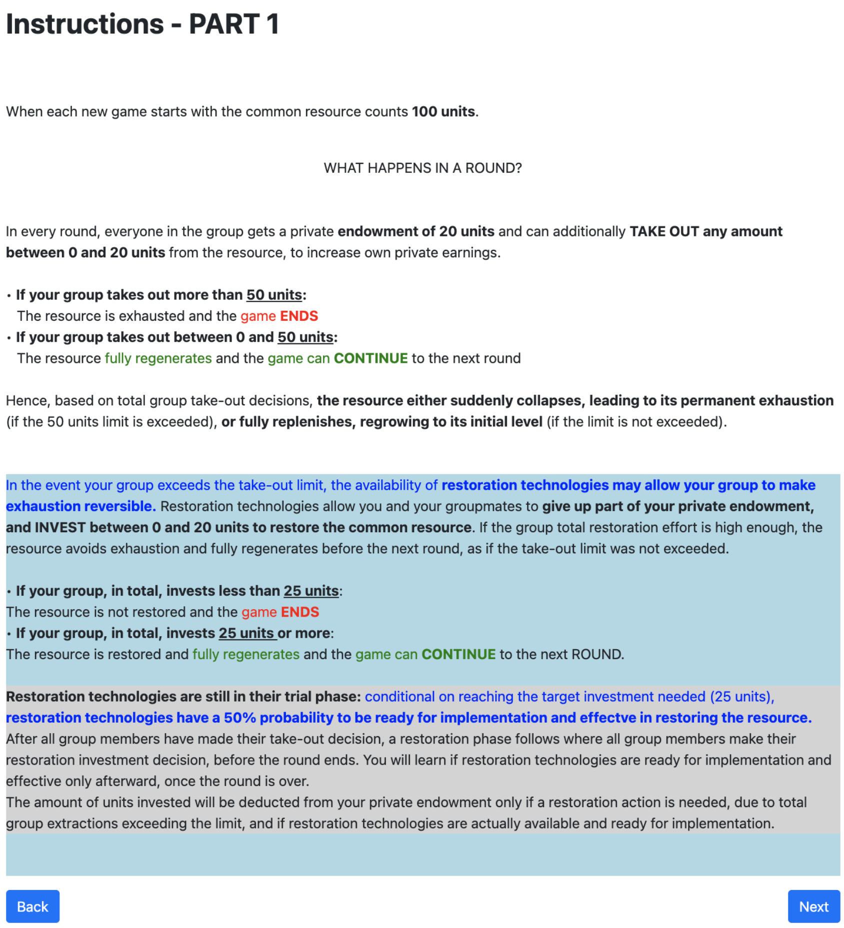
Hence, based on total group take-out decisions, **the resource either suddenly collapses, leading to its permanent exhaustion** (if the 50 units limit is exceeded), **or fully replenishes, regrowing to its initial level** (if the limit is not exceeded).

In the event your group exceeds the take-out limit, the availability of **restoration technologies may allow your group to make exhaustion reversible.** Restoration technologies allow you and your groupmates to **give up part of your private endowment, and INVEST between 0 and 20 units to restore the common resource**. If the group total restoration effort is high enough, the resource avoids exhaustion and fully regenerates before the next round, as if the take-out limit was not exceeded.

- **If your group, in total, invests less than 25 units**:
The resource is not restored and the game **ENDS**
- **If your group, in total, invests 25 units or more**:
The resource is restored and fully regenerates and the game can **CONTINUE** to the next ROUND.

Restoration technologies are still in their trial phase: conditional on reaching the target investment needed (25 units), **restoration technologies have a 50% probability to be ready for implementation and effectve in restoring the resource.**
After all group members have made their take-out decision, a restoration phase follows where all group members make their restoration investment decision, before the round ends. You will learn if restoration technologies are ready for implementation and effective only afterward, once the round is over.
The amount of units invested will be deducted from your private endowment only if a restoration action is needed, due to total group extractions exceeding the limit, and if restoration technologies are actually available and ready for implementation.

Treatment T5: Certain & High-Cost Restoration



Instructions - PART 1

When each new game starts with the common resource counts **100 units**.

WHAT HAPPENS IN A ROUND?

In every round, everyone in the group gets a private **endowment of 20 units** and can additionally **TAKE OUT any amount between 0 and 20 units** from the resource, to increase own private earnings.

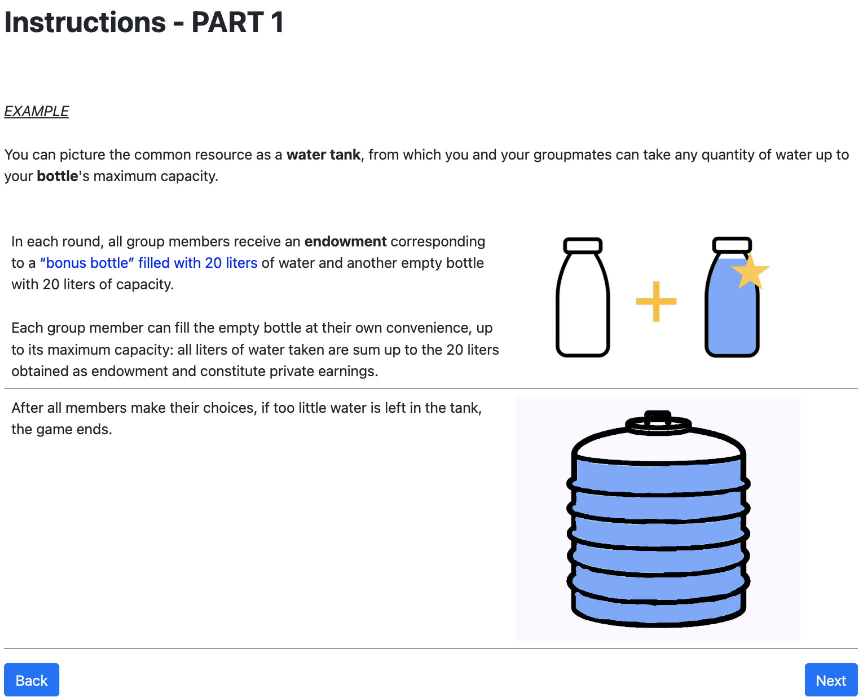
- **If your group takes out more than 50 units:**
  The resource is exhausted and the game **ENDS**
- **If your group takes out between 0 and 50 units:**
  The resource fully regenerates and the game can **CONTINUE** to the next round

Hence, based on total group take-out decisions, **the resource either suddenly collapses, leading to its permanent exhaustion** (if the 50 units limit is exceeded), **or fully replenishes, regrowing to its initial level** (if the limit is not exceeded).

In the event your group exceeds the take-out limit, the availability of **restoration technologies may allow your group to make exhaustion reversible.** Restoration technologies allow you and your groupmates to **give up part of your private endowment, and INVEST between 0 and 20 units to restore the common resource**. If the group total restoration effort is high enough, the resource avoids exhaustion and fully regenerates before the next round, as if the take-out limit was not exceeded.

- **If your group, in total, invests less than 25 units**:
The resource is not restored and the game **ENDS**
- **If your group, in total, invests 25 units or more**:
The resource is restored and fully regenerates and the game can **CONTINUE** to the next ROUND.

Restoration technologies are still in their trial phase: conditional on reaching the target investment needed (25 units), **restoration technologies have a 50% probability to be ready for implementation and effectve in restoring the resource.**
After all group members have made their take-out decision, a restoration phase follows where all group members make their restoration investment decision, before the round ends. You will learn if restoration technologies are ready for implementation and effective only afterward, once the round is over.
The amount of units invested will be deducted from your private endowment only if a restoration action is needed, due to total group extractions exceeding the limit, and if restoration technologies are actually available and ready for implementation.



Instructions - PART 1

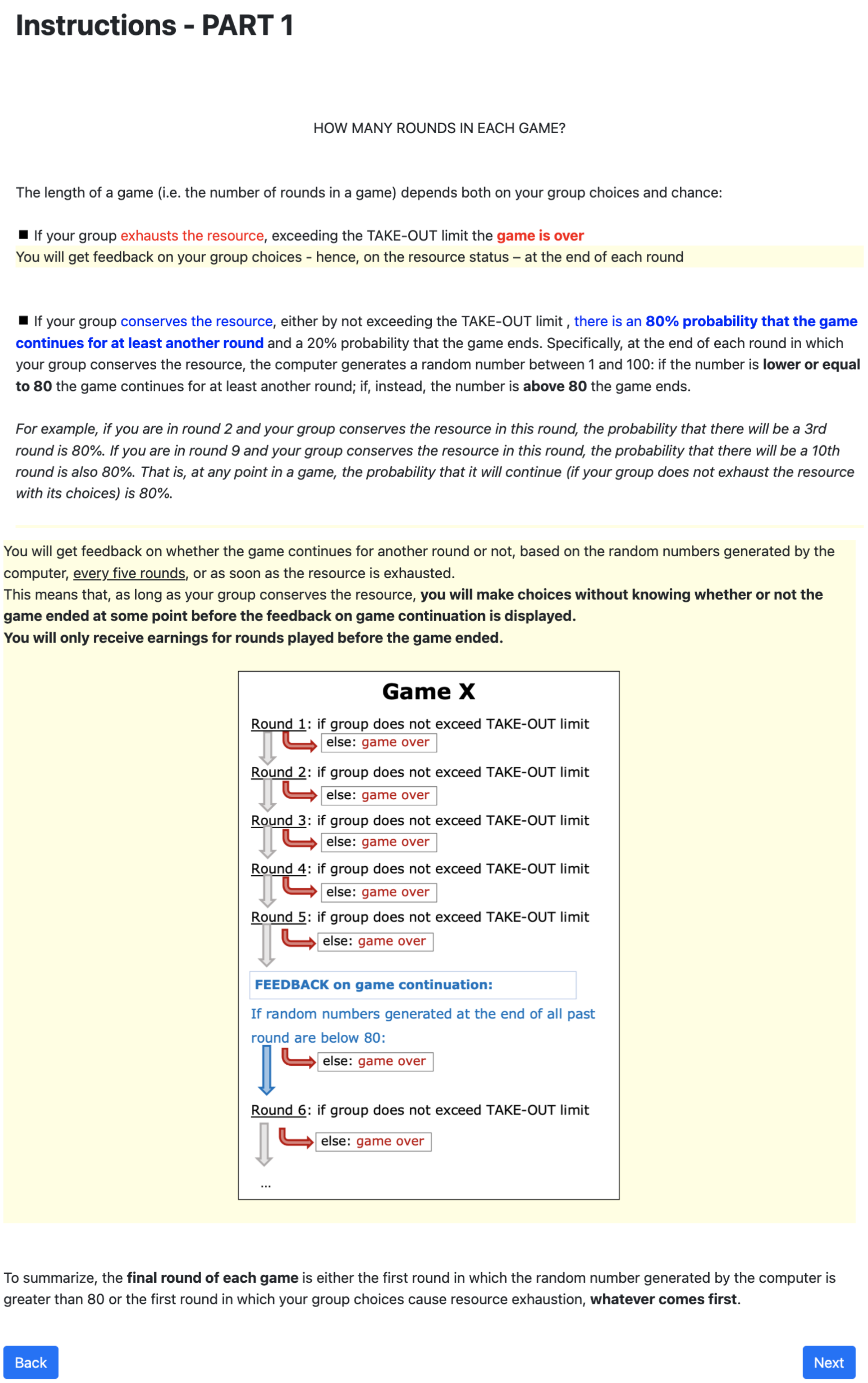
EXAMPLE

You can picture the common resource as a **water tank**, from which you and your groupmates can take any quantity of water up to your **bottle**'s maximum capacity.

In each round, all group members receive an **endowment** corresponding to a "bonus bottle" filled with 20 liters of water and another empty bottle with 20 liters of capacity.

Each group member can fill the empty bottle at their own convenience, up to its maximum capacity: all liters of water taken are sum up to the 20 liters obtained as endowment and constitute private earnings.

After all members make their choices, if too little water is left in the tank, the game ends.



Instructions - PART 1

HOW MANY ROUNDS IN EACH GAME?

The length of a game (i.e. the number of rounds in a game) depends both on your group choices and chance:

- If your group exhausts the resource, exceeding the TAKE-OUT limit the **game is over**

You will get feedback on your group choices - hence, on the resource status – at the end of each round

- If your group conserves the resource, either by not exceeding the TAKE-OUT limit , there is an **80% probability that the game continues for at least another round** and a 20% probability that the game ends. Specifically, at the end of each round in which your group conserves the resource, the computer generates a random number between 1 and 100: if the number is **lower or equal to 80** the game continues for at least another round; if, instead, the number is **above 80** the game ends.

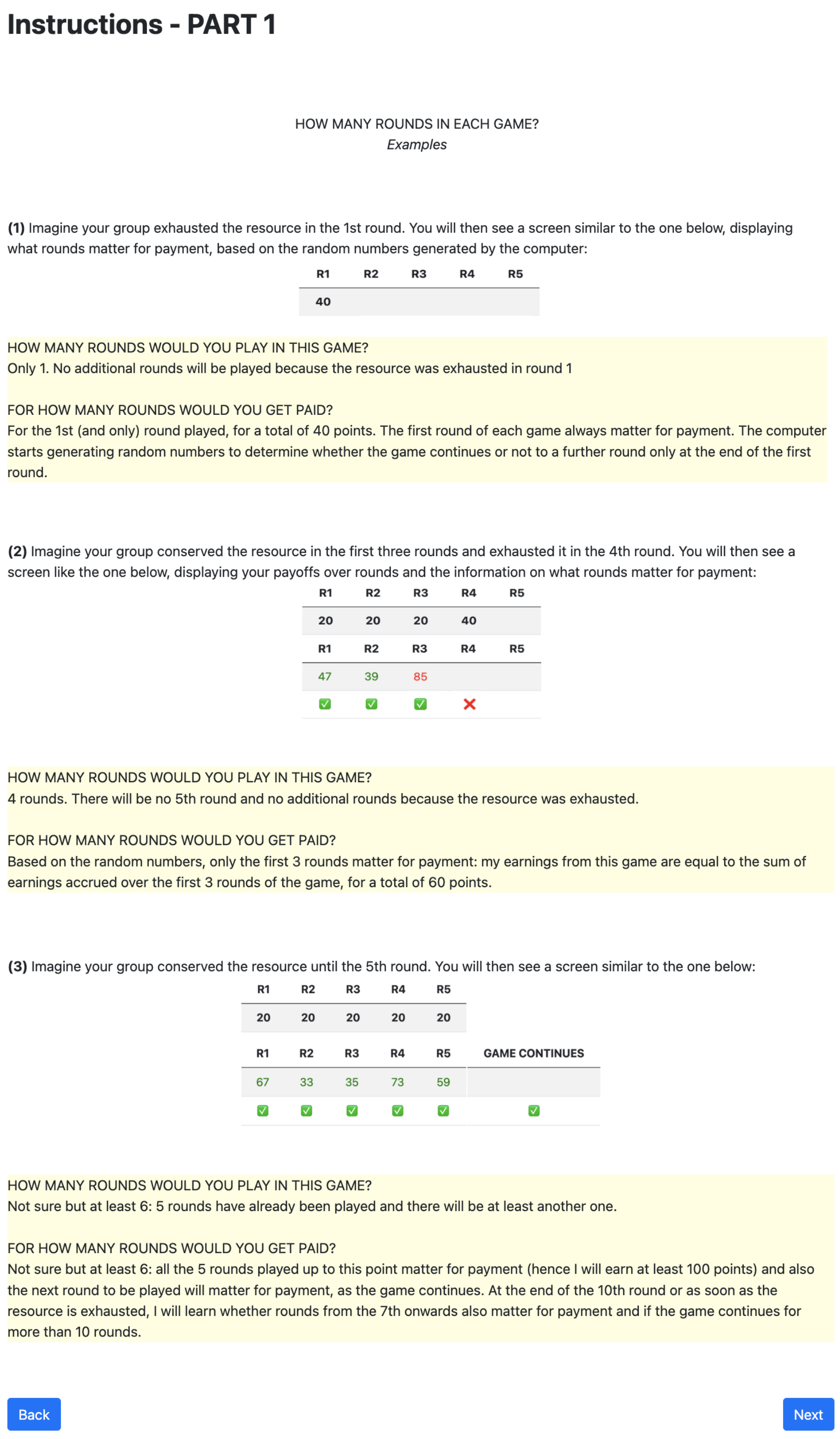
For example, if you are in round 2 and your group conserves the resource in this round, the probability that there will be a 3rd round is 80%. If you are in round 9 and your group conserves the resource in this round, the probability that there will be a 10th round is also 80%. That is, at any point in a game, the probability that it will continue (if your group does not exhaust the resource with its choices) is 80%.

You will get feedback on whether the game continues for another round or not, based on the random numbers generated by the computer, every five rounds, or as soon as the resource is exhausted.
This means that, as long as your group conserves the resource, **you will make choices without knowing whether or not the game ended at some point before the feedback on game continuation is displayed.**
You will only receive earnings for rounds played before the game ended.

Game X

Round 1: if group does not exceed TAKE-OUT limit
else: game over
Round 2: if group does not exceed TAKE-OUT limit
else: game over
Round 3: if group does not exceed TAKE-OUT limit
else: game over
Round 4: if group does not exceed TAKE-OUT limit
else: game over
Round 5: if group does not exceed TAKE-OUT limit
else: game over
FEEDBACK on game continuation:
If random numbers generated at the end of all past round are below 80:
else: game over
Round 6: if group does not exceed TAKE-OUT limit
else: game over
...

To summarize, the **final round of each game** is either the first round in which the random number generated by the computer is greater than 80 or the first round in which your group choices cause resource exhaustion, **whatever comes first**.



Instructions - PART 1

HOW MANY ROUNDS IN EACH GAME?
Examples

(1) Imagine your group exhausted the resource in the 1st round. You will then see a screen similar to the one below, displaying what rounds matter for payment, based on the random numbers generated by the computer:

R1	R2	R3	R4	R5
40				

HOW MANY ROUNDS WOULD YOU PLAY IN THIS GAME?
Only 1. No additional rounds will be played because the resource was exhausted in round 1

FOR HOW MANY ROUNDS WOULD YOU GET PAID?
For the 1st (and only) round played, for a total of 40 points. The first round of each game always matter for payment. The computer starts generating random numbers to determine whether the game continues or not to a further round only at the end of the first round.

(2) Imagine your group conserved the resource in the first three rounds and exhausted it in the 4th round. You will then see a screen like the one below, displaying your payoffs over rounds and the information on what rounds matter for payment:

R1	R2	R3	R4	R5
20	20	20	40	

R1	R2	R3	R4	R5
47	39	85		
✓	✓	✓	✗	

HOW MANY ROUNDS WOULD YOU PLAY IN THIS GAME?
4 rounds. There will be no 5th round and no additional rounds because the resource was exhausted.

FOR HOW MANY ROUNDS WOULD YOU GET PAID?
Based on the random numbers, only the first 3 rounds matter for payment: my earnings from this game are equal to the sum of earnings accrued over the first 3 rounds of the game, for a total of 60 points.

(3) Imagine your group conserved the resource until the 5th round. You will then see a screen similar to the one below:

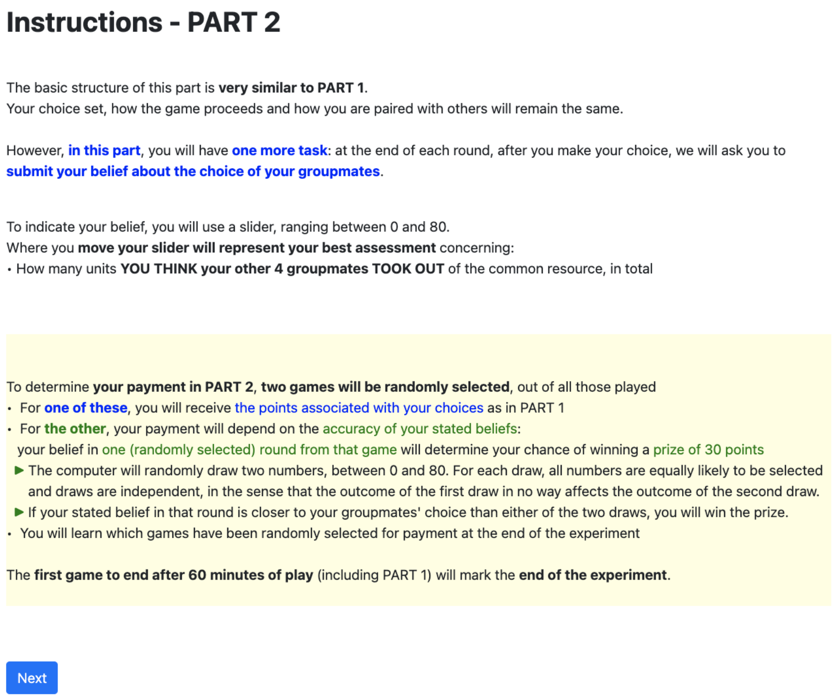
R1	R2	R3	R4	R5
20	20	20	20	20

R1	R2	R3	R4	R5	GAME CONTINUES
67	33	35	73	59	
✓	✓	✓	✓	✓	✓

HOW MANY ROUNDS WOULD YOU PLAY IN THIS GAME?
Not sure but at least 6: 5 rounds have already been played and there will be at least another one.

FOR HOW MANY ROUNDS WOULD YOU GET PAID?
Not sure but at least 6: all the 5 rounds played up to this point matter for payment (hence I will earn at least 100 points) and also the next round to be played will matter for payment, as the game continues. At the end of the 10th round or as soon as the resource is exhausted, I will learn whether rounds from the 7th onwards also matter for payment and if the game continues for more than 10 rounds.

Treatment T1: No Restoration



Instructions - PART 2

The basic structure of this part is **very similar to PART 1**.
Your choice set, how the game proceeds and how you are paired with others will remain the same.

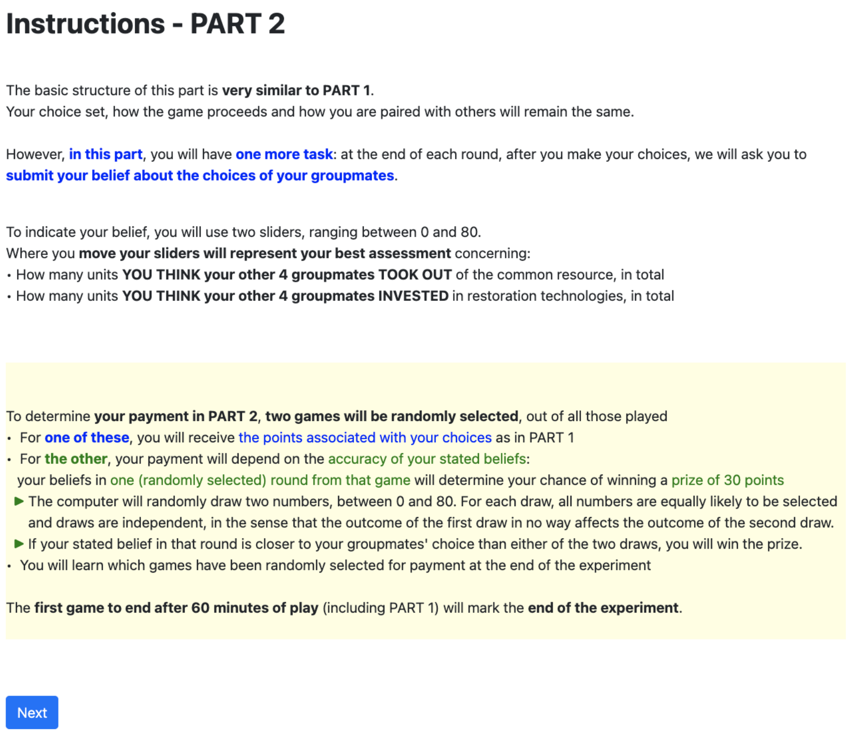
However, **in this part**, you will have **one more task**: at the end of each round, after you make your choice, we will ask you to **submit your belief about the choice of your groupmates**.

To indicate your belief, you will use a slider, ranging between 0 and 80.
Where you **move your slider will represent your best assessment** concerning:
- How many units **YOU THINK your other 4 groupmates TOOK OUT** of the common resource, in total

To determine **your payment in PART 2**, **two games will be randomly selected**, out of all those played
- For **one of these**, you will receive the points associated with your choices as in PART 1
- For **the other**, your payment will depend on the accuracy of your stated beliefs:
  your belief in one (randomly selected) round from that game will determine your chance of winning a prize of 30 points
  - ▶ The computer will randomly draw two numbers, between 0 and 80. For each draw, all numbers are equally likely to be selected and draws are independent, in the sense that the outcome of the first draw in no way affects the outcome of the second draw.
  - ▶ If your stated belief in that round is closer to your groupmates' choice than either of the two draws, you will win the prize.
- You will learn which games have been randomly selected for payment at the end of the experiment

The **first game to end after 60 minutes of play** (including PART 1) will mark the **end of the experiment**.

Treatments with Restoration (T2-T5)



Instructions - PART 2

The basic structure of this part is **very similar to PART 1**.
Your choice set, how the game proceeds and how you are paired with others will remain the same.

However, **in this part**, you will have **one more task**: at the end of each round, after you make your choices, we will ask you to **submit your belief about the choices of your groupmates**.

To indicate your belief, you will use two sliders, ranging between 0 and 80.
Where you **move your sliders will represent your best assessment** concerning:

- How many units **YOU THINK your other 4 groupmates TOOK OUT** of the common resource, in total
- How many units **YOU THINK your other 4 groupmates INVESTED** in restoration technologies, in total

To determine **your payment in PART 2**, **two games will be randomly selected**, out of all those played

- For **one of these**, you will receive the points associated with your choices as in PART 1
- For **the other**, your payment will depend on the accuracy of your stated beliefs:
  your beliefs in one (randomly selected) round from that game will determine your chance of winning a prize of 30 points
  - ▶ The computer will randomly draw two numbers, between 0 and 80. For each draw, all numbers are equally likely to be selected and draws are independent, in the sense that the outcome of the first draw in no way affects the outcome of the second draw.
  - ▶ If your stated belief in that round is closer to your groupmates' choice than either of the two draws, you will win the prize.
- You will learn which games have been randomly selected for payment at the end of the experiment

The **first game to end after 60 minutes of play** (including PART 1) will mark the **end of the experiment**.

C Results - All Supergames

Results reported in this section are based on participants' behavior in Round 1 and Block 1 in all supergames played: results are *qualitatively* unchanged with respect to results reported in the main text, which are based on the restricted sample of observations from "experienced participants", including only Round 1 and Block 1 evidence from supergames 4+[22].

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[22] As for the main analysis, due to some minor and unexpected technical issues, we exclude N=6 groups from the analysis on Block 1 behavior: groups 1,3 from session 3 (T2); group 1 from session 4 (T3); groups 1,2,3 from session 5 (T4).

Table 6: Resource Life & Payoffs (Block 1), Statistical Tests for ATEs

	Pr(Resource Conserved)	Resource Life Length	Round Payoff	Cumulative Payoff
	Group		*Individual*	
T2 - Uncertain / Low	-0.063	-0.486	-0.529***	-15.493*
	(0.051)	(0.312)	(0.143)	(9.266)
T3 - Certain / Low	0.036	0.192	1.380***	12.841
	(0.049)	(0.297)	(0.273)	(8.755)
T4 - Uncertain / High	-0.055	-0.422	-0.736***	-13.282
	(0.071)	(0.435)	(0.156)	(12.524)
T5 - Certain / High	-0.025	-0.067	-1.516***	-6.322
	(0.046)	(0.286)	(0.188)	(8.837)
Constant	0.851***	3.939***	29.900***	116.460***
	(0.046)	(0.263)	(0.084)	(7.906)
Observations	4221	1110	21105	5550
R2-adj		0.019		
R2-overall			0.060	0.038
σ_u	1.253		1.811	15.710
σ_e			3.236	46.996
ρ	0.323		0.238	0.101

Notes. Column 1 reports Average Marginal Effects for the Logit-RE model: an observation is a group in a round of a supergame; Column 2 reports OLS Estimates: an observation is a group in a supergame; Column 3 reports GLS-RE Estimates: an observation is a subject in a round of a supergame; Column 4 reports GLS-RE Estimates: an observation is a subject in a supergame. In each column, the dependent variable is: (1) Dummy variable equal to one if the group manages to conserve the resource, either by not exceeding the extractions limit or by implementing successful restoration actions in each round of Block 1 actually played; (2) Resource life length, corresponding to the number of rounds actually played by each group, out of the first 5; (3) Individual round payoff, in each round of Block 1 actually played; (4) Individual cumulative payoff accrued over all rounds actually played in Block 1. The baseline treatment is T1 - Baseline. Results are based on (round or cumulative) Block 1 evidence, in all supergames. Standard errors clustered at the session level.

Table 7: Analysis of Payoffs Dispersion (Block 1), Statistical Tests for ATEs

	Round Payoff SD	Cumulative Payoff	Cum. Extraction SD	Cum. Restoration^{PR} SD	Cum. Payoff SD
T2 - Uncertain / Low	1.644***	3.942***	3.484***	-4.075***	
	(0.576)	(1.250)	(1.223)	(0.721)	
T3 - Certain / Low	2.063***	8.232***	6.207***		
	(0.405)	(1.305)	(1.080)		
T4 - Uncertain / High	1.070*	1.648**	0.520	-3.643***	
	(0.636)	(0.782)	(0.680)	(0.758)	
T5 - Certain / High	1.630***	4.306***	1.928**	-1.575**	
	(0.365)	(0.757)	(0.882)	(0.741)	
Cum. Extraction SD					0.888***
					(0.024)
Cum. Restoration^{PR} SD					0.593***
					(0.081)
Constant	1.239***	3.173***	3.173***	5.373***	0.396
	(0.289)	(0.568)	(0.568)	(0.661)	(0.253)
Observations	4221	1110	1110	798	798
R2-adj (overall)	(0.103)	0.181	0.144	0.165	0.896

Notes. SD: Standard Deviation - *Within-Group.* Column 1 reports GLS-RE Estimates: an observation is a group in a round of a supergame; Columns 2-5 report OLS Estimates: an observation is a group in a supergame. In each column, the dependent variable is: Dispersion, measured through within-group standard deviation, in (1) Round Payoffs in Block 1; (2,5) Cumulative Payoffs in Block 1; (3) Cumulative Extraction choices in Block 1; (4) Cumulative Payoff-Relevant Restoration choices in Block 1: restoration choices are payoff-relevant only if restoration is needed, because the extraction threshold is exceeded, and available - and otherwise valued as zero. Results are based on cumulative Block 1 evidence from all supergames. Standard errors clustered at the session level.

D Early vs. Late supergames

In this section, we formally compare participants' Round 1 extraction and restoration behavior in early (1 to 3) vs. late supergames. We show results for two different definitions of "late" supergames: (i) all supergames from the 4^{th} onwards; (ii) supergames 4-to-6, which allows for a more balanced subsamples' comparison. Within treatment, net of learning effects that exacerbate treatment effects over time, participants' Round 1 behavior does not differ substantially between early and late supergames.

Table 8: Extraction & Restoration Choices, Round 1: ATEs in Early vs. Late Supergames

	Extraction		Restoration	
	Late: 4+	*Late: 4-6*	*Late: 4+*	*Late: 4-6*
T2 - Uncertain / Low	0.364	0.364	-0.161	-0.161
	(0.288)	(0.288)	(0.319)	(0.319)
T3 - Certain / Low	1.550***	1.550***		
	(0.459)	(0.459)		
T4 - Uncertain / High	0.039	0.039	5.128***	5.128***
	(0.360)	(0.361)	(0.714)	(0.714)
T5 - Certain / High	0.053	0.053	4.286***	4.286***
	(0.283)	(0.283)	(0.685)	(0.685)
I_{LATE}	0.621***	0.522**	0.099	0.219
	(0.217)	(0.217)	(0.183)	(0.182)
$T2 \cdot I_{LATE}$	-0.137	0.069	-0.433	-0.203
	(0.316)	(0.371)	(0.276)	(0.265)
$T3 \cdot I_{LATE}$	6.039***	5.492***		
	(0.538)	(0.551)		
$T4 \cdot I_{LATE}$	0.154	0.072	-1.064**	-0.817**
	(0.278)	(0.262)	(0.430)	(0.326)
$T5 \cdot I_{LATE}$	-0.312	-0.203	-0.831*	-0.750*
	(0.306)	(0.303)	(0.460)	(0.407)
Constant	9.242***	9.242***	5.728***	5.728***
	(0.214)	(0.214)	(0.244)	(0.244)
Observations	5580	3600	4020	2880
R2-overall	0.376	0.309	0.141	0.150
σ_u	1.923	1.975	4.149	4.141
σ_e	2.381	2.582	3.482	3.428
ρ	0.395	0.369	0.587	0.593

Notes. GLS-RE estimates: an observation is a subject in a supergame. In each column, the dependent variable is: (1-2) Individual extraction choice; (3-4) Individual restoration choice. The baseline treatment in columns 1 and 2 is T1 - Baseline. The baseline treatment in columns 3 and 4 is T3 - Certain / Low. I_{LATE} is a dummy variable equal to one for supergames 4+. Results are based on Round 1 behavior in all supergames (columns 1 and 3) and in supergames 4-6 only (columns 2 and 4). Standard errors clustered at the session level.

E Results - All Rounds & All Supergames

Results reported in this section are based on participants' behavior in all rounds of all supergames played: results are *qualitatively* unchanged with respect to results reported in the main text, which are based on the restricted sample of observations from "experienced participants", including only Round 1 or Block 1 choices taken in supergames 4+[23].

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[23] As for the main analysis, due to some minor and unexpected technical issues, we exclude N=8 groups from the analysis on Block 1 behavior: groups 1,3 from session 3 (T2); group 1 from session 4 (T3); groups 1,2,3 from session 5 (T4); and groups 1,4 from session 1 (T1), who experienced the glitch while playing rounds belonging to Block 2.

Table 9: Resource Life & Payoffs (All Rounds), Statistical Tests for ATEs

	Pr(Resource Conserved)	Resource Life Length	Round Payoff	Cumulative Payoff
	Group		*Individual*	
T2 - Uncertain / Low	-0.057	-0.597	-0.537***	-19.520
	(0.053)	(0.535)	(0.146)	(16.109)
T3 - Certain / Low	0.033	0.270	1.588***	17.501
	(0.048)	(0.551)	(0.296)	(16.634)
T4 - Uncertain / High	-0.043	-0.404	-0.709***	-13.311
	(0.069)	(0.641)	(0.182)	(19.023)
T5 - Certain / High	-0.021	-0.164	-1.487***	-9.632
	(0.046)	(0.479)	(0.177)	(14.739)
Constant	0.849***	4.648***	29.937***	137.971***
	(0.045)	(0.420)	(0.091)	(12.946)
Observations	4990	1108	24950	5540
R2-adj		0.005		
R2-overall			0.067	0.016
σ_u	1.187		1.816	23.269
σ_e			3.150	91.161
ρ	0.300		0.249	0.061

Notes. Columns 1 reports Average Marginal Effects for the Logit-RE model: an observation is a group in a round of a supergame; Columns 2 reports OLS Estimates: an observation is a group in a supergame; Columns 3 reports GLS-RE Estimates: an observation is a subject in a round of a supergame; Columns 4 reports GLS-RE Estimates: an observation is a subject in a supergame. In each column, the dependent variable is: (1) Dummy variable equal to one if the group manages to conserve the resource, either by not exceeding the extractions limit or by implementing successful restoration actions in each round of Block 1 actually played; (2) Resource life length, corresponding to the number of rounds actually played by each group, out of the first 5; (3) Individual round payoff, in each round of Block 1 actually played; (4) Individual cumulative payoff accrued over all rounds actually played in Block 1. The baseline treatment is T1 - Baseline. Results are based on (round or cumulative) Block 1 evidence in all rounds of all supergames. Standard errors clustered at the session level.

Table 10: Analysis of Payoffs Dispersion (All Rounds), Statistical Tests for ATEs

	Round Payoff SD	Cumulative Payoff	Cum. Extraction SD	Cum. Restoration^{PR} SD	Cum. Payoff SD
T2 - Uncertain / Low	1.625***	4.249***	3.709***	-4.383***	
	(0.574)	(1.252)	(1.220)	(0.865)	
T3 - Certain / Low	1.975***	8.814***	6.509***		
	(0.409)	(1.641)	(1.419)		
T4 - Uncertain / High	1.055*	1.594**	0.376	-4.002***	
	(0.639)	(0.755)	(0.664)	(0.901)	
T5 - Certain / High	1.649***	4.635***	2.078*	-1.657*	
	(0.364)	(0.843)	(1.032)	(0.877)	
Cum. Extraction SD					0.909***
					(0.015)
Cum. Restoration^{PR} SD					0.601***
					(0.066)
Constant	1.264***	3.579***	3.579***	5.833***	0.284*
	(0.293)	(0.543)	(0.543)	(0.819)	(0.139)
Observations	4990	1108	1108	798	798
R2-adj (overall)	(0.091)	0.148	0.110	0.174	0.920

Notes. SD: Standard Deviation - *Within-Group*. Columns 1 reports GLS-RE Estimates: an observation is a group in a round of a supergame; Columns 2-5 report OLS Estimates: an observation is a group in a supergame. In each column, the dependent variable is the dispersion, measured through within-group standard deviation, in: (1) Round Payoffs in Block 1; (2,5) Cumulative Payoffs in Block 1; (3) Cumulative Extraction choices in Block 1; (4) Cumulative Payoff-Relevant Restoration choices in Block 1: restoration choices are payoff-relevant only if restoration is needed, because the extraction threshold is exceeded, and available - and otherwise valued as zero. Results are based on cumulative evidence at the supergame level from all supergames. Standard errors clustered at the session level.

F Before vs. After Beliefs elicitation

In this section, we formally compare participants' Round 1 extraction and restoration behavior in supergames before and after beliefs' elicitation. We show results for two different definitions of these two subsamples: (i) Supergames 1-to-6 vs. Supergames 7+ (ii) Supergames 5-6 vs. Supergames 7-8, which allows for a more balanced subsamples' comparison. Within treatment, net of learning effects, participants' Round 1 behavior does not markedly differ before and after.

Table 11: Before vs. After Beliefs' Elicitation - Round 1 choices, Statistical tests for ATEs

	Extraction		Restoration	
	1-6 vs. 7+	*5-6 vs. 7-8*	*1-6 vs. 7+*	*5-6 vs. 7-8*
T2 - Uncertain / Low	0.399*	0.429	-0.262	-0.263
	(0.206)	(0.346)	(0.286)	(0.342)
T3 - Certain / Low	4.296***	7.721***		
	(0.566)	(0.671)		
T4 - Uncertain / High	0.075	0.062	4.719***	4.121***
	(0.313)	(0.327)	(0.767)	(0.897)
T5 - Certain / High	-0.049	-0.138	3.911***	3.392***
	(0.160)	(0.176)	(0.678)	(0.729)
I_{AFTER}	0.405**	-0.025	-0.244**	-0.306***
	(0.196)	(0.131)	(0.120)	(0.118)
$T2 \cdot I_{AFTER}$	-0.334	-0.309	-0.487*	-0.328
	(0.219)	(0.271)	(0.257)	(0.224)
$T3 \cdot I_{AFTER}$	4.497***	0.853**		
	(0.640)	(0.427)		
$T4 \cdot I_{AFTER}$	0.286	0.217	-0.844*	0.023
	(0.274)	(0.162)	(0.445)	(0.293)
$T5 \cdot I_{AFTER}$	-0.270	-0.148	-0.517	0.342
	(0.233)	(0.156)	(0.667)	(0.482)
Constant	9.503***	9.833***	5.837***	5.938***
	(0.129)	(0.137)	(0.159)	(0.093)
Observations	5580	2240	4020	1760
R2-overall	0.299	0.546	0.142	0.117
σ_u	1.886	2.367	4.149	4.822
σ_e	2.631	1.707	3.477	2.867
ρ	0.339	0.658	0.587	0.739

Notes. GLS-RE Estimates: an observation is a subject in a round. In each column, the dependent variable is: (1)-(2) Extraction choices at the individual level; (3)-(4) Round 1 Restoration choices at the individual level. I_{AFTER} is a dummy variable equal to one if the observation is collected starting from the 7^{th} supergame onwards. Standard errors clustered at the session level.

G Additional Tables

Descriptive Statistics: Number of supergames played

Table 12: Number of Supergames played within a Session, Summary Statistics

	Observations	Mean	Std. Dev.	Min	Max
T1 - Baseline	6	13	2.97	10	18
T2 - Uncertain / Low	6	9	1.67	6	11
T3 - Certain / Low	6	7.67	1.21	7	10
T4 - Uncertain / High	6	8.67	0.82	8	10
T5 - Certain / High	6	8.17	1.17	7	10

Notes. An observation is a session: each session counts 20 participants and includes 60 minutes of play. The number of supergames played within a session statistically differs from the T1 - Baseline in all treatments with Restoration. Non-parametric Wilcoxon (Mann–Whitney) test statistics (exact p-values): *T1 vs. T2* z-stat = 2.441 (0.0130); *T1 vs. T3* z-stat = 2.797 (0.0065); *T1 vs. T4* z-stat = 2.771 (0.0065); *T1 vs. T5* z-stat = 2.756 (0.0065). Non-parametric Kruskal-Wallis test: including all treatments χ^2 = 15.026 (0.0046); excluding T1 - Baseline χ^2 = 4.337 (0.2273).

Descriptive Statistics: Comprehension Questions

Table 13: Share of correctly answered Comprehension Questions, Summary Statistics

	a. First attempt				
	Observations	Mean	Std. Dev.	Min	Max
T1 - Baseline	120	2.54	0.62	1	3
T2 - Uncertain / Low	120	2.02	0.88	0	3
T3 - Certain / Low	120	2.28	0.83	0	3
T4 - Uncertain / High	120	2.11	0.85	0	3
T5 - Certain / High	120	2.3	0.84	0	3
	b. Second attempt				
	Observations	Mean	Std. Dev.	Min	Max
T1 - Baseline	47	2.79	0.46	1	3
T2 - Uncertain / Low	80	2.6	0.57	1	3
T3 - Certain / Low	62	2.69	0.56	1	3
T4 - Uncertain / High	73	2.58	0.58	1	3
T5 - Certain / High	58	2.67	0.54	1	3

Notes. An observation is a subject. In all treatment conditions, subjects must answer three comprehension questions: the questions are always the same, and the correct answers to the latter are treatment-specific. Subjects have two attempts to answer the questions before moving to the game stage: *Panel a* shows the share of correctly answered questions after subjects' first attempt; *Panel b* shows the share of correctly answered questions for subjects who engage in the second attempt, after failing to answer all questions correctly in the first attempt. The share of correctly answered questions is statistically different from the Baseline in all treatments with Restoration at the end of the first attempt: in all treatments with restoration, the share of correctly answered questions is lower and this difference is stronger if the availability of restoration technologies is uncertain (irrespective of restoration costs). Non-parametric Kruskal-Wallis equality-of-populations rank test statistic (p-value): 28.113 (0.001). Mann-Whitney-Wilcoxon test statistics on equality of medians (p-values): *T1 vs. T2* z-stat = 4.891 (0.000); *T1 vs. T3* z-stat = 2.330 (0.0198); *T1 vs. T4* z-stat = 4.092 (0.000); *T1 vs. T5* z-stat = 2.050 (0.0404). The share of correctly answered questions for subjects who engage in the second attempt is not statistically different across treatments. Non-parametric Kruskal-Wallis equality-of-populations rank test statistic (p-value): 6.438 (0.1688).

Additional Results

Table 14: Extraction & Restoration Choices (Round 1), Statistical Tests for ATEs

	Extraction Choice	Pr(Excessive Group Extraction)	Restoration Choice	Pr(Sufficient Group Restoration)
T2 - Uncertain / Low	0.209	0.200**	-0.564*	-0.226**
	(0.185)	(0.082)	(0.305)	(0.091)
T3 - Certain / Low	7.544***	0.807***		
	(0.612)	(0.054)		
T4 - Uncertain / High	0.194	0.112	4.088***	-0.757***
	(0.383)	(0.123)	(0.953)	(0.057)
T5 - Certain / High	-0.274**	-0.030	3.463***	-0.790***
	(0.138)	(0.063)	(0.653)	(0.030)
Constant	9.857***	0.175***	5.828***	0.830***
	(0.098)	(0.051)	(0.079)	(0.026)
Observations	3780	756	2580	516

Notes. Columns 1 and 3 report GLS-RE estimates: an observation is a subject in a supergame. Columns 2 and 4 report Average Marginal Effects for Logit models: an observation is a group in a supergame. In each column, the dependent variable is: (1) Individual extraction choice; (2) Dummy equal to one if the group extraction threshold is exceeded; (3) Individual restoration choice; (4) Dummy equal to one if the group effort is sufficient for restoration irrespective of whether restoration is needed and/or available. The baseline treatment in columns 1 and 2 is T1. The baseline treatment in columns 3 and 4 is T3. Standard errors clustered at the session level.

Dispersion Analysis using Gini indicators

In this section, we replicate the same analysis on (Block 1) Round and Cumulative Payoffs dispersion, displayed in Table 4, using the Gini indicator as a measure of dispersion, rather than the standard deviation. Results on the differences across treatments and on the relative importance of the dispersion in cumulative extraction and restoration to explain dispersion in cumulative payoffs are mostly unchanged.

Table 15: Summary Statistics on Resource Restoration, Round 1

		Restoration Effort Sufficient $\sum r_i \geq T_R$			Restoration Successful $\sum r_i \geq T_R$ & Restoration available
		Overall	*ELE=0*	*ELE=1*	
T2 - Uncertain / Low	%	60.42	63.3	55.56	37
	N	144	90	54	54
T3 - Certain / Low	%	83	100	82.73	82.73
	N	112	2	110	110
T4 - Uncertain / High	%	7.35	7	7.69	5
	N	136	97	39	39
T5 - Certain / High	%	4	3.77	5.55	5.55
	N	124	106	18	18

Notes. An observation is a group in the first round of a supergame. The restoration effort is sufficient if group restoration efforts are equal to or greater than the treatment-specific threshold ($\sum r_i \geq T_R$). ELE=0 is the subsample of observations in which the extraction limit is not exceeded; hence, there is no need for restoration (because total group extraction was below the threshold, $\sum e_i \leq T_E$), while ELE=1 is the subsample of observations in which extraction limit is exceeded in the first stage, hence restoration is needed (because group extraction was above the threshold). Restoration is successful if restoration efforts meet the threshold when needed (ELE=1) and the technology is available.

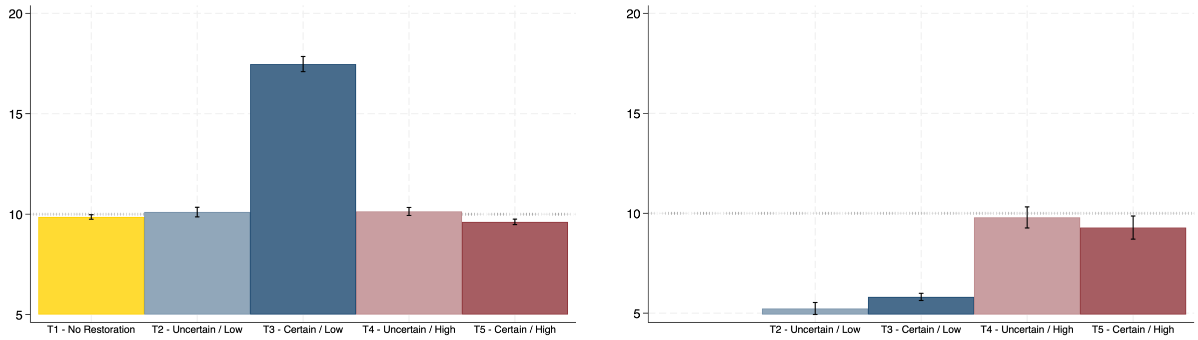
Table 16: Analysis of Payoffs Dispersion (Block 1), Statistical Tests for ATEs

	Round Payoff *Gini*	Cumulative Payoff *Gini*	Cum. Extraction *Gini*	Cum. Restoration^{PR} *Gini*	Cum. Payoff *Gini*
T2 - Uncertain / Low	0.027***	0.024***	0.053**	-0.017	
	(0.010)	(0.009)	(0.024)	(0.025)	
T3 - Certain / Low	0.031***	0.027***	0.019		
	(0.006)	(0.006)	(0.013)		
T4 - Uncertain / High	0.027*	0.033*	0.016	-0.023	
	(0.016)	(0.019)	(0.022)	(0.042)	
T5 - Certain / High	0.037***	0.036***	0.019	0.123***	
	(0.008)	(0.009)	(0.015)	(0.041)	
Cum. Extraction *Gini*					0.392***
					(0.054)
Cum. Restoration^{PR} *Gini*					0.093***
					(0.018)
Constant	0.015***	0.014***	0.042***	0.135***	0.003
	(0.004)	(0.004)	(0.011)	(0.015)	(0.003)
Observations	2867	750	750	510	510
R2-adj (overall)	(0.081)	0.096	0.078	0.073	0.486

Notes. Gini: Gini indicator - *Within-Group*. Column 1 reports GLS-RE Estimates: an observation is a group in a round of a supergame; Columns 2-5 report OLS Estimates: an observation is a group in a supergame. In each column, the dependent variable is: Dispersion, measured through within-group standard deviation, in (1) Round Payoffs in Block 1; (2,5) Cumulative Payoffs in Block 1; (3) Cumulative Extraction choices in Block 1; (4) Cumulative Payoff-Relevant Restoration choices in Block 1: restoration choices are payoff-relevant only if restoration is needed, because the extraction threshold is exceeded, and available - and otherwise valued as zero. Results are based on cumulative Block 1 evidence, from supergames 4+ (experienced subjects). Standard errors clustered at the session level.

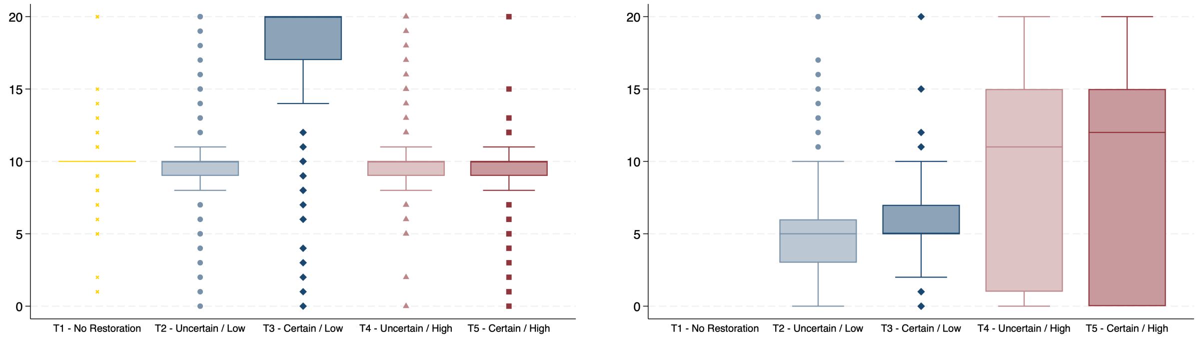
H Additional Figures

Figure 7: Mean Individual Extraction and Restoration Choices, Round 1



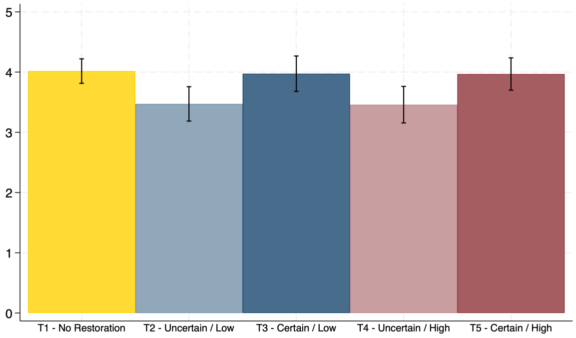
Notes: Whiskers denote 95% confidence intervals. *Left panel*: Extraction choices: Mann-Whitney-Wilcoxon test statistics on equality of medians (p-values): *T1 vs. T2* z-stat$=-1.358$ (0.175); *T1 vs. T3* z-stat$=-27.675$ (0.000); *T1 vs. T4* z-stat$=1.059$ (0.290); *T1 vs. T5* z-stat$=1.589$ (0.112). Kolgomorov-Smirnov test statistics on equality of distributions (p-values): *T1 vs. T2* D=0.0892 (0.002); *T1 vs. T3* D=0.7614 (0.000); *T1 vs. T4* D=0.0451(0.339); *T1 vs. T5* D=0.0549 (0.169). *Right panel*: Restoration choices: Mann-Whitney-Wilcoxon test statistics on equality of medians (p-values): *T3 vs. T2* z-stat$=-6.404$ (0.000); *T3 vs. T4* z-stat$=-10.299$ (0.000); *T3 vs. T5* z-stat$=-7.493$ (0.000). Kolgomorov-Smirnov test statistics on equality of distributions (p-values): *T3 vs. T2* D=0.1837 (0.000); *T3 vs. T4* D=0.5387 (0.000); *T3 vs. T5* D=0.5212 (0.000).

Figure 8: Box Plots of Individual Extraction and Restoration Choices, Round 1



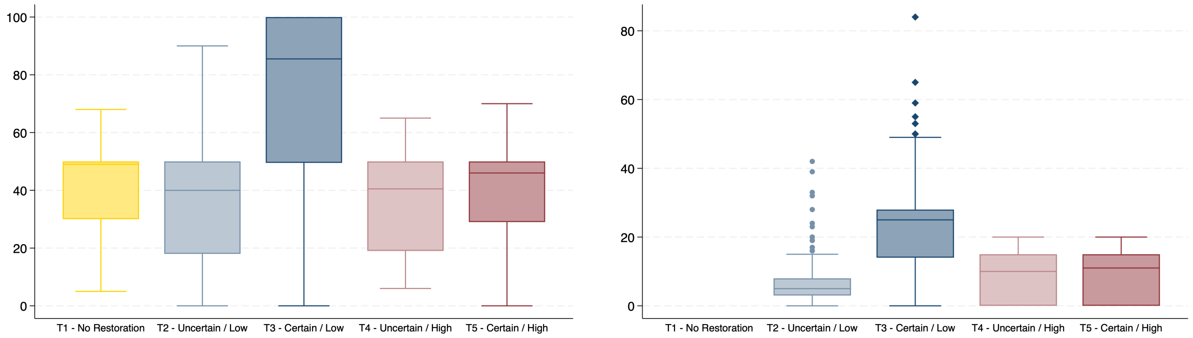
Notes: The left-hand panel shows data for extraction choices; the right-hand panel for restoration choices.

Figure 9: Resource Life Length: Block 1 (Rounds 1-5)



Notes. Whiskers denote 95% confidence intervals. Mann-Whitney-Wilcoxon test statistics on equality of medians (p-values): *T1 vs. T2* z-stat=3.506 (0.0005); *T1 vs. T3* z-stat=0.712 (0.4765); *T1 vs. T4* z-stat=2.206 (0.0274); *T1 vs. T5* z-stat=3.278 (0.001). Kolgomorov-Smirnov test statistics on equality of distributions (p-values): *T1 vs. T2* D=0.2029 (0.001); *T1 vs. T3* D=0.0562 (0.970); *T1 vs. T4* D=0.1770 (0.009); *T1 vs. T5* D= 0.0668 (0.859).

Figure 10: Box Plots of Cumulative Extraction and Restoration Choices in Block 1



Notes. The left-hand side panel shows cumulative individual extractions in Rounds 1-5. The right-hand panel shows cumulative payoff-relevant individual restoration actions in Block 1. Restoration actions are payoff-relevant if the extraction limit is exceeded and restoration technologies are available.