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Abstract

Common pool resources (CPRs) are usually exploited one generation after another – often overexploited - meaning there is an intergenerational link between the consumers – e.g., water for farming activities. This key dimension is often not considered in theoretical or field experiments, due to the difficultly in approaching it. We want to overcome this barrier introducing the hypothesis of ''intergenerational altruism'' for CPRs. The implication is that altruism reduce the exploitation of the natural resources, since the agents recognize that the exploitation not only creates negative externalities for their own generation, but also for all future generations. An alternative hypothesis is the ''intergenerational equity'' where the agents restrain their consumption to equalize their income over time. To prove these hypotheses, we conducted a field experiment in four farming communities located in the Bolivian Department of Chuquisaca during the third quarter of 2019. We consider common water for farming activities as a CPRs, since these communities use this resource for several decades, the intergenerational link is evident. Our intergenerational field experiment includes four treatments based on the replacement rate of the resources – i.e., FAST, SLOW, RESTART or normal replacement, under one-shot non-cooperative game without feedback. We also introduce two variations, the possibility to accumulate water in a dam, which modify the availability of CPRs. Second, the possibility to manage the common farming water through the traditional social arrangement of the Water Judge, which is a representative member of the community delegated to solve problems related with water management, named SAT treatment. The results showed that our hypothesis was not probed since the intergenerational link does not mitigate the overexploitation of CPRs. Nevertheless, we also found that the "Water Judge" could be a cost-effective treatment in small farming communities.

JEL Classification : C72; C92; D62; Q20.
Keywords: Common pool resources, intergenerational altruism and equity, free riders.

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Resumen

Los bienes de uso común (CPRs) generalmente se explotan una generación tras otra – suelen ser sobre explotados - lo que significa que existe un enlace intergeneracional entre los consumidores – e.g. agua para usos agrícolas. La dimensión Inter temporal a menudo no es tomada en cuenta en los experimentos teóricos y de campo, debido a su compleja aproximación metodológica. Queremos superar esta barrera introduciendo la hipótesis de "altruismo intergeneracional", la cual implica que la explotación de un recurso de uso común disminuye, debido a que los agentes reconocen que la extracción del este recurso no solo crea externalidades negativas para su propia generación, sino también para aquellas futuras. Una hipótesis alternativa es la "equidad intergeneracional" donde los agentes restringen su consumo para suavizar sus ingresos a lo largo del tiempo. Para comprobar estas hipótesis, realizamos un experimento de campo en cuatro comunidades agrícolas ubicadas en el departamento boliviano de Chuquisaca durante el tercer trimestre de 2019. Consideramos el agua para usos agrícolas como un CPRs, dado que estas comunidades utilizan este recurso durante varias décadas el vínculo intergeneracional es evidente. Nuestro experimento de campo intergeneracional incluye cuatro tratamientos basados en la tasa de reposición del recurso – i.e., RÁPIDO, LENTO, REINICIO o reposición normal; en un juego no cooperativo de una sola vez sin retroalimentación. También introducimos dos variaciones, la posibilidad de acumular agua en una represa, modificando la disponibilidad de CPRs. En segundo lugar, la posibilidad de gestionar el agua a través de un arreglo social tradicional denominado Juez del Agua, que es un miembro representante de la comunidad delegado para resolver problemas relacionados con la gestión de este recurso, denominado tratamiento SAT. Los resultados muestran que la hipótesis no pudo probarse, dado que el vínculo intergeneracional no mitiga la sobreexplotación de los CPRs. No obstante, también descubrimos que el "Juez del agua" podría ser un tratamiento costo-efectivo en pequeñas comunidades agrícolas.

Clasificación JEL: C72; C92; D62; Q20.
Palabras clave: Recursos de uso común, altruismo y equidad intergeneracional; conducta de polizón.

1. Introduction

A common-pool resource (CPRs) is a good whose size or characteristics makes it costly, but not impossible to exclude potential beneficiaries from obtaining benefits from its use – e.g., an irrigation system. Gordon (1954) argues that CPRs exploitation leads to the "Tragedy of the Commons", which implies that human behavior is driven by the maximization of individual payoffs and not by social preferences, as a result of which the overexploitation of resources "occurs". Later, Ostrom (1992) said that subjects try to find a cooperative management of CPRs leading to cost-effective solutions.

On the one hand, the CPRs field experiments have shown that the resource is usually overexploited due to strong free-rider behavior and the exclusion of users is extremely costly. On the other hand, the lab experiments support the likelihood of cost-effective self-governance solutions for CPRs overexploitation, as Ostrom, (1999) highly remark. Lastly, the CPRs is a type of good usually exploited one generation after another, so there is an intergenerational link between them – this key characteristic is often ignored for simplicity – as evidence suggest, experiments with intergenerational CPRs mechanisms does not mitigate the overexploitation across distant generations of users.

Our two research questions are: i) How can the appropriators contribute to the sustainability of an intergenerational CPRs? When agents recognize that the resource extraction not only creates negative externalities for their own generation, but also for all future generations, and as a result decide to reduce their exploitation, they show "intergenerational altruism"; and ii) What happened when subjects increase their social preferences for the next generation? For example, trying to equalize their income, this behavior is known in the literature as intergenerational equity.

To prove these hypotheses, we conducted a field experiment in four farming communities located in the Bolivian Department of Chuquisaca during the third quarter of 2019. We consider common water for farming activities as a CPRs, since these communities use this resource for several decades, the intergenerational link is evident. Our intergenerational field experiment includes four treatments based on the replacement rate of the resources – i.e., FAST, SLOW, RESTART or normal replacement, under one-shot non-cooperative game without feedback. We also introduce two variations, the possibility to accumulate water in a dam, which modify the availability of CPRs. Second, the possibility to manage the common farming water through the traditional social arrangement of the Water Judge, which is a representative member of the community delegated to solve problems related with water management, named SAT treatment.

The hypothesis of the exploitation constraint was not realistic as regards to intergenerational altruism, though we did find evidence that intergenerational links affect subjects' expectations concerning the behavior of their peers. The players expect their peers to face up to the intergenerational responsibility, but they do not reduce their own exploitation levels. Effective exploitation reduction is lower than we expected. In all the treatments the exploitation effort was higher than social equilibrium, and slightly lower than the Nash equilibrium. As a result, we considered all the players as free riders, with low expectations of others' altruistic behavior. Conversely, they seek to equalize their income over time

In the case of the SAT treatment the players seek to achieve a weak intertemporal equity, since they assume costly action to equalize their income over time by restraining their consumption compared with the Nash equilibrium. This treatment does not increase consensus related to other treatments but does reduce the uncertainty of others' behavior. When everything is fine there is a decrease in selfish attitudes, but not in other contexts. Anyway, the Water Judge is a powerful social arrangement, but weak in mitigating the overexploitation of intergenerational CPRs.

The paper is organized as follows: In the second section, we presented the related literature review. In the next section, we described the procedure to select the communities in which the field experiment will be conducted. In the section four, we described in detail de model and their set-up. In the next two sections, we analyses the results and presented the conclusions, respectively.

2. Literature review of Common-pool resources

There are many CPRs from which the exclusion of users is not feasible or is very costly - e.g., fisheries, water resources, etc. Gordon (1954) argues that the conflict of CPRs exploitation leads to the "Tragedy of the Commons". For Hardin (1968), human behavior is driven by the maximization of individual payoffs and not by socially optimal solutions. Recently, Ostrom (1990, 1998) confirms the necessity of appropriators to arrive at cooperative management for CPRs. Finally, Kuckartz, Grunenberg (2002) and WB (2003) remarks the hard evidence that many resources are being overexploited.

Many lab and field experiments have been designed to develop evidence supporting the likelihood of sustained self-governance of CPRs. Ostrom et al (1994) employ simple static CPRs with treatments like communication and punishment between appropriators – many similar experiments were conducted - trying to verify if a mitigation effect was found for the CPRs. However, CPRs are usually found in intertemporal contexts with intergenerational link between appropriators - e.g., water in farming communities is used one generation after another. Due to this link many mitigation mechanisms are not available across distant generations of users, hence we need to introduce the dynamic over the time.

The simple static CPRs experiments demonstrated that extraction levels quickly converge to the socially inefficient equilibrium [Andreoni (1993); Keser and Gardner (1999); Ledyard (1995); Walker, R. Gardner (1992); Walker et al (1990)]. The uncertainty of appropriation pattern worsens the problem [Budescu et al (1995); Moxnes (1998)]. In the case of dynamic CPRs the overexploitation problem is intensified with the intertemporal link between extraction periods [Herr et al (1997); Mason and Philips, (1997)]. Few treatments have been shown to mitigate the inefficiency problem – e.g., two-way communication, collective action, and indefinite repeated play, for further detail see [Carpenter (2000); Hackett et al (2000); Margreiter and Sutter (2004); Walker et al (2000)].

There is an important difference between dynamic intergenerational experiments (DI-CPRs) with indefinite play and a dynamic single-generation experiment (DSG-CPRs) [Mason and Polasky (1994)]. Notice that with a DSG the same individuals are active in all extraction periods, while in the DI case - all sets of individuals are active in each generation - none of the instruments that appear to mitigate the static CPRs be able to function through an intergenerational setting - e.g., two-way communication. Likewise, it is senseless to sanction the self-serving behavior of generations that have long passed. Finally, assuming indefinite play between appropriators from distant generations is not feasible.

With DSG there is more room for altruism - intergenerational social preferences - because individuals know that their consumption restraint has positive effects not only on their own generation, but also on all future generations. The altruism predicts higher CPRs appropriation in non-intergenerational treatments – e.g., RESTART or normal static replacement, compared with the treatments with an intergenerational link. Notice that subjects take costly actions to enhance the equitable distribution of their income [Bolton and Ockenfels (2000); Fehr and Schmidt (1999)], while altruism suggests an income reduction. It must be clear that altruism and equity go in opposite directions.

Based on the strict principle of equity, appropriators could incur certain costs with the purpose of destroying the income opportunities of future generations. Since the weaker version of intergenerational equity is more frequent [Arrow et al (1995); Pezzey (1992); Riley (1980); Solow (1974, 1991)] named sustainable development approach – we will assume that notion – where the consumption opportunities of future generations should be at least at the same level as consumption today, without ruling out higher future consumption levels.

Chermak and Krause (2002) designed an overlapping generations CPRs experiment, with three players that enter the game with a one period lag and live for three periods. They applied two treatments, where the players know their positions in the game and other in which this information is eliminated. The appropriators restraint more they consumption when they are informed, this behavior reveals the player's position in the finite game and the moment of the decision within the player's lifetime.

Sadrieh (2003) developed an intergenerational CPR game with several generations represented by a single player without intragenerational links. The experiment considers that each period is a one-shot, one-player game with a single extraction decision, with the purpose to analyze if intergenerational altruism restrains the extraction behavior of the players. Andreoni (1995) defined this type of altruism as a "warm glow" altruism, where there is absence of intergenerational equal opportunities.

Herr et al (1997) developed a dynamic non-intergenerational CPRs game, where the players' exploitation behaviors in early periods affect their own cost of exploitation in later periods. The main result is that the myopic behavior of subjects exacerbates the tragedy of the commons problem. Finally, Mason and Phillips (1997) explored the effects of limiting the number of players – firms - that exploit a CPRs in a single generation. They experiment is an indefinitely repeated play in a Cournot market, with the porpoise to analyze the tradeoff between welfare loss from increased exploitation of the CPRs and welfare gain from increased competition if the number of active players in the market is higher. They found that that the level of cooperation is higher in a static game in relation to a dynamic one.

3. Communities selected for the experiment

To conduct our field experiment we selected four communities in two municipalities in the Bolivian Department of Chuquisaca. The main challenge in a field experiment is the isolation of local influences on the behavior of CPRs appropriators. We needed to find communities that were homogeneous to compare between them, with few specific differences. Since our interest is to study the intergenerational extraction of CPRs in farming communities with dams, we selected the Municipalities of San Lucas and Yamparáez in Chuquisaca, which satisfy these characteristics (see Table 1).

Table 1. *Communities selected for the experiment*

Ñame of the Project	Category	Municipality	Community	Language	Social Arrangements	Main Economic Activity	Type of Agricultural Production	Potato Production TN/ha.	Cost (Bs.)	Number of Families	Irrigation Area (ha.)	Financing Program	Degree of Homogeneity Between Communities
Chaupicocha	Micro Irrigation System/Finished	Nor Cinti	San Lucas, Chuquisaca	Quechua	Ayllus and Agrarian Labor Union	Agriculture	Potato, maize and barley	14.81	1.483.732	39	39	Mi Agua I,II,II	1
Sunchu Pampa	Micro Irrigation System/Finished	Nor Cinti	San Lucas, Chuquisaca	Quechua	Ayllus and Agrarian Labor Union	Agriculture	Potato, maize and barley	15.34	1.569.004	48	50	Mi Agua I,II,II	0.96
Molle Punku	Micro Irrigation System/Finished	Yamparaez	Yamparaez, Chuquisaca	Quechua	Ayllus and Agrarian Labor Union	Agriculture	Potato, maize and barley	15.5	2.834.748	75	80	Mi Agua I,II,II	0.94
Esquisma II	Micro Irrigation System/Finished	Yamparaez	Yamparaez, Chuquisaca	Quechua	Ayllus and Agrarian Labor Union	Agriculture	Potato, maize and barley	16.45	2.631.624	106	108	PROAR-CAF	0.98
Total								15.525	8,519,108	268	277		

Source: Own elaboration based on CAF (2016)

The communities of Chaupicocha and Sunchu Pampa are in the Municipality of Nor Cinti. The topography has plains, low hills, small hills in the north (high plateau region), and high mountains with elevated peaks in the south. The climate is temperate, with an average temperature of 68°F and annual precipitation of 700 mm. The inhabitants are Quechua and have *ayllus* and farmer unions as social organization. Almost the entire population is engaged in extensive agriculture, with livestock as a secondary activity. The main annual crops are – i.e., maize, potatoes, wheat, barley, beans, and peppers. The inhabitants migrate temporarily to the cities between April and September to increase their family income. Another part of the population is dedicated to informal trade and marketing of handcrafts.

The communities of Molle Punku and Esquisma are in the Municipality of Yamparáez. The topography goes from important valleys like Escana and Sotomayor, to the higher area with a high plateau climate, at over 3,000 meters above sea level. The municipality has several ravines that provide water for irrigation, with the Pilcomayo as its main river. Almost all the inhabitants are Quechua, and their social organization is based on unions and associations. Yamparáez has extensive grazing areas and cultivable soils, including forest areas, with potato, maize, wheat, and barley crops.

On one side, we selected two communities of the Municipality of Nor Cinti – i.e., Chaupicocha and Sunchu Pampa, which are similar in language, social arrangements, economic activity, agricultural production, productivity, and very similar in terms of irrigation area and number of families. On the other side, we chose two communities in the Municipality of Yamparáez – i.e., Molle Punku and Esquisma, which differ slightly in the size of irrigation area and number of families with irrigation systems. Since the four communities are close to each other in pairs and as a whole; and they are quite similar in number of families, average life expectancy and their inhabitant's permanence in the community - more than three generations – we consider that the intergenerational links exist.

To analyze the degree of comparability between communities, we built a symmetric index of homogeneity between pairs and as a whole. The communities are homogenous and comparable when the index's range is between 0.9 and 1.1. Table 1 indicates that all four communities are adequate for our field experiment. According to their characteristics, we assign the four treatments, as follows: a) The community of Chaupicocha was taken to be the baseline community, or the RESTART treatment; b) the SAT treatment or Water Judge, took place in the community of Molle Punku; c) the Fast Growth Treatment (FGT) took place in the community of Esquisma, with mighty rivers; and d) the Slow Growth Treatment (SGT) took place in the community of Sunchu Pampa. We will explain the treatments later; but notice that we randomly selected the experimental players within the communities.

4. The model and setup

We modify Fisher (2015) by introducing the possibility of a multiple piecewise function with "n" alternatives in which more than one this formula is used to define the output. Each formula has its own domain, and it is the union of all these smaller domains. We notate this idea like this:

$$f(x) = \begin{cases} formula\ 1\ if\ \ "x"\ is\ domain\ 1 \\ formula\ 2\ if\ \ "x"\ is\ domain\ 2 \\ \quad\quad . \\ formula\ n\ if\ \ "x"\ is\ domain\ n \end{cases}$$

Later, we evaluate a four piecewise function and determine that only formulas 1 and 2 have relevant domain for this experiment: $D_1\{0,9\}$ and $D_1\{9,24\}$. Under this specification a CPRs is also exploited by three symmetric players, each one is endowed with "e" units of effort. Each player chooses X_i (effort) to be exerted in exploiting the CPRs with $0 \leq X_i \leq e$. The production function F(x) is concave, with its maximum within the range of players' endowments:

$$F(0) = 0, \frac{dF(x^*)}{dx} = 0, \text{ when } 0 < x^* < ne, \text{ and } \frac{d^2F(x)}{d^2x} < 0.$$

The two-piece linear function has a positive and negative slope, respectively:

$$F(x) = \begin{cases} 0{,}18x & if \quad 0 \le x \le 9 \\ 9{,}55 - 0{,}17x & if \quad 9 \le x \le 24 \end{cases}$$

The marginal rate of return is greater than zero for x<9, but less than zero for x>9. The social optimum is exactly at x = 9 and the social optimum with a symmetric player is $x_i = x^{SO} = 3$. A single player's return on the exploitation of the CPRs given by $R_i(x_i)$ depends on the own choice and the choices made by others. What player "i" receives is the ratio of their own exploitation effort to the total exploitation effort.

$$R_i(x_i) = \frac{x_i}{x} F(x) = \begin{cases} 0{,}18x_i & if\ 0 < x \le 9 \\ 9{,}55\left(\frac{x_i}{x}\right) - 0{,}17x_i & if\ 9 < x < 24 \end{cases}$$

The marginal return of a single player from exploiting the CPRs is constant and positive if total exploitation is below social optimum, x<9 - no negative externalities-. When total exploitation surpasses the social optimum, x>9 the marginal return of exploitation is no longer constant, due to the negative externality. In a symmetric Nash equilibrium, each player chooses an exploitation effort $x_i = x^{Nash} = 6$ which is above the socially optimal level.

When a CPRs is exploited by one generation after another, notice that the payoff depends on – i.e., the exploitation effort, the extent of exploitation by previous generations and the natural rate of resource growth. The availability of the resource at the time of exploitation depends on the quantity of reserves: $R^t =$ the reserves of generation "t". The payoff of player "i" in generation "t" is defined as:

$$\pi_i = r_i R^t$$

r_i = is the fraction of the resources that player "i" receives.

Only the quantity of reserves available change across generations, determining the absolute level of payoffs. Since marginal returns are not affected by any change in the quantity of available resources, the equilibrium always remains unchanged across generations. However, absolute income opportunities vary, depending on the extent of preceding generations' exploitation and the rate of natural growth.

If the players in a generation aim at providing the next generation with the same income opportunities as they have themselves, it is necessary that they make exploitation effort choices that compensate the natural growth of the resource. Such growth-compensating behavior of equal opportunities is viewed as a basic fairness norm. The relationship between equilibrium behavior and growth-compensating behavior depends on the natural growth rate of the resource.

- If the resource grows slower than necessary to compensate the equilibrium exploitation, growth compensation requires that players choose exploitation efforts below the equilibrium level.
- If the resource grows faster than the equilibrium exploitation, growth compensation requires that players choose exploitation efforts above the equilibrium level.

The design and setup

Our field experiment tries to compare treatments with and without CPRs intergenerational link, following Chermak and Krause (2002); Sadrieh (2003); Herr et al. (1997); and Mason and Phillips (1997. We keep constant in the experiment: i) the strategy space; ii) the Nash equilibrium; and iii) the strategy combinations corresponding to the intergenerational social optimum. Notice, the Nash equilibrium in this CPRs exploitation game is above the socially optimal level as usual.

The experiment has different water growth rates across treatments. First, the water stock in any period is a function of the – i.e., previous period's stock, harvest, and the natural growth rate. Second, the Water Judge is a local authority who reallocate the exploitation effort. Third, the players live for one period and the length of the intergenerational chain and position of the players within it is hidden. Finally, every period involves the same intergenerational CPRs game with three players (see, Table 2).

Table 2. *The experiment designs*

I. Treatments	**With intergenerational link**	**SGT**: the growth rate of the resource is too low as to compensate for equilibrium exploitation. This means that the resource stock is not sustained, if every generation extracts the equilibrium quantities ".	Constant strategy space, Nash equilibrium, strategy combinations corresponding to the intergenerational social optimum	Nash equilibrium exploitation is above the socially optimal level	The resource stock in any period is a function of the previous period's stock and harvest, as well as the natural growth rate of the resource
		FGT: the natural growth of the CPR overcompensates the total equilibrium exploitation of the appropriators.	idem	idem	idem
		SAT: Similar setting to FGT, but with a social arrangement (Ruling Judge)	idem	idem	idem
	Without intergenerational link	**RESTART:** All parameters are constant to the initial SGT.	idem	idem	
II. Between or within	Between				
III.Order effect	One shot non-cooperative game (with no feed back)				
IV. Incentives	Experimental currency translated in real money at the end of the game for each player				
V. Replicability	Homogeneity and exogenous criteria's.				
VI. Control	Survey				
VII. Framing	Pilot				
VIII. Transparency	Ethical protocol				
IX. Bias	Dotation effect, risk adverse				
X. Independency	Generation by chains (no players)				

Source: Own elaboration

The experiment was designed with three active treatments and one control treatment: a) the Slow Growth Treatment (SGT) or SLOW for simplicity; b) the Fast Growth Treatment (FGT) or FAST for simplicity; c) the Social Arrangement Treatment (SAT) or Water Judge; and d) the RESTART Treatment. We performed a pilot to ensure the independency, replicability, adequate incentives and to limit the effect of dotation in the experiment. The setup for our symmetric game is presented in Table 3.

Table 3. *Experimental setup for the symmetric game*

Treatment	Social optimum	Nash equilibrium	Growth rate	Growth compensation	Chains	Generations per chain	Base year Reserves	Total players
FGT	3	6	1.75	6	4	4	178	48
SGT	3	6	1.25	2	4	4	178	48
RESTART	3	6			4	4	178	48
SAT	3	6	1.75	6	4	4	178	48
								192

Source: Own elaboration

In the case of the FGT and SAT treatments the CPRs has a natural growth rate of 1.75, therefore the growth compensation requires a total exploitation effort x = 18 - e.g., three symmetric players with an effort of x = 6 each one.

$$\textbf{FGT \& SAT :} \qquad R^{t+1} = (1 - \left(\frac{1}{24}\right) * (x - 18))R^{t}$$

The SLOW treatment has a natural growth rate of 1.25 – the growth compensation is achieved with a total exploitation effort of x = 6 – e.g., x = 2 for the symmetric case. Finally, in the RESTART treatment, each round of the game start from the beginning:

$$\textbf{SGT}: \quad R^{t+1} = (1 - \left(\frac{1}{24}\right) * (x-6))R^t$$
$$\textbf{RESTART}: \quad R^{t+1} = R^t$$

Experimental procedure

As we mentioned the experiment was conducted at four different communities in the Department of Chuquisaca in Bolivia. The locations were separated enough to avoid contact between players of the communities, but close enough to guarantee the existence of intergenerational links. The experiment includes 204 players and 17 Water Judges. We eliminated players with incomplete information to avoid any bias – they were informed that the number of generations is fixed and limited, but they do not know the current number of generations in a chain, or their own position in the chain – resulting 192 subjects and 16 Water Judges in four chains-generations-treatments (see Table 4).

Table 4. *Number of subjects per treatment*

Communities	Treatment	Number of Subjects	Judge of Water
Esquisma	FGT	48	n.a.
Sunchu pampa	SGT	48	n.a.
Chaupicocha	RESTART	48	n.a.
Molle Punku	SAT	48	16
		192	

Source: Own elaboration

All the players were separately - one meter apart from the others – in a desk in office of the local municipality. Previously, the players were trained - for an average of 45 minutes – how to use the decision sheet and the game procedures[2]. The experiment took eight hours including the training and the coffee break. Notice, that none of the players at any location were in the same game, and each of the three members in a generation were at different locations. We guarantee that different intergenerational chains were intertwined, so that subsequent decision-makers at each location always belonged to different chains.

The decision sheets are tables with eight rows - own effort choices - and 15 columns - the sum of the effort choices of the other two players – see Appendices 4 to 7. A cell contains two entries: a) the top values are percentages of the current generation reserve return (see box on the top right corner of the sheet) divided by the exploitation effort (see left corresponding row), given the sum of other players' choices equal to the number shown on top of the corresponding column; and b) the bottom value in percentage, representing the effect of the exploitation effort choices of the own generation on the reserves of the following generation (increasing or decreasing). Finally, each player also bet the sum of exploitation efforts of the other players in the own generation, with a payment of 20 units of currency that decreased 25% according to the distance of the guess. After the experiment, each subject's earnings were converted to bolivianos (Bs.), with a maximum profit of two daily wages in the community.

[2] We do not include these results on the analysis.

Expected results

We assume the growth rate of the resource in the SLOW treatment is enough to compensate the equilibrium exploitation - the resource stock is not sustained if every generation exploits their equilibrium quantities – as Pearce and Turner (1990) remark. On the one hand, we set up a treatment without intergenerational links, this is the RESTART treatment, where all parameters in every generation are the same as the initial parameters. On the other hand, we examine the CPRs in the case the growth of rate overcompensates the exploitation equilibrium due to the existence of a dam, which is the FAST treatment. Finally, we introduce a setting like the FAST treatment, but with the Water Judge to manage the CPRs appropriation.

The intergenerational predicts a higher CPRs appropriation in the RESTART treatment compared with the other treatments. We expect a strong appropriation in the SLOW treatment, in which the resource is inevitably depleted if players show no altruistic restraint. In contrast, the restraining effect of the intergenerational link may not be very strong in the FAST and SAT treatments. Since the equilibrium leaves more resources to future generations than were available currently, we expect a higher exploitation effort in the FAST treatment than in the SAT treatment.

If the players want to equalize payoffs across generations the intergenerational hypothesis implies in the SLOW case an appropriation restraint, as an altruistic preference. In the FAST treatment the altruism towards future generations implies restraint, while the intergenerational equity hypothesis implies extracting even more than in the Nash equilibrium. Thus, the predictions of altruism and equity go in opposite directions. Notice, the Water Judge verify a behavior in between, because it reinforces the altruistic behavior, but the monetary incentives are like the FAST treatment.

There are cases where subjects' behavior is guided by the principle of sustainable development - the extraction levels are lower in the SLOW than in the FAST treatment, but there should be no difference in extraction levels when comparing the FAST to the RESTART treatment, because a lower extraction in the FAST treatment, helps future generations, that are better off anyway. If the Water Judge operates well, we expect to see lower extraction levels, even compared to the SLOW treatment.

When we analyze the expectations of subjects concerning the behavior of their peers, the data allows us to assess the extent to which subjects choose payoff maximizing best replies to own expectations, and the extent to which they deliberately sacrifice own payoff by extracting less than they consider like optimal. We expect expectations to be aligned with the altruism hypothesis, where the intentional sacrifices will be observed especially in the treatments with an intergenerational link - i.e., SLOW compared with RESTART. The strict equity implies that subjects in the FAST treatment should expect intentional and costly resource destruction, while the sustainability implies that no sacrifices are predicted even in the FAST or RESTART. We expect the Water Judge might mitigate this behavior.

Analysis of the subjects' predictions of others' behavior is complex. Notice, that in the treatments with an intergenerational link, we assume that subjects expect significantly less extraction by their peers than in the RESTART treatment, especially with the Water Judge. The players expectations are aligned with the intergenerational altruism hypothesis and expected to see greater restraint in extraction behavior in the presence than in the absence of an intergenerational link [Andreoni (1990)].

5. Reported results

The choices

Table 5 shows the frequency distributions of the exploitation effort choices in our four treatments. As we expected, in the SLOW treatment, the mean of the exploitation effort was the highest of all treatments, with 5.13 units. Also, the SAT treatment shows the lowest exploitation effort, with 4.35 units, meaning the Water Judge decreases the exploitation effort. In the case of the RESTART treatment the mean of 4.73 units is higher than the FAST treatment with 4.42 units, as we expected. Notice, the FAST treatment includes the accumulation of water in a dam, therefore the players have less incentive to overexploit the CPRs than in the case of the RESTART treatment - the compensation growth of the resource is enough - (see Appendix 1).

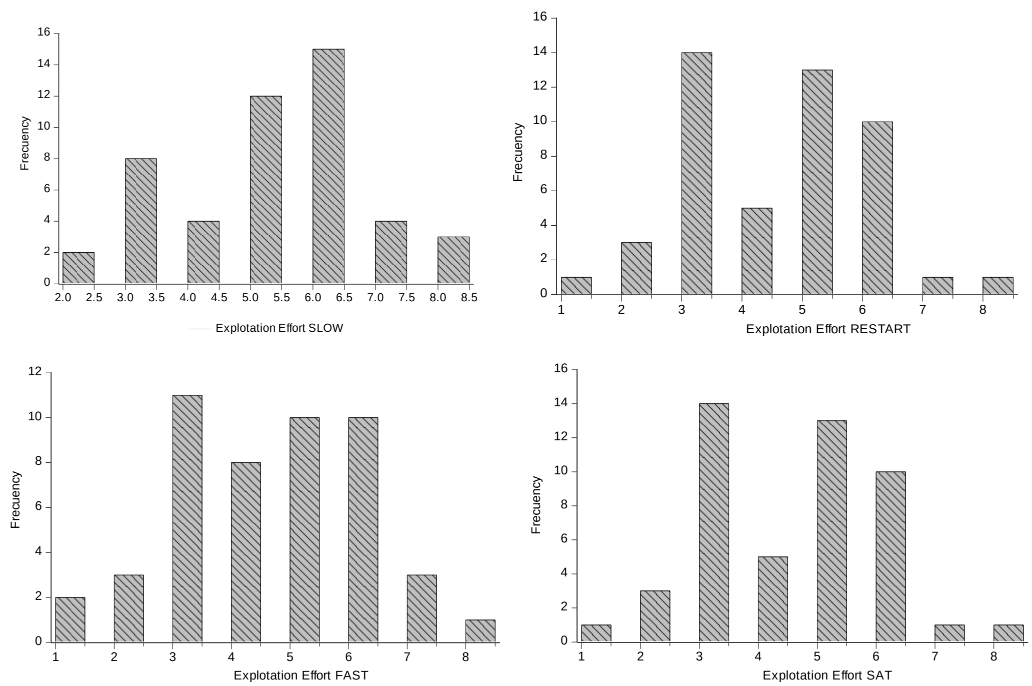
Table 5. *Exploitation effort choices*

Treatments:	FAST	SLOW	RESTART	SAT
Mean	4.42	5.13	4.73	4.35
Std. Dev.	1.64	1.54	1.43	1.51
Jarque-Bera	0.82	1.04	0.37	0.77
Probability	0.66	0.60	0.83	0.68
Sum	212.00	246.00	227.00	209.00
Sum Sq. Dev.	125.67	111.25	95.48	106.98
Observations	48	48	48	48

Source: Own elaboration based on GRETEL

Figure 1 shows that in average all treatments are above the social equilibrium SO=3, but with mix behaviors of the players. There are some players that tend to the social equilibrium, but in average we verify an overexploitation, as predicted by the theory – especially in the SLOW and RESTART treatments – there is an evident concentration of exploitation effort around Nash equilibrium = 6.

Figure 1. *Frequency distribution of exploitation effort choices*



We remark that the average of the four treatments are significantly smaller than predicted by the Nash equilibrium of x=6, but higher than the symmetric social optimum of x=3.

Except the RESTART treatment, the setup includes an intergenerational link to compare observed data to the growth compensation. The exploitations efforts are significantly smaller than the growth compensation efforts of 6 in the FAST and SAT treatments, while they are significantly greater than the growth compensation effort in the SLOW treatment (see, Table 3). The players in all the treatments were willing to restrict personal exploitation in favor of cooperation. We find no evidence for growth-compensating behavior, meaning that players restrict their exploitation efforts in the SLOW, but expand them in the FAST treatment. Nevertheless, we verify this compensation behavior in the case of the Water Judge. The growth rate is the main difference between FAST and SLOW treatments results. In the case of the Water Judge the players restrict their effort even more than in the FAST treatment, because the Water Judge reduces the uncertainty of other players' behavior.

The predictions

The players have the incentive to receive payments for accurately predicting the sum of the exploitation efforts of the other participants in their own generation. Figure 2 shows the frequency distribution of subjects' predictions in each of the four treatments, where the mass of all distributions is higher than the Nash equilibrium, meaning that all the players without concern of the treatment believe that the other players will overexploit the resource.

Figure 2. *Frequency distribution of subjects' predictions*

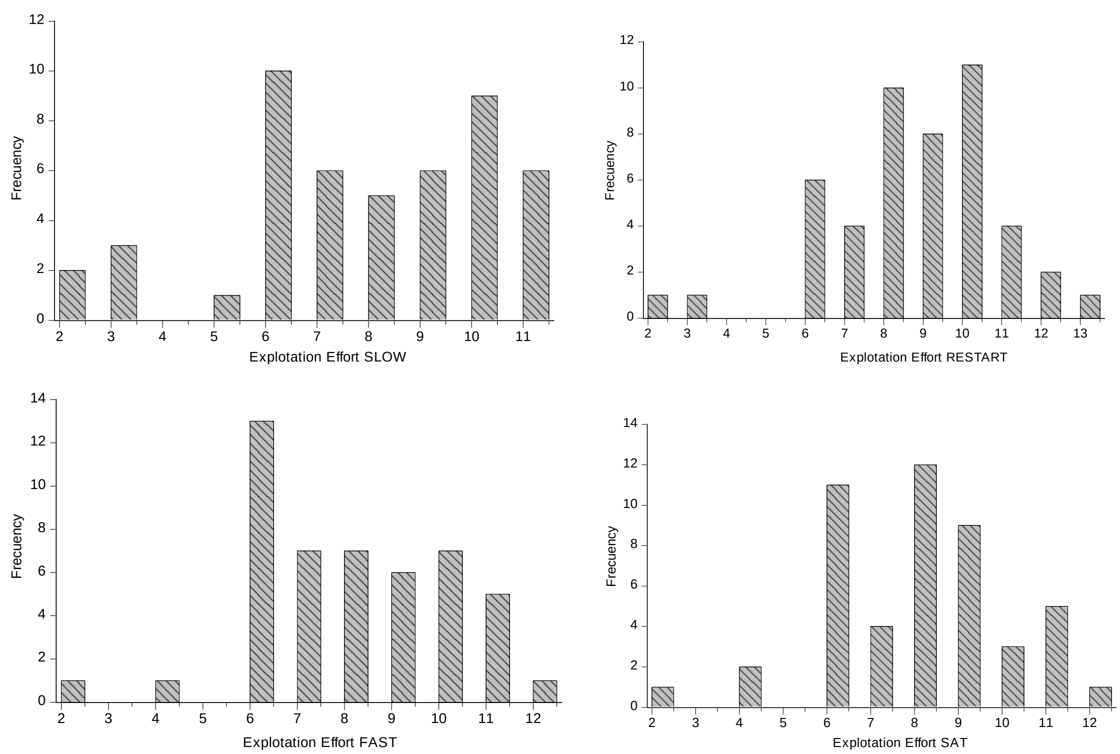


Table 6 presents the mean and standard deviation of players' predictions. Predictions in all the intertemporal treatments are smaller than subjects' predictions in RESTART, meaning the intergenerational scope awake subjects' expectations of observing others' altruistic behavior.

Table 6. *Subjects' predictions of others' exploitation efforts*

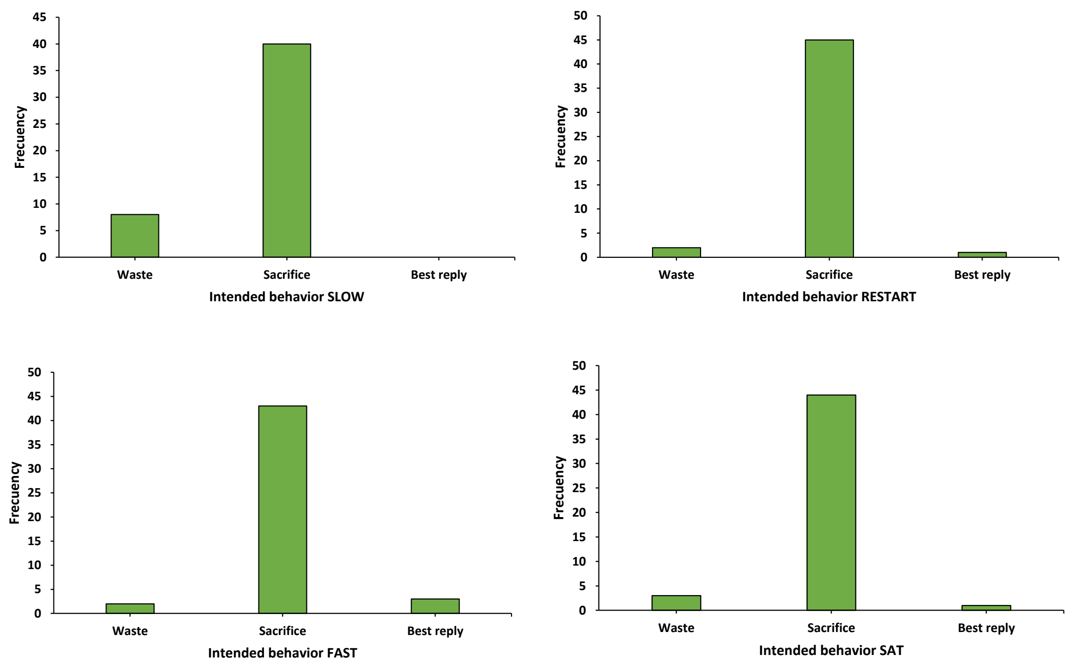
Treatments:	FAST	SLOW	RESTART	SAT
Mean	7.92	7.71	8.58	7.88
Std. Dev.	2.09	2.50	2.15	2.05
Jarque-Bera	0.32	2.98	6.09	0.96
Probability	0.85	0.22	0.05	0.62
Sum	380.00	370.00	412.00	378.00
Sum Sq. Dev.	205.67	293.92	217.67	197.25
Observation:	48	48	48	48

Source: Own elaboration based on GRETEL

Best reply to own prediction compared to own exploitation effort choice

The players' exploitation effort choices are the best replies to their own predictions of others' behavior. Nevertheless, they intend to maximize their own payoffs, but fail to do so, due to wrong expectations concerning the choices made by the other players. Figure 3 displays the distribution of subjects classified according to their effort choice being a best reply to their own prediction of others' behavior ("intended best reply") or being too low ("intended sacrifice"), or too high ("intended waste").

Figure 3. *Distribution of subjects classified according to their effort choice being a best reply*



Some players do not intend to play pay-off by maximizing best reply strategies. We observe in all the treatments that they choose an exploitation effort level that is too low compared to the best reply to their own prediction. The discrepancy between the best reply-prediction and the current effort choice is negative in all treatments, meaning the players intend to sacrifice part of their pay-off for the well-being of others.

The intended sacrifice is very similar in all four treatments. On average, players in RESTART intend to sacrifice 3.85 units of effort, while players in FAST and SAT intend to sacrifice about 3.50 and 3.32 units of effort, respectively. In the caso of the SLOW treatment the players only sacrifice 2.58 units of effort, meaning this treatment is perceived as a critical situation with less altruistic behavior. Since the setups in FAST and SAT treatments are similar, the difference between then is attributable to the Water Judge. As expected, RESTART is perceived by the players as a stable situation, and they are therefore willing to sacrifice more than in the other treatments.

It seems that best reply and waste choices are uncommon in all treatments, most players expect the others in their own generation behave cooperatively. Table 7 shows the intended exploitation effort as the best reply to the own predictions of other players. Comparing this reply to own exploitation effort choice, we verify that all the players without concern of the treatment, believe that others will exploit at a level above the Nash equilibrium of 6 units of effort.

Table 7. *Intend exploitation effort as the best reply to own prediction of other players*

Treatments:	FAST	SLOW	RESTART	SAT
Mean	6.71	6.58	6.56	6.77
Std. Dev.	0.50	0.50	0.58	0.42
Jarque-Bera	17.89	8.03	6.64	13.52
Probability	0.00	0.02	0.04	0.00
Sum	322.00	316.00	315.00	325.00
Sum Sq. Dev.	11.92	11.67	15.81	8.48
Observations	48	48	48	48

Source: Own elaboration based on GRETEL

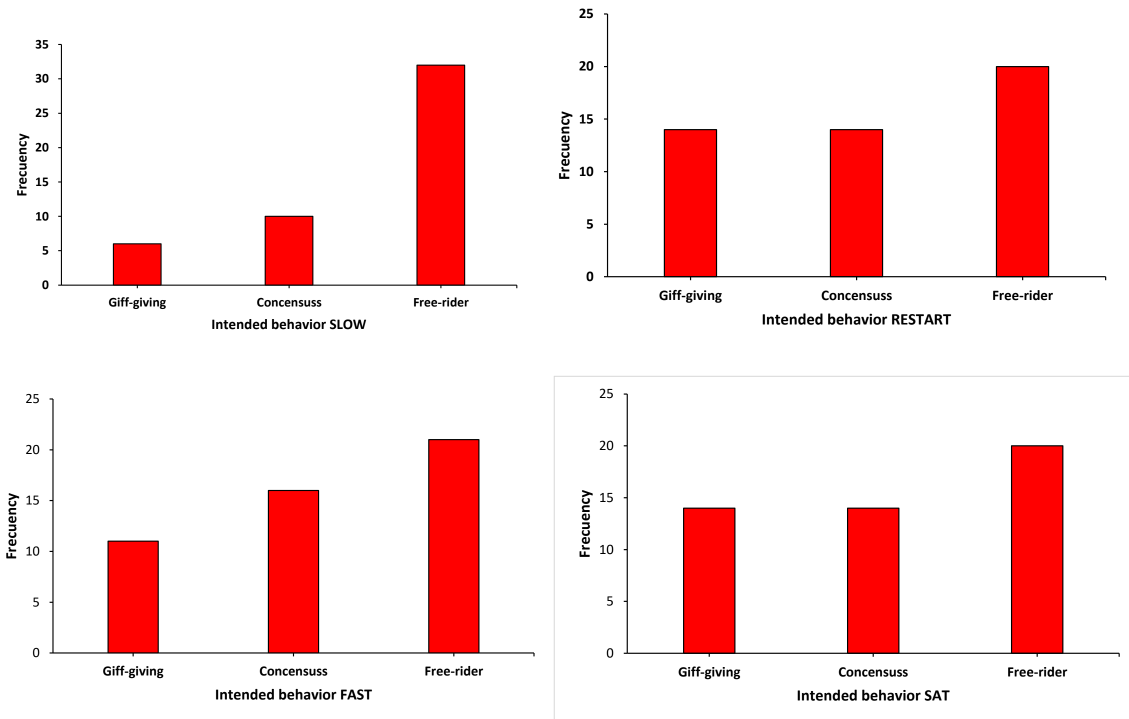
Prediction of exploitation effort choices

Notice that the comparison between the own choice of exploitation effort and that expected of others, reveals the intention of behavior. If a player chooses a lower exploitation effort than he/she expects from the others, then this player is intentionally being more altruistic or intentionally being "gift-giving." The opposite situation reveals the intention to take advantage of peers, well known as "intentional free-riding." Finally, if players choosing the same exploitation effort, they expect from others to be in "consensus".

Figure 4 shows that players exhibit a clearly intended free-rider behavior in all four treatments, especially in SLOW. Unexpectedly, the Water Judge does not show a higher level of intended consensus compared with the other treatments - we argue that the Water Judge does not foster consensus - but guarantees less uncertainty. In other words, the players do not believe in altruistic behavior, but rather in a control institution. Finally, as we expected, the players are equally gift-giving except in the SLOW treatment.

When there is an intergenerational link, but subjects know that sustaining intergenerational equity requires a large CPRs restraint, the number of players who intentionally free ride on their peers increases dramatically. It seems that subjects in such cases — SLOW treatment — greedily grab large chunks of the pie for themselves, hoping that their peers will have strong altruistic behavior considering the environmental difficulties. Since most players share this free-riding attitude, total exploitation efforts turn out rather high, so that a mismatch emerges between expectations and actions. Notice that the comparison between the own choice of exploitation effort and that expected of others reveal to some extent the intention of behavior. If a subject chooses a lower exploitation effort than he/she expects from the others, then this subject is intentionally being more altruistic or intentionally being "gift-giving." The opposite situation reveals the intention to take advantage of peers, well known as "intentional free-riding." Finally, subjects choosing the same exploitation effort they expect from others evidently intend to be in "consensus".

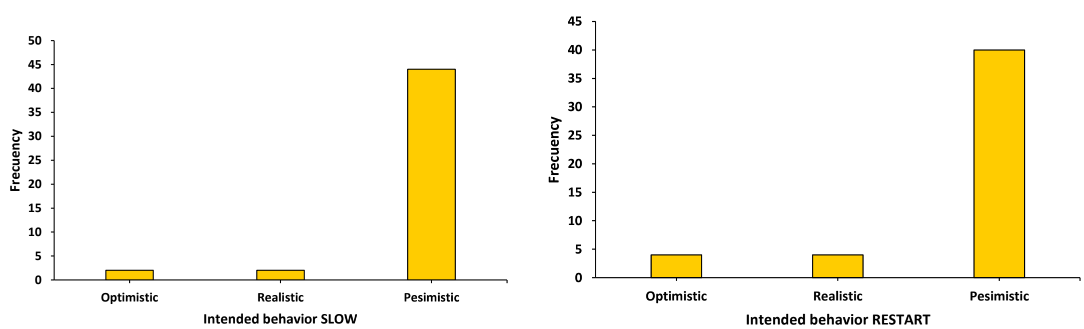
Figure 4. *Prediction of exploitation effort choices*

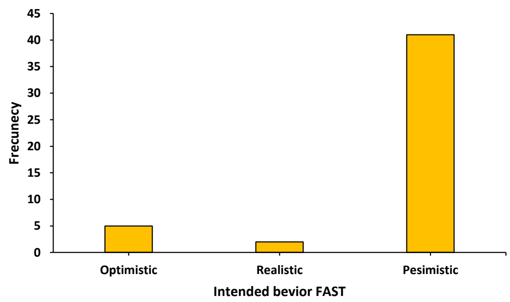


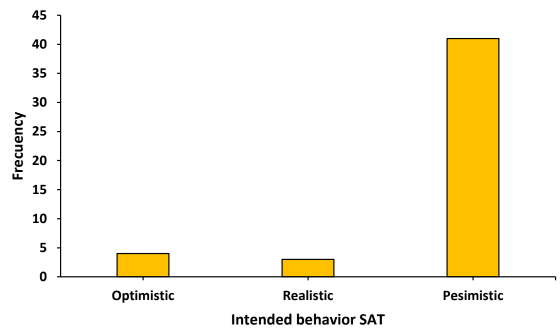
Deviation of subjects' predictions from the actual behavior of others

Figure 5 reveals that players expectations about each other's cooperation are inadequate. The prediction of the exploitation efforts chosen by the others is smaller than what they chose. Most subjects in all treatments are too pessimistic, and the other two categories - i.e., optimistic, and realistic, present a very low frequency. The results suggests that players may be driving by the observed effects, and the dominant type of players were the free-riders with pessimistic intentions, intending to free-ride on their peers, and being pessimistic about others' behavior.

Figure 5. *Expectations that subject have about each other's cooperation*







Testing the robustness of the experiment

In this section we run an econometric robust model to verify the consistency of our result related to the original setup connecting the multiple pieces-function. Notice that robust regression methods are designed to be not overly affected by violations of assumptions in ordinary least squared; mainly by the underlying data-generating process. Least squares estimation is highly sensitive to outliers - this is not normally a problem if the outlier is simply an extreme observation drawn from the tail of a normal distribution - however, if the outlier results from a non-normal measurement error, then it compromises the validity of the regression results if a non-robust regression technique is used.

In this paper we selected this technique, because robust methods are adequate when there are a strong evidence of heteroscedasticity, categorical effects or outliers – that might not be eliminated – providing more accuracy for many field scenarios (Maronna, 2006). We applied M-estimation, which addresses dependent variable outliers where the value of the dependent variable differs markedly from the regression model norm. Robust regression replaces squaring of residuals, with a function that gives less weight to outliers. The model specification is the following:

$$S = a_0 + a_1 G + a_2 E + a_3 E_{-1} + e$$

Where:

S = the pay-off of each player

G = the current stock of the resource

E = the exploitation effort

e = error

The model presents a Rw-S of 98.9% (weighted R2), the results are presented in Table 8. According to Renaud and Feser (2010), this statistic provides a better measure of fit than for robust estimations; and Rn which is a robust version of a Wald test. We reject the null hypothesis that all non-intercept coefficients are equal to zero, following (Huber, 1981):

$$\boldsymbol{f(x)} = \begin{cases} \frac{x^2}{2} \; if \mid X \mid \leq c = 1.345 \\ c\mid X \mid - \frac{x^2}{2} \; otherwise \end{cases}$$

Table 8. *Robust regression output*

Dependent Variable: SCORE

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	9.775947	3.831475	2.551484	0.0107
G	0.989946	0.011308	87.54753	0.0000
EFFORT	0.15057	0.161939	0.929797	0.3525
EFFORT(-1)	-0.153639	0.140196	-1.095883	0.2731
		Robust Statistics		
R-squared	0.839851	Adjusted R-squared		0.831708
Rw-squared	0.995748	Adjust Rw-squared		0.995748
Akaike info criterion	69.66066	Schwarz criterion		78.97958
Deviance	490.0498	Scale		2.802227
Rn-squared statistic	10229.54	Prob(Rn-squared stat.)		0.000000
		Non-robust Statistics		
Mean dependent var	119.0635	S.D. dependent var		42.21537
S.E. of regression	3.0958	Sum squared resid		565.4549

M settings: weight=Bisquare, tuning=4.685, scale=MAD (median centered)

Huber Type I Standard Errors & Covariance

Method: Robust Least Squares M-estimatin

Source: Own elaboration based on Gretel

Finally, Table 9 shows a comparison between the estimated coefficient and the original parameterization according to the technical mission in the communities.

Table 9. *Comparison between the result and the parameterization*

	Parametrization	Estimation	Condition	Significance
Constant	9.55	9.77		***
G	1	0.989		***
Effort	0.18	0.1505	if 0≤x≤9	n.s
Effort(1)	0.17	-0.1536	if 9≤x≤24	n.s.

Source: Own elaboration based on thecnichal mission and GRETEL

*** 99% estatistical significance

n.s non-estatistical significance

6. Conclusions

CPRs are usually exploited one generation after another – often overexploited – with an intergenerational link between the consumers. We tested this behavior introducing the hypothesis of "intergenerational altruism", which reduce the exploitation of the natural resources since the agents recognize that the exploitation not only creates negative externalities for their own generation, but also for all future generations. An alternative hypothesis is the "intergenerational equity" where the agents restrain their consumption to equalize their income over time.

To prove these hypotheses, we conducted a field experiment in four farming communities located in the Bolivian Department of Chuquisaca during the third quarter of 2019. We consider common water for farming activities as a CPRs, since these communities use this resource for several decades, the intergenerational link is evident. Our field experiment includes four treatments based on the replacement rate of the resources – i.e., FAST, SLOW, RESTART or normal replacement, under one-shot non-cooperative game without feedback. We also introduce two variations, the possibility to accumulate water in a dam, which modify the availability of CPRs. Second, the possibility to manage the common farming water through the traditional social arrangement of the Water Judge, which is a representative member of the community delegated to solve problems related with water management.

The hypothesis of the exploitation constraint was not realistic as regards to intergenerational altruism, though we did find evidence that intergenerational links affect players' expectations concerning the behavior of their peers. The players expect their peers to face up to the intergenerational responsibility, but they do not reduce their own exploitation levels. Effective exploitation reduction is lower than we expected, since in all the treatments the exploitation effort was higher than social equilibrium[3], and slightly lower than the Nash equilibrium. We considered all the players as free riders, with low expectations of others' altruistic behavior - conversely, they seek to equalize their income over time -.

In the case of the Water Judge, the players seek to achieve a weak intertemporal equity[4], since they assume costly action to equalize their income over time by restraining their consumption compared with the Nash equilibrium. They slightly wanted to offset the consumption of future generations, and in the case of low resources availability, they do not mind destroying the income opportunities of other generations. This treatment does not increase consensus but does reduce the uncertainty of other players' behavior.

The players predict that intergenerational links will be an incentive for constraining resource extraction. Since the strategies in the game are substitutes, they decide to increase their own extraction as the best reply to others' reduction. There is a particularly high frequency of intended pessimism, even worsen it in the SLOW treatment, by increasing exploitation and driving a wedge between beliefs and actions of the appropriators. Our results have some strong negative implications for policies relying on self-governance of intergenerational CPRs, except in the case of the Water Judge.

Notice that the Water Judge do not increase the consensus of the players, but he reduces the uncertainty, especially in the FAST treatment. When everything is fine there is a decrease in selfish attitudes, but not in other contexts. Anyway, the Water Judge is a powerful social arrangement compared to others - e.g., two-way pre-play communication or post-play punishment, but weak in mitigating the overexploitation of intergenerational CPRs. The problem is the interaction between the current generation and several unborn generations.

We found that even the free rider behavior the subjects care about others, because the average extraction level is below the NASH equilibrium in all the treatments. Also, we observe that intergenerational responsibility is recognized, even if subjects are hoping that others will face up to this responsibility. Policies that consider these results may improve setting for sustainability, such as emulating the mechanisms proven to be valuable within a generation or across generations – e.g., the punishment possibility that allows sanctioning appropriators today if their behavior harms the interests of future generations. Finally, if voluntary restraint is required, it seems that providing information on the actual extraction levels may at least help avoid the extreme optimism that we observe.

[3] We expected the free rider behavior in the SLOW treatment, but not necessarily in the others.
[4] The intertemporal equity is also known as sustainable development approach.

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Appendix 1. The choices

Test for Equality of Variances Between Series				
Sample: 1 48				
Included observations: 48				
Method		**df**	**Value**	**Probability**
Bartlett		3.000	0.898	0.826
Levene		(3, 188)	0.920	0.432
Brown-Forsythe		(3, 188)	0.899	0.443
		Category Statistics		
			Mean Abs.	**Mean Abs.**
Variable	**Count**	**Std. Dev.**	**Mean Diff.**	**Median Diff.**
FGT	48	1.635163	1.375000	1.375000
SGT	48	1.538513	1.218750	1.208333
RESTART	48	1.425297	1.096354	1.062500
SAT	48	1.508692	1.297743	1.270833
All	192	1.547355	1.246962	1.229167
Bartlett weighted standard deviation: 1.528758				

Source: Own elaboration based on Gretel

Test for Equality of Means Between Series				
Sample: 1 48				
Included observations: 48				
Method		**df**	**Value**	**Probability**
Anova F-test		(3, 188)	2.558369	0.0565
Welch F-test*		(3, 104.334)	2.479151	0.0653
*Test allows for unequal cell variances				
		Analysis of Variance		
Source of Variation		**df**	**Sum of Sq.**	**Mean Sq.**
Between		3	17.9375	5.979167
Within		188	439.375	2.337101
Total		191	457.3125	2.394306
		Category Statistics		
				Std. Err.
Variable	**Count**	**Mean**	**Std. Dev.**	**of Mean**
FGT	48	4.416667	1.635163	0.236015
SGT	48	5.125	1.538513	0.222065
RESTART	48	4.729167	1.425297	0.205724
SAT	48	4.354167	1.508692	0.217761
All	192	4.65625	1.547355	0.111671

Source: Own elaboration based on Gretel

Appendix 2. The predictions

Test for Equality of Variances Between Series				
Sample: 1 48				
Included observations: 48				
Method		**df**	**Value**	**Probability**
Bartlett		3	2.391898	0.4951
Levene		(3, 188)	1.331476	0.2655
Brown-Forsythe		(3, 188)	1.249119	0.2933
Category Statistics				
			Mean Abs.	**Mean Abs.**
Variable	**Count**	**Std. Dev.**	**Mean Diff.**	**Median Diff.**
FGT	48	2.091862	1.715278	1.708333
SGT	48	2.500709	2.065972	2.041667
RESTART	48	2.152024	1.659722	1.625
SAT	48	2.048611	1.572917	1.541667
All	192	2.213614	1.753472	1.729167
Bartlett weighted standard deviation: 2.205530				

Source: Own elaboration based on Gretel

Test for Equality of Means Between Series				
Sample: 1 48				
Included observations: 48				
Method		**df**	**Value**	**Probability**
Anova F-test		(3, 188)	1.47	0.22
Welch F-test*		(3, 104.204)	1.44	0.23
*Test allows for unequal cell variances				
Analysis of Variance				
Source of Variation		**df**	**Sum of Sq.**	**Mean Sq.**
Between		3.00	21.42	7.14
Within		188.00	914.50	4.86
Total		191.00	935.92	4.90
Category Statistics				
				Std. Err.
Variable	**Count**	**Mean**	**Std. Dev.**	**of Mean**
FGT	48	7.92	2.09	0.30
SGT	48	7.71	2.50	0.36
RESTART	48	8.58	2.15	0.31
SAT	48	7.88	2.05	0.30
All	192	8.02	2.21	0.16

Source: Own elaboration based on Gretel

Appendix 3. The reply

Test for Equality of Variances Between Series			
Sample: 1 48			
Included observations: 48			
Method	**df**	**Value**	**Probability**
Bartlett	3.00	4.48	0.21
Levene	(3, 188)	6.21	0.00
Brown-Forsythe	(3, 188)	1.88	0.13

Category Statistics

Variable	Count	Std. Dev.	Mean Abs. Mean Diff.	Mean Abs. Median Diff.
FGT	48	0.50	0.43	0.29
SGT	48	0.50	0.49	0.42
RESTART	48	0.58	0.53	0.44
SAT	48	0.42	0.35	0.23
All	192	0.51	0.45	0.34

Bartlett weighted standard deviation: 0.504633

Source: Own elaboration based on Gretel

Test for Equality of Means Between Series			
Sample: 1 48			
Included observations: 48			
Method	**df**	**Value**	**Probability**
Anova F-test	(3, 188)	1.881636	0.1341
Welch F-test*	(3, 103.87)	2.000831	0.1185

*Test allows for unequal cell variances

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	3	1.44	0.48
Within	188	47.88	0.25
Total	191	49.31	0.26

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
FGT	48	6.71	0.50	0.07
SGT	48	6.58	0.50	0.07
RESTART	48	6.56	0.58	0.08
SAT	48	6.77	0.42	0.06
All	192	6.66	0.51	0.04

Source: Own elaboration based on Gretel

Appendix 4. Pay-off in the FAST treatment

Please, choose on of the eight possibilities here				
Subject	Location	Current stock G	% of G	Personal pay-off

FGT

Please, click here	Indicate your predictions of the sum of the sum of the choice by the other participants													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]

	My decision, please tick below	the sum of the choice made by the other particiapnts of your group of three													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	[]	57	57	57	57	57	57	57	48.45	41.8	36.1	30.4	26.6	22.8	19.95
		71.25													
2	[]	114	114	114	114	114	114	96.9	82.65	71.25	61.75	53.2	45.6	38.95	33.25
		67.45													
3	[]	171	171	171	171	171	145.35	124.45	107.35	92.15	79.8	68.4	58.9	50.35	42.75
		63.65													
4	[]	228	228	228	228	193.8	166.25	142.5	122.55	105.45	91.2	78.85	67.45	57	48.45
		59.85													
5	[]	285	285	285	242.25	207.1	178.6	153.9	132.05	114	97.85	83.6	71.25	60.8	50.35
		55.1													
6	[]	342	342	290.7	248.9	213.75	184.3	158.65	136.8	117.8	100.7	85.5	72.2	59.85	48.45
		51.3													
7	[]	399	339.15	289.75	249.85	214.7	185.25	159.6	137.75	116.85	99.75	83.6	70.3	57	45.6
		47.5													
8	[]	387.6	331.55	285	245.1	211.85	182.4	156.75	133.95	114	95.95	79.8	64.6	51.3	38.95
		43.7													

[]	my pay-off in % of the current G
(green)	change of the stock for the next group of three in % of the current G

Appendix 5. Pay-off in the SLOW treatment

Please, choose on of the eight possibilities here

Subject	Location	Current stock G	% of G	Personal pay-off

Please, click here	Indicate your predictions of the sum of the sum of the choice by the other participants													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]

	My decision, please tick below	the sum of the choice made by the other particiapnts of your group of three													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	[]	57	57	57	57	57	57	57	48.45	41.8	36.1	30.4	26.6	22.8	19.95
		(+13)	(+8)	(+4)	(+0)	(-4)	(-8)	(-13)	(-17)	(-21)	(-25)	(-29)	(-33)	(-38)	(-42)
2	[]	114	114	114	114	114	114	96.9	82.65	71.25	61.75	53.2	45.6	38.95	33.25
		(+8)	(+4)	(+0)	(-4)	(-8)	(-13)	(-17)	(-21)	(-25)	(-29)	(-33)	(-38)	(-42)	(-46)
3	[]	171	171	171	171	171	145.4	124.5	107.4	92.15	79.8	68.4	58.9	50.35	42.75
		(+4)	(+0)	(-4)	(-8)	(-13)	(-17)	(-21)	(-25)	(-29)	(-33)	(-38)	(-42)	(-46)	(-50)
4	[]	228	228	228	228	193.8	166.3	142.5	122.6	105.5	91.2	78.85	67.45	57	48.45
		(+0)	(-4)	(-8)	(-13)	(-17)	(-21)	(-25)	(-29)	(-33)	(-38)	(-42)	(-46)	(-50)	(-54)
5	[]	285	285	285	242.3	207.1	178.6	153.9	132.1	114	97.85	83.6	71.25	60.8	50.35
		(-4)	(-8)	(-13)	(-17)	(-21)	(-25)	(-29)	(-33)	(-38)	(-42)	(-46)	(-50)	(-54)	(-58)
6	[]	342	342	290.7	248.9	213.8	184.3	158.7	136.8	117.8	100.7	85.5	72.2	59.85	48.45
		(-8)	(-13)	(-17)	(-21)	(-25)	(-29)	(-33)	(-38)	(-42)	(-46)	(-50)	(-54)	(-58)	(-63)
7	[]	399	339.2	289.8	249.9	214.7	185.3	159.6	137.8	116.9	99.75	83.6	70.3	57	45.6
		(-13)	(-17)	(-21)	(-25)	(-29)	(-33)	(-38)	(-42)	(-46)	(-50)	(-54)	(-58)	(-63)	(-67)
8	[]	387.6	331.6	285	245.1	211.9	182.4	156.8	134	114	95.95	79.8	64.6	51.3	38.95
		(-17)	(-21)	(-25)	(-29)	(-33)	(-38)	(-42)	(-46)	(-50)	(-54)	(-58)	(-63)	(-67)	(-71)

[]	my pay-off in % of the current G
(green cell)	change of the stock for the next group of three in % of the current G

Appendix 6. Pay-off in the RESTART treatment

Please, choose on of the eight possibilities here

Subject	Location	Current stock G	% of G	Personal pay-off

RESTART	Indicate your predictions of the sum of the sum of the choice by the other participants													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Please, click here	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]

	My decision, please tick	the sum of the choice made by the other particiapnts of your group of three													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	[]	57	57	57	57	57	57	57	48.45	41.8	36.1	30.4	26.6	22.8	19.95
		(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)
2	[]	114	114	114	114	114	114	96.9	82.65	71.25	61.75	53.2	45.6	38.95	33.25
		(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)
3	[]	171	171	171	171	171	145.4	124.5	107.4	92.15	79.8	68.4	58.9	50.35	42.75
		(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)
4	[]	228	228	228	228	193.8	166.3	142.5	122.6	105.5	91.2	78.85	67.45	57	48.45
		(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)
5	[]	285	285	285	242.3	207.1	178.6	153.9	132.1	114	97.85	83.6	71.25	60.8	50.35
		(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)
6	[]	342	342	290.7	248.9	213.8	184.3	158.7	136.8	117.8	100.7	85.5	72.2	59.85	48.45
		(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)
7	[]	399	339.2	289.8	249.9	214.7	185.3	159.6	137.8	116.9	99.75	83.6	70.3	57	45.6
		(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)
8	[]	387.6	331.6	285	245.1	211.9	182.4	156.8	134	114	95.95	79.8	64.6	51.3	38.95
		(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)	(+0)

Appendix 7. Pay-off in the SAT treatment

Please, choose on of the eight possibilities here

Subject	Location	Current stock G	% of G	Personal pay-off

	Indicate your predictions of the sum of the sum of the choice by the other participants													
Please, click here	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]	[]

	My decision, please tick below	the sum of the choice made by the other particiapnts of your group of three													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	[]	54.2	54.2	54.2	54.2	54.2	54.2	54.2	46.0	39.7	34.3	28.9	25.3	21.7	19.0
		(+78,75)	(+74,55)	(+70,35)	(+66,15)	(+60,9)	(+56,7)	(+52,5)	(+48,3)	(+44,1)	(+39,9)	(+34,65)	(+30,45)	(+26,25)	(+22,05)
2	[]	108.3	108.3	108.3	108.3	108.3	108.3	92.1	78.5	67.7	58.7	50.5	43.3	37.0	31.6
		(+74,55)	(+70,35)	(+66,15)	(+60,9)	(+56,7)	(+52,5)	(+48,3)	(+44,1)	(+39,9)	(+34,65)	(+30,45)	(+26,25)	(+22,05)	(+17,85)
3	[]	162.5	162.5	162.5	162.5	162.5	138.1	118.2	102.0	87.5	75.8	65.0	56.0	47.8	40.6
		(+70,35)	(+66,15)	(+60,9)	(+56,7)	(+52,5)	(+48,3)	(+44,1)	(+39,9)	(+34,65)	(+30,45)	(+26,25)	(+22,05)	(+17,85)	(+13,65)
4	[]	216.6	216.6	216.6	216.6	184.1	157.9	135.4	116.4	100.2	86.6	74.9	64.1	54.2	46.0
		(+66,15)	(+60,9)	(+56,7)	(+52,5)	(+48,3)	(+44,1)	(+39,9)	(+34,65)	(+30,45)	(+26,25)	(+22,05)	(+17,85)	(+13,65)	(+8,4)
5	[]	270.8	270.8	270.8	230.1	196.7	169.7	146.2	125.4	108.3	93.0	79.4	67.7	57.8	47.8
		(+60,9)	(+56,7)	(+52,5)	(+48,3)	(+44,1)	(+39,9)	(+34,65)	(+30,45)	(+26,25)	(+22,05)	(+17,85)	(+13,65)	(+8,4)	(+4,2)
6	[]	324.9	324.9	276.2	236.5	203.1	175.1	150.7	130.0	111.9	95.7	81.2	68.6	56.9	46.0
		(+56,7)	(+52,5)	(+48,3)	(+44,1)	(+39,9)	(+34,65)	(+30,45)	(+26,25)	(+22,05)	(+17,85)	(+13,65)	(+8,4)	(+4,2)	(+0)
7	[]	379.1	322.2	275.3	237.4	204.0	176.0	151.6	130.9	111.0	94.8	79.4	66.8	54.2	43.3
		(+52,5)	(+48,3)	(+44,1)	(+39,9)	(+34,65)	(+30,45)	(+26,25)	(+22,05)	(+17,85)	(+13,65)	(+8,4)	(+4,2)	(+0)	(+4,2)
8	[]	368.2	315.0	270.8	232.8	201.3	173.3	148.9	127.3	108.3	91.2	75.8	61.4	48.7	37.0
		(+48,3)	(+44,1)	(+39,9)	(+34,65)	(+30,45)	(+26,25)	(+22,05)	(+17,85)	(+13,65)	(+8,4)	(+4,2)	(+0)	(+4,2)	(+8,4)

[]	my pay-off in % of the current G
(green)	change of the stock for the next group of three in % of the current G

Appendix 8. Gross experiment data

FAST		Player 1			Player 2			Player 3				
Int. chain	Generation	Decision	Prediction	Best reply	Decision	Prediction	Best reply	Decision	Prediction	Best reply	Other players	Total effort
1	1	8	6	7	3	6	7	4	7	7	7	15
1	2	3	6	7	7	9	7	5	10	6	12	15
1	3	1	2	7	6	6	7	5	9	7	11	12
1	4	2	6	7	4	8	7	4	10	6	8	10
2	1	5	8	7	2	7	7	3	8	7	5	10
2	2	4	7	7	7	10	6	6	7	7	13	17
2	3	5	10	6	1	10	5	5	11	6	6	11
2	4	6	11	6	6	4	6	7	9	7	13	19
3	1	6	12	6	3	6	7	4	7	7	7	13
3	2	2	8	7	4	8	7	3	7	7	7	9
3	3	3	8	7	6	11	6	5	7	7	11	14
3	4	5	10	6	5	9	7	6	11	7	11	16
4	1	6	6	7	5	8	7	6	11	6	11	17
4	2	3	6	7	6	6	7	3	6	7	9	12
4	3	5	10	6	3	6	7	3	6	7	6	11
4	4	3	6	7	4	9	7	4	9	7	8	11

SLOW		Player 1			Player 2			Player 3				
Int. chain	Generation	Decision	Prediction	Best reply	Decision	Prediction	Best reply	Decision	Prediction	Best reply	Other players	Total effort
1	1	6	10	6	6	9	7	8	6	7	14	20
1	2	7	10	6	5	10	6	6	10	6	11	18
1	3	3	6	7	5	7	7	4	3	6	9	12
1	4	3	6	7	3	6	7	3	6	7	6	9
2	1	3	7	7	6	11	6	5	11	6	11	14
2	2	4	3	6	6	8	7	7	11	6	13	17
2	3	5	8	7	5	11	6	6	10	6	11	16
2	4	2	6	7	4	2	7	6	7	7	10	12
3	1	6	8	7	6	11	6	6	9	7	12	18
3	2	6	11	6	4	8	7	6	7	6	10	16
3	3	5	10	6	6	10	6	5	10	6	11	16
3	4	6	10	6	8	6	7	7	2	7	15	21
4	1	3	6	7	5	9	7	5	8	7	10	13
4	2	8	5	6	3	6	7	5	9	7	8	16
4	3	5	9	7	2	6	7	3	7	7	5	10
4	4	6	7	7	5	9	7	7	3	6	12	18

RESTART		Player 1			Player 2			Player 3				
Int. chain	**Generation**	**Decision**	**Prediction**	**Best reply**	**Decision**	**Prediction**	**Best reply**	**Decision**	**Prediction**	**Best reply**	**Other players**	**Total effort**
1	1	4	13	6	2	6	7	5	11	6	7	11
1	2	7	8	7	4	9	7	4	8	7	8	15
1	3	5	10	6	6	9	7	4	10	6	10	15
1	4	4	7	7	7	10	6	4	7	7	11	15
2	1	5	10	5	6	12	6	5	8	7	11	16
2	2	4	8	7	4	8	7	4	8	7	8	12
2	3	2	6	7	5	9	7	5	10	6	10	12
2	4	3	7	7	5	10	6	4	10	6	9	12
3	1	3	6	7	3	6	7	1	2	7	4	7
3	2	6	9	7	6	11	6	4	9	7	10	16
3	3	5	10	5	5	10	6	6	11	6	11	16
3	4	5	8	7	4	10	6	5	8	7	9	14
4	1	5	8	7	8	3	6	3	7	7	11	16
4	2	6	11	6	4	9	7	6	10	6	10	16
4	3	4	8	7	5	9	7	8	6	7	13	17
4	4	6	12	6	6	6	7	5	9	7	11	17

SAT		Player 1			Player 2			Player 3				
Int. chain	**Generation**	**Decision**	**Prediction**	**Best reply**	**Decision**	**Prediction**	**Best reply**	**Decision**	**Prediction**	**Best reply**	**Other players**	**Total effort**
1	1	3	6	7	5	10	6	5	9	7	10	13
1	2	4	8	7	6	6	7	3	6	7	9	13
1	3	6	4	6	3	9	7	6	9	7	9	15
1	4	3	9	7	7	11	6	4	7	7	11	14
2	1	5	11	6	6	12	6	3	6	7	9	14
2	2	3	8	7	5	8	7	6	11	6	11	14
2	3	4	9	7	5	9	7	5	11	6	10	14
2	4	6	11	6	3	8	7	4	8	7	7	13
3	1	5	10	6	2	6	7	3	9	7	5	10
3	2	6	7	7	3	6	7	6	9	7	9	15
3	3	3	8	7	5	8	7	3	6	7	8	11
3	4	5	8	7	5	7	7	5	9	7	10	15
4	1	2	6	7	3	8	7	2	6	7	5	7
4	2	6	4	6	4	8	7	6	7	7	10	16
4	3	3	6	7	5	10	6	3	8	7	8	11
4	4	8	6	7	1	2	7	5	8	7	6	14