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An Intergenerational Common Pool Resource Experiment

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Abstract

Many renewable resources are in intergenerational common pools, exploited by one generation after another. In our experiment, the stock available to each generation depends on the extent of exploitation by previous generations and on resource's growth rate, which is either "slow" or "fast." Subjects show altruistic restraint in exploitation, but not enough to achieve the social optimum. The presence of an intergenerational link induces subjects – both in "slow" and in "fast" – to expect less resource exploitation from each other than subjects expect in a single generation control. On average, expectations are too optimistic, especially in "slow," where intended free-riding behavior is predominant.

Keywords

intergenerational common pool resources, growth and altruism, free-riding intentions

JEL Codes

C72, C92, D62, Q20

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1. Introduction

Many resources are in common pools from which the exclusion of users is not feasible or very costly (e.g. fisheries, forests, grazing systems, wildlife, water resources, clean air, etc.). In his formal analysis of the problem of common pool resources (CPR), Gordon (1954) expresses the contention that their exploitation inevitably leads to "the tragedy of the commons" (Hardin 1968), when human behavior is driven by the maximization of individual payoffs and not by the desire to achieve a socially optimal solution. While surveys confirm a wide-spread desire in the population for arriving at a cooperative management of critical natural resources (e.g. Kuckartz and Grunenberg 2002), there is also well-established general knowledge that many resources are being overexploited – even to the point of no return (e.g. Noble 2002; World Bank 2002). Recent field studies[1] have helped to derive a number of parameters that enhance the likelihood of sustained self-governance (Ostrom 1999). Many of these parameters (e.g. communication and punishment) have been validated experimentally. A closer look at the literature, however, reveals that essentially all mechanisms that have been shown to mitigate the overexploitation problem are not easily available across distant generations of users. Since almost all naturally occurring CPRs are intergenerational common pools, it seems obvious that intergenerational dynamics constitute an important aspect of CPR exploitation and deserve more attention. The question we address in this paper is whether the intergenerational perspective of the CPR appropriators can contribute to the sustainability of the resource use.

Isolating structural influences on appropriation behavior in CPR field data appears difficult, because it is often hard to find instances that are sufficiently comparable, but differ only with respect to a specific feature. To this end experimental studies on a number of CPR structures have proven valuable. In simple static CPRs, extraction levels quickly converge to the socially inefficient equilibrium (Walker, Gardner, and Ostrom 1990; Walker and Gardner 1992; Andreoni 1993; Ledyard 1995; Keser and Gardner 1999). Uncertainty about appropriation capacity and complexity exacerbate the CPR over-exploitation (Budescu, Rapoport, and Suleiman 1995; Moxnes 1998). Similarly, the over-exploitation problem is aggravated in dynamic CPRs with an intertemporal link between extraction periods (Herr, Gardner, and

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[1] For overviews see Ostrom 1990; Ostrom, Gardner, and Walker 1994; Ostrom 1998. A non-exhaustive enumeration of CPRs that have been examined: Sweeney, Tollison, and Willett (1974) study fishes, oil, and manganese nodules. Morrow and Hull (1996) study forest exploitation in the Palcazu Valley of Peru. Gardner, Moore, and Walker (1997) study groundwater depletion. Pena Torres (1997) studies fishing in Chile. Gardner, Herr, Ostrom, and Walker (2000) study proportional cutbacks of chlorofluorocarbon emissions and of the fishing fleets in the EU. Grafton, Squires, and Fox (2000) study British Columbia halibut fishery.

Walker 1997; Mason and Phillips 1997). Only two-way communication, collective action, and indefinite repeated play have been shown to mitigate the inefficiency problem (Ostrom, Walker, Gardner 1992 and 1994; Hackett, Schlager, and Walker 1994; Mason and Phillips 1997; Carpenter 2000; Walker, Gardner, Herr, Ostrom 2000; Margreiter and Sutter 2001).

All these experiments have dealt with single generation common pool resource problems. In reality, however, many resources are in intergenerational common pools, i.e. are exploited by one generation after another. Our research interest is to study extraction behavior in such dynamic multi-generational CPRs. Note, that there is an important structural difference between the dynamic *intergenerational* CPRs and the dynamic single generation CPRs studied before (Herr, Gardner, and Walker 1997; Mason and Phillips 1997). In the latter, the same individuals are active in all extraction periods, while in the former disjoint sets of individuals are active in each generation. This has crucial implications, because none of the instruments that appear to mitigate the commons problem, can be easily implemented in the intergenerational setting. For one thing, two-way communication is not possible across all generations of an intergenerational CPR. For another thing, there is no means of sanctioning self-serving behavior of generations that have long past. Finally, assuming indefinite play between appropriators from distant generations is not feasible. While, these mechanisms that are effectively used in single generation CPRs are not available in the intergenerational context, there is more room in the latter for altruism, because individuals know that their restraint has positive effects not only on the own generation, but also on all future generations to come. Our main working hypothesis, the *intergenerational altruism hypothesis*, is that in a typical CPR situation the extent of exploitation decreases as agents recognize that resource extraction not only creates negative externalities for the own generation, but also for all future generations. Hence, we expect to see lower extraction rates in an experimental CPR game with multiple interlinked generations, than in the standard single generation CPR settings.

We introduce a new experimental design that allows us to compare treatments with and without an intergenerational link, while keeping constant the strategy space, the Nash equilibrium, and the strategy combinations corresponding to the intragenerational social optimum. As usual, the Nash equilibrium exploitation in our CPR game is well above the socially optimal level. In our main treatment, 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. As in most models of naturally occurring CPRs, the growth rate of the resource in our main treatment is too low as to compensate for equilibrium exploitation (Pearce and Turner 1990).

This means that the resource stock is not sustained, if every generation extracts the equilibrium quantities. Since the resource grows slower than it is exploited in equilibrium, we call our main treatment the *slow growth* treatment.

We compare behavior in the slow growth treatment to two controls. On the one hand, we look at a setting in which no intergenerational link exists. Since all parameters in every generation of this static control treatment are exactly the same as the initial parameters in the slow growth treatment, we call this setup the *restart* treatment. On the other hand, we examine a setting in our second control treatment, in which the natural growth of the common pool resource overcompensates the total equilibrium exploitation of the appropriators. Hence, we call this control the *fast growth* treatment.

While the intergenerational altruism hypothesis predicts higher CPR appropriation in the restart treatment than in either of the treatments with an intergenerational link, we expect the effect to be especially strong in the slow growth treatment, in which the resource is inevitably depleted if subjects show no altruistic restraint. In contrast, the restraining effect of the intergenerational link may not be very strong in the fast growth treatment, since even equilibrium behavior leaves more resources to the future generations than were available to the current generation.

An alternative hypothesis is based on the growing literature on equity preferences. There is ample experimental evidence that subjects take costly actions in order to enhance the equitable distribution of income (Fehr and Schmidt 1999; Bolton and Ockenfels 2000). Thus, we conjecture that subjects may intend to equalize payoffs across generations. In the case of the slow growth treatment, this *intergenerational equity hypothesis* simply implies restraint in extraction, just as altruistic preferences would. In the case of the fast growth treatment, however, altruism towards later 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. The possibility to disentangle altruistic and equity preferences is the reason we introduce the fast growth control.

The strict equity principle discussed above implies that subjects are actually willing to incur a cost to destroy income opportunities of future generations. Although this type of destructive behavior has been observed in many other experiments, it seems quite extreme in the intergenerational context.[2] A weaker intergenerational equity principle that is frequently discussed (Solow 1974; Riley 1980; Pezzey 1992, 1997; Arrow, Cline, Mäler, Munasinghe, Stiglitz 1995) is based on the notion of *sustainable development* maintaining that consumption opportunities of future generations should be *at least* at the same level as consumption today, but not ruling out higher future consumption levels.[3] The combination of our main treatment and the two controls enables us to check for the hypothesis that subjects' behavior is guided by the principle of sustainable development (*sustainable development hypothesis*). If this is the case, we will observe extraction levels that are lower in the slow growth than in either of the two control treatments. But, we should not detect a difference in the extraction levels when comparing the fast growth to the restart treatment, because choosing lower extraction levels in the fast growth treatment helps future generations that are better off anyway.

In addition to the extraction decisions, we elicit 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 the subjectively optimal amount. Since we have no reason to believe that the expectations will not be aligned with the actual behavior, our altruism hypothesis implies that intentional sacrifices will be observed to a greater extent in the treatments with an intergenerational link – especially in the slow growth treatment – than in the restart treatment. The (strict) equity hypothesis implies that subjects in the fast growth treatment should expect intentional and costly resource destruction, while the sustainability hypothesis implies that no sacrifices are predicted in the fast and restart controls.

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[2] In ultimatum game experiments, for example, in which the proposer offers a fraction of a fixed sum of money to the receiver, subjects in the receiver position often destroy the entire cake by rejecting the offer if it is perceived as unfair (Güth, Schmittberger, Schwarze 1982; Camerer and Thaler 1995). Similar behavior has also been observed in other games (Fehr and Gächter 2000; Abbink, Irlenbusch, and Renner 2000; Bosman and van Winden 2002; Falk, Fehr, and Fischbacher forthcoming). Note that this type of purely destructive behavior is different from the strategic destruction behavior that is meant to increase the own income opportunities. Mason and Polasky (1994), for example, present a model in which an incumbent extractor may choose to destroy part of a common pool resource in order to deter entry of new extractors.

[3] The Brundtland Report, "Our Common Future", (United Nation's World Commision on Environmental and Development 1987) defines "sustainable development" as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Following up on this, the United Nations Conference on Environment and Development (Rio de Janeiro, 3-14 June 1992) states the goal: "Principle 3 - The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations." Clearly, the model we implement in our experiment abstracts from many of the measurement and comparison difficulties that arise in real world settings. It is this simplification, however, that enables us to draw unambiguous conclusions from the observed behavior.

We find that in all treatments actual extraction is below the Nash equilibrium level, but well above the symmetric social optimum. This reluctance to fully exploit the resource has also been observed in earlier experiments with single generation CPRs.[4] We observe significantly lower exploitation levels in the fast growth treatment than in the restart treatment. This observation contradicts both the intergenerational equity and the sustainability hypotheses. It is, however, in line with our intergenerational altruism hypothesis. But, intergenerational altruism also does not seem to be fully supported by our data either, because the observed extraction levels in the slow growth treatment are not significantly smaller than those in the restart treatment. This is an especially surprising result, since all three hypotheses predict lower extraction levels in the slow growth treatment than in restart.

The analysis of the subjects' predictions of others' behavior sheds some light on this puzzling result. In the two treatments with an intergenerational link, subjects expect significantly less extraction by their peers than in the restart treatment. Hence, in subjects' expectations the intergenerational altruism hypothesis holds, i.e. just as we had, our subjects also expected to see greater restraint in extraction behavior in the presence than in the absence of an intergenerational link. While the majority of subjects in the fast growth and the restart treatments actually live up to what they expect from others, the majority of subjects in the slow growth treatment appropriate more of the resource than they expect others to do.[5] Since the intergenerational growth rate is the only difference between treatments, we must conclude that the awareness of the difficulty to sustain a resource over generations destroys the positive effect of the intergenerational link on expectations by increasing the free-riding intentions. Hence, our initial hope that an intergenerational link may mitigate the overexploitation problem of a common pool resource was in vain.

The discrepancy we find between subject's expectations and their appropriation behavior suggests that people's expressed understanding for the need of restraint in intergenerational resource use does not necessarily imply that they will take the corresponding actions. Thus, it

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[4] In some of the reported single generation cases, observed extraction converges to the level predicted by the Nash equilibrium with repetition of the game. However, the mean extraction always tends to be somewhat below rather than above Nash levels (e.g. Walker, Gardner, and Ostrom 1990, Keser and Gardner 1999).

[5] We thank an anonymous referee for pointing out that the individual CPR appropriations in our game are strategic substitutes, which means that expecting low extraction from others results in incentives to increase own extraction. Note that while observed behavior in our main treatment is in line with this prediction, it is not in line with the observed behavior in the fast growth control, in which lower expected appropriation by others does not result in choosing higher own levels of resource extraction.

seems that the sustainable use of common pool resources should not be expected on a purely voluntary basis, even if surveys indicate a broad awareness and approval of the principle of sustainable development in the population.[6]

The rest of the paper is organized as follows. In section 2, we briefly discuss some of the related literature. In sections 3 and 4 we present the game and the theoretical predictions. In sections 5 and 6 we report on the experimental setup and procedure. Our results are presented in sections 7, 8, and 9. Section 10 summarizes and concludes.

2. Related Literature

The experiments that come closest to our design are by Chermak and Krause (2002), by Sadrieh (2003), by Herr, Gardner, and Walker (1997), and by Mason and Phillips (1997). Chermak and Krause (2002) report an overlapping generations CPR experiment, in which each of the three players enters the game with a one period delay and lives for three periods. In the informed treatment, players know their positions, while in the uninformed treatment they do not. The focus of the paper is on detecting correlations between personal traits of the subjects (gender, religion, political standing, etc) and their resource exploitation behavior. One interesting aspect of the results is that the information treatment plays a significant role for many of the detected effects. For example, subjects with no religious affiliation show significantly more restraint when they are informed than when they are not. It seems that the information is important, because it reveals the instance of the decision within a player's "lifetime," as well as the position of the player in the finite game. Both of these variables play no role in our experiment. First, our players "live" only a single period and, thus, have no dynamic programming problem. Second, our design masks both the length of the intergenerational chain and the position of a player therein. Finally, every period in our game consists of the same intragenerational CPR game with three players, while the periods in the Chermak and Krause (2002) design consist of different "stage" games with different numbers of active players. Especially, about half of the periods are one-player games and not intragenerational CPR games.

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[6] In a recent representative survey commissioned by the German ministry of environmental affairs, 78 percent of the interviewed individuals expressed their approval to the statement "We should not use more of the resources than regenerate." (Kuckartz and Grunenberg 2002)

Sadrieh (2003) examines the case of an intergenerational CPR game in which every generation is represented by a single player. No intragenerational conflict exists, because each period is a one-shot, one-player game in which the player makes a single extraction decision. As in our experiment, the growth rate of the CPR is varied across treatments. The main interest of that study is to uncover the structure of intergenerational altruism that motivates restraint in extraction behavior. It turns out that a simple form of “warm glow” altruism, as suggested by Andreoni (1990, 1995), organizes the data well, while the benchmark of intergenerational equal opportunities plays no role. Our results are consistent with these findings. Specifically, our experiment confirms that subjects behavior is not at all guided by the desire to create strictly equal opportunities for all generations.

The game experimented by Herr, Gardner, and Walker (1997) is not an intergenerational CPR game, but a dynamic CPR game in which the players exploitation behavior in early periods influences their own cost of exploitation in later periods. Their main result is that the myopic behavior of subjects in the dynamic setting exacerbates the tragedy of the commons problem. Mason and Phillips (1997) investigate the effects of limiting the number of firms that exploit a static or a dynamic single generation CPR. Their experimental design that implements indefinitely repeated play in a Cournot market is conducive to cooperation. They analyze the trade-off between the welfare loss from the increased exploitation of the CPR and the welfare gain from the increased competition if the number of active firms in the market were increased. They find that in their static CPR setting cooperation levels are higher than in their dynamic setting, especially in markets with few firms. Hence, they conclude that increasing the number of firms in the static CPR setting is more likely to be beneficial for welfare than in the dynamic setting, in which the CPR is exploited more aggressively. Thus, there is more evidence for the tendency of resource dynamics to aggravate the over-exploitation problem. The shared element of both studies with our experiment lies in the dynamics of resource growth, but their strategic situation is different from ours since our players can exploit the resource only at a single point of time.

3. The Basic Common Pool Resource Model

In the basic model, a common resource is exploited by three symmetric players, each endowed with e units of effort. Each player i chooses the effort x_i to be exerted in exploiting the common resource with $0 \leq x_i \leq e$.[7] The total exploitation effort x (i.e. the sum of all three players' exploitation efforts) determines the production of the common resource.

Following the literature on common resources (Dasgupta and Heal 1974; Ostrom, Gardner, and Walker 1994), we assume that the production function $F(x)$ is "hump" shaped, i.e. it is concave with its maximum within the range of players' endowments. Hence, $F(0) = 0$, $dF(x^*)/dx = 0$ with $0 < x^* < ne$, and $d^2F(x)/d^2x < 0$. To simplify the computations, we mimic the "hump" shape using a two-piece linear function, with a positive slope in the first and a negative slope in the second part:

$$F(x) = \begin{cases} 0.6x & \text{if} \quad 0 \leq x \leq 9 \\ 8.1 - 0.3x & \text{if} \quad 9 \leq x \leq 24 \end{cases} \tag{1}$$

Since the marginal rate of return is greater than zero for $x < 9$, but smaller than zero for $x > 9$, it is obvious that the social optimum is exactly at $x = 9$ (remember that we assume that the marginal rate of return from the best alternative activity is zero). Thus, the social optimum with symmetric exploitation effort choices is reached when each player i chooses $x_i = x^{SO} = 3$.

A single player's return on the exploitation of the common resource depends both on the own choice and the choices made by others. More specifically, the fraction of the total return of the common resource that player i receives is defined by the ratio of the own exploitation effort x_i to the total exploitation effort x. Equation (2) specifies the return of player i.

$$r_i(x_i) = \frac{x_i}{x} F(x) = \begin{cases} 0.6x_i & \text{if} \quad 0 \leq x \leq 9 \\ 8.1\left(\dfrac{x_i}{x}\right) - 0.3x_i & \text{if} \quad 9 \leq x \leq 24 \end{cases} \tag{2}$$

Note that the marginal return of a single player from exploiting the common resource is constant and positive as long as total exploitation is below social optimum, i.e. $x < 9$. In this range, players' exploitation actions do not cause negative externalities for the others. When total exploitation surpasses the social optimum, i.e. $x > 9$, the marginal return of exploitation to a player is no longer constant, due to the negative externality caused by the other players'

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[7] The remaining effort, $e - x_i$, is exerted in some other "safe" activity with a return normalized to zero.

exploitation actions. It is easily verified that in symmetric Nash equilibrium each player i chooses an exploitation effort $x_i = x^{Nash} = 6$ which is well above the socially optimal level.[8]

4. The Intergenerational Common Pool Resource Model

When a resource is exploited by one generation after another, the payoff of the exploitation effort depends on the extent of exploitation by previous generations and the natural rate of resource growth. Thus, in an intergenerational framework, the availability of the resource at the time of exploitation must be modeled explicitly. To do so, the basic model described in the previous section is modified in a very simple way: We introduce a new variable R^t ("the reserves of the generation t") that is a measure for the amount of resources that are available to the generation t. The payoff of player i in the generation t is defined as

$$\pi_i = r_i R^t \tag{3}$$

The basic model's return r_i is now interpreted as the fraction of the resources that player i receives. Thus, in terms of relative payoffs (relative to the exogenously determined reserves R^t), every generation plays exactly the same basic game. The only parameter that may change from generation to generation is the amount of resources available to the generation. This then determines the absolute level of payoffs.

Since marginal returns are not affected by any change in the amount of available resources, equilibrium behavior always remains unchanged across generations. However, absolute income opportunities can dramatically vary, depending on the extent of preceding generations' exploitation and on the rate of natural growth. If the players in a generation aim at providing the next generation with exactly the same income opportunities as they have themselves, it is necessary that they make exploitation effort choices that just compensate the natural growth of the resource. Such *growth compensating* behavior is focal, because the provision of equal opportunities is often viewed as a basic fairness norm.

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[8] Maximizing the first part of the payoff function leads to (symmetric) choices of $x_i = x^{SO} = 3$. This, however, is not an equilibrium, because every player has an incentive to increase the own exploitation effort, given the others stay at x^{SO}. Hence, the equilibrium must be in the upper range of the return function. In that range, the derivative of the return function is $\frac{dr_i}{dx_i} = 8.1\left(\frac{x - x_i}{x^2}\right) - 0.3$ and the first order condition $x_i = -\sum_{j\neq i} x_j + \sqrt{27\sum_{j\neq i} x_j}$ is satisfied for all $i = 1, 2, 3$ at the symmetric Nash equilibrium $x_i = x^{Nash} = 6$. Note that the second order condition is always satisfied as long as all players choose strictly positive effort levels.

Clearly, 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. But, if the resource grows faster than the equilibrium exploitation can offset, growth compensation requires that players choose exploitation efforts above equilibrium level. Thus, if behavior is affected by a growth compensation norm, then a variation of growth rates should lead to systematic differences in exploitation effort choices.

5. Experimental Setup

In our experimental conditions we vary the growth rate of the resource, while keeping all other parameters equal. In the *fast growth* treatment (FAST) the common resource has a natural growth rate of 1.875. Taking the exploitation effort into account, the reserves R^t in FAST develop according to equation (4). As is easily verified, growth compensation requires that total exploitation effort is $x = 21$. This can, for example, be attained with symmetric effort choices of $x_i^{GC} = 7$.

$$R^{t+1} = \left(1 - \frac{1}{24}\left(x^t - 21\right)\right)R^t \tag{4}$$

In the *slow growth* treatment (SLOW) the common resource has a natural growth rate of 1.25. Taking the exploitation effort into account, the reserves R^t in SLOW develop according to equation (5). Growth compensation in SLOW is achieved with a total exploitation effort of $x = 6$, which implies $x_i^{GC} = 2$ for the symmetric case.

$$R^{t+1} = \left(1 - \frac{1}{24}\left(x^t - 6\right)\right)R^t \tag{5}$$

Finally, we conduct a control treatment (RESTART) with no intergenerational links, which means that every generation starts with exactly the same resource endowment as presented in equation (6). Thus, in RESTART equal income opportunities are present *per se*, leaving behavior completely unaffected by growth compensation issues.

$$R^{t+1} = R^t \tag{6}$$

Table 1 summarizes our experimental setup. Our treatments are identical concerning the social optimum and the Nash equilibrium benchmarks. They differ only in the growth compensation benchmark. Note that growth compensation in FAST implies exerting greater exploitation effort than in Nash equilibrium and in social optimum, i.e. $x^{SO} < x^{Nash} < x^{GC}$ in FAST. On the other hand, growth compensation in SLOW implies exerting less exploitation effort than in Nash equilibrium and in social optimum, i.e. $x^{GC} < x^{SO} < x^{Nash}$ in SLOW.

Table 1 also indicates that each treatment was experimented with 4 independent *intergenerational chains* each consisting of 4 *generations*. In each generation there are three subjects playing the basic common pool resource game. The game is a proper one-shot non-cooperative game, because subjects interact anonymously and each subject is part of only one generation and makes exactly one exploitation effort choice.

Table 1 – Experimental Setup

	symmetric choice at				
Treatment	social optimum x_i^{SO}	Nash equilibrium x_i^{Nash}	growth compensation x_i^{GC}	chains	generations per chain
FAST	3	6	7	4	4
SLOW	3	6	2	4	4
RESTART	3	6	–	4	4

The reserves of the first generation in an intergenerational chain were set to $R^1 = 183$ in experimental currency units for all chains and for all treatments. For all other generations, the reserves are calculated according to the equations (4) – (6), depending on the treatment. This means that $R^t = 183$ for all four generations of each of the four intergenerational chains of the RESTART treatment. In the other two treatments, the reserves available to a non-initial generation are determined by the exploitation effort choices of the preceding generations in the intergenerational chain.

It is important to note that every generation plays a one-shot game, not knowing of the own position within the intergenerational chain and having no information on the exploitation effort choices made by the subjects in the preceding generations. Furthermore, the subjects could not infer their generation's position from the size of their reserves, because of three reasons. First, we deliberately chose the initial generation's reserve to be unrecognizable as a "starting number," i.e. instead of choosing a multiple of 50, such as 100, 150 or 200, we chose the number 183.[9] Second, no information whatsoever was given on the size of the reserves of the initial generation. Third, the only information that subjects were given concerning the length of the intergenerational chains was that these are finite.[10]

Since from a subject's point of view, any generation could have been the initial, the final, or an intermediate generation, the absolute value of the reserves is the only variable that might have a differentiating effect on the generations' behavior within a treatment. As reported in the results section below, we do not find any correlation between the value of the reserves and the decisions made by the subjects. Hence, we can treat each generation in our experiment as an independent observation of the one-shot basic game.

6. Experimental Procedure

The experiment was conducted at three different locations around the law school and the cafeteria of the University of Bonn. The locations were well apart as to avoid contact between subjects at the three different points. Students walking in and out of the buildings were encouraged to participate. Participation was restricted to one instance only. About 160 subjects took part in the experiment.

The subjects were informed that the number of generations is fixed and limited. They, however, neither knew the actual number of generations in an intergenerational chain, nor which position their generation had in the chain. Towards the end of the experiment subjects could have noticed that the number of new subjects being recruited has dropped. To avoid difficulties with uncontrolled effects concerning the last generations of subjects, the data from the last groups has been omitted from the analysis. This leaves us with 144 subjects in four chains of four generations for each of the three treatments.

Each subject was seated in a separate "cubical" that we had set up by placing wooden dividers on desks. The subjects were told to study the instruction sheet and the decision sheet (see the appendix) carefully, before making their decisions. Any questions concerning the rules of the

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[9] Note that the value of the reserves was rounded to the next integer for all generations.

[10] To avoid any contamination of the data, we do not use the data from the very last chains of our experimental session. The subjects in these last 10 to 15 minutes of the experiment may have believed that they are in one of the last generations, if they had noticed that only few new recruits are coming in.

game and the experimental procedures were answered by the experimenters. Subjects on average spent about 15 minutes for the entire procedure. The experiment took 4 hours.

The instructions made clear that none of the other recruits currently at the location would be in the same game as the subject making a decision. This was realized by having each of the three members of a generation at a different location. Additionally, multiple intergenerational chains were intertwined so that subsequent decision makers at each location always belonged to different chains.

Exploitation effort choices were restricted to the integers {1, ..., 8} in all treatments. The decision sheets (see appendix) present tables with 8 rows (own effort choices) and 15 columns (the sum of the effort choices of the other two players). Each cell in a table contains two entries. The top entry in a cell represents the return r of the exploitation effort indicated on the left of the corresponding row, given the sum of the other players' choices is equal to the number shown on top of the corresponding column. The displayed returns are percentages of the current generation's reserves R^t that was recorded in a box on the top right corner of the decision sheet before the subject received the sheet.

The bottom entry in each cell of the table on the decision sheet represented the effect of the exploitation effort choices of the own generation on the reserves R^{t+1} of the following generation. The numbers indicate the percentage by which the current generation's reserves R^t are increased or decreased in order to obtain the following generation's reserves R^{t+1}. Since our treatments only differed in the effect of choices on future generations, the decision sheets given to subjects only differed in the bottom entries.

In addition to the exploitation effort choice that had to be indicated on the decision sheet, each subject was also asked to guess the sum of exploitation efforts of the other players in the own generation. To ensure the validity of these guesses the subjects received an additional small payment that decreased linearly with the distance of the guess from the actual choices. For a perfect guess a subject received 20 Taler (the experimental currency unit), from which one Taler was deducted for each effort unit deviation. After completing the experiment, each subject's earnings were converted at the rate of DM 0.05 per Taler. Average earnings were about DM 12.62 including the payment for the prediction. At the time of the experiment, one DM was roughly equal to € 0.51 or to $0.44.

7. Results: Choices

Figure 1 shows the frequency distributions of exploitation effort choices in our three treatments. The mass of all distributions lies between the Nash equilibrium effort $x_i^{Nash} = 6$ and the symmetric social optimum $x_i^{SO} = 3$.

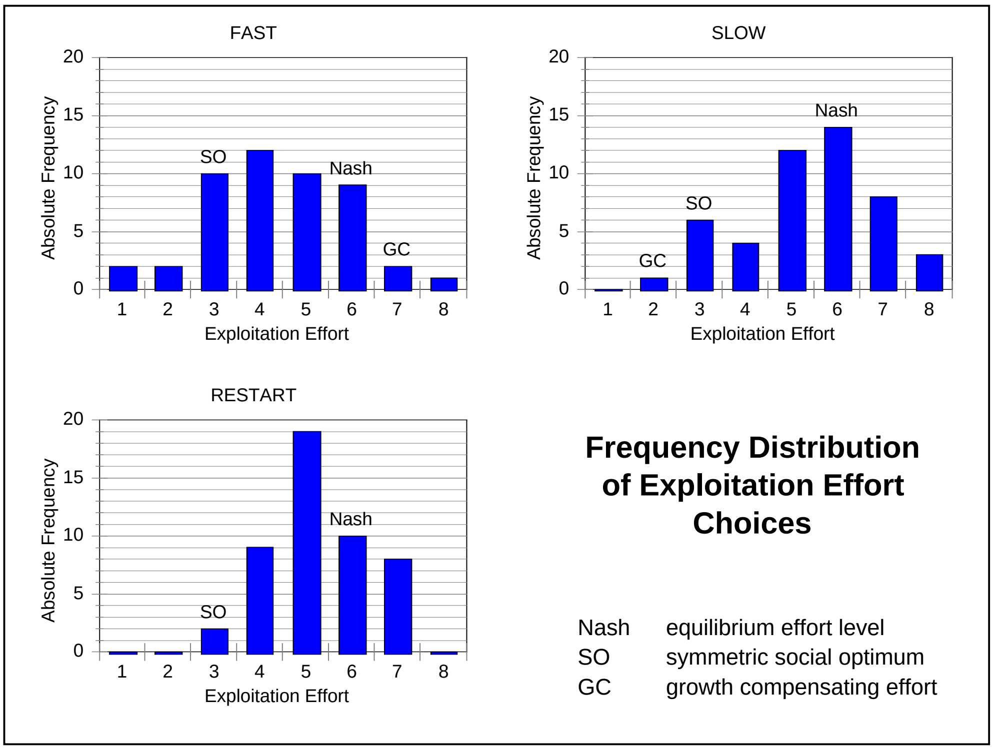

Figure 1 – Frequency distribution of exploitation effort choices

Table 2 contains the means and the standard deviations of the exploitation effort choices. With the mean of 4.38 and the mode at 4, exploitation effort choices in FAST are significantly smaller than in SLOW and in RESTART (Mann-Whitney U-Test at the .01 level two-tailed). Although the modes of exploitation effort distributions in the SLOW treatment and in the RESTART treatment are different (6 in SLOW vs. 5 in RESTART), no significant difference can be detected between exploitation efforts in the two treatments.

The means of the observed exploitation effort choices in all three treatments are significantly smaller than predicted by the Nash equilibrium $x_i^{Nash} = 6$ (Binomial Test at the .01 level two-tailed). While being smaller than in equilibrium, observed exploitation is significantly greater than expected in the symmetric social optimum $x_i^{SO} = 3$ in all three treatments (Binomial Test at the .01 level two-tailed). These results are summarized in table 3.

In the case of the two treatments with an intergenerational link, we can compare observed data also to the growth compensation benchmark. As can be seen in the last row of table 3, observed exploitation effort choices are significantly smaller than the growth compensation effort $x_i^{GC} = 7$ in the FAST treatment, while they are significantly greater than the growth compensation effort $x_i^{GC} = 2$ in the SLOW treatment.

Table 2 – Observed Exploitation Effort Choices

	FAST	SLOW	RESTART
mean	4.38	5.42	5.27
SD	1.52	1.47	1.09

Exploitation effort choices in FAST are significantly smaller than in SLOW and in RESTART (Mann-Whitney U-Test, .01 level two-tailed). There is no significant difference (not even on the .20 level two-tailed) between the latter two.

Summarizing, we find that observed exploitation effort levels are significantly below the Nash equilibrium level and above the symmetric social optimum in all treatments. While this indicates that subjects in all treatments were willing to restrict personal exploitation in favor of mutual cooperation, they did not manage to fully arrive at the symmetric social optimum. Furthermore, we find no evidence whatsoever for growth compensating behavior, which would imply that subjects restrict their exploitation efforts in the SLOW, but expand them in the FAST treatment. Instead, subjects in FAST actually restrict their efforts significantly more than the subjects in SLOW. Since the growth rate is the only difference between the two intergenerational treatments, we must conclude that the awareness of the difficulty to sustain a resource over generations – such as in SLOW – generates less restraint than the knowledge that the resource is easily increased over generations – as in FAST. It is conceivable, for example, that subjects' perception of the payoff information table (see appendix) was influenced by the fact that in FAST the table only contains positive entries for the generation to generation resource development, while the corresponding table in SLOW mainly contains negative entries. Such perception biases ("framing effects") have been reported occasionally in experiments with other decision tasks (Tversky and Kahneman 1981). Finally, it should be noted that the difference in restraint cannot be due to a simple wealth effect, because we find no significant correlation between the size of the endowment and the extent of restraint.

Table 3 – Treatment to Benchmark Comparisons of Exploitation Effort Choices

Benchmark	FAST vs. Benchmark	SLOW vs. Benchmark	RESTART vs. Benchmark
Nash equilibrium ($x_i^{Nash} = 6$)	< ***	< ***	< ***
symmetric social optimum ($x_i^{SO} = 3$)	> ***	> ***	> ***
growth compensation (FAST: $x_i^{GC} = 7$; SLOW: $x_i^{GC} = 2$)	< ***	> ***	— —

Binomial Test comparing observed efforts to the benchmark cut points; significance levels: *** = .01 two-tailed

8. Results: Predictions and Intentions

The subjects in our experiment received incentive compatible payments for accurately predicting the sum of the exploitation efforts of the other two participants in their own generation. Figure 2 shows the frequency distribution of subjects' predictions in each of the three treatments. A clear difference between the distribution of the predictions made in each treatment is evident. While subjects in FAST expect their peers to be very cooperative (almost one third of the subjects actually expect to see others choosing the symmetric social optimum), the subjects in SLOW have very dispersed beliefs that tend to be closer to the equilibrium levels than in FAST. The beliefs of subjects in RESTART are less dispersed, but seem to be even closer to equilibrium than in SLOW.

The mean and the standard deviation of subjects' predictions, shown in table 4, support this impression. Predictions both in FAST and SLOW are significantly smaller than subjects' predictions in RESTART (Mann-Whitney U-Test – at .02 and .10, two-tailed). It seems that the mere presence of an intergenerational context – as in the case of the FAST and the SLOW treatments – evokes subjects' expectations of observing others' altruistic behavior (i.e. smaller exploitation effort choices). Note, however, that the intergenerational aspect adds to the expectation of cooperative behavior that is already present in absence of a intergenerational link. In all three treatments, i.e. including RESTART, the predicted sum of others' exploitation effort choices is significantly smaller than in Nash equilibrium (Binomial Test – at .01 two-tailed – when comparing predictions to the value 12, which is the sum of others' effort choices in Nash equilibrium).

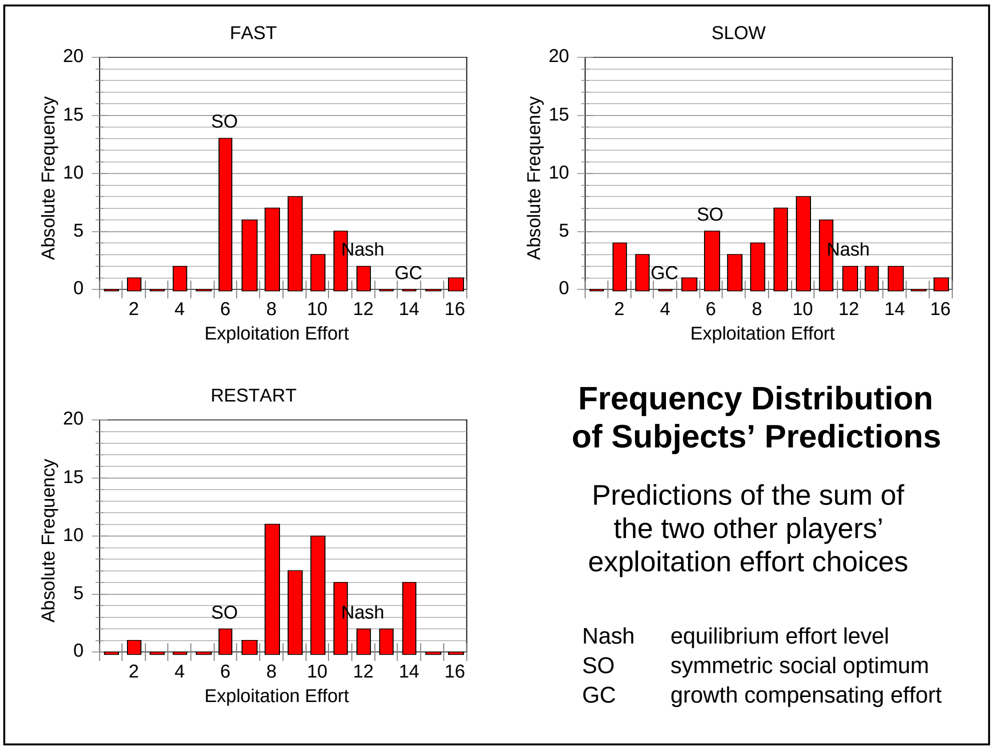

Figure 2 – Frequency distribution of subjects' predictions

One might conjecture that subjects' exploitation effort choices are simply best replies to the own miscalibrated predictions of others' behavior. If this is the case, then we can assert that subjects actually intend to maximize their own monetary 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").

It is obvious that most subjects do not intend to play monetary payoff maximizing best reply strategies. The majority of subjects in all three treatments choose an exploitation effort level that is too low compared to the best reply to their own prediction. The figures in table 4 show that the discrepancy between the best reply to the prediction and the actual effort choice is significantly negative in all treatments. This means that subjects in all three treatments intend to sacrifice some of their payoff for the well-being of others. The intended sacrifice is significantly greater in FAST than in either of the two other treatments (Mann-Whitney U-Test at $\alpha = .01$ two-tailed) both in relative terms (i.e. in percent of the available funds) and in absolute terms (i.e. sacrifice in €). On average, subjects in FAST intend to sacrifice about € 2, while subjects in SLOW and RESTART intend to sacrifice only about € .25. No significant difference can be detected between SLOW and RESTART. We are confident that the observed sacrifices cannot be fully attributed to confusion, because the subjects could simply look up the best response to any given prediction in the provided payoff table. Given this transparency of the decision situation, we believe that our subjects made deliberate and informed choices.

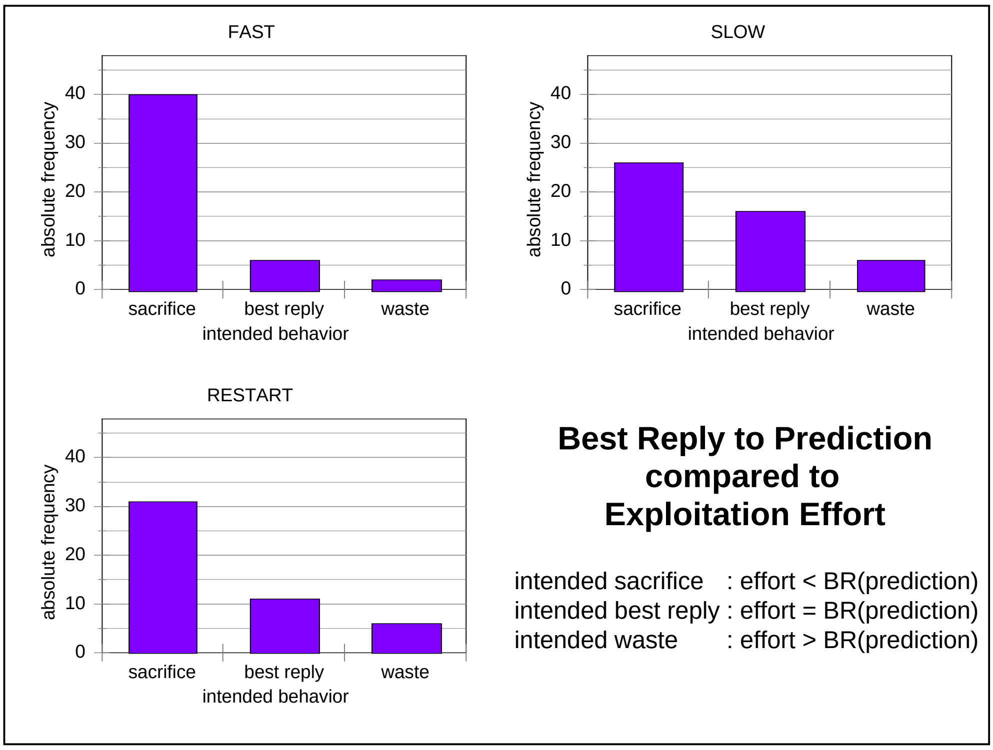

Figure 3 – Best reply to own prediction compared to own exploitation effort choice

Figure 3 suggests that there might also be some treatment differences concerning the frequency the best reply behavior. It seems that best reply choices are most frequently observed in the SLOW treatment, while smaller than best reply choices are most frequent in the FAST treatment. These treatment differences, however, are not significant.

Most subjects expect the others' in their generation to behave cooperatively and intend to be cooperative themselves. But, is there a consensus[11] between the extent of the own cooperation and the cooperation expected from the others? Table 4 shows that the difference of the own exploitation effort choice minus the effort choice expected of the others is almost zero in the FAST and the RESTART treatment, but not so in the SLOW treatment. Only in the SLOW treatment the own exploitation effort choices are significantly different (greater) than the exploitation effort expected from others.

Table 4 – Predictions of the sum of others' exploitation effort choices

	FAST	SLOW	RESTART
own effort minus best reply to the own prediction	– 2.33 *** (1.69)	– 1.02 *** (1.79)	– 1.06 *** (1.46)
own effort minus predicted average effort	.39 (1.74)	1.17 * (2.03)	.35 (1.44)

Each cell contains the variable's mean and (standard deviation).

Significantly different from zero (Binomial Test) at α = * .10 two-tailed, *** .02 two-tailed

Note that the comparison between the own choice of exploitation effort and that expected of others reveals the intention of the behavior to some extent. If a subject chooses a lower exploitation effort than he or she expects from others, then this subject is intentionally being more altruistic than he or she predicts the others to be. We refer to this type of behavior as "intentional gift-giving." In contrast, if a subject chooses a higher exploitation effort than he or she expects from others, then this subject reveals the intention to take an advantage over the peers. We refer to this behavior as "intentional free-riding." Finally, subjects choosing exactly the same exploitation effort as they expect from others obviously intend to be in "consensus" with the others.

Figure 4 shows the distribution of the three possible types of intended behavior in each of our treatments. Looking at the figure is seems that the intended behavior distributions are rather similar in FAST and RESTART, but quite different in SLOW, where almost two-thirds of the subjects exhibit intended free-riding behavior. Statistical tests show that this impression is correct: There is significantly more intended free-riding in SLOW than in either of the two other treatments (Fisher's Exact Test both at the .05 level, one-tailed).

This analysis reveals an important difference between the treatments: When there is an intergenerational link, but subjects know that sustaining intergenerational equity requires a large amount of restraint (i.e. large sacrifices compared to the selfish equilibrium), the number of subjects who intentionally free-ride on their peers increases dramatically. It seems that subjects in such cases – such as in our SLOW treatment – greedily grab large chunks of the pie for themselves, hoping that their peers will behave strongly altruistic in light of the environmental difficulties. Since most subjects share this free-riding attitude, total

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[11] Expecting others to do as you do, even though they actually do not, is a well-known bias in judgement, often referred to as the *false consensus effect* (Ross, Greene, and House 1977).

exploitation efforts actually turn out rather high, so that a mismatch emerges between expectations and actions.

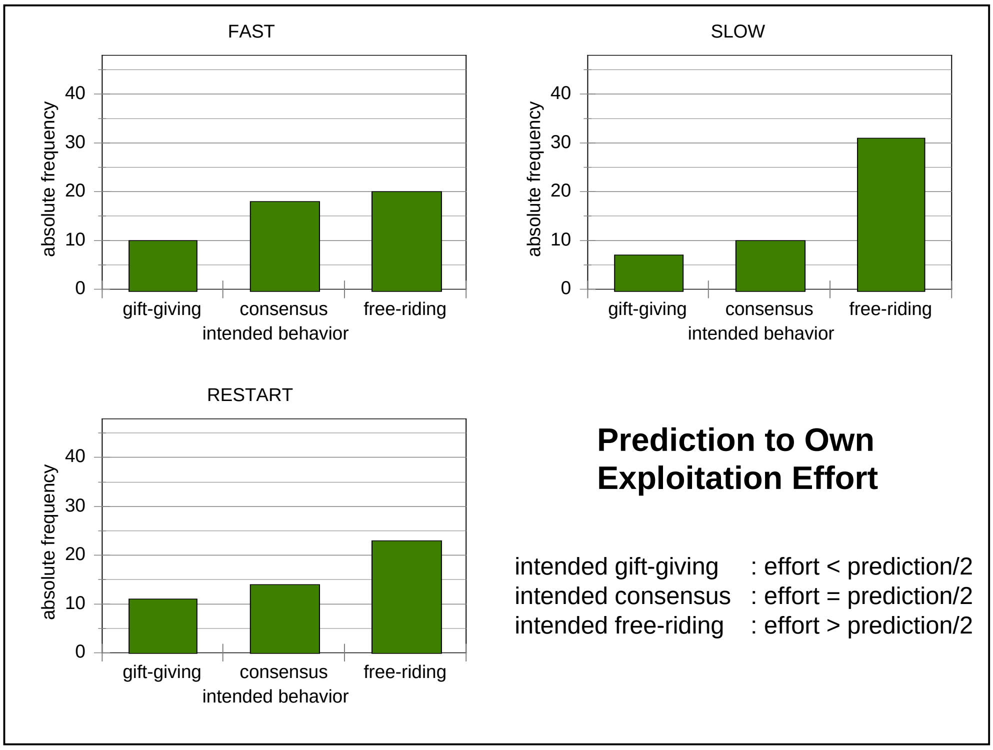

Figure 4 – Prediction to exploitation effort choices

Table 5 reveals that the expectations that subjects have about each others' cooperation are too "optimistic," i.e. the prediction of the exploitation efforts chosen by the others is smaller than the actually chosen. The deviations of the predictions from the sum of the actual efforts chosen by the others are significantly smaller than zero in all three treatments.

Table 5 – Predictions of the sum of others' exploitation effort choices

	FAST	SLOW	RESTART
prediction of the sum of others' efforts	7.98 (2.47)	8.50 (3.42)	9.83 (2.45)
prediction minus actual sum of others' efforts	– .77 ** (3.45)	– 2.33 *** (3.62)	– .71 *** (3.14)

Each cell contains the variable's mean and (standard deviation).

Predicted sum of others' effort choices both in FAST and in SLOW are significantly smaller than in RESTART (Mann-Whitney U-Test, .02 and .10 level, resp., two-tailed). The difference between the predictions in FAST and in SLOW is not significant (probably due to the high dispersion in SLOW).

Significantly different from zero (Binomial Test) at α = ** .05 two-tailed, *** .02 two-tailed

Prediction deviations in SLOW are significantly greater than in FAST and in RESTART. (Mann-Whitney U-Test, .05, two-tailed). The difference between the prediction deviations in FAST and in RESTART is not significant.

Figure 5 confirms that the majority of subjects in all three treatments are too optimistic. It also reveals that the distributions of optimistic and pessimistic subjects across treatments are quite similar. However, although the counts are similar, the extent is not. The extent of subjects' optimism is most exaggerate in the SLOW treatment, in which the average deviation of predictions from actual choices of others (shown in table 5) is about three times greater than in the FAST and in the RESTART treatments. This treatment difference proves to be statistically significant for both at the .05 level, two-tailed, using a Mann-Whitney U-Test.

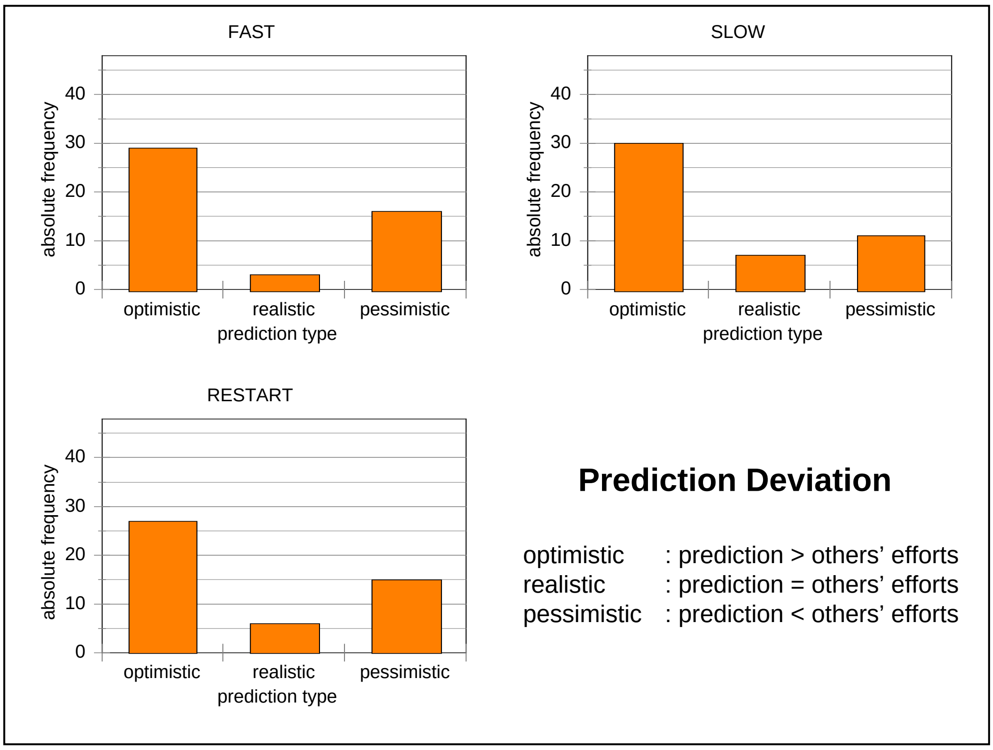

Figure 5 – Deviation of subjects' predictions from the actual behavior of the others

In the two treatments with an intergenerational link, subjects expect significantly less extraction by their peers than in the restart treatment. But, since expectations fall well below actual behavior in most cases, the majority of subjects are too optimistic in all three treatments. However, the extent of optimism in the slow growth treatment is about 3 times as high as in the two control treatments. This is due to two different effects. Compared to the fast growth control, the expectations in the slow growth treatment are similar, but the actual extraction levels are much greater. Compared to the restart control, the actual extraction levels in the slow growth treatment are similar, but the expectations on extraction by peers is much lower. Hence, in our main treatment we find strong evidence for *optimistic free-riding*, i.e.

subjects expect others to exercise more restraint in resource extraction than the others actually do (*optimism*) and than they themselves are willing to do (*free-riding*).

The result described above indicates that certain types of subjects may be predominantly driving the observed effects. Figure 6 shows the distribution of subject types across treatments. The nine possible types of subjects result from the interaction of the prediction types and intended behavior types. An OG subject, for example, has made a too optimistic prediction of the behavior of the others and has revealed the intention to be even more cooperative than he or she expects the others to be. The distributions displayed in figure 6 support the results so far. There is hardly a difference between the distributions of subject types in FAST and in RESTART. In these two treatments the distributions are relatively flat, with the most frequent type (OF = optimistic and intended free-riding) at about one-third of all subjects and the second most frequent type (OC = optimistic and intended consensus) at about one fourth of all subjects. In contrast, the distribution of subject types in SLOW is much more extreme, with almost half of the subjects being OF (optimistic and intended free-riding) and the next most frequent category being PF (pessimistic and intended free-riding) with only about one-eighth of all subjects.

Again, figure 6 underlines that the optimistic free-riding subject type (OF), that intends to free-ride on his or her peers, while optimistically over-estimating their willingness to act cooperative, dominates the SLOW treatment. We had expected that the intergenerational link will reduce exploitation efforts. This was not the case, since the exploitation efforts in SLOW lead to the same high levels as observed in RESTART. However, the subjects in SLOW (just as in FAST) shared our expectation, hoping that their peers will reduce exploitation. This is the expectation to action discrepancy that defines free-riding intentions. Wide-spread optimism is a natural consequence when – as in the SLOW treatment – a majority of individuals exhibits this type of intentional free-riding behavior.

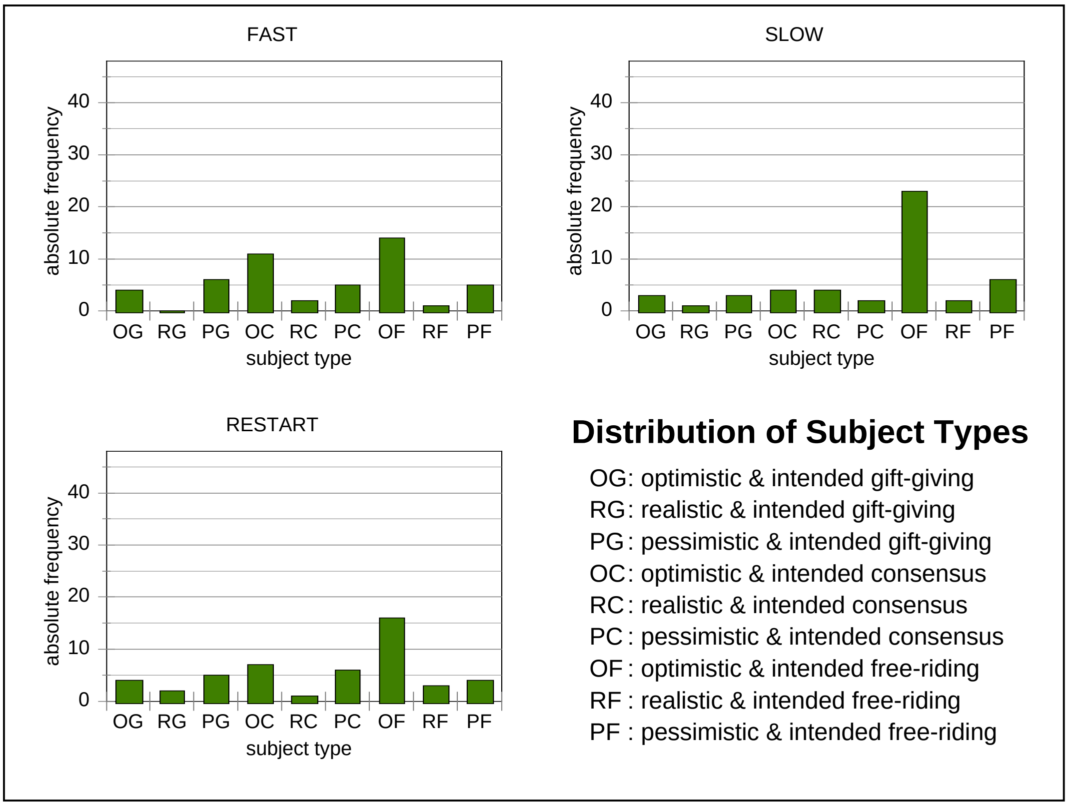

Figure 6 – Distribution of subject types

9. Summary and Conclusion

With this experiment we set out to test the hypothesis that the overexploitation of common pool resources may be lower than predicted by earlier experimental studies, because most of these experiments employ models in which the concern for future generations is screened out. Altruistic concern for future generations, however, may provide substantial incentives to constrain the exploitation of resources, because of leverage effect of the resource growth dynamics. The effects of any altruistic deviation from the sustainable extraction path are multiplied over innumerable future generations, turning a small sacrifice into a huge gift. In fact, a growing number of surveys provide evidence for a broad popular concern for the well-being of future generations. Especially, the approval ratings for concepts of intergenerational equity (such as the concept of “sustainable development”) have been on the rise (e.g. Kuckartz and Grunenberg 2002). Given the theoretical consideration and the empirical evidence, our initial conjecture that adding an intergenerational link to a standard common resource pool experiment will lead to reduced exploitation levels seemed plausible.

Unfortunately, however, our experimental results prove the hypothesis to be too optimistic. We do find clear and strong evidence that the presence of an intergenerational link affects subjects' expectations concerning the behavior of their peers. But, while expecting their peers to face up to the intergenerational responsibility, subjects do not reduce their own exploitation levels in the presence of an intergenerational link. Since considerable restraint in resource extraction is expected, yet only moderate restraint is practiced, the resource stock diminishes in a social climate of unjustified optimism.

Our subjects predict – just as we originally had – that intergenerational concern genuinely entails some potential for constraining resource extraction. Entertaining such beliefs in a common pool resource dilemma means that the expected opportunity cost of restraint increases, because the strategies in the game are substitutes, i.e. an increase of the own extraction is the best reply to others' reduction of extraction. Hence, while altruistic motives in the intergenerational setting seem to make restraint in extraction more attractive, financial incentives (matched with the wrong beliefs concerning the others) seem to support increased extraction. Notably, this financial incentive seems to offset the altruistic motive for most of the subjects in our main experimental treatment with slow growth, in which extraction levels are not lower than in the control treatment without an intergenerational link. The balance is opposite in our fast growth control treatment, in which the extraction levels are lower than in the main treatment, but the predictions of others' behavior is similar. Taken together these results show an especially high frequency of optimistic, but free-riding subjects in our main treatment. It seems clear that the intergenerational link, which we had hoped would mitigate the commons problem, does not help at all. In a way, it even worsens the situation compared to the case without an intergenerational link, by 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 common pools. The problem is severe, because none of the instruments that have been found to mitigate the overexploitation problem in intragenerational settings are readily available in intergenerational CPR management. Two-way pre-play communication, for example, that has been found to be a very effective means of enhancing efficiency in single-generation common pool resource extraction, is not available across generations. The same holds for the post-play punishment and repeated interaction. The actions we take today are *faît à complis* for the unborn generations of tomorrow, which have no means of communicating with us or administering a (repeated) penalty on us. Furthermore, our experimental results indicate that the broad popular support of intergenerational equity notions that are commonly found in polls are more likely to reflect the well-known support-a-good-cause-as-long-as-others-pay-the-bill attitude than a strong commitment to sacrifice substantial amounts of current consumption.

Even though our results seem very negative with respect to the intergenerational concern, we do see some light at the horizon. First, we find that subjects genuinely care about others, because the average extraction level is well-below the equilibrium levels in all treatments. Second, we observe that the intergenerational responsibility is actually recognized, even if subjects in our main treatment, obviously are hoping that others will face up to this responsibility. In our view, policies that make use of these two phenomenon can succeed in creating a favorable setting for sustainability. For example, environmental policy may be more successful, if the popular mood of the electorate is used to establish constitutional rights for future generations, before dealing with specific cases. This can have the advantage that voters, who – as in our experiment – may not willing to show enough restraint when their income is immediately affected, may – as the survey data indicates – nevertheless vote for a general rule. Such constitutional rights can then be used to emulate those mechanisms across generations that have proven valuable within a generation. They can, for example, implement a 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.

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Appendix 1 – Instructions

[The original instructions were in German. They are available upon request from the authors.]

Welcome to this experiment! Next to you, there are a number of other persons participating in this experiment. All participants are matched in groups of three. A number of these groups form a chain. A chain consists of a first, a last and an undisclosed number of intermediate groups. No participant is informed on the position of the own group within the chain.

An endowment is made available to the first group in the chain. Every other group receives the endowment that the preceding group in the chain has left over. Thus, the endowment is passed from one group to the next and develops according to the decisions in the chain. The payoff potential of a group depends on the endowment left to it. Apart from possible differences in endowment, the decision situation is identical for all participants in a chain.

The other two members of your group are simultaneously at other experiment locations on campus. The group preceding our group has already participated in the experiment. The succeeding groups will participate after you. The participants, who are currently at your experiment location are associated to other chains. Thus, you see no other member of your chain: neither from a preceding, nor from the current, nor from a succeeding group.

Decisions and payoffs in different chains are completely independent from each other.

The task of each participant is to choose one of the numbers 1, 2, 3, 4, 5, 6, 7 or 8.

The decisions in a group jointly affect the payoffs of the group members. The table printed on the decision sheet shows these effects on payoffs. All participants in your chain receive exactly the same table, but not necessarily the same endowment as you do. However, all three members of a specific group – also of your group – have the same endowment.

Every **white cell** in the table displays the possible payoff that you will receive, if you select the number in the corresponding row and the sum of the numbers chosen by the other two members of your group is the number of the corresponding column.

Please, note that the possible payoffs are given in percent of the current endowment. This means, that after every member of your group has made a decision, your payoff in "Taler" is determined as follows: if the respective entry in the table is *x*, then you receive *x*% of the current endowment.

The sum of the decisions in a group affects the endowment left for the succeeding group in the chain. The numbers in the **gray cells** of the table determine the way in which the endowment for the next group changes.

If the cell that is determined by the decisions contains "+/-0," then the endowment does not change. If a number *y* is indicated there, together with a "+", then the endowment is increased by y% for the succeeding group. If a number *y* is indicated there, together with a "-", then the endowment is decreased by y% for the succeeding group. The new endowment is calculated in this way and left for the succeeding group in the chain. The members of that group face the same decision situation as you do, except for the possibly changed endowment.

Furthermore, it is your task to mark your guess concerning the sum of the decisions of the other two members of your group.

The closer your prediction is to the actual decisions of the two other participants, the higher the bonus that you additionally receive. If your prediction exactly matches the actual decisions, you receive 20 Taler. If your prediction does not perfectly match the actual decisions, your bonus will be reduced by as many Talers as your prediction deviates from actual decisions.

After all members of your group have made their decisions, your payoff and your bonus will be calculated and paid to you in cash, using an **exchange rate of DM 0,05 per Taler**.

If you still have questions, please refer to one of our assistants.

We wish you success!

Appendix 2 – Decision Sheets

location

0

(current stock G)

Please, tick the box indicating your prediction of the sum of choices by the other participants.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
please tick here	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Please, choose one of the eight possibilities here.

my decision		the sum of the chocies made by the other participants in your group of three														
please tick below		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	[ ]	60	60	60	60	60	60	60	51	44	38	32	28	24	21	18
		+75	+71	+67	+63	+58	+54	+50	+46	+42	+38	+33	+29	+25	+21	+17
2	[ ]	120	120	120	120	120	120	102	87	75	65	56	48	41	35	30
		+71	+67	+63	+58	+54	+50	+46	+42	+38	+33	+29	+25	+21	+17	+13
3	[ ]	180	180	180	180	180	153	131	113	97	84	72	62	53	45	38
		+67	+63	+58	+54	+50	+46	+42	+38	+33	+29	+25	+21	+17	+13	+8
4	[ ]	240	240	240	240	204	175	150	129	111	96	83	71	60	51	42
		+63	+58	+54	+50	+46	+42	+38	+33	+29	+25	+21	+17	+13	+8	+4
5	[ ]	300	300	300	255	218	188	162	139	120	103	88	75	64	53	43
		+58	+54	+50	+46	+42	+38	+33	+29	+25	+21	+17	+13	+8	+4	+0
6	[ ]	360	360	306	262	225	194	167	144	124	106	90	76	63	51	41
		+54	+50	+46	+42	+38	+33	+29	+25	+21	+17	+13	+8	+4	+0	+4
7	[ ]	420	357	305	263	226	195	168	145	123	105	88	74	60	48	37
		+50	+46	+42	+38	+33	+29	+25	+21	+17	+13	+8	+4	+0	+4	+8
8	[ ]	408	349	300	258	223	192	165	141	120	101	84	68.6	54.5	41.7	30
		+46	+42	+38	+33	+29	+25	+21	+17	+13	+8	+4	+0	+4	+8	+13

my payoff in %
of the current G
x
y
change of the
stock for
the next group
of three in %
of the current G

% of G
equals
Taler
plus
20
minus
(prediction deviation)
equals
Taler
times
0.05 DM
equals
DM
personal
payoff

You are welcome to write any comments here:

Sheet 1) FAST treatment

location

0

(current stock G)

Please, tick the box indicating your prediction of the sum of choices by the other participants.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
please tick here	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Please, choose one of the eight possibilities here.

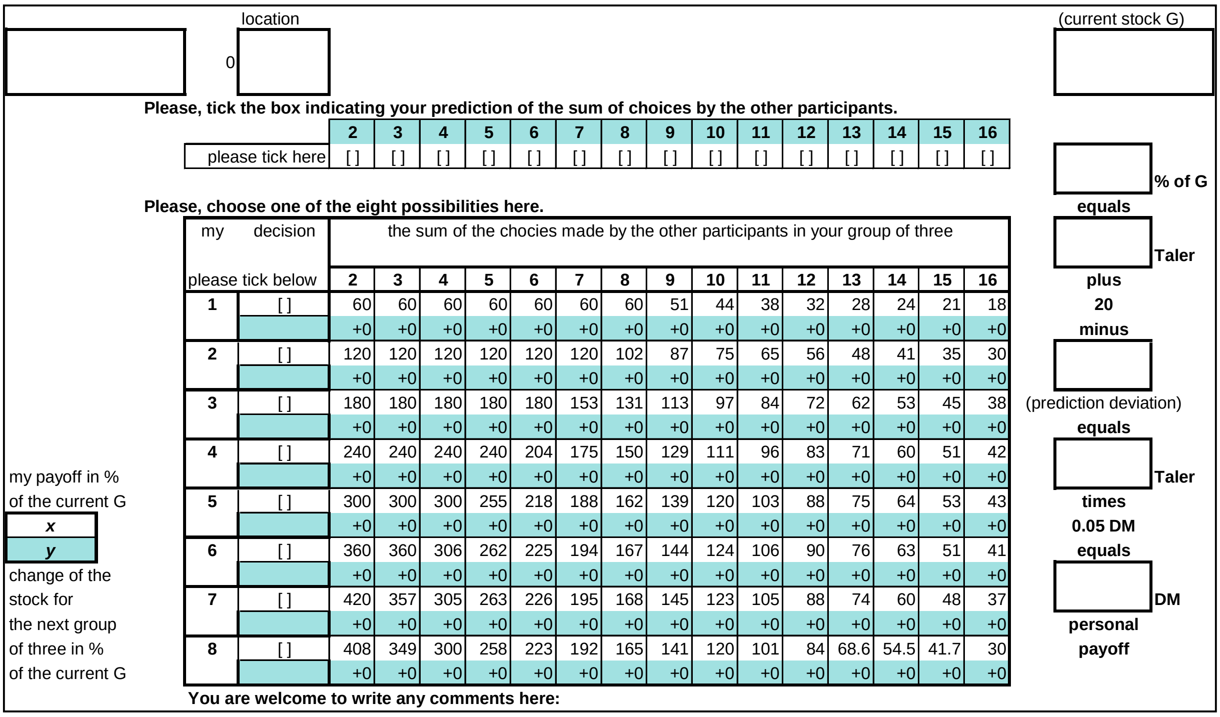
my decision		the sum of the chocies made by the other participants in your group of three														
please tick below		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	[ ]	60	60	60	60	60	60	60	51	44	38	32	28	24	21	18
		+13	+8	+4	+0	-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46
2	[ ]	120	120	120	120	120	120	102	87	75	65	56	48	41	35	30
		+8	+4	+0	-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50
3	[ ]	180	180	180	180	180	153	131	113	97	84	72	62	53	45	38
		+4	+0	-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54
4	[ ]	240	240	240	240	204	175	150	129	111	96	83	71	60	51	42
		+0	-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58
5	[ ]	300	300	300	255	218	188	162	139	120	103	88	75	64	53	43
		-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58	-63
6	[ ]	360	360	306	262	225	194	167	144	124	106	90	76	63	51	41
		-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58	-63	-67
7	[ ]	420	357	305	263	226	195	168	145	123	105	88	74	60	48	37
		-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58	-63	-67	-71
8	[ ]	408	349	300	258	223	192	165	141	120	101	84	68.6	54.5	41.7	30
		-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58	-63	-67	-71	-75

my payoff in %
of the current G
x
y
change of the
stock for
the next group
of three in %
of the current G

% of G
equals
Taler
plus
20
minus
(prediction deviation)
equals
Taler
times
0.05 DM
equals
DM
personal
payoff

You are welcome to write any comments here:

Sheet 2) SLOW treatment



location

0

(current stock G)

Please, tick the box indicating your prediction of the sum of choices by the other participants.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
please tick here	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Please, choose one of the eight possibilities here.

my decision		the sum of the chocies made by the other participants in your group of three														
	please tick below	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	[ ]	60	60	60	60	60	60	60	51	44	38	32	28	24	21	18
		+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0
2	[ ]	120	120	120	120	120	120	102	87	75	65	56	48	41	35	30
		+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0
3	[ ]	180	180	180	180	180	153	131	113	97	84	72	62	53	45	38
		+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0
4	[ ]	240	240	240	240	204	175	150	129	111	96	83	71	60	51	42
		+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0
5	[ ]	300	300	300	255	218	188	162	139	120	103	88	75	64	53	43
		+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0
6	[ ]	360	360	306	262	225	194	167	144	124	106	90	76	63	51	41
		+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0
7	[ ]	420	357	305	263	226	195	168	145	123	105	88	74	60	48	37
		+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0
8	[ ]	408	349	300	258	223	192	165	141	120	101	84	68.6	54.5	41.7	30
		+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0	+0

my payoff in %
of the current G

x
y

change of the
stock for
the next group
of three in %
of the current G

% of G
equals
Taler
plus
20
minus
(prediction deviation)
equals
Taler
times
0.05 DM
equals
DM
personal
payoff

You are welcome to write any comments here:

Sheet 3) RESTART treatment

Appendix 3 – Data

Table A2.1 – Data treatment FAST

Intergenerational Chain	Generation	Player 1			Player 2			Player 3			Endowment [DM]
		Decision	Prediction	Best Reply	Decision	Prediction	Best Reply	Decision	Prediction	Best Reply	
1	1	8	6	7	3	6	7	4	7	7	9.15
1	2	3	6	7	7	11	6	5	10	6	11.44
1	3	1	2	7	6	6	7	5	9	7	14.30
1	4	2	6	7	4	8	7	4	8	7	19.73
2	1	5	8	7	4	8	7	3	8	7	9.15
2	2	4	7	7	7	9	7	6	7	7	12.63
2	3	5	11	6	1	16	5	5	11	6	14.77
2	4	6	4	6	6	9	7	4	9	7	20.98
3	1	6	12	6	3	6	7	4	7	7	9.15
3	2	2	6	7	4	8	7	4	9	7	12.17
3	3	5	8	7	4	7	7	5	7	7	17.77
3	4	5	10	6	5	9	7	6	9	7	22.92
4	1	6	11	6	3	6	7	6	11	6	9.15
4	2	3	6	7	6	4	6	3	6	7	11.44
4	3	5	10	6	3	6	7	3	6	7	15.78
4	4	3	6	7	4	9	7	4	12	6	22.41

Table A2.2 – Data treatment SLOW

Intergene rational Chain	Gene-ration	Player 1			Player 2			Player 3			Endow-ment [DM]
		Decision	Pre-diction	Best Reply	Decision	Pre-diction	Best Reply	Decision	Pre-diction	Best Reply	
1	1	6	10	6	6	9	7	8	14	5	9.15
1	2	7	13	6	5	10	6	6	10	6	3.84
1	3	7	10	6	5	7	7	4	10	6	1.92
1	4	3	6	7	3	6	7	3	6	7	1.11
2	1	3	11	6	6	11	6	5	11	6	9.15
2	2	4	3	6	6	8	7	7	5	7	6.13
2	3	5	8	7	5	14	5	6	12	6	3.31
2	4	2	6	7	4	2	7	6	11	6	1.92
3	1	6	12	6	6	11	6	6	9	7	9.15
3	2	6	3	6	4	8	7	7	2	7	4.58
3	3	5	10	6	6	10	6	5	13	6	2.47
3	4	6	10	6	8	16	5	7	9	7	1.43
4	1	3	6	7	5	9	7	5	8	7	9.15
4	2	8	3	6	7	11	6	5	9	7	6.50
4	3	5	9	7	7	2	7	3	7	7	2.73
4	4	6	7	7	5	9	7	7	2	7	1.72

Table A2.3 – Data treatment RESTART

Intergene rational Chain	Gene-ration	Player 1			Player 2			Player 3			Endow-ment [DM]
		Decision	Pre-diction	Best Reply	Decision	Pre-diction	Best Reply	Decision	Pre-diction	Best Reply	
1	1	4	13	6	7	14	5	5	11	6	9.15
1	2	7	14	5	4	9	7	5	10	6	9.15
1	3	5	10	6	6	9	7	4	10	6	9.15
1	4	5	11	6	7	14	5	4	7	7	9.15
2	1	5	14	5	6	12	6	5	8	7	9.15
2	2	5	9	7	4	8	7	5	10	6	9.15
2	3	7	2	7	5	9	7	5	10	6	9.15
2	4	3	8	7	5	14	5	4	10	6	9.15
3	1	3	6	7	7	10	6	6	6	7	9.15
3	2	6	9	7	6	11	6	4	11	6	9.15
3	3	5	14	5	5	10	6	6	11	6	9.15
3	4	5	8	7	5	8	7	5	8	7	9.15
4	1	5	8	7	7	10	6	7	8	7	9.15
4	2	6	11	6	5	9	7	6	10	6	9.15
4	3	4	8	7	5	9	7	7	13	6	9.15
4	4	6	12	6	6	8	7	4	8	7	9.15