



HAL
open science

Taxation, redistribution and observability in social dilemmas

Daniel A Brent, Lata Gangadharan, Anca Mihut, Marie Claire Villeval

► **To cite this version:**

Daniel A Brent, Lata Gangadharan, Anca Mihut, Marie Claire Villeval. Taxation, redistribution and observability in social dilemmas. 2017. halshs-01609971v1

HAL Id: halshs-01609971

<https://shs.hal.science/halshs-01609971v1>

Preprint submitted on 4 Oct 2017 (v1), last revised 1 Oct 2018 (v2)

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

WP 1726 – October 2017

Taxation, redistribution and observability in social dilemmas

Daniel A. Brent, Lata Gangadharan, Anca Mihut, Marie Claire Villeval

Abstract:

In the presence of social dilemmas, cooperation is more difficult to achieve when populations are heterogeneous because of conflicting interests within groups. We examine cooperation in the context of a non-linear common pool resource game, in which individuals have unequal extraction capacities and have to decide on their extraction of resources from the common pool. We introduce monetary and nonmonetary policy instruments in this environment. One instrument is based on two variants of a mechanism that taxes extraction and redistributes the tax revenue. The other instrument varies the observability of individual decisions. We find that the two tax and redistribution mechanisms reduce extraction, increase efficiency and decrease inequality within groups. The scarcity pricing mechanism, which is a per-unit tax equal to the marginal extraction externality, is more effective at reducing extraction than an increasing block tax that only taxes units extracted above the social optimum. In contrast, observability impacts only the Baseline condition by encouraging free-riding instead of creating moral pressure to cooperate.

Keywords:

Common Pool Resource game, taxation mechanisms, observability, cooperation, heterogeneity, experiment

JEL codes:

C92, H23, D74

Taxation, redistribution and observability in social dilemmas

Daniel A. Brent^a, Lata Gangadharan^b, Anca Mihut^c and Marie Claire Villeval^{c,d}

This version: 4 October 2017

Abstract: In the presence of social dilemmas, cooperation is more difficult to achieve when populations are heterogeneous because of conflicting interests within groups. We examine cooperation in the context of a non-linear common pool resource game, in which individuals have unequal extraction capacities and have to decide on their extraction of resources from the common pool. We introduce monetary and non-monetary policy instruments in this environment. One instrument is based on two variants of a mechanism that taxes extraction and redistributes the tax revenue. The other instrument varies the observability of individual decisions. We find that the two tax and redistribution mechanisms reduce extraction, increase efficiency and decrease inequality within groups. The scarcity pricing mechanism, which is a per-unit tax equal to the marginal extraction externality, is more effective at reducing extraction than an increasing block tax that only taxes units extracted above the social optimum. In contrast, observability impacts only the Baseline condition by encouraging free-riding instead of creating moral pressure to cooperate.

Keywords: Common Pool Resource game, taxation mechanisms, observability, cooperation, heterogeneity, experiment

JEL Codes: C92, H23, D74

^a Department of Economics, Louisiana State University, Business Education Complex, Baton Rouge, LA 70803-6306, U.S.A. dbrent@lsu.edu

^b Department of Economics, Monash University, Clayton, Australia. lata.gangadharan@monash.edu

^c Univ Lyon, CNRS, GATE, 93 Chemin des Mouilles, F-69130, Ecully, France. mihut@gate.cnrs.fr, villeval@gate.cnrs.fr

^d IZA, Bonn, Germany. villeval@gate.cnrs.fr

Acknowledgments: We thank the participants at the IMEBESS conference for useful comments. We are grateful to Q. Thévenet for assistance in programming the experiment. This research has been supported by funding from the Australian Cooperative Research Centre for Water Sensitive Cities (CRC grant number 20110044). It was performed within the framework of the LABEX CORTEX (ANR-11-LABX-0042) of Université de Lyon, within the program Investissements d’Avenir (ANR-11-IDEX-007) operated by the French National Research Agency.

1. Introduction

Often individuals are confronted with situations in which their personal interest is not in harmony with the well-being of the community to which they belong. Researchers and policy makers continue to explore diverse mechanisms to encourage cooperation in the presence of such social dilemmas (for surveys, see Ledyard 1995; Chaudhuri 2011). But mechanisms that work when populations face the same opportunities and derive the same benefits from the collective goods may not be as effective when populations are heterogeneous in that respect. Indeed, the tension between private and social interests can be aggravated in such groups because of increased inequality and the presence of normative conflicts regarding what one ought to do in such circumstances (Nikiforakis *et al.* 2012; Reuben and Riedl 2013; Weng and Carlsson 2015; Gangadharan *et al.* 2017). This raises the question of which policy intervention can be effective in such environments, both with regard to reduced free-riding and more equal income distribution.

In this study, we examine the impact of monetary and non-monetary mechanisms when agents are heterogeneous, using a backdrop of a non-linear Common Pool Resource game.¹ The agents vary in terms of their ability to extract a resource from a common pool. This corresponds to situations in which some individuals have limited access to environmental resources compared to others in the community.² In such situations, the pursuit of efficiency may require asymmetric

¹ Common Pool Resource games represent a class of social dilemmas in which individuals decide how much to take from a shared common resource, which is rivalrous in consumption since whatever is taken by someone cannot be used by others (Ostrom 1990). The benefits of extracting an extra unit of the resource are private, but its costs are borne by all individuals. Consuming according to one's own private interest exhausts the resource, but if people extract less than privately optimal, then the common pool generates future benefits for the whole group (Ostrom 2000).

² This can be illustrated by the following examples: access to resources from the fisheries is limited for low income families who cannot afford to invest in a boat; some water rights are based on land ownership; individuals living at different distances from dams which are publicly financed have differential costs of accessing water (*e.g.*, Rockstrom

conservation efforts by different members. Although efficiency may not always conflict with equality, unequal access to the resource may render cooperation more difficult to establish. Disadvantaged members may consider that the sacrifice of refraining from consuming the resource should be borne by the privileged members. On the contrary, advantaged members may consider that earning their status entitles them to exploit resources as they wish. If these individuals extract at their full capacity, it both reduces efficiency and increases inequality.

Our research objective is to examine the ability of some institutional mechanisms to promote cooperation, maximize social welfare and reduce inequality in the presence of heterogeneity. We measure the performance of these mechanisms with respect to resource conservation, efficiency and distributive equality, highlighting the importance of these three criteria and mitigating the usual tradeoff between them. To the best of our knowledge, researchers have not yet adopted such an approach in common pool resource environments.

Specifically, we consider two centralized pricing mechanisms in situations where individuals have heterogeneous potential impacts on the resource. These mechanisms have two components: *i*) an efficiency maximization dimension introduced by means of a Pigovian tax meant to internalize the external costs of extraction and attain the Pareto optimal level of welfare and *ii*) an inequality reduction dimension that is achieved through an equal redistribution of the collected tax towards all the group members.

et al. 2009; Kummu *et al.* 2010); the access to natural resources such as water, sanitation, or forests has been restricted for discriminated populations (see, *e.g.*, Borooah 2015 and UN-Water 2014 on castes in India, Schelhas 2002 on native tribes in the U.S., UNEP 2013 on the exclusion of women from benefiting from resource wealth in conflict-affected areas). Discrimination in the access to natural resources can directly emanate from laws and practices that intentionally exclude some people from equal treatment; it can also be indirect: the requirement of a municipal registration certificate to subscribe to a local water provider can exclude people living in informal settlements, (UN-Water, 2014).

These mechanisms are built on the pricing schemes that are referred to in the literature as the “scarcity-pricing” structure and the “increasing block rate” structure (Dana 1999; Duke and Ehemann 2002). Standard increasing block rate tariffs propose higher rates for higher successive blocks of consumption that increase starting from the first basic block, which is aimed to fulfill essential needs. Scarcity-pricing tariffs charge each unit consumed, where the charge accounts for the scarcity of the resource. We select these mechanisms because they are commonly used to encourage conservation of common pool resources and because they have different distributional implications.³ Our mechanisms maintain the essence of the pricing schemes discussed above by selecting the units that face a higher marginal price, such that the increasing block rate only charges for units above the social optimum, whereas the scarcity pricing mechanism applies a tax to each unit of resource extracted. In our setting the increasing block rate, similar to scarcity-pricing, represents a Pigovian tax by setting the scarcity price at the marginal external cost. We add a redistributive component that is meant to address inequality due to heterogeneous extraction ability. This is important, as pricing mechanisms on their own are often not very effective in redistributing income. While both mechanisms should achieve economic efficiency, the scarcity pricing mechanism is expected to perform better at reducing inequality. Indeed, if the advantaged individuals consume more of the common resources than others, the pricing mechanism sanctions them and compensates everyone.⁴

³ Increasing block rate tariff systems are among the most common mechanisms for charging electricity and water, implemented in more than 90 countries around the world (World Bank 2001; Eaton 2015). Scarcity pricing schemes are less used but they have been recently strongly advised for water pricing as a response to drought problems (Grafton and Kompas 2007; Grafton and Ward 2008) and for addressing some electricity pricing issues through operating reserves (Hogan 2013).

⁴ Note that we use pricing mechanism and tax interchangeably; it is important to keep in mind that these mechanisms impose a price on extraction above the private cost of extraction in the baseline case.

In addition to these pricing mechanisms, we examine the impact of a non-monetary intervention on extraction, efficiency and inequality. We introduce observability by informing each individual about the extraction decisions and the payoffs of each group member. Social information has been encouraged by the tenants of libertarian paternalism (Thaler and Sunstein 2008) and promoted by nudge units and companies to influence individual behavior.⁵ Given the political challenges with raising prices on natural resources, non-monetary mechanisms may be attractive tools to encourage conservation (see Brent *et al.* 2017 for a review).

There is evidence that observability affects pro-social behavior (*e.g.*, see Ferraro and Price 2013; Delaney and Jacobson 2016; and a brief review in Section 2). It may signal what the norm is in the group (Cialdini 2003) and influence conditional cooperators, as shown in the context of public goods games (Fischbacher and Gächter 2011). Nevertheless, the net effects of such instruments are not clearly quantified in the context of common pool resource dilemmas, especially when individuals have heterogeneous extraction capacities. Social information can also backfire if it leads individuals who extracted less than the average under limited information to imitate those who extract the most, especially when groups are heterogeneous.⁶

⁵ For example, in a conservation program the American electricity company Opower sent normative mails to consumers about the energy usage of their household compared to that of the neighboring households, which led to a mean reduction of consumption of about 2% (Alcott 2011). Hotels have introduced normative messages to persuade clients to reuse their towels (Goldstein *et al.* 2008; Schultz *et al.* 2008). Several examples of environmental nudges can be found in Nielsen *et al.* (2016) and on blogs like <http://nudges.org/tag/environment/> or <http://blog.nature.org/science/2014/04/26/environmental-sustainability-nudges-economics-paul-ferraro/> A difference with our intervention is that we give detailed information on each other group member's decisions and payoffs.

⁶ For example, Ayres *et al.* (2013) relate interventions in which households received reports comparing their domestic electricity and natural gas consumption to the consumption of nearby similar-sized households. Peer feedback reduced overall energy usage, but while the cuts were the largest among the households with the highest pre-treatment consumption, peer feedback increased the energy use of the households who previously consumed less than the average. In addition, while Ferraro *et al.* (2011) found a long-term conservation effect of social information, Alcott and Rogers (2012) show that the impact of comparative information vanishes over time. See also Ölander and Thørgesen (2014) on the limitations of social information on behavioral changes to protect the environment.

Another contribution of our study is assessing the consequences of the interaction between these monetary and non-monetary mechanisms, beyond a comparative analysis of their respective impact. Using a common pool resources game, Delaney and Jacobson (2016) found that, net of costs, the efficiency achieved by the provision of information is similar to that of a Pigovian subsidy. But it is not clear that this similarity would persist with the introduction of heterogeneity in extraction capacities. We investigate whether price-based mechanisms crowd-out the impact of social information on the extraction behavior of heterogeneous individuals. Understanding the interplay between these mechanisms is permitted by the use of a laboratory experiment, which allows us to identify their causal effects on behavior.

To summarize, our contribution is threefold. First, we introduce heterogeneity in terms of extraction capacities in a common pool resource game, whereas heterogeneity in social dilemmas is usually introduced through different endowment levels or different returns from a public account. Over-extraction in our case generates inefficiency and exacerbates inequality by particularly harming the disadvantaged group. Second, we introduce two mechanisms combining Pigovian-based taxation and redistribution in the context of social dilemmas. Third, we compare the impact of these two monetary mechanisms with that of a non-monetary mechanism and study their interactions, in terms of three performance indicators: extraction, efficiency and equality.

Our main findings are that the two pricing and redistribution mechanisms significantly reduce the mean level of extraction, increase efficiency, and reduce inequality. The strongest impact is associated with the scarcity pricing mechanism, both in terms of resource conservation and decreasing inequality, regardless of the observability condition. In the absence of pricing mechanisms, observability and social information about other group members' decisions and earnings *increase* the level of extraction instead of motivating individuals to reduce their resource

use. However, the introduction of our tax and redistribution mechanisms eliminates this perverse effect of social information and observability on behavior. These findings suggest that Pigovian instruments remain more powerful in changing behavior than social nudges when populations are heterogeneous. Our results provide important insights for relevant yet underexplored situations in which lack of cooperation can generate inefficiency, inequality and harm powerless individuals.

The remainder of this paper is organized as follows. Section 2 discusses the related literature. Section 3 presents the experimental design and procedures. Section 4 develops our predictions. Section 5 reports the results and section 6 discusses our findings and concludes.

2. Related Literature

Our paper contributes to two main strands of the literature. First is the well-established literature on mechanisms proposed to mitigate conflicts in resource use in the presence of social dilemmas.

Centralized mechanisms include structural non market based (such as command and control) and market based (such as pricing) instruments. As the non-market based mechanisms mainly aim to impose restrictions on consumption leading to inefficient outcomes (*e.g.*, Mansur and Olmstead 2012), most economists advocate for pricing mechanisms (*e.g.*, Plott 1983; Dalhuisen *et al.* 2003; Olmstead and Stavins 2009). One common centralized pricing mechanism to manage common pool resources (CPR, hereafter) is the increasing block rate scheme (IBR, hereafter) in which users pay different amounts for different consumption levels (Ito 2014; Borenstein 2012). Another monetary mechanism advocated for by economists is the scarcity-based pricing instrument (SP, hereafter) where prices vary inversely with the available supply to reflect the scarcity value (Grafton and Kompas 2007; Hogan 2013). Given their efficiency properties, there have also been attempts to implement Pigovian taxes in several countries (McMorran and Nellor 1994). However, pure Pigovian taxes are difficult to implement due to challenges in quantifying

the marginal social damage and concerns about tax aversion (*e.g.*, Mitchell and Carson 1999; Kallbekken *et al.* 2011; Heres *et al.* 2013).

To our knowledge, mechanisms combining tariff structures like an increasing block scheme or scarcity pricing with the efficiency advantages of a Pigovian tax have not been considered. Furthermore, to include social objectives most proposals suggest to offer rebates to the low-income consumers (Grafton and Kompas 2007), to define primary or basic blocks of consumption that are offered at lower price (Barraque and Montginoul 2015) or a combination of the two. Evidence of policies that combine pricing mechanisms for resources management with a redistribution scheme, similar to fiscal policies (Hartman 2002) for reducing inequalities, is scarce. Our study is a step in this direction.

Economic incentives are, however, not the sole drivers of choices in social dilemmas (*e.g.*, Ostrom 1990; Fehr and Gächter 2000; Masclet *et al.* 2003; Dugar 2013; Peeters and Vorsatz 2013). Social preferences, *i.e.* the concern for others' payoff, may motivate individuals to not over-exploit common pool resources. Evidence from the literature suggests that providing information on the actions of others might change behavior by triggering conformity to a social norm of conduct (*e.g.*, Allcott and Mullainathan 2010; Ferraro and Price 2013), because of the fear of receiving social penalties for non-compliance (Akerlof 1980), or due to social learning (Banerjee 1992). Consistent with this, studies show that individuals are more likely to contribute to public goods if they are informed about others' contributions (*e.g.*, Cialdini 2003; Frey and Meier 2004; Shang and Croson 2009). In contrast, Noussair and Tucker (2007) and Khadjavi *et al.* (2014) find that revealing all decisions in public good games can have a negative impact on cooperation. Chaudhuri and Paichayontvijit (2010) show that social feedback accelerates the decay of cooperation and Brent *et al.* (2015) show interactions between social information and

alternative conservation policies. Delaney and Jacobson (2016) find that in a CPR with homogenous players information provision on congestion reduces over-extraction, but not durably. Social information therefore can also potentially create unintended effects on cooperation.⁷

Second, our paper is related to the recent literature on the impact of heterogeneity in social dilemmas. When individuals are heterogeneous in a public good game, a trade-off between efficiency and equality may appear (Nikiforakis *et al.* 2012; Reuben and Riedl 2013; Gangadharan *et al.* 2017). Most of the proposed mechanisms provide incentives to maximize efficiency, considered as the ultimate criteria for the assessment of a mechanism. But focusing exclusively on this criterion may deprive some individuals from accessing the resource and aggravate inequality. Criteria of equality can be of paramount importance, especially if basic needs are not being met or if there are big disparities among individuals and groups. While some find a negative effect of heterogeneity on cooperation (*e.g.*, Van Dijk *et al.* 2002; Cherry *et al.* 2005, Anderson *et al.* 2008; Gangadharan *et al.* 2017), others report a positive effect (*e.g.*, Chan *et al.* 1996; Buckley and Croson 2006; Reuben and Riedl 2013).

Due to the perceived similarity of public goods and CPR, we might expect to observe similar results for the CPR as reported for public good games. However, concrete evidence on such dilemmas is scarce. Differences could appear due to the more destructive framing of an extraction environment compared to a contribution environment (*e.g.*, Dickinson *et al.* 2014).

⁷ Researchers have also explored the impact of public display of identity on pro-social behavior. For example, Andreoni and Petrie (2004) show that making visible the contributions of participants to public goods in conjunction with their photos leads to a substantial increase in contributions. In Rege and Telle (2004), making identity and choices public leads to higher contributions in a one shot public good game. In Coricelli *et al.* (2010), displaying the photo of a cheater in a tax experiment deters cheating. In Samek and Sheremeta (2014), contributions are affected more by shame (recognition of the lowest contributor) than by prestige (recognition of the highest contributor). In contrast, in Cason *et al.* (2016) observability has a limited impact on behavior in an audit experiment.

Apestequia and Maier-Rigaud (2006) argue that the difference in outcomes between CPR and public good games is not just due to the framing of the games, but also to the different strategic environments produced by whether the good is rival or not.

3. Experimental design and procedures

3.1. Design

Our experiment consists of a between-subject 3x2 factorial design and is based on a non-linear Common Pool Resource game. The first dimension varies the monetary incentives to cooperate by introducing corrective pricing mechanisms. The second dimension alters the non-monetary incentives by varying whether or not decisions are observable. We first describe the baseline treatment without observability (Baseline-NO, hereafter), before presenting the other treatments.

Baseline treatment with no observability

We form groups of four subjects who remain matched together throughout the session. All groups participate in the CPR game for 18 periods. At the beginning of each period, each group receives a common pool resource of 60 units. Group members decide simultaneously on the number of units they want to extract from the common pool.

Groups are heterogeneous with regards to their members' maximum extraction capacity. Each group consists of two players with a higher extraction capacity and two players with a lower capacity. An extraction capacity is assigned to the subjects based on their relative performance in a preliminary encryption task similar to that used in Erkal *et al.* (2011), Charness *et al.* (2014), and Gangadharan *et al.* (2017). Subjects are given a table assigning a number to each letter of the alphabet and are asked to encode sets of letters into numbers in ten minutes. To avoid introducing wealth effects, the task is not incentivized. To minimize selection effects, when performing this task subjects are not yet aware of the content of the rest of the session. They only know that: *i*)

their relative performance in this task will affect their maximum payoff opportunities in the next part; *ii*) they will be placed in groups of four, two of which would be of “type A” and two of “type B”; *iii*) and these types differ in their payoff opportunities. After the ten minutes have elapsed, the program ranks the subjects based on the number of words they encoded. The top 50% performers are assigned to the type that is allowed to extract up to a maximum of 20 units from the CPR, whereas the bottom 50% are assigned to the type that is only allowed to extract up to a maximum of 10 units. Subjects are informed of their type at the beginning of the CPR game, and they maintain the same type throughout the experiment.

In the CPR game, each subject simultaneously chooses the number of units he is willing to extract from the common pool, x_i . This extraction generates a private revenue to the subject represented by a concave utility function that increases at a decreasing rate up to a maximum level. Each unit extracted entails a fixed and exogenous cost, c , incurred by the subject. It also generates a negative externality, captured by a variable group cost that depends on the appropriation decisions of all group members.⁸ Thus, the payoff function is defined as follows:

$$\pi_i = ax_i - bx_i^2 - cx_i - d \sum_{j=1}^n x_j \quad (1)$$

In equation (1), the first two terms capture the private revenue function, with $a=9$ and $b=0.2$. The third term represents the private extraction cost, with $c=0.1$, which implies that each unit extracted costs 0.1 ECU (Experimental Currency Unit). The last term captures the social cost

⁸ The social dilemma setting can be modelled in different ways: in some studies individuals have linear payoff functions (for example, Fehr and Gächter 2000), in others the payoff functions are non-linear. Spraggon (2002, 2004) and Cason and Gangadharan (2013, 2016) report results using a non-linear revenue function, while other studies introduce non-linearity in the cost function (Ostrom *et al.* 1992). Cason and Gangadharan (2015) show that non-linearities could play an important role in the effectiveness of instruments for improving cooperation in social dilemmas, as in more complex non-linear settings, the optimal choices become more difficult to identify. In this study we choose the more realistic environment of a non-linear payoff function, with a quadratic private revenue function. The social cost incurred has a linear functional form as it makes it easier to implement the main characteristics of the Increasing Block Rate and Scarcity Pricing tools in other treatments.

of extraction, with $d=1$, which depends on the total amount extracted by all group members. These parameters are the same for all the subjects, regardless of their type, *i.e.* types affect only the maximum extraction capacity. This setting depicts a social dilemma problem since a subject's extraction decision not only affects his payoff but also the payoff of his group members, such that extracting above the social optimum lowers everyone else's payoff from the common pool resource and exacerbates the social dilemma. At the end of each period subjects are only informed of their own payoff. This allows them to draw information on the total amount withdrawn from the common pool but they receive no feedback on the other members' individual decisions. The final earnings are the sum of payoffs in three periods randomly selected at the end of the session.

Pricing treatments with no observability

The pricing treatments introduce two mechanisms that modify the monetary incentives for cooperation: Scarcity Pricing (SP-NO, hereafter) and Increasing Block Rate (IBR-NO, hereafter). Both mechanisms aim at increasing the subjects' cooperativeness, but in contrast to the existing literature, in our mechanism we augment these pricing schemes in two ways. First, while the core characteristics of the IBR and SP are kept intact (our IBR proposal only charges the block of consumption represented by the units extracted above the social optimum level, whereas the SP charges every unit extracted from the common pool), we compute the tax according to the Pigovian tax principles. Second, we add to the primary objectives of these mechanisms (consumption reduction and efficiency maximization) the inequality reduction goal by incorporating a redistributive dimension directly into the mechanism.

Therefore, the SP-NO treatment introduces a tax and a redistribution mechanism in the CPR game, such that regardless of their type subjects have to pay a unitary tax, t , for each unit

extracted. The value of this Pigovian tax is meant to internalize the social cost generated by the individual decisions of extraction, such that $t=(n-1)d$. The total amount of the tax collected is then redistributed equally among the group members, regardless of their type and their extraction decision.⁹ The previous payoff function (1) is augmented in SP-NO with two terms, as follows:

$$\pi_i = ax_i - bx_i^2 - cx_i - d \sum_{j=1}^n x_j - tx_i + \frac{t \sum_{j=1}^n x_j}{n} \quad (2)$$

The fifth term (tx_i) in (2) represents the value of the tax. In the experiment, t is equal to 3: each unit extracted faces a per-unit tax of 3 ECU. The last term $\left(\frac{t \sum_{j=1}^n x_j}{n}\right)$ represents the share of the tax revenue that is redistributed to each subject. At the end of each period, subjects are informed of their own payoff, the tax paid and the amount of the tax transferred to them.

Similar to the SP-NO treatment, the IBR-NO treatment introduces both a tax and a redistribution mechanism, but the tax applies only to the units extracted above the social optimum level. Each unit extracted beyond the 12th one is taxed. While the 12 units correspond to the social optimum, the subjects are not explicitly made aware of this. Thus, this mechanism can only sanction the high-type subjects, since the low-type cannot extract more than 10 units. Similar to SP-NO, the total tax revenue is then redistributed equally between the group members, regardless of their type and their extraction decision. The payoff function in IBR-NO is the following:

$$\pi_i = ax_i - bx_i^2 - cx_i - d \sum_{j=1}^n x_j - t(x_i - x^*) + \frac{t \sum_{j=1}^n (x_j - x^*)}{n} \quad (3)$$

The fifth term, $t(x_i - x^*)$, captures the taxation applied to deviations beyond the optimal level of extraction, $x^* = \frac{a - c - dn}{2b}$. The last term, $\frac{t \sum_{j=1}^n (x_j - x^*)}{n}$, represents the individual share of the tax

⁹ We chose equal redistribution among all members, in order to avoid interference with other behavioral effects that could arise from a redistribution only towards the low-type for instance and to be able to clearly isolate the effects of the mechanisms that we propose.

revenue that is redistributed to each subject. At the end of each period, the feedback provided to subjects is the same as in SP-NO.

Treatments with observability

We ran three other treatments in which we maintain the same conditions as described above, but in which we allow for observability. We refer to these treatments as Baseline-O, SP-O and IBR-O. At the end of each period, subjects are informed about the extraction decision, the total payoff of each member of their group after taxation and redistribution, the total amount extracted by the group and the amount of the tax paid and redistributed in the SP-O and IBR-O treatments. A neutral identifier is assigned to each subject (“Participant 1/2/3/4”) that is kept constant throughout the session. Since the composition of each group is the same for all periods, subjects are able to keep track of the decisions of the other group members across periods. This intervention increases the visibility of each individual’s behavior within his group.¹⁰ Therefore, in total we have three treatments with no observability of others' individual decisions (Baseline-NO, IBR-NO and SP-NO) and three treatments with observability (Baseline-O, IBR-O and SP-O).

Elicitation of individual characteristics

Since we expect that social preferences may affect behavior in our experiment, we elicited the subjects’ social value orientation (SVO) (Murphy *et al.* 2011). Subjects had to make six successive decisions, each one consisting of choosing one option among nine options for distributing different amounts between the subject and another anonymous person. One decision is randomly selected for payment. This SVO task was completed online approximately one week

¹⁰ We also ran a pilot session in which at the end of each period we showed to all the group members the photo of the subject(s) that extracted the most in that period. We did not find any significant impact of this disclosure on extraction decisions. Therefore, we do not report more on this session.

before the laboratory session to limit the risk of contamination with the CPR game. Payment for the SVO task was made at the end of the laboratory session.

We also elicited a number of individual characteristics at the end of the laboratory session, including age, gender, religiosity, and political orientation. To elicit risk attitudes, following Dohmen *et al.* (2011) subjects were asked: “Are you generally a person who is fully willing to take risks or do you try to avoid taking risks?” They had to report how they see themselves on a scale graduated from 0 (avoid taking risks) to 10 (being fully prepared to take risks).

3.2. Experimental procedures

The experimental sessions were conducted at GATE-Lab, Lyon, France. The experiment was computerized using the Z-Tree software (Fischbacher 2007). Subjects were recruited by email using Hroot (Bock *et al.* 2014). 144 subjects participated in a total of 15 sessions. Most were undergraduate students from local business, engineering, and medical schools (95%) with an average age of 21 years (S.D.=2.34). We have collected observations for six independent groups per treatment, *i.e.* 36 groups in total.

When subjects registered for the experiment, approximately one week before the date of the lab session, they were sent an invitation email to complete the online SVO questionnaire. Completing this task took less than ten minutes. Participants were informed that they would learn their payoff for this task and receive their payment only at the end of the laboratory session. Only those who completed the online task were allowed to participate in the session.

In the lab session, at their arrival subjects were randomly assigned to a cubicle after drawing a tag from a bag. The instructions were distributed and read aloud for each part after completion of the previous part (see Appendix 1). The non-linear environment in the CPR game is more realistic than a linear environment but it can also make it more challenging for the subjects to

identify the value of their payoff associated with every possible decision. Hence, we checked the subjects' understanding by means of a comprehension questionnaire. Further, subjects could use a computer interface to explore how different choices that they and the other group members made could affect their payoff (see a screenshot in Appendix 1). This interface was made available in each period before subjects could enter their extraction decision.

Each session lasted about two hours. The average payoff were 24.4 Euros (S.D.= € 5.6), including a € 5 show-up fee and the payoff from the SVO task (€ 6.1 on average). Payoffs were paid in private in a separate room.

4. Predictions

If individuals are only interested in maximizing their individual payoff, they should disregard the negative externality of their decision on others. From equation (1) in Baseline-NO, we can derive the player's best reply function and then infer the symmetric Nash equilibrium, $x_{NE} = \frac{a-c-d}{2b}$ which equates the individual marginal payoff ($a-2bx$) with the marginal cost of extraction ($c+d$). In equilibrium, the level of extraction decreases with the individual cost (c) and the coefficient of the quadratic term of the private payoff function (b). With our parameter values, the dominant Nash equilibrium strategy is for each group member to extract 19.8 units. Since the low-type subjects have a capacity constraint, they should extract up to their maximum capacity of 10 units. In equilibrium, a high-type subject earns 38.4 ECU, which is 304% more than what a low-type member earns (9.5 ECU). The total group payoffs amount to 95.5 ECU.

In contrast, the social optimum, which equates the marginal private payoff with the marginal social costs and accounts for the negative externality generated by extractions is $x^* = \frac{a-c-nd}{2b}$, corresponding to 12.3 units per person using our parameters. If each high-type subject extracts

this optimal amount while the low-type subjects extract their maximum capacity, the total group payoffs amount to 118 ECU, with 34.5 ECU for the high-type and 24.5 ECU for the low-type subjects. Inequality is drastically decreased, as a high-type subject now earns only 41% more than a low-type group member.

In the SP-NO treatment, due to the introduction of tax and redistribution, the Nash equilibrium now corresponds to the social optimum, $x_{NE} = \frac{a-c-nd}{2b}$. The equilibrium level of extraction is 12.3 units per member. The predicted payoffs are 31.1 ECU for the high-type subjects and 27.9 ECU for the low-type ones. The level of inequality between the two types is reduced substantially compared to the baseline treatment; a high-type subject now earns 11% more than a low-type subject. In equilibrium, the total group payoffs amount to 118 ECU.

In the IBR-NO treatment, the equilibrium level of extraction also corresponds to the social optimum due to the tax and redistribution, and is again equal to 12.3 units per group member. In equilibrium, a high-type subject earns 34.5 ECU, a low-type subject earns 24.5 ECU, and the total group payoffs are again 118 ECU. Payoffs are similar to those obtained in Baseline-NO under the social optimum. Indeed, in equilibrium the high-type subjects extract the level that corresponds to the social optimum, and thus they do not pay taxes and no redistribution occurs. Since their extraction capacity is bounded, the low-type subjects do not pay any tax. Therefore, the IBR primarily addresses efficiency goals, without fulfilling any inequality reduction through redistribution, whereas the SP targets both efficiency gains and inequality reductions through the redistributive dimension of the mechanism. As a result, the level of inequality is larger in IBR-NO compared to SP-NO (the high-type subjects earn 41% more than the low-type subjects, instead of 11% more as in SP-NO).

If one assumes that individuals have standard preferences, introducing observability does not alter the previous predictions. Deviations from the equilibrium or the social optimum could however result from behavioral dimensions related to peer effects and conditional cooperation, image concerns (Benabou and Tirole 2003), or inequity aversion (Fehr and Schmidt 1999). In the presence of such motivations, the effects of observability may either improve or hinder cooperation. On the one hand, if subjects dislike being identified as a free rider who causes damage to the group, they may extract less in a treatment with observability than in the corresponding treatment without observability – this is the main rationale of such social nudges. On the other hand, if individuals can observe each group member’s level of extraction and if this level exceeds their own level, they can indirectly punish others by extracting more in the next period. Conditional cooperation with self-serving biases may arise, like in Voluntary Contribution Mechanism games (Fischbacher and Gächter 2011). Observing peers’ behavior can also lead to increased extraction as individuals may aim to conform to the norm of the group. Finally, with observability the extraction by the high-type subjects can be directly compared to that of the low-type subjects. Inequality averse people may adjust their extraction level so as to reduce the degree of payoff inequality in the group. The net effect of these opposite forces on extraction decisions is an empirical question and our experimental study can help provide some insights on the impact of observability in such environments.

We summarize our main hypotheses as follows:

Hypothesis 1: Under the tax and redistribution mechanisms, the mean extraction levels are lower than in the Baseline and they correspond to the social optimum, with no difference between the two pricing mechanisms.

Hypothesis 2: Under the tax and redistribution mechanisms, efficiency (measured as the sum of payoffs) is higher than in the Baseline, with no difference between the two pricing mechanisms.

Hypothesis 3: The scarcity pricing mechanism is the most effective in reducing payoffs inequality between the high-type and the low-type players, compared to the other treatments.

Hypothesis 4: Under standard selfish preferences, observability has no impact on behavior. Behavioral motivations could however lead observability to influence extraction levels.

5. Results

We analyze the mean extraction levels by type of subject and by treatment, before considering efficiency and, finally, inequality. Throughout the section, we refer to Table 2. This table reports summary statistics on the extraction level, the payoffs, and the ratio of actual payoffs to the social optimum payoff by subject type and by treatment. It reports the gap between high- and low-type subjects' payoffs, in percentage points, as an indicator of within-group inequality.

Table 2 shows the significance levels from two-sided pairwise Mann-Whitney rank-sum tests (M-W, hereafter) comparing each treatment with the corresponding Baseline, for a given observability condition. The mean decision or payoff of a group of six subjects across periods gives one independent observation. We complement this analysis with estimates from econometric regressions that include individual specific variables.

Table 2. Summary statistics on extraction, payoffs and inequality

Treatments	Baseline-NO	SP-NO	IBR-NO	Baseline-O	SP-O	IBR-O
<i>Mean extraction (number of units)</i>						
All subjects	13.81 (4.60)	11.84*** (2.72)	12.02*** (2.90)	14.58*** (4.90)	12.00*** (2.42)	12.12*** (2.34)
- High-type	17.98 (2.09)	14.30*** (0.79)	14.41*** (1.78)	19.30*** (1.10)	14.12*** (1.43)	14.31*** (0.82)
- Low-type	9.65 (0.76)	9.39 (1.16)	9.64 (1.00)	9.86* (0.29)	9.89* (0.25)	9.93 (0.16)
<i>Percentage of low-type and high-type subjects that extract at their maximum capacity</i>						
- High-type	29.62	0.46***	5.09***	65.27***	0.92***	1.38***
- Low-type	85.18	76.38**	90.74*	90.74*	95.83*	95.37*
<i>Payoffs (in ECU)</i>						

All subjects	25.41 (0.5)	28.53*** (1.03)	28.31*** (0.86)	24.31*** (0.78)	28.84*** (0.34)	28.95*** (0.24)
- High-type	39.05 (4.06)	31.48*** (0.62)	34.19*** (2.05)	38.69 (1.38)	30.97*** (0.84)	34.27*** (0.58)
- Low-type	11.75 (4.75)	25.58*** (0.62)	22.42*** (5.61)	9.94* (2.31)	26.72*** (1.11)	23.62*** (0.91)
<i>Ratio of mean payoff to the optimum</i>						
All groups	0.86 (0.01)	0.97*** (0.03)	0.96*** (0.03)	0.82*** (0.02)	0.98*** (0.01)	0.98*** (0.01)
- High-type	1.13 (0.02)	0.91*** (0.01)	0.99*** (0.02)	1.12 (0.01)	0.90*** (0.01)	0.99*** (0.01)
- Low-type	0.34 (0.04)	0.74*** (0.03)	0.65*** (0.05)	0.28* (0.01)	0.77*** (0.01)	0.68*** (0.01)
<i>Inequality: Gap between high- and low- type subjects' payoffs, in percentage point</i>						
Gap at the extraction level	232.39	113.24***	102.30***	289.41*	83.02***	87.12***
Final Gap	232.39	23.28***	52.5***	289.41*	15.99***	45.09***

Notes: Standard deviations are in parentheses. ***, ** and * indicate significance at the 0.01, 0.05, and 0.1 level, respectively, in Mann-Whitney tests comparing the SP-NO and the IBR-NO treatments with Baseline-NO, SP-O and IBR-O with Baseline-O, and Baseline-O with Baseline-NO, with one single value per group taken as an independent observation. Two-sample tests of proportions have been used for the shares of subjects extracting at their maximum capacity.

5.1. Extraction behavior

We introduce our first result:

Result 1: *a) The extraction level is reduced by the introduction of the two tax mechanisms in both observability conditions. b) In the absence of a tax mechanism, subjects extract more under observability compared to the Baseline with no observability. c) The tax mechanism eliminates the negative effect of observability.*

Results *a)*, *b)* and *c)* hold for the whole group of subjects taken together and for the high-type subjects taken in isolation. The high-type subjects drive most of the aggregate results because the low-type subjects cannot even extract at the level of the social optimum due to their constraint.

Support for Result 1. Figure A1 in Appendix 2 displays the mean ratio of individual extraction to the social optimum for each group within each treatment. It reveals little difference in behavior across groups within a treatment. Table 2 indicates that on average subjects extract 13.81 units in

Baseline-NO, 11.84 in SP-NO and 12.02 in IBR-NO. In Baseline-NO, the mean extraction exceeds both the Nash equilibrium and the optimum (Wilcoxon signed rank test –W, hereafter-, $p < 0.01$ in both cases). It also differs significantly from the level of extraction in the two other treatments (M-W, $p < 0.01$ for the two pairwise comparisons). Indeed, the two mechanisms considerably reduce the number of units extracted that do not differ from the optimum of the Baseline-NO treatment (M-W, $p = 0.916$ for SP-NO and $p = 0.833$ for IBR-NO). The difference between SP-NO and IBR-NO is not significant (M-W, $p = 0.872$).

In the observability treatments, Table 2 indicates that on average subjects extract 14.58 units in Baseline-O, 12 in SP-O and 12.12 in IBR-O. In Baseline-O, the mean extraction is also higher than the equilibrium and the optimum (W tests, $p < 0.01$ for both). Similar to the condition with no observability, subjects extract significantly less in SP-O and in IBR-O compared to Baseline-O (M-W, $p < 0.01$ for both). The mean extraction levels do not differ from the optimum level (W tests, $p = 0.248$ for SP-O and $p = 0.345$ for IBR-O). This supports Hypothesis 1. We find no difference when comparing the extraction levels under the two tax mechanisms (M-W, $p = 0.748$).

Without a tax mechanism, observability significantly increases the mean level of extraction (M-W, $p = 0.016$ for Baseline-NO vs. Baseline-O). To further explore the impact of observability on cooperation, Figure 1 displays the evolution of the mean extraction over time, by treatment.

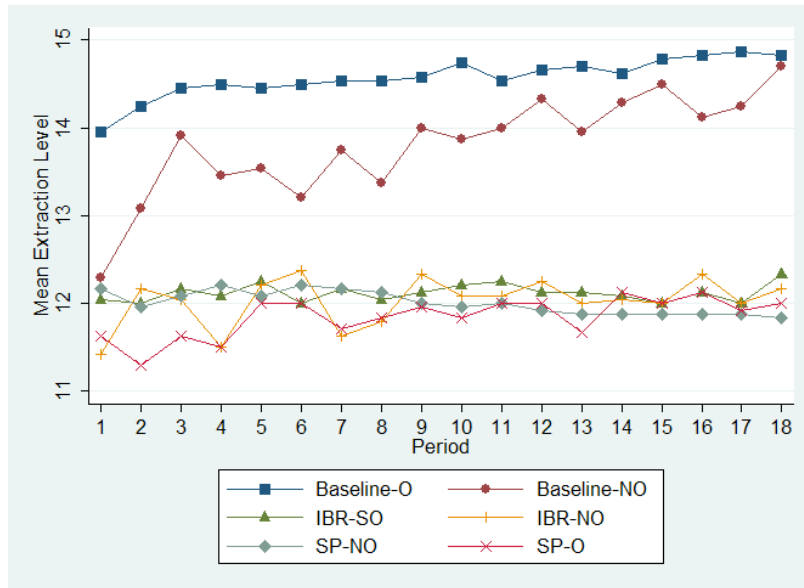


Figure 1. Evolution of the mean extraction level over time, by treatment

This figure reveals three interesting findings. First, as early as the first period a significantly higher extraction level is observed in Baseline-O compared to Baseline-NO in which the mean individual extraction corresponds to the optimal level ($M-W, p=0.017$). 16 out of 24 subjects (67%) extract at their maximum capacity level in period 1 in Baseline-O compared with 8 out of 24 (33%) in Baseline-NO. This is intriguing because at this point, the only difference between these two treatments is that in Baseline-O the participants know that their decisions will be revealed to the others. This behavior in the first period is not consistent with social image since if they were willing to preserve their image subjects should take less, knowing that their behavior will be made public. It is not consistent either with peer pressure since when they decide on their withdrawal subjects have not received any feedback on others' behavior yet. In fact, high-type subjects have no reluctance to show others that they free ride completely since the beginning of the game. One possible interpretation is that some participants use observability to signal to

others that they will have to take responsibility themselves to preserve the resource.¹¹ Some may also try to impose immediately a norm of high extraction to mitigate the potential guilt in case others show more cooperative intentions.

Second, Figure 1 shows that free-riding develops over time as a norm. This may be driven by two effects. Conditional cooperation constitutes a social sanctioning mechanism such that, if the others extract a lot, even a cooperative subject may decide to extract regardless of the consequences. Social learning constitutes another possible explanation if some players are uncertain about the strategy to adopt and mimic the behavior of others. Extraction converges progressively to the Nash equilibrium and the slope is steeper when subjects are not informed of the individual decisions of others. Third, Figure 1 indicates no difference between Baseline-O and Baseline-NO in the last period (M-W, $p=0.719$).

The introduction of a tax mechanism removes the negative effect of observability on extraction behavior. The extraction levels do not differ significantly between SP-NO and SP-O (M-W, $p=0.335$), nor between IBR-NO and IBR-O ($p=0.470$). Behavior is not affected by more precise information about others' decisions, probably because people behave optimally. Overall, these results support standard economic theory in that observability has no impact on behavior.

A separate examination of the behavior of the high-type subjects reveals the same patterns. The evolution of mean extractions over time by the high-type and the low-type subjects respectively is depicted in Figure A2 in Appendix 2. For the high-type subjects the pattern is similar to that described for the pooled set of subjects. They extract less in SP-NO and IBR-NO

¹¹ This behavior could be influenced by similar motives as those modelled by Varian (1994) in an endogenous timing game. He shows that subjects may be willing to move first and contribute nothing to a public account to force followers to provide the public good on their own. In our environment, subjects may extract at their maximum capacity from the very beginning to show group members that they will have to preserve the resource themselves.

than in Baseline-NO and less in SP-O and IBR-O than in the Baseline-O (M-W, $p=0.003$ in all cases). The difference in behavior between Baseline-NO and Baseline-O is significant ($p=0.016$), but not between SP-NO and SP-O ($p=0.628$) nor between IBR-NO and IBR-O ($p=0.688$). In contrast, low-type subjects show little reaction to the treatments because of the cap put on their extraction. Their mean level of extraction differs neither between Baseline-NO and SP-NO, nor between Baseline-NO and IBR-NO ($p=0.688$ and $p=0.872$, respectively). Similarly, we find no difference between Baseline-O and SP-O, nor between Baseline-O and IBR-O ($p=0.187$ and $p=0.144$, respectively). Observability does not lead to differences in decisions ($p=0.808$ for Baseline-NO vs. Baseline-O, $p=0.087$ for SP-NO vs. SP-O and $p=0.259$ for IBR-NO vs. IBR-O).

We now turn to an econometric analysis to identify the determinants of the individual extraction decision, controlling for subject characteristics. We pool the data of all treatments together. Table 3 reports the marginal effects of variables in six Tobit regressions with standard errors clustered at the group level. These models allow us to account both for the lack of independence of individual decisions within groups and for the left and right censoring of data. Models (1) and (2) pool all the subjects together, regardless of their type. Models (3) and (4) consider only the high-type subjects and models (5) and (6) only the low-type subjects. In models (1), (3) and (5), the independent variables include a variable for each treatment, with the baseline-NO treatment as the reference category, and a variable for the high-type subjects. Models (2), (4) and (6) also include the mean extraction in the group (excluding the subject's own decision) in the previous period, a time trend to control for the evolution of decisions over time, a variable capturing the number of subjects in a session to control for various session sizes, and a number of individual characteristics (being a male, age, individualistic orientation in the SVO test, risk attitude, religiosity, and political orientation).

Table 3. Determinants of the extraction decisions at the individual level

Dependent variable: Extraction decision	Random-effects Tobit models					
	All subjects		High-Type subjects		Low-Type subjects	
	(1)	(2)	(3)	(4)	(5)	(6)
Baseline-O	0.944*** (0.273)	1.125*** (0.330)	2.041*** (0.631)	1.751*** (0.539)	1.492 (1.193)	1.050 (1.379)
IBR-O	-1.802*** (0.215)	-2.327*** (0.482)	-3.948*** (0.324)	-3.836*** (0.314)	3.108** (1.422)	3.885*** (1.199)
IBR-NO	-1.888*** (0.202)	-2.535*** (0.500)	-3.828*** (0.315)	-3.714*** (0.336)	.838 (1.580)	1.650 (1.660)
SP-O	-1.917*** (0.304)	-2.574*** (0.564)	-4.141*** (0.562)	-3.782*** (0.393)	3.120* (1.7464)	4.085*** (1.452)
SP-NO	-2.078*** (0.275)	-2.674*** (0.519)	-3.957*** (0.308)	-3.601*** (0.297)	-1.495 (1.904)	-.329 (1.529)
High type-subject	6.149*** (0.423)	5.440*** (0.449)	-	-	-	-
Mean extraction level $t-1$	-	-0.286 (0.113)	-	0.338** (0.172)	-	.538** (.252)
Period	-	0.037*** (0.012)	-	0.008 (0.016)	-	.356*** (.069)
Control variables	No	Yes	No	Yes	No	Yes
Number of observations	2592	2592	1296	1296	1296	1296
Left-censored obs.	2	2	0	0	2	2
Right-censored obs.	222	222	222	222	1154	1154
R ²	0.272	0.379	0.221	0.271	0.039	0.118
Log-likelihood	-5010.624	-4270.021	-2327.849	-2181.643	-685.291	-629.041

Notes: The Table reports marginal effects from Tobit regressions. Standard errors clustered at a group level in parentheses. The control variables include the following variables: a variable capturing the number of subjects in a session to control for various session sizes, gender, age, individualistic orientation in the SVO test, risk attitude, religiosity and political orientation. Risk attitude takes a value between 1 and 10, with a higher value associated with more willingness to take risk. A dummy is included to account for subjects who agree to answer the question on religiosity, and the religiosity variable is coded 1 for “I never pray”, 2 for “I pray less than once per week”, 3 for “I pray at least once per week”, 4 for “I pray every day”. Another dummy is included to account for subjects who agree to answer the question on political orientation, and the political orientation variable takes the value 1 for “extreme left”, 2 for “left”, 3 for “center”, 4 for “green”, 5 for “right” and 6 for “extreme right”. Individualistic social value orientation is defined as a binary variable, equal to 0 when “pro-social” and 1 when “individualistic”. The control variables include the session size. ***, ** and * indicate significance at the 0.01, 0.05, and 0.1 level, respectively.

Models (1) and (2) confirm that in the baseline treatments, subjects extract significantly more when they get feedback about the decisions of the others. The two tax mechanisms have a significant negative impact on the amount extracted compared to the Baseline-NO treatment,

regardless of the observability condition. Equality of coefficient tests comparing the coefficients of SP-NO and IBR-NO and the coefficients of SP-O and IBR-O indicate that the two mechanisms have similar effects on extraction ($p=0.338$ and $p=0.641$, respectively). The impact of the mechanisms is not significantly different when there is no observability ($p=0.590$ for SP-NO vs. SP-O; $p=0.386$ for IBR-NO vs. IBR-O). Model (2) indicates that extraction increases significantly over time. Except the subject's type that is highly significant, none of the individual characteristics have any effect on the amount extracted in any model (except in model (4) where religiosity is marginally significantly and negative).¹²

Models (3) and (4) for the high-type subjects indicate that the same variables are significant as in the regressions on the pooled sample of subjects. In contrast, models (5) and (6) reveal less impact of the treatments on the low-type subjects' behavior. For the Baseline-O, as they have limited extraction capacity, low-type subjects do not have that much room to maneuver in order to impose a certain norm of extraction as the high-type. Interestingly, when the two monetary instruments are used in combination with observability, low-type subjects significantly increase their extraction level, as they are able to observe the much higher extraction levels of the high-type subjects. Therefore, the mechanisms that we propose might have a perverse effect on extraction behavior, such that depending on the proportion of the low-type subjects in the total population, we may obtain some undesirable outcomes.

Complementary econometric analyses are reported in Tables A1 and A2 in Appendix 2. These Tables report the estimates from random-effects Generalized Least Squares models in

¹² In particular, the SVO categories are never significant. We also computed a Pearson correlation coefficient (r) for the SVO values and the decisions made for all treatments, but again the results show no significant or relevant impact of the SVO ($r= -0.074$ and $p=0.731$ for SP-NO; $r=-0.114$ and $p=0.592$ for SP-O; $r= -0.091$ and $p=0.672$ for IBR-NO; $r= -0.281$ and $p=0.184$ for IBR-O; $r=0.298$ and $p=0.156$ for Baseline-NO; $r=0.173$ and $p=0.416$ for Baseline-O).

which the dependent variable is the change in the individual extraction decisions between period t and period $t-1$.¹³ Table A1 shows a convergence to the norm as individuals decrease (increase) their extraction level between $t-1$ and t when they extracted more (less, respectively) than their group members in $t-1$, under both conditions of observability. Comparing coefficients with and without observability indicates that there is no significant difference between them - either for the positive or for the negative deviation between the individual's and the mean group's extraction level in $t-1$ ($p > 0.1$ in all models). Table A2 shows that in each condition, paying a tax in $t-1$ leads to a decrease in the level of extraction in the next period, while receiving a tax transfer increases this level. The amounts of the tax paid and tax received have a significantly higher impact in IBR compared to SP ($p < 0.01$ for both IBR-NO vs. SP-NO and IBR-O vs. SP-O), whereas differences between the two observability conditions for the same treatment are not significant ($p > 0.1$ in all models).

5.2. Efficiency

We now study the impact of our mechanisms on efficiency. Efficiency is measured by the sum of payoffs within a group. We introduce our second result:

Result 2: *a) The two tax mechanisms allow groups to converge to the maximum efficiency in both observability conditions. b) In the absence of a tax mechanism, efficiency is slightly lower when the actions of each group member are observable compared to the Baseline with no observability. c) With either tax mechanism, observability does not impact efficiency.*

Support for Result 2. As indicated in Table 2, in both observability conditions each tax mechanism increases mean efficiency significantly compared to the Baseline (M-W, $p = 0.003$ for both SP-NO and IBR-NO vs. Baseline-NO; and for both SP-O and IBR-O vs. Baseline-O),

¹³ The independent variables include the deviations from the mean group extraction level in $t-1$ (Table A1) or the tax paid and the tax revenue received in $t-1$ (Table A2). Robust standard errors are clustered at the group level. In both Tables, model (1) is for all the subjects, model (2) for the high-type and model (3) for the low-type individuals.

whereas the difference between the two tax treatments is not significant ($p=0.336$ without observability and $p=0.748$ with observability). This supports Hypothesis 2. In the absence of a tax mechanism, efficiency is decreased by observability (M-W, $p=0.025$ for Baseline-NO vs. Baseline-O). In contrast, the introduction of a tax and redistribution mechanism eliminates the impact of observability on efficiency ($p=0.872$ for SP-NO vs. SP-O and $p=0.374$ for IBR-NO vs. IBR-O). Figure A3 in Appendix 2 displays the ratio of the mean total group payoff to the social optimum for each group, by treatment. This figure indicates that almost all groups get very close to the maximum efficiency when a tax mechanism is introduced, regardless of the observability condition. The ratio is significantly lower than 1 both in Baseline-NO and in Baseline-O (W, $p<0.01$ in both cases).

We report in Table A3 in Appendix 2 the results of six random-effects GLS regressions with robust standard errors clustered at the group level in which the dependent variable is the individual payoffs in a period. Models (1) and (2) pool all the data together, while models (3) and (4) consider the high-type sub-sample, and models (5) and (6) the low-type sub-sample. Models (1), (3) and (5) include the same independent variables as the corresponding models in Table 3. Models (2), (4) and (6) are similar to the corresponding models in Table 3, excluding the mean group extraction in $t-1$.

Models (1) and (2) in Table A3 show a significant increase in a subject's payoff when either of the tax schemes are introduced, providing further support for Hypothesis 2. Pairwise tests of differences across treatments (t -tests) conducted on model (2) indicate that the coefficients do not differ between SP-NO and IBR-NO ($p=0.582$), SP-NO and SP-O ($p=0.956$), and IBR-NO and IBR-O ($p=0.239$). They differ between SP-O and IBR-O ($p=0.016$). These models confirm that, in the absence of a corrective mechanism and relative to Baseline-NO, informing the subjects

about their group members' individual decisions decreases payoffs by 1.1 ECU. The time trend is not significant but models (3) to (6) reveal that this results from movements in opposite directions for the high-type and the low-type subjects.

Considering each type of subject separately, we find that both tax mechanisms decrease the payoff of the high-type subjects and increase that of the low-type subjects. For both types, the SP mechanism has a stronger effect than IBR: t -tests conducted on model (4) for the high-type subjects conclude that the coefficients differ significantly between SP-NO and IBR-NO and between SP-O and IBR-O ($p < 0.01$ in both cases); similar tests applied to model (6) for the low-type subjects reach the same conclusion ($p = 0.029$ and $p < 0.01$, respectively). This results from the fact that IBR can only sanction extractions above the maximum capacity of the low-type subjects. We also observe that the difference in payoffs between Baseline-NO and Baseline-O is negative and significant at the 5% level for the low-type subjects, but not for the high-type subjects, whose payoffs are less affected by the less cooperative behavior in Baseline-O. In contrast, relative to Baseline-NO, observability does not impact payoffs when a tax scheme is introduced (t -tests; high-type subjects: $p = 0.409$ for SP-NO vs. SP-O and $p = 0.737$ for IBR-NO vs. IBR-O; low-type subjects: $p = 0.162$ and $p = 0.146$, respectively).

5.3. Inequality within groups

We now study the ability of our mechanisms to moderate the degree of inequality between high- and low-type individuals. Our last result is as follows:

Result 3: *a) The payoff inequality between high- and low-type individuals is reduced by the two tax mechanisms, regardless of the observability condition. b) In the absence of a tax mechanism, observability increases inequality. c) With a tax mechanism, observability reduces inequality under SP but not under IBR.*

Support for Result 3. To measure the effect of our mechanisms on the evolution of inequality, we

first consider the payoff gap between the high-type and the low-type subjects before taxation and redistribution. The negative externalities generated by the non-cooperative behavior of the high-type subjects over time mainly harm the low-type subjects. As indicated in Table 2, the payoffs gaps are 102% in IBR-NO and 113% in SP-NO, 87% in IBR-O and 83% in SP-O (M-W tests, $p < 0.01$ for all pairwise comparisons). There is no difference between the gap observed in SP-NO and IBR-NO ($p = 0.631$) and between SP-O and IBR-O ($p = 0.631$). As a comparison, the high-type subjects earn on average 232% more than the low-type subjects in Baseline-NO and 289% in Baseline-O.

The high-type subjects pay on average 42.78 ECU (S.D.=2.71) of tax in SP and only 7.08 ECU (S.D.=1.15) in IBR (M-W, $p < 0.01$) and significantly more than what the low-type pay as a tax: 28.78 ECU (S.D.=2.09) in SP (M-W, $p < 0.01$). After redistribution both types receive 35.78 ECU (S.D.= 1.82 for the high-type and S.D.= 0.75 for the low-type) in SP, which is significantly more (M-W, $p < 0.01$) compared to IBR where they get back only 3.54 ECU (S.D.=0.61 for the high-type and S.D.=0.56 for the low-type). Therefore, the tax net effect is positive in the case of the low-type (7 ECU for SP and 3.54 for IBR) and negative for the high-type (-7 ECU for SP and -3.54 for IBR), with a significantly higher impact on inequality reduction in the case of SP mechanism (M-W, $p < 0.01$).

As a result, by increasing the payoffs of the low-type subjects dramatically and by reducing that of the high-type subjects, both tax mechanisms reduce the degree of inequality when considering the payoffs over the 18 periods. The decrease in inequality is particularly strong under the SP mechanism. This pattern is clearly visible in Figure 3 that displays the evolution of the mean payoffs over time, by type and by treatment. As indicated in Table 2, after tax and redistribution the payoffs gap is 53% in IBR-NO and 23% in SP-NO, 45% in IBR-O and 16% in

SP-O (M-W, $p < 0.01$ for each gap). This supports Hypothesis 3. Both differences between SP-NO and IBR-NO ($p = 0.010$) and between SP-O and IBR-O ($p = 0.033$) are significant.

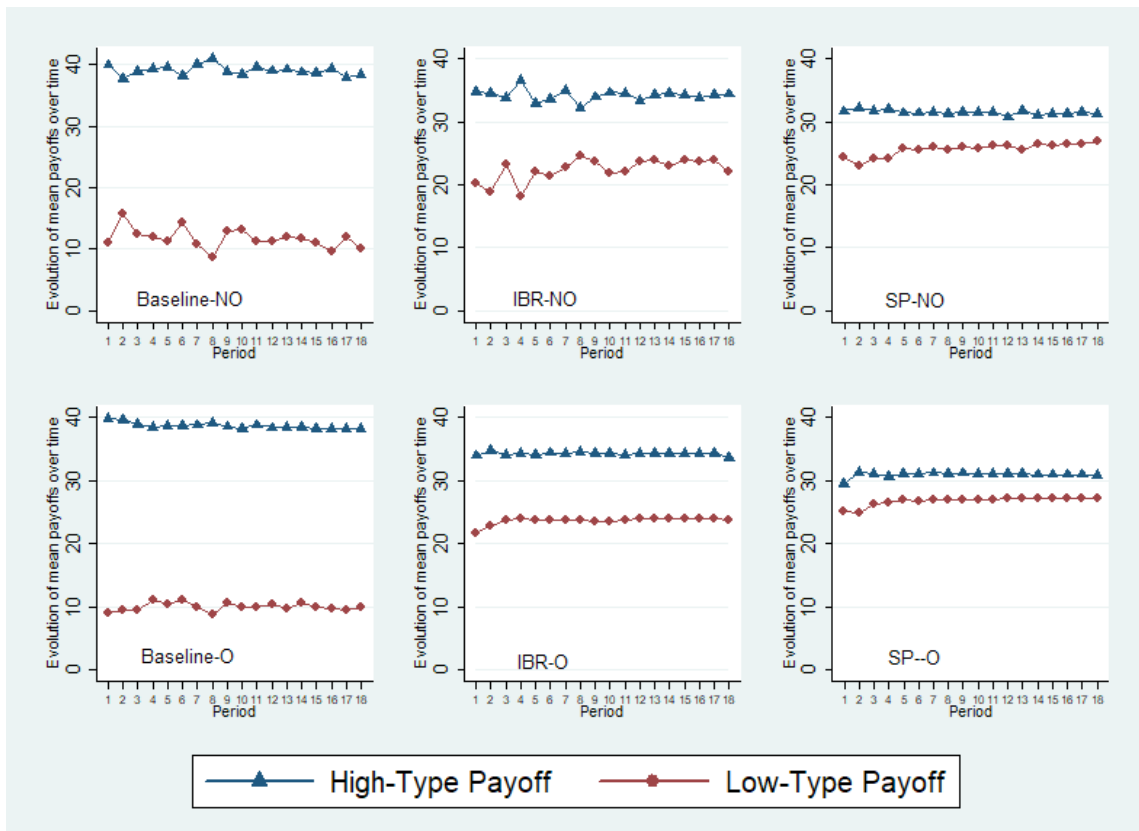


Figure 3. Evolution of mean payoffs over time, by type and by treatment

Finally, we note that observability has a limited impact on inequality. It increases inequality in the Baseline treatment but not significantly so (M-W, $p = 0.149$). In treatments with tax and redistribution, the influence of observability is most of the time insignificant and negligible in magnitude.¹⁴

¹⁴ The ratio of actual payoffs to the payoffs corresponding to the optimum play is 0.34 in Baseline-NO and only 0.28 in Baseline-O for the low-type subjects, while it is constant at respectively 1.12 and 1.13 for the high-type subjects. The ratio is 0.74 in SP-NO and 0.77 in SP-O for the low-type and 0.91 and 0.90 for the high-type subjects, respectively. The ratio is 0.65 in IBR-NO and 0.68 in IBR-O for the low-type and 0.99 for the high-type subjects in both conditions.

6. Discussion and conclusion

Individuals are frequently tempted to over extract common resources. The harmful consequences for society of such behavior are well documented. Designing mechanisms to preserve the provision of collective resources is a crucial concern in many domains, and particularly so in environmental policy making. This problem is even more challenging when some individuals are able to exploit natural resources more extensively than others. This makes cooperation more difficult to achieve and generates payoff inequalities that are the source of potential conflicts.

In the context of a non-linear Common Pool Resource game in which individuals have unequal extraction capacities, we introduced two mechanisms based on both sanction (in the form of a Pigovian tax) and redistribution of the tax revenue. Our results show that both monetary mechanisms improve cooperation by reducing the level of extraction, increasing efficiency and reducing payoffs inequality. Their impact on cooperation is in line with the consensus in the literature about the efficiency generated by the use of Pigovian instruments. Extending this literature, we show that this type of instrument is efficiency-enhancing even when populations are heterogeneous in their extraction capacities. The addition of a redistribution mechanism enables groups to reduce payoff inequality, especially in the case of the scarcity pricing mechanism that taxes each unit extracted.

We also examined the impact of a non-monetary intervention making individual extraction decisions visible to the other group members, expecting that observability and social comparisons would create a greater moral pressure on individuals. In fact, in the absence of a combined tax and redistribution mechanism, observability encourages people to extract *more*, even prior to receiving information about others' behavior. The increase in extraction when decisions are observable is the opposite of the stigma effect. As early as the first period of the game a majority

of high-type subjects extract at their maximum capacity level knowing that their individual decision would be made public. Observability potentially signals to group members that everyone is responsible for resource conservation and the high-types would not subsidize the low-types, or to install a norm of high extraction to avoid feeling guilty of overexploiting the resource themselves. Interestingly, our two combined mechanisms were able to eliminate the harmful effect of observability on the extraction levels by the high-type subjects. This effect of observability on increased extraction is consistent with studies on tax evasion that show that bad examples from peers' behavior increase fraud, whereas good examples have no impact (Lefebvre *et al.*, 2015). These results suggest that social nudging based on the dissemination of peer information may backfire and may not produce the outcomes expected. This is consistent with the observations of Ayres *et al.* (2013) in the domain of electricity and natural gas consumption.

The effectiveness of the pricing mechanisms suggests that formal mechanisms, by themselves, can create a focal point by expressing social values.¹⁵ When individuals are unsure of the appropriate social norms, prices may establish the norm. Moreover, adding redistribution further enhances the normative power of the monetary mechanisms, as it makes clear that taxes help disadvantaged members of the community. Adding observability to these formal mechanisms may not significantly increase the information about these norms and hence does not significantly alter behavior. Regulatory pricing mechanisms therefore may have an important role to play in focusing individuals on cooperative norms, over and above their efficiency properties.

Our study can inform public policy on the impacts of combining both pricing and social mechanisms but it can be further extended in several directions. Although the Increasing Block

¹⁵ In fact the legal or regulatory system often represents these social values. Cooter (1998) argues that by expressing social values the law can tip a system into a new and perhaps better equilibrium.

Rate mechanism is effective in increasing cooperation and reducing inequality, announcing a threshold beyond which extraction is taxed might generate a reference point that influences subjects' decisions. Moreover, we cannot exclude that observability does not generate any stigma because subjects in our study “earned” their extraction capacity through their performance in the preliminary real-effort task: high-type subjects may therefore feel entitled to take advantage of their relative position (Gächter and Riedl, 2005). While we aimed to design an environment akin to what is observed around us, where an advantaged position is often earned, it might be interesting to examine whether observability would have a different effect if extraction capacities were assigned randomly.

Finally, we have considered inequality in terms of extraction capacity. Possible extensions could examine whether different sources of inequality, for example in terms of returns from the common pool resource, would have different consequences on extraction and whether taxation would have a different impact in the presence of different kinds of inequality. Moreover, it would be interesting to analyze the effects of the mechanisms proposed under partial redistribution, oriented only towards the low-type subjects. We leave this for further investigation.

Reference list

- Abrahamse, W., Steg, L., Vlek, C., Rothengatter, T. (2005). A Review of Intervention Studies Aimed at Household Energy Conservation. *Journal of Environmental Psychology* 25(3), 273–291.
- Akerlof, G.A. (1980). A theory of social custom, of which unemployment may be one consequence. *The Quarterly Journal of Economics* 94(4), 749-775.
- Akerlof, G. A., Kranton, R.E. (2000). Economics and Identity. *The Quarterly Journal of Economics* 115(3), 715-753.
- Allcott, H., Mullainathan, S. (2010). Behaviour and Energy Policy. *Science* 327(5970), 1204-1205.
- Allcott, H. (2011). Consumers' Perceptions and Misperceptions of Energy Costs. *American Economic Review* 101(3), 98-04.
- Allcott, H., Rogers, T. (2014). The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation. *American Economic Review* 104(10), 3003-3037.
- Anderson, L.R., Mellor, J.M., Milyo, J. (2008). Inequality and public good provision: An experimental analysis. *Journal of Socio-Economics* 37, 1010-1028.
- Andreoni, J., Miller, J. (2000). Giving According to GARP: An Experimental Test of the Rationality of Altruism. Mimeo University of Wisconsin and Carnegie Mellon University.
- Andreoni, J., Petrie, R., (2004). Public goods experiments without confidentiality: a glimpse into fund-raising. *Journal of Public Economics* 88(7-8), 1605-1623.
- Andreoni, J., Gee, L.K. (2012). Gun for hire: delegated enforcement and peer punishment in public goods provision. *Journal of Public Economics* 96(11–12), 1036–1046.
- Apestequia, J., Maier-Rigaud, F. P. (2006). The Role of Rivalry: Public Goods versus Common-Pool Resources. *The Journal of Conflict Resolution* 50 (5), 646-663.
- Ayres, I., Raseman, S., Shih, A. (2013). Evidence from Two Large Field Experiments that Peer Comparison Feedback Can Reduce Residential Energy Usage. *Journal of Law, Economics and Organization* 29(5), 992-1022.
- Banerjee, A. (1992). A Simple Model of Herd Behavior. *The Quarterly Journal of Economics* 107(3), 797-817.
- Bardhan, P., Dayton-Johnson, J. (2007). Inequality and the Governance of Water Resources in Mexico and South India. in Baland, J.M., Bardhan, P., and Bowles, S. (eds), *Inequality, Cooperation, and Environmental Sustainability*, Oxford: Oxford University Press, 97-130.
- Barraque, B., Montginoul, M. (2015). How to Integrate Social Objectives into Water Pricing. Water Pricing Experiences and Innovations. *Global Issues in Water Policy* 9, 359-371.
- Becker, G. (1974). A theory of social interactions. *Journal of Political Economy* 82, 1063–1094.

- Benabou, R., Tirole, J. (2003). Intrinsic and extrinsic motivation. *Review of Economic Studies* 70, 489-520.
- Bernheim, B.D. (1994). A Theory of Conformity. *Journal of Political Economy* 102(5), 841–877.
- Blackman, A., Harrington, W. (1999). The Use of Economic Incentives in Developing Countries: Lessons from International Experience with Industrial Air Pollution. Discussion Paper 99-39. Washington, DC: Resources for the Future.
- Bluffstone, R. (1999). Are the Costs of Pollution Abatement Lower in Central and Eastern Europe? Evidence from Lithuania. *Environment and Development Economics* 4 (4), 449-470.
- Bock, O., Baetge, I., Nicklisch, A. (2014). Hroot: Hamburg Registration and Organization Online Tool. *European Economic Review* 71, 117-120.
- Bolton, G. E., Ockenfels, A. (2000). A theory of equity, reciprocity and competition. *American Economic Review* 100, 166-193.
- Borenstein, S. (2012). The Redistributive Impact of Nonlinear Electricity Pricing. *American Economic Journal: Economic Policy* 4(3), 56-90.
- Borooah, V.K., Sabharwal, N.S., Diwakar, D.G., Mishra, V.K., Naik, A.K. (2015). *Caste, Discrimination and Exclusion in Modern India*. New-Delhi: Sage.
- Brent, D. A., Cook, J. H., Olsen, S. (2015). Social comparisons, household water use, and participation in utility conservation programs: Evidence from three randomized trials. *Journal of the Association of Environmental and Resource Economists* 2 (4), 597-627.
- Brent, D., Friesen, L., Gangadharan, L., Leibbrandt, A. (2016). Behavioral Insights from Field Experiments in Environmental Economics. Monash Economics Working Papers.
- Buckley, E., Croson, R. (2006). Income and wealth heterogeneity in the voluntary provision of linear public goods. *Journal of Public Economics* 90(4-5), 935-955.
- Cason, T., Gangadharan, L. (2013). Empowering neighbors versus imposing regulations: an experimental analysis of pollution reduction schemes. *Journal of Environmental Economics and Management* 65, 469-484.
- Cason, T., Gangadharan, L. (2015). Promoting cooperation in nonlinear social dilemmas through peer punishment. *Experimental Economics* 18 (1), 66-88.
- Cason, T., Friesen, L., Gangadharan, L. (2016). Regulatory performance of audit tournaments and compliance observability. *European Economic Review* 85, 288-306.
- Cason, T., Gangadharan, L. (2016). Swords without covenants do not lead to self-governance. *Journal of Theoretical Politics* 28 (1), 44-73.
- Chan, K.S., Mestelman, S., Moir, R., Muller, R.A. (1999). Heterogeneity and the voluntary provision of public goods. *Experimental Economics* 2(1), 5-30.
- Charness, G., Masclet, D., Villeval M.C. (2014). The dark side of competition for status. *Management Science* 60(1), 38-55.
- Chaudhuri, A. (2011). Sustaining cooperation in laboratory public goods experiments: a selective survey of the literature. *Experimental Economics* 14(1), 47-83.

- Chaudhuri, A., Paichayonvijit, T. (2010). Does strategic play explain the decay in contributions in laboratory public goods games? Experimental Evidence. Working paper, University of Auckland.
- Cherry, T.L., Kroll, S., Shogren, J.F. (2005). The impact of endowment heterogeneity and origin on public good contributions: evidence from the lab. *Journal of Economic Behavior & Organization* 57(3), 357-365.
- Cialdini, R.B. (2003). Crafting normative messages to protect the environment. *Current Directions in Psychological Science* 12, 105-109.
- Cooter, R. 1998. "Expressive Law and Economics." *Journal of Legal Studies*, 27(S2), 585-607.
- Coricelli, G., Joffily, M., Montmarquette, C., Villeval, M. C. (2010). Cheating, emotions, and rationality: An experiment on tax evasion. *Experimental Economics* 13, 226-247.
- Daflon, B. (2012). Solidarity and the design of equalization: setting out the issues. *eJournal of Tax Research* 10(1), 138-164.
- Dalhuisen, J.M., Florax, R.J.G.M., de Groot, H.L.F., Nijkamp, P. (2003). Price and income elasticities of residential water demand: A meta-analysis. *Land Economics* 79, 292-308.
- Dana, J.D. (1999). Equilibrium Price Dispersion under Demand Uncertainty: The Roles of Costly Capacity and Market Structure. *RAND Journal of Economics* 30, 632-660.
- Delaney, J., Jacobson, S. (2016). Payments or Persuasion: Common Pool Resource Management with Price and Non-Price Measures. *Environmental & Resource Economics* 65(4), 747-772.
- Dickinson, D. L., Tiefenthaler, J. (2002). What Is Fair? Experimental Evidence. *Southern Economic Journal* 69(2), 414-428.
- Dickinson, D. L., Masclet, D., Villeval, M. C. (2015). Norm enforcement in social dilemmas: An experiment with police commissioners. *Journal of Public Economics* 126, 74-85.
- Dohmen, T., Falk, A., Huffman, D., Sunde, U., Schupp, J., Wagner, G.G. (2011). Individual Risk Attitudes: Measurement, Determinants, and Behavioral Consequences. *Journal of the European Economic Association* 9(3), 522-550.
- Dugar, S. (2013). Non-monetary incentives and opportunistic behavior: Evidence from a laboratory public good game. *Economic Inquiry* 51(2), 1374-1388.
- Duke, J.M., Ehemann, R. (2002). The Conservation of Residential Water – Scarcity Pricing of Water in Northern New Castle County. Extension Reports, University of Delaware, Department of Food and Resource Economics, No 15811.
- Eaton, D. (2015). Paying for clean water. GGKP Annual Conference 29–30 January 2015, Venice.
- Eek, D., Biel, A., Gärling, T. (2001). Cooperation in asymmetric social dilemmas when equality is perceived as unfair. *Journal of Applied Social Psychology* 31(3), 649-666.
- Egas, M., Riedl, A. (2008). The economics of altruistic punishment and the maintenance of cooperation. *Proceedings of the Royal Society B* 275(1637), 871-878.

- Elberg Nielsen, A.S., Sand, H., Sorensen, P., Knutsson, M., Martinsson, P., Perrson, E., Wollbrant, C. (2016). *Nudging and pro-environmental behavior*. Nordic Council of Ministers, TemaNord 2016-553.
- Erkal, N., Gangadharan, L., Nikiforakis, N. (2011). Relative Earnings and Giving in a Real Effort Experiment. *American Economic Review* 101(7), 3330-3348.
- Falk, A., Fischbacher, U. (1999). A Theory of Reciprocity. Institute for Empirical Research in Economics, University of Zurich, Working Paper No. 6.
- Falk, A., Fehr, E., Fischbacher, U. (2000). Testing Theories of Fairness –Intentions Matter. Institute for Empirical Research in Economics, University of Zurich, Working Paper No. 63.
- Falk, A., Fehr, E., Fischbacher, U. (2000). Appropriating the Commons. Institute for Empirical Research in Economics, University of Zurich, Working Paper No. 55.
- Falkinger, J., Fehr, E., Gächter, S., Winter-Ebmer, R. (2000). A Simple Mechanism for the Efficient Provision of Public Goods: Experimental Evidence. *American Economic Review* 90(1), 247-264.
- Fehr, E., Kirchsteiger, G., Riedl, A. (1998). Gift Exchange and Reciprocity in Competitive Experimental Markets. *European Economic Review* 42, 1-34.
- Fehr, E., Schmidt, K. (1999). A Theory of Fairness, Competition, and Cooperation. *The Quarterly Journal of Economics* 114, 817-868.
- Fehr, E., Gächter, S. (2000). Cooperation and Punishment in Public Goods Experiments. *American Economic Review* 90, 980-994.
- Fehr, E., Gächter, S. (2002). Altruistic punishment in humans. *Nature* 415, 137–140.
- Ferraro, P., Miranda, J., Price, MK. (2011). The Persistence of Treatment Effects with Norm-Based Policy Instruments: Evidence from a Randomized Environmental Policy Experiment. *American Economic Review* 101(3), 318-322.
- Ferraro, P.J., Price, MK. (2013). Using non-pecuniary strategies to influence behavior: evidence from a large-scale field experiment. *Review of Economics and Statistics* 95(1), 64-73.
- Ferraro, P., Miranda, J. (2013). Heterogeneous Treatment Effects and Mechanisms in Information-Based Environmental Policies: Evidence from a Large-Scale Field Experiment. *Resource and Energy Economics* 35(3), 356–379.
- Fischbacher, U. (2007). z-Tree: Zurich Toolbox for Ready-made Economic Experiments. *Experimental Economics* 10(2), 171-178.
- Fischbacher, U., Gächter, S. (2010). Social preferences, beliefs, and the dynamics of free-riding in public good experiments. *American Economic Review* 100 (1), 541-556.
- Frey, B., Meier, S. (2004). Social Comparisons and Pro-Social Behavior: Testing Conditional Cooperation in a Field Experiment. *American Economic Review* 94(5), 1717-1722.
- Gächter, S., Riedl, A. (2005). Moral property rights with infeasible claims. *Management Science* 51(2), 249-263.

- Gangadharan, L., Nikiforakis, N., Villeval, M.C. (2017). Normative Conflict and the Limits of Self-Governance in Heterogeneous Populations. Forthcoming, *European Economic Review*.
- Gerber, A., Rogers, T. (2009). Descriptive Social Norms and Motivation to Vote: Everybody's Voting and So Should You. *Journal of Politics* 71, 1-14.
- Gneezy U, Rustichini A. (2000). A fine is a price. *Journal of Legal Studies* 29(1), 1-17.
- Goldstein, N.J., Cialdini, R.B., Griskevicius, V. (2008). A Room with a Viewpoint: Using Social Norms to Motivate Environmental Conservation in Hotels. *Journal of Consumer Research* 35(3), 472-482.
- Grafton, Q. R., Kompas, T. (2007). Pricing Sydney water. *Australian Journal of Agricultural and Resource Economics* 51(3), 227-241.
- Grafton, Q. R., Ward, M.B. (2008). Prices versus rationing: Marshallian Surplus and Mandatory Water restrictions. *The Economic Record* 84, S57-65.
- Hartman, D.A. (2002). Does progressive taxation redistribute income? Institute for Policy Innovation: Policy Report no. 162.
- Heres, D, Kallbekken, S, Galarraga, I. (2013). Understanding public support for externality-correcting taxes and subsidies: A lab experiment. Working Paper 2013-04.
- Hogan, W. (2013). Electricity Scarcity Pricing Through Operating Reserves. *Economics of Energy and Environmental Policy* 2(2).
- Kallbekken S, Kroll S, Cherry TL. (2011). Do you not like Pigou, or do you not understand him? tax aversion and revenue recycling in the lab. *Journal of Environmental Economics and Management* 62(1), 53-64.
- Kerr, N. L. (1995). Norms in social dilemmas. In D. Schroeder (ed.), *Social dilemmas: Social psychological perspectives*, New York: Pergamon Press, 31-47.
- Khadjavi, M., Lange, A., Nicklisch, A. (2014). The Social Value of Transparency and Accountability: Experimental Evidence from Asymmetric Public Goods Games. WiSo-HH Working Paper No. 12, University of Hamburg.
- Kummu, M., Ward, P., de Moel, H., Varis, O. (2010). Is physical water scarcity a new phenomenon? Global assessment of water shortage over the last two millennia. *Environmental Research Letters* 5(3), 034006.
- Ito, K. (2014). Do Consumers Respond to Marginal or Average Price? Evidence from Nonlinear Electricity Pricing. *American Economic Review* 104(2), 537-563.
- Janssen, M., Holahan, R., Lee, A., Ostrom E. (2010). Lab Experiments for the Study of Social-Ecological Systems. *Science* 328 (5978), 613-617.
- Ledyard, J. (1995). Public goods: A survey of experimental research, in Kagel, J.H. , and Roth, A.E. (eds.), *Handbook of experimental economics*, Princeton: Princeton University Press.
- Lefebvre, M., Pestieau, P., Riedl, A., Villeval, M.C. (2015). Tax Evasion and Social Information: An Experiment in Belgium, France and the Netherlands. *International Tax and Public Finance* 22, 401-425.

- Mansur, E.T., Olmstead, S. (2012). The value of scarce water: Measuring the inefficiency of municipal regulations. *Journal of Urban Economics* 71(3), 332-346.
- Masclot, D., Noussair, C., Tucker, S., Villeval, M.C. (2003). Monetary and Non-Monetary Punishment in the Voluntary Contributions Mechanism. *American Economic Review* 93(1), 366-380.
- McMorran, R. T., Nellor, David C. L. (1994). Tax Policy and the Environment: Theory and Practice. International Monetary Fund, Washington, D.C.
- Mitchell, R., Carson, R. (1999). Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington, DC, Resources for the Future.
- Murphy, R.O., Ackermann, K.A., Handgraaf, M.J.J. (2011). Measuring Social Value Orientation. *Judgment and Decision Making* 6, 771-781.
- Nikiforakis, N. (2008). Punishment and counter-punishment in public good games: Can we really govern ourselves? *Journal of Public Economics* 92 (1-2), 91–112.
- Nikiforakis, N., Noussair, C.N., Wilkening, T. (2012). Normative Conflict and Feuds: The Limits of Self-Enforcement. *Journal of Public Economics* 96(9-10), 797-807.
- Noussair, C., Tucker, S. (2007). Public Observability of Decisions and Voluntary Contributions in a Multi-Period Context. *Public Finance Review* 35, 176-198.
- Olmstead, S. M., Stavins, R. (2008). Comparing Price and Non-Price Approaches to Urban Water Conservation. NBER Working Papers 14147.
- Ostrom, E. (1990). *Governing the Commons –The Evolution of Institutions for Collective Action*. New York: Cambridge University Press.
- Ostrom, E., Walker, J., Gardner, R. (1992). Covenants With and Without a Sword: Self Governance is Possible. *American Political Science Review* 86, 404-417.
- Ostrom, E. (2000). Collective Action and the Evolution of Social Norms. *Journal of Economic Perspectives* 14, 137-158.
- Peeters, R., Vorsatz, M. (2013). Immaterial rewards and sanctions in a voluntary contribution experiment. *Economic Inquiry* 51(2), 1442-1456.
- Plott C. (1983). Externalities and corrective policies in experimental markets. *The Economic Journal* 93(369), 106-127.
- Rabin, M. (1993). Incorporating Fairness into Game Theory and Economics. *American Economic Review* 83(5), 1281-1302.
- Rege, M., Telle, K. (2004). The impact of social approval and framing on cooperation in public good situations. *Journal of Public Economics* 88(7-8), 1625-1644.
- Reuben, E., Riedl, A. (2013). Enforcement of Contribution Norms in Public Good Games with Heterogeneous Populations. *Games and Economic Behavior* 77, 122-137.
- Rockström, J., Falkenmark, M., Karlberg, L., Hoff, H., Rost, S., Gerten, D. (2009). Future water availability for global food production: the potential of green water for increasing resilience to global change. *Water Resources Research* 45(7).

- Samek, A.S., Sheremeta, R. M. (2014). Recognizing contributors: an experiment on public goods. *Experimental Economics* 17(4), 673-690.
- Schelhas, J. (2002). Race, Ethnicity, and Natural Resources in the United States: A Review. *Natural Resources Journal* 42, 723-763.
- Schroeder, D. A., Steel, J. E., Woodell, A. J., Bembenek, A. (2003). Justice within social dilemmas. *Personality and Social Psychology Review* 7, 374–387.
- Schultz, W.P., Khazian, A.M., Zaleski, A.C. (2008). Using normative social influence to promote conservation among hotel guests. *Social Influence* 3(1), 4-23.
- Shang, J., Croson, R. (2009). Field Experiments in Charitable Contribution: The Impact of Social Influence on the Voluntary Provision of Public Goods. *The Economic Journal* 119(540), 1422-1439.
- Spraggon, J. 2002. “Exogenous Targeting Instruments as a Solution to Group Moral Hazard.” *Journal of Public Economics*. 84(2): 427-456.
- Spraggon, J. 2004. “Testing Ambient Pollution Instruments with Heterogeneous Agents.” *Journal of Environmental Economics and Management* 48(2): 837-856.
- Thaler, R.H., Sunstein, C. (2008). *Nudge: Improving Decisions about Health, Wealth, and Happiness*. New Haven, CT: Yale University Press.
- Tyler, T. R., Degoey, P. (1995). Collective restraint in a social dilemma situation: The influence of procedural justice and community identification on the empowerment and legitimacy of authority. *Journal of Personality and Social Psychology* 69(3), 482-497.
- UNEP (2013). *Women and Natural Resources Unlocking the Peacebuilding Potential*. United Nations Environment Programme, UN Women, PBSO and UNDP.
- UN-Water (2014). *Eliminating discrimination and inequalities in access to water and sanitation*. United Nations.
- van Dijk, F., Sonnemans, J., van Winden, F. (2002). Social ties in a public good experiment. *Journal of Public Economics* 85, 275-299.
- Varian, H.R. (1994). Sequential Provision of Public Goods. *Journal of Public Economics* 53, 165-186.
- Weng, Q., Carlsson, F. (2015). Cooperation in teams: The role of identity, punishment, and endowment distribution. *Journal of Public Economics* 126, 25-38.
- World Bank (2001). World Development Report 2000/2001 Attacking Poverty. World Development Report; New York: Oxford University Press. © World Bank. <https://openknowledge.worldbank.org/handle/10986/11856> License: CC BY 3.0 IGO.

Appendix 1. Instructions (translated from French)

Introduction (Common to all treatments)

Baseline

We thank you for taking part in this experiment. Please switch off your mobile phone. This is an experiment on decision making. Please read the following instructions carefully.

This experiment is composed of two distinctive and compulsory parts: an online questionnaire that you have already completed and this experimental session. Your earnings for the online questionnaire will be given to you in cash in a sealed envelope at the end of this session.

Today's session contains two parts. You have received the instructions for the first part. You will receive the instructions for the second part after completing this part.

Your final earnings for this session will consist in your gains for part 2. You will also receive 5 Euros for showing-up on time. None of the other participants will ever know how much you earned in the experiment. You will be paid in cash at the end of the session in a separate private room.

All the decisions you will make in this experiment will remain anonymous and confidential. Please do not talk to one another during the experiment. After having finished reading these instructions and if you do not have any question, please wait quietly until we start the experiment. Otherwise, please raise your hand and the experimenters will come to you and answer your questions in private. At any time, you can also call the experimenter by pressing the red button on the side of your desk.

Part 1 (Common to all treatments)

In the first part, all participants will perform an encoding task. The task is the same for everyone. You will be presented with a set of letters that form “words” with no specific meaning and your task will be to encode these letters by substituting them with numbers. The task decision screen is shown in Figure 1.

Example: You are given the word LFAT. The Table shows that L=3, F=6, A=8, and T=19.

Once you encode a word correctly, the computer will prompt you with another word to encode. Once you encode that word, you will be given another word and so on. This process will continue for 5 minutes. All group members will be given the same words to encode in the same sequence.

Part 1

1 sur 1

Temps restant (en secondes): 81

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
8	12	14	10	9	6	24	22	7	5	11	3	18	1	21	16	23	2	13	19	25	4	26	17	20	15

you are coding now word number 1

WORD: I A N V H X I

CODE:

Notes:

- Press TAB to pass to the previous case.
- Press Shift+TAB to pass to the following case.
- Once you have finished coding, press the OK button in order to check the coding and pass to the following word.

OK

Figure 1 Screenshot of the task in Part 1

The relative performance of each individual in this part will influence the maximum amount they can earn in the next part. In the next part, participants will be divided into groups of four. You will therefore be in a group with three other participants. There will be two types of participants in each group. We will refer to them as “Type A” and “Type B”. Of the four individuals in each group, two will be of Type A and two of Type B.

The allocation of types depends on the relative performance of each person compared with that of the other participants in the task of Part 1. At the end of Part 1, the computer will rank the participants based on the number of words they encoded:

- The top 50% of the individuals in the group will be assigned the Type A.
- The bottom 50% of the individuals will be assigned the Type B. If two or more participants tie, the computer will determine their type randomly.

In the next part, the Type A participants will have more chances to increase their earnings compared to the Type B participants. More information about this will be given at the beginning of the second part.

You will be informed as to whether you are of Type A or Type B at the beginning of Part 2. You will keep the same type. You will not be informed about the precise number of words encoded by each of your group members until the end of the experiment. At that time, this will be done using a table indicating the number of words decoded by each member of your group.

Please read again these instructions. If you have any question, we will answer your questions in private.

Part 2 – Baseline-NO treatment

(The instructions for part 2 in Baseline-O treatment are similar, except for specificities indicated in italics)

This part consists of 18 periods. All the transactions in this part are conducted in Experimental Currency Units (ECU). These ECU will be converted to Euro at the end of the experiment, at a rate of:

$$6 \text{ ECU} = 1 \text{ Euro}$$

At the end of the experiment the computer will randomly select three different periods for your payment in this part. Your payoff in this part will be represented by the sum of your payoffs in these three randomly selected periods that will be converted to Euros for payment. Please note that, depending on your decision and the decisions of the others in your group it is possible to have negative profit and the end of a period and even have a negative sum of the profits for the three periods selected for payment for part 2. In this case, even if part 2 will be selected for your final payment of the session, you won't have any losses as the value of the show up fee will cover entirely any negative profits in part 2.

At the beginning of this part, you will be randomly divided into groups of four. You will therefore be in a group with three other participants. **The composition of each group will remain the same throughout this part.** The identities of each participant will be kept anonymous. No one will ever know who was in his group. The computer will randomly assign you a neural identifier (for instance, Participant 1, Participant 2, Participant 3 or Participant 4), that you will keep throughout the 18 periods.

Based on the number of words that you and the members of your group encoded in Part 1, you have been assigned the role of either a “Type A” or a “Type B” participant. At the beginning of Part 2, the computer will inform you about your type: Type A or Type B. **Your type will remain the same throughout the 18 periods in this part.** In each group, there will two Type A and two Type B participants.

Each period will take place as follows:

- Each group of four participants will receive a common account of 60 units of resources at the beginning of each period. This amount is the same for each group.
- You will decide how many units you decide to withdraw from this common resource account.
- You can withdraw between 0 and your maximum withdrawal capacity.
- Your maximum withdrawal capacity depends on your type (A or B).
 - o Type A participants will be able to withdraw up to 20 units of resource.
 - o Type B participants will be able to withdraw up to 10 units of resource.

The sum of the maximum withdrawal capacities of the four participants in a group is 60 units, that is the total amount of the common resource account.

How is your payoff for the period determined?

Your total payoff in each period will depend on two elements:

- a) a payoff for the amount that you withdraw from the common account

-

- b) a cost for the total amount withdrawn by your whole group

a) Your payoff for the amount you withdraw from the common account depends only on the number of units that you decided to withdraw. The formula describing your withdrawal payoff is:

$$\text{Your withdrawal payoff} = 9 \cdot W - 0,2 \cdot W^2 - 0,1 \cdot W$$

where W is your withdrawal decision

We have distributed to you a table displaying the payoffs associated with each possible withdrawal. Please look at this table. For example, if you withdraw 20 units, your withdrawal payoff is 98 ECU; if you withdraw 10 units, your withdrawal payoff is 69 ECU, ... etc.

b) The group cost depends on the total amount withdrawn by all the members of your group, including yourself. Each group member has to pay this cost. This cost for each group member represents 1 ECU for each unit withdrawn:

$$\text{Group cost} = 1 \text{ ECU} \cdot \text{total amount withdrawn by the 4 group members}$$

Thus, each unit that you withdraw from the common account implies a cost of 1 ECU that is deducted from your payoff but also from the payoff of each group member. Similarly, each unit withdrawn by another group member from the common account increases your cost and the cost of each other group member by 1 ECU.

Consequences of participants' decisions

On the one hand, the withdrawal decision of Type A and B participants determines the payoff associated to their withdrawal and the cost for the group. Each unit withdrawn implies a group cost of 1 ECU.

Example:

Suppose that a participant withdraws 15 units. The decision leads to:

- a payoff for this participant of: $(9 \cdot 15) - (0.2 \cdot 15 \cdot 15) - (0.1 \cdot 15) = 88.5$ ECU

- a group cost for the participant and for the other members of the group of: $15 \cdot 1$ ECU = 15 ECU

Your decision

Your task in each period is to choose the amount of your withdrawal by picking a number between 0 and your maximum possible withdrawal. If you do not want to withdraw any unit, just type 0.

After learning whether you are Type A or a Type B participant and before making your decision, you can use your computer to explore how different choices that you and others in your group can make might affect your total payoff. You can enter different values for your withdrawal and for the withdrawal of other group members to explore the consequences on your payoff (see screenshot below).

After having explored the consequences of various possible decisions, you have to press the button indicating that you are ready to make your decision (the one that will count for your payoff). As soon as you have pressed this button, your computer will display a screen in which you will be able to enter your withdrawal decision.

Part 2
Please note that you can move the sliders below on the withdrawal quantities to test different options before moving to the final decision

Your extraction	0	1	2	3	4	5	6	7	8	9	10
Your profit	0.0	7.7	15.0	21.9	28.4	34.5	40.2	45.5	50.4	54.9	59.0

withdrawal of other type A players: [slider] 0

withdrawal of type B players: [slider] 0

I am now ready to make a choice of withdrawal

continue to entering your choice

Figure 2 Screenshot of the decision testing in Part 2

End of the period

After all participants have made their withdrawal decision, you will receive a feedback indicating: your decision of the period and your profit for the period, as displayed in the screenshot below.

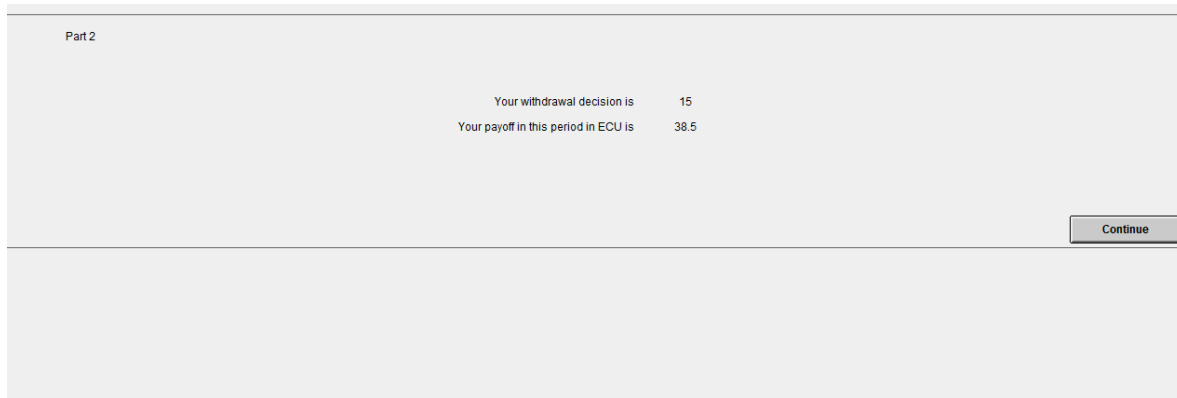


Figure 3. Screen shot of the end of the period feedback in Part 2

(In Baseline-O, these paragraphs are replaced with the following:

After all participants have made their withdrawal decision, you will receive a feedback indicating: your decision of the period, the total amount withdrawn by the group and your profit for the period, as displayed in the screenshot below. You will also receive information related to the results of the other participants in your group in a feedback table. You will be able to find out which were the withdrawal decision of the other three participants and their profit.

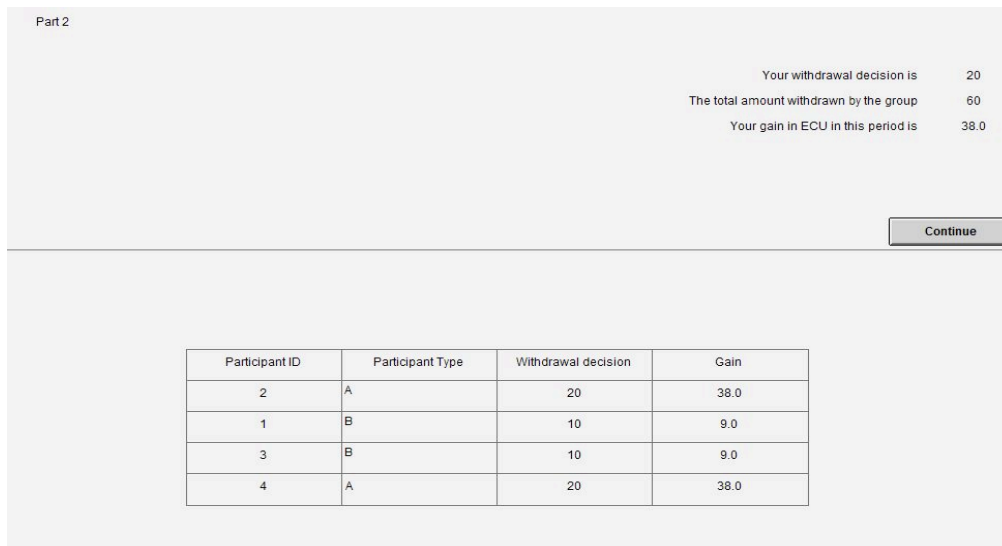


Figure 3. Screenshot of the end of the period feedback in Part 2)

At the end of the period, a new period starts automatically and the group receives a new common resource account of 60 units.

To sum up:

- You belong to a group of 4 participants: 2 are Type A and 2 are Type B.

- Your type has been assigned based on your relative performance in part 1 and you will keep the same type throughout this part.
- You and the 3 other participants in your group have to choose simultaneously the level of resource withdrawn from a common group account in each period.
- The maximum amount that Type A participants are allowed to withdraw is higher than the maximum amount allowed for Type B participants.

Please read these instructions again. If you have any question, please raise your hand and we will come to help you. Please answer the control questions that have been distributed to you.

Part 2 – SP-NO treatment

(The instructions for part 2 in SP-O treatment are similar, except for specificities indicated in italics)

This part consists of 18 periods. All the transactions in this part are conducted in Experimental Currency Units (ECU). These ECU will be converted to Euro at the end of the experiment, at a rate of:

$$6 \text{ ECU} = 1 \text{ Euro}$$

At the end of the experiment the computer will randomly select three different periods for your payment in this part. Your payoff in this part will be represented by the sum of your profits in these three randomly selected periods that will be converted to Euros for payment. Please note that, depending on your decision and the decisions of the others in your group it is possible to have negative profit and the end of a period and even have a negative sum of the profits for the three periods selected for payment for part 2. In this case, even if part 2 will be selected for your final payment of the session, you won't have any losses as the value of the show up fee will cover entirely any negative profits in part 2.

At the beginning of this part, you will be randomly divided into groups of four. You will therefore be in a group with three other participants. **The composition of each group will remain the same throughout this part.** The identities of each participant will be kept anonymous. No one will ever know who was in his group. The computer will randomly assign you a neural identifier (for instance, Participant 1, Participant 2, Participant 3 and Participant 4), that you will keep throughout the 18 periods.

Based on the number of words that you and the members of your group encoded in Part 1, you have been assigned the role of either a “Type A” or a “Type B” participant. At the beginning of Part 2, the computer will inform you about your type: Type A or Type B. **Your type will remain the same throughout the 18 periods in this part.** In each group, there will two Type A and two Type B participants.

Each period will take place as follows:

- Each group of four participants will receive a common account of 60 units of resources at the beginning of each period. This amount is the same for each group.
- You will decide how many units you decide to withdraw from this common resource account.
- You can withdraw between 0 and your maximum withdrawal capacity.
- Your maximum withdrawal capacity depends on your type (A or B).
 - Type A participants will be able to withdraw up to 20 units of resource.
 - Type B participants will be able to withdraw up to 10 units of resource.

The sum of the maximum withdrawal capacities of the four participants in a group is 60 units, that is the total amount of the common resource account.

How is your payoff for the period determined?

Your total payoff in each period will depend on four elements:

a) a payoff for the amount that you withdraw from the common account

-

b) a cost for the total amount withdrawn by your whole group

-

c) a tax you will have to pay for each unit you withdraw

+

d) a tax transfer that you will receive for each unit withdrawn by the all four participants in your group

a) Your payoff for the amount you withdraw from the common account depends only on the number of units that you decided to withdraw. The formula describing your withdrawal payoff is:

$$\text{Your withdrawal payoff} = 9*W - 0,2*W^2 - 0,1*W$$

where W is your withdrawal decision

We have distributed to you a table displaying the payoffs associated with each possible withdrawal. Please look at this table. For example, if you withdraw 20 units, your withdrawal payoff is 98 ECU; if you withdraw 10 units, your withdrawal payoff is 69 ECU ... etc.

b) The group cost depends on the total amount withdrawn by all the members of your group, including yourself. Each group member has to pay this cost. This cost for each group member represents 1 ECU for each unit withdrawn:

$$\text{Group cost} = 1 \text{ ECU} * \text{total amount withdrawn by the 4 group members}$$

Thus, each unit that you withdraw from the common account implies a cost of 1 ECU that is deducted from your payoff but also from the payoff of each group member. Similarly, each unit withdrawn by another group member from the common account increases your cost and the cost of each other group member by 1 ECU.

c) Each participant has to pay a tax for each unit he/she withdraws from the common account. This tax that corresponds to 3 ECU for each unit they have withdrawn from the common account.

$$\text{Tax} = 3*W$$

d) The total amount of the tax collected from the four group participants is equally shared and transferred between the four participants. Thus, both Type A and B participants, will receive 25% of the tax collected from the whole group members.

$$\text{Tax Transfer} = 25% * (\text{total tax paid by the group participants})$$

Example:

Suppose that in a group one Type A participants withdraws 15 units, the other Type A withdraws 20 units and the two Type B withdraw 5 units each. They have to pay a tax of 3 ECU for each unit withdrawn.

The amount of the tax paid by the first Type A participant is: $15 \cdot 3 \text{ UME} = 45 \text{ UME}$
The amount of the tax paid by the second Type A participant is: $20 \cdot 3 \text{ UME} = 60 \text{ UME}$
The amount of the tax paid by the first Type B participant is: $5 \cdot 3 \text{ UME} = 15 \text{ UME}$
The amount of the tax paid by the second Type B participant is: $5 \cdot 3 \text{ UME} = 15 \text{ UME}$
The total tax paid amounts to: $45 + 60 + 15 + 15 = 135 \text{ ECU}$.

In this example, each participant then receives a **tax transfer** that represents: $25\% \cdot 135 \text{ ECU} = 33.75 \text{ ECU}$.

Consequences of participants' decisions

On the one hand, the withdrawal decision of Type A and B participants determines the payoff associated to their withdrawal and the cost for the group. On the other hand, it also influences the amount of the tax paid and therefore the amount of the tax equally shared and transferred to the four group participants. Each unit withdrawn implies a group cost of 1 ECU, a tax of 3 ECU that is then transferred and shared equally between all the four group members.

Example:

Suppose that a participant withdraws 15 units. The decision leads to:

- a payoff for this participant of: $(9 \cdot 15) - (0.2 \cdot 15 \cdot 15) - (0.1 \cdot 15) = 88.5 \text{ ECU}$
- a group cost for the participant and for the other members of the group of: $15 \cdot 1 \text{ ECU} = 15 \text{ ECU}$
- a tax paid by this participant of: $15 \cdot 3 \text{ ECU} = 45 \text{ ECU}$
- a tax redistributed to the four group participants: 45 ECU , therefore $45 \text{ ECU} \cdot 25\% = 11.25 \text{ ECU}$ for each group participant

Your decision

Your task in each period is to choose the amount of your withdrawal by picking a number between 0 and your maximum possible withdrawal. If you do not want to withdraw any unit, just type 0.

After learning whether you are a Type A or a Type B participant and before making your decision, you can use your computer to explore how different choices that you and others in your group can make might affect your total payoff. You can enter different values for your withdrawal and for the withdrawal of other group members to explore the consequences on your payoff (see screenshot below).

After having explored the consequences of various possible decisions, you have to press the button indicating that you are ready to make your decision (the one that will count for your payoff). As soon as you have pressed this button, your computer will display a screen in which you will be able to enter your withdrawal decision.

Part 2

Please note that you can move the sliders below on the withdrawal quantities to test different options before moving to the final decision

Your extraction	0	1	2	3	4	5	6	7	8	9	10
Your profit	0.0	7.7	15.0	21.9	28.4	34.5	40.2	45.5	50.4	54.9	59.0

withdrawal of other type A players

withdrawal of type B players

I am now ready to make a choice of withdrawal

Figure 2. Screenshot of the decision testing in Part 2

End of the period

After all participants have made their withdrawal decision, you will receive a feedback indicating your decision of the period and your payoff of the period.

Partie 2

Your withdrawal decision is 17

Your payoff in ECU in this period is 42.5

Figure 3. Screen shot of the end of the period feedback in Part 2

(In SP-O, these paragraphs are replaced with the following:

After all participants have made their withdrawal decision, you will receive a feedback indicating: your decision of the period, the total amount withdrawn by the group, the total amount of the tax paid by the participants and paid by yourself, the tax transfer you received and your profit for the period, as displayed in the screenshot below. You will also receive information related to the results of the other participants in your group in a feedback table. You will be able to find out which were the withdrawal decision of the other three participants, both Type A and Type B, their profit but also the amount of the tax they have paid and the amount of the tax they received.



Figure 3. Screenshot of the end of the period feedback in Part 2)

At the end of the period, a new period starts automatically and the group receives a new common resource account of 60 units.

To sum up:

- You belong to a group of 4 participants: 2 are Type A and 2 are Type B.
- Your type has been assigned based on your relative performance in part 1 and you will keep the same type throughout this part.
- You and the 3 other participants in your group have to choose simultaneously the level of resource withdrawn from a common group account in each period.
- The maximum amount that Type A participants are allowed to withdraw is higher than the maximum amount allowed for Type B participants.
- For each unit withdrawn each participant has to pay a tax and the total amount of taxes collected from the group is equally split and transferred to the four group members.

Please read these instructions again. If you have any questions please raise your hand and we will come to help you. Please answer the control questions that have been distributed to you.

Part 2 – IBR-NO treatment

(The instructions for part 2 in IBR-O treatment are similar, except for specificities indicated in italics)

This part consists of 18 periods. All the transactions in this part are conducted in Experimental Currency Units (ECU). These ECU will be converted to Euro at the end of the experiment, at a rate of:

$$6 \text{ ECU} = 1 \text{ Euro}$$

At the end of the experiment the computer will randomly select three different periods for your payment in this part. Your payoff in this part will be represented by the sum of your profits in these three randomly selected periods that will be converted to Euros for payment. Please note that, depending on your decision and the decisions of the others in your group, it is possible to have negative profit and the end of a period and even have a negative sum of the profits for the three periods selected for payment for part 2. In this case, even if part 2 will be selected for your final payment of the session, you won't have any losses as the value of the show up fee will cover entirely any negative profits in part 2.

At the beginning of this part, you will be randomly divided into groups of four. You will therefore be in a group with three other participants. **The composition of each group will remain the same throughout this part.** The identities of each participant will be kept anonymous. No one will ever know who was in his group. The computer will randomly assign you a neural identifier (for instance, Participant 1, Participant 2, Participant 3 and Participant 4), that you will keep throughout the 18 periods.

Based on the number of words that you and the members of your group encoded in Part 1, you have been assigned the role of either a “Type A” or a “Type B” participant. At the beginning of Part 2, the computer will inform you about your type: Type A or Type B. **Your type will remain the same throughout the 18 periods in this part.** In each group, there will two Type A and two Type B participants.

Each period will take place as follows:

- Each group of four participants will receive a common account of 60 units of resources at the beginning of each period. This amount is the same for each group.
- You will decide how many units you decide to withdraw from this common resource account.
- You can withdraw between 0 and your maximum withdrawal capacity.
- Your maximum withdrawal capacity depends on your type (A or B).
 - Type A participants will be able to withdraw up to 20 units of resource.
 - Type B participants will be able to withdraw up to 10 units of resource.

The sum of the maximum withdrawal capacities of the four participants in a group is 60 units, that is the total amount of the common resource account.

How is your payoff for the period determined?

If you are a type A participant:

Your total payoff in each period will depend on four elements:

- a) a payoff for the amount that you withdraw from the common account

-

- b) a cost for the total amount withdrawn by your whole group

-

c) a tax you will have to pay for each unit you withdraw above the 12th unit

+

d) a tax transfer that you will receive for each unit withdrawn by the type A participants in your group above the 12th unit withdrawn

a) **Your payoff for the amount you withdraw** from the common account depends only on the number of units that you decided to withdraw. The formula describing your withdrawal payoff is:

$$\text{Your withdrawal payoff} = 9*W - 0,2*W^2 - 0,1*W$$

where W is your withdrawal decision

We have distributed to you a table displaying the payoffs associated with each possible withdrawal. Please look at this table. For example, if you withdraw 20 units, your withdrawal payoff is 98 ECU; if you withdraw 10 units, your withdrawal payoff is 69 ECU, ... etc.

b) The **group cost** depends on the total amount withdrawn by all the members of your group, including yourself. Each group member has to pay this cost. This cost for each group member represents 1 ECU for each unit withdrawn:

$$\text{Group cost} = 1 \text{ ECU} * \text{total amount withdrawn by the 4 group members}$$

Thus, each unit that you withdraw from the common account implies a cost of 1 ECU that is deducted from your payoff but also from the payoff of each group member. Similarly, each unit withdrawn by another group member from the common account increases your cost and the cost of each other group member by 1 ECU.

c) **For every unit withdrawn above the 12th unit**, each type A participant would have to pay a tax. This tax that corresponds to 3 ECU for each additional unit above the 12th unit. If you withdraw less than 12 units, you don't pay any tax.

$$\text{Tax} = 3 * R > 12$$

where $R > 12$ represents the amount of units withdrawn above the 12th unit

d) The total amount of the tax collected from the Type A participants, for the units withdrawn above the 12th unit, is equally shared and transferred between the four participants. Thus, both Type A and B participants, will receive 25% of the tax collected from the Type A members.

$$\text{Tax Transfer} = 25\% * (\text{total tax paid by the Type A participants})$$

Example:

Suppose that in a group one Type A participants withdraws 15 units, the other type A withdraws 20 units and the two type B withdraw 5 units each. They have to pay a tax of 3 ECU for each unit withdrawn above the 12th unit.

The amount of the tax paid by the first Type A participant is: $(15-12)*3 \text{ UME} = 9 \text{ UME}$

The amount of the tax paid by the second Type A participant is: $(20-12)*3 \text{ UME} = 24 \text{ UME}$

The total tax paid amounts to: $9+24 = 33 \text{ ECU}$.

In this example, each participant then receives a **tax transfer** that represents: $25\% * 33 \text{ ECU} = 8.25 \text{ ECU}$.

If you are a Type B participant:

Your payoff is determined in the same manner as for the Type A participants, except for the fact that the Type B participants won't pay any tax for the units withdrawn above the 12th unit. In fact, the Type B

participants are able to withdraw a maximum amount of 10 units. Type B's payoff depends on three elements:

a) a payoff for the amount that you withdraw from the common account

-

b) a cost for the total amount withdrawn by your whole group

+

c) a tax transfer that you will receive for each unit withdrawn by the Type A participants in your group above the 12th unit withdrawn

Consequences of Type A participants' decisions

The withdrawal decision of a Type A participant determines the payoff associated to their withdrawal and the cost for the group. This decision also influences the amount of the tax paid and therefore the amount of the tax equally shared and transferred to the four group participants. Each unit withdrawn implies a group cost of 1 ECU and each unit withdrawn above the 12th unit implies a tax of 3 ECU that is then transferred and shared equally between all the four group members.

Example:

Suppose that a Type A participant withdraws 15 units. The decision leads to:

- a payoff for this participant of: $(9 \cdot 15) - (0.2 \cdot 15 \cdot 15) - (0.1 \cdot 15) = 88.5$ ECU

- a group cost for the participant and for the other members of the group of: $15 \cdot 1$ ECU = 15 ECU

- a tax paid by this participant of: $(15 - 12) \cdot 3$ ECU = 9 ECU

- a tax redistributed to the four group participants: 9 ECU, therefore $9 \text{ ECU} \cdot 25\% = 2.25$ ECU for each group participant.

Consequences of Type B participants' decisions

The withdrawal decision of a Type B participant determines the payoff associated to their withdrawal and the cost for the group. Each unit withdrawn implies a group cost of 1 ECU.

Example:

Suppose that a Type B participant withdraws 8 units. The decision leads to:

- a payoff for this participant of: $(9 \cdot 8) - (0.2 \cdot 8 \cdot 8) - (0.1 \cdot 8) = 58.4$ UME

- a group cost for the participant and for the other members of the group of: $8 \cdot 1$ ECU = 8 ECU

Your decision

Your task in each period is to choose the amount of your withdrawal by picking a number between 0 and your maximum possible withdrawal. If you do not want to withdraw any unit, just type 0.

After learning whether you are Type A or a Type B participant and before making your decision, you can use your computer to explore how different choices that you and others in your group can make might affect your total payoff. You can enter different values for your withdrawal and for the withdrawal of other group members to explore the consequences on your payoff (see screenshot below).

After having explored the consequences of various possible decisions, you have to press the button indicating that you are ready to make your decision (the one that will count for your payoff). As soon as you have pressed this button, your computer will display a screen in which you will be able to enter your withdrawal decision.

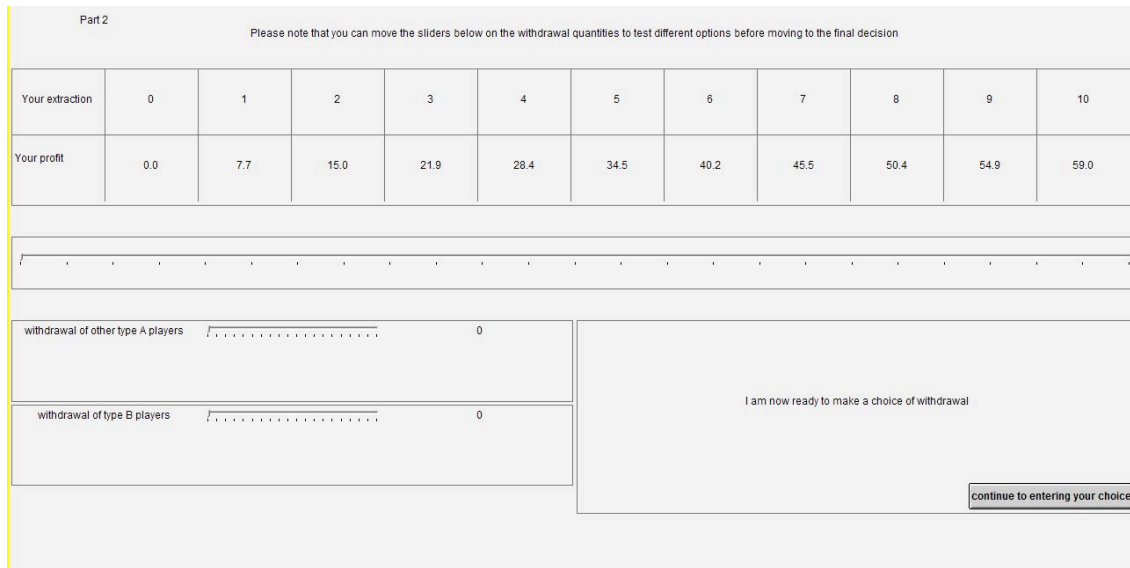


Figure 2 Screenshot of the decision testing in Part 2

End of the period

After all participants have made their withdrawal decision, you will receive a feedback indicating your decision of the period and your payoff of the period.

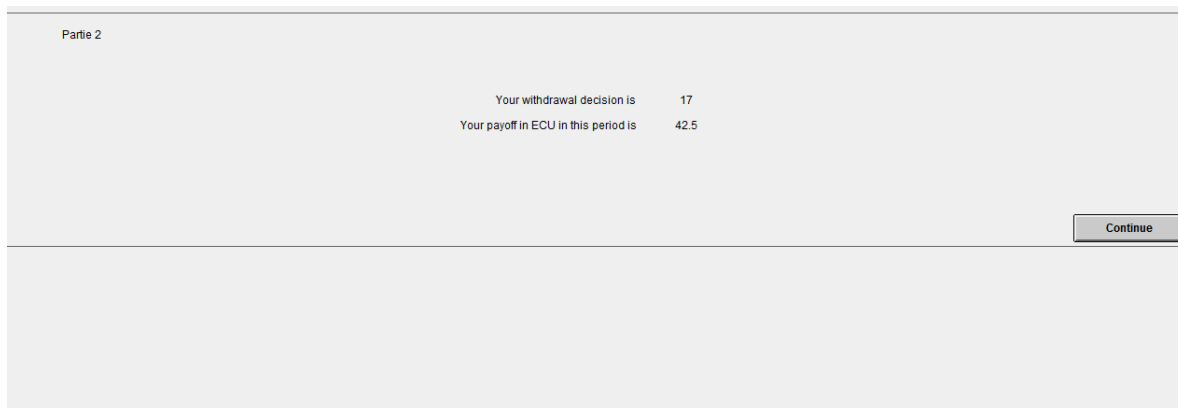


Figure 3. Screenshot of the end of the period feedback in Part 2

(In IBR-O, these paragraphs are replaced with the following:

After all participants have made their withdrawal decision, you will receive a feedback indicating: your decision of the period, the total amount withdrawn by the group, the total amount of the tax paid by the participants and paid by yourself, the tax transfer you received and your profit for the period, as displayed in the screenshot below.

You will also receive information related to the results of the other participants in your group in a feedback table. You will be able to find out which were the withdrawal decision of the other three

participants, both Type A and Type B, their profit but also the amount of the tax they have paid and the amount of the tax they received.

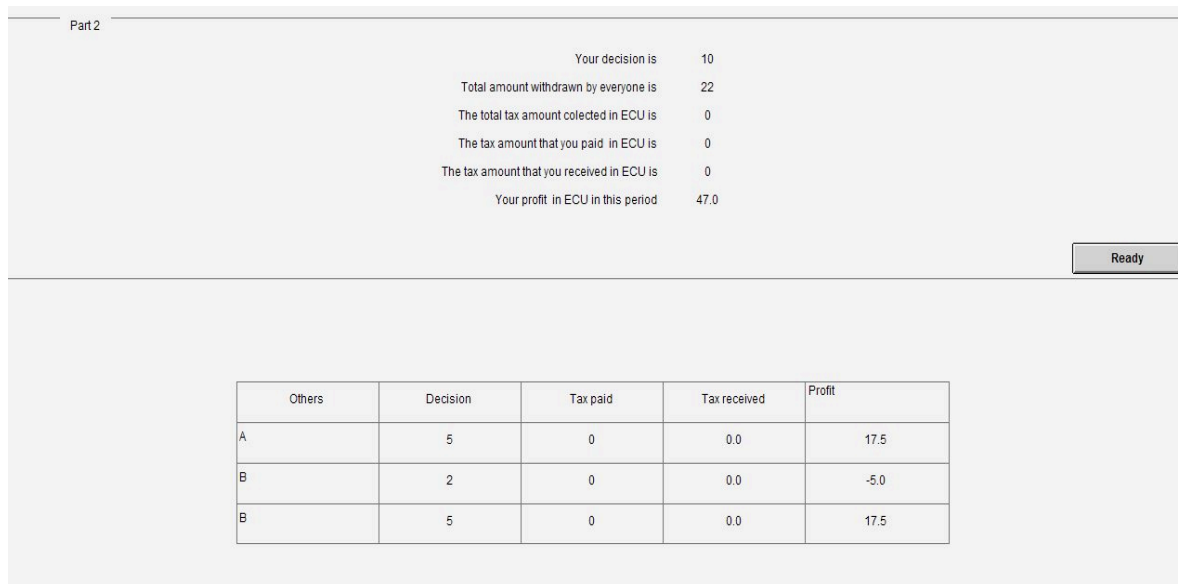


Figure 3. Screenshot of the end of the period feedback in Part 2)

At the end of the period, a new period starts automatically and the group receives a new common resource account of 60 units.

To sum up:

- You belong to a group of 4 participants: 2 are Type A and 2 are Type B.
- Your type has been assigned based on your relative performance in part 1 and you will keep the same type throughout this part.
- You and the 3 other participants in your group have to choose simultaneously the level of resource withdrawn from a common group account in each period.
- The maximum amount that Type A participants are allowed to withdraw is higher than the maximum amount allowed for Type B participants.
- For each unit withdrawn above the 12th unit each Type A participant has to pay a tax and the total amount of taxes collected from the group is equally split and transferred to the four group members.

Please read these instructions again. If you have any questions please raise your hand and we will come to help you. Please answer the control questions that have been distributed to you.

Appendix 2. Figures and Tables

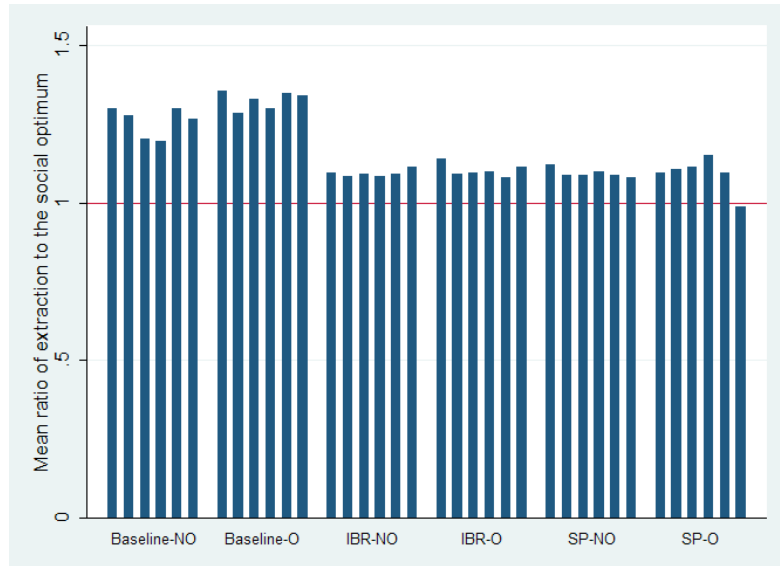


Figure A1. Mean ratio of extraction to the social optimum, by group and by treatment

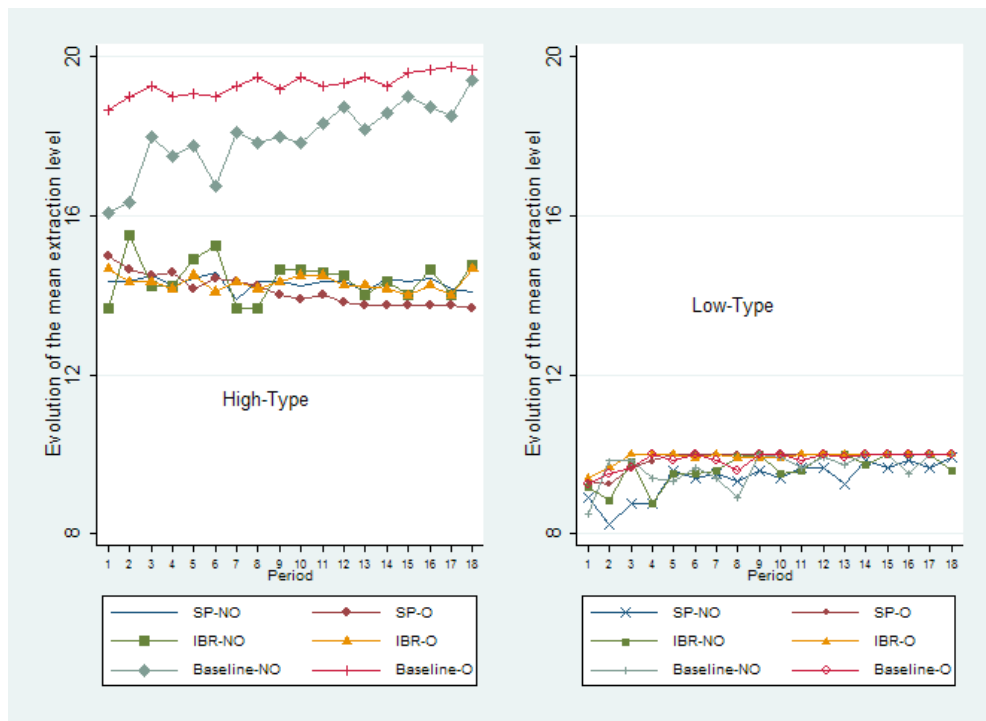


Figure A2. Evolution of the mean extraction level over time, by treatment and by subject type

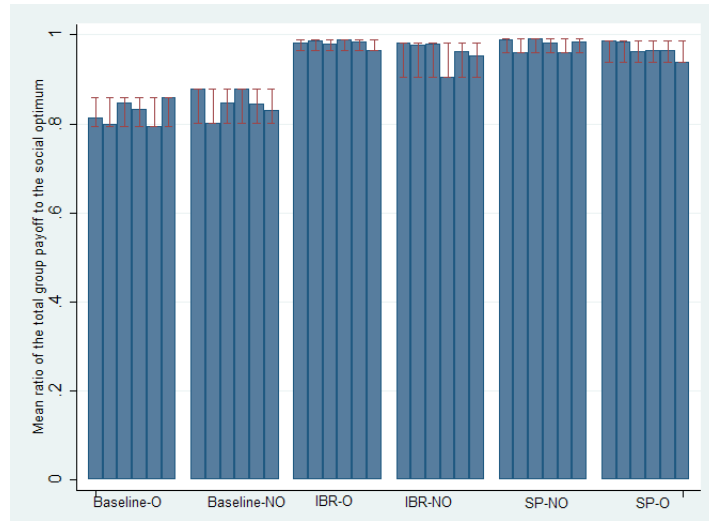


Figure A3. Mean ratio of the total group payoff to the social optimum, by group and by treatment

Table A1. Changes in the individual extraction decisions between period t and period $t-1$ as a function of deviations from the mean group extraction level in $t-1$

Dependent variable: $e_i^t - e_i^{t-1}$	Random-effects GLS models		
	All subjects (1)	High-Type (2)	Low-Type (3)
Positive deviation in $t-1$ in NO (max $\{0; e_i - \bar{e}_j\}$)	-0.286*** (0.048)	-0.271*** (0.042)	-
Negative deviation in $t-1$ in NO (max $\{0; \bar{e}_j - e_i\}$)	0.250*** (0.052)	2.243*** (0.352)	0.227*** (0.049)
Positive deviation in $t-1$ in O (max $\{0; e_i - \bar{e}_j\}$)	-0.340*** (0.050)	-0.310*** (0.048)	-
Negative deviation in $t-1$ in O (max $\{0; \bar{e}_j - e_i\}$)	0.183*** (0.041)	-	0.176*** (0.039)
High-Type subject	2.070*** (0.368)	-	-
Constant	-0.525 (0.383)	2.888*** (0.951)	-0.893** (0.365)
N	2592	1289	1294
R ²	0.160	0.252	0.133

Notes: The Table reports estimates from random-effects GLS regressions. Standard errors clustered at a group level in parentheses. ***, ** and * indicate significance at the 0.01, 0.05, and 0.1 level, respectively. In these models, we control for individual characteristics (age, gender, risk attitude, religiousness, political orientation and social value orientation), period and session size. For the High-Type subject pool we only registered 7 cases in which we observed negative deviations from the average in O (max $\{0; \bar{e}_j - e_i\}$). Therefore, we dropped these observations from model (2). Similarly for the Low-Type subject pool, we recorded only 18 observations with a positive deviation from the average in NO (max $\{0; e_i - \bar{e}_j\}$). We dropped these observations from model (3). In model (3), there was no observations with a positive deviation in O (max $\{0; \bar{e}_j - e_i\}$).

Table A2. Changes in the individual extraction decisions between period t and period $t-1$ as a function of tax paid and tax revenue received in $t-1$

Dependent variable: $e_i^t - e_i^{t-1}$	Random-Effects GLS models		
	All subjects (1)	High-Type (2)	Low-Type (3)
Tax paid SP-O $t-1$	-0.066*** (0.012)	-0.110*** (0.029)	-0.059 (0.038)
Tax received SP-O $t-1$	0.060*** (0.007)	0.116*** (0.033)	0.049 (0.031)
Tax paid IBR-O $t-1$	-0.129*** (0.020)	-0.220*** (0.019)	-
Tax received IBR-O $t-1$	0.062*** (0.015)	0.299*** (0.058)	0.007 (0.012)
Tax paid SP-NO $t-1$	-0.073*** (0.018)	-0.176*** (0.042)	-0.179*** (0.049)
Tax received SP-NO $t-1$	0.067* (0.009)	0.201*** (0.048)	0.143*** (0.039)
Tax paid IBR-NO $t-1$	-0.186*** (0.018)	-0.250*** (0.035)	-
Tax received IBR-NO $t-1$	0.091*** (0.018)	0.277*** (0.091)	0.033** (0.015)
High-Type Subject	0.691*** (0.173)	-	-
Constant	-0.138*** (0.050)	0.406*** (0.129)	0.010 (0.041)
N	2592	1296	1296
R ²	0.092	0.134	0.064

Notes: The Table reports estimates from random-effects GLS regressions, excluding the data from the two Baseline conditions. Standard errors clustered at a group level are in parentheses. ***, ** and * indicate significance at the 0.01, 0.05, and 0.1 level, respectively.

Table A3. Determinants of individual payoffs

Dependent variable: Individual payoff	All subjects		High-Type subjects		Low-Type subjects	
	(1)	(2)	(3)	(4)	(5)	(6)
Baseline-O	-1.101*** (0.352)	-1.157*** (0.458)	-0.356 (0.279)	-.333 (0.291)	-1.841** (0.731)	-1.503** (0.756)
IBR-O	3.534*** (0.211)	3.786*** (0.450)	-4.779*** (0.287)	-4.782*** (0.324)	11.851*** (0.564)	11.980*** (0.605)
IBR-NO	2.897*** (0.377)	3.077*** (0.547)	-4.855*** (0.269)	-4.750*** (0.341)	10.653*** (0.919)	10.921*** (0.897)
SP-O	3.432*** (0.240)	2.748*** (0.512)	-8.078*** (0.313)	-8.161*** (0.310)	14.947*** (0.650)	14.930*** (0.660)
SP-NO	3.119*** (0.436)	2.714*** (0.549)	-7.572*** (0.283)	-7.632*** (0.320)	13.815*** (0.996)	13.547*** (1.091)
High type-subject	14.768*** (1.666)	14.291*** (1.609)	-	-	-	-
Period	-	0.019 (0.015)	-	-0.024** (0.011)	-	0.064** (0.030)
Control variables	No	Yes	No	Yes	No	Yes
Constant	18.026*** (0.866)	19.954*** (4.768)	39.05*** (0.249)	41.272*** (1.146)	11.769*** (0.556)	8.352*** (1.521)
Number of observations	2592	2592	1296	1296	1296	1296
R ²	0.616	0.631	0.644	0.650	0.695	0.701

Notes: Table reports estimates from random-effects GLS regressions with robust standard errors clustered at the group level in parentheses. The control variables include the following socio-demographic variables. Risk attitude takes a value between 1 and 10, with a higher value associated with more willingness to take risk. A dummy is included to account for subjects who agree to answer the question on religiosity, and the religiosity variable is coded 1 for “I never pray”, 2 for “I pray less than once per week”, 3 for “I pray at least once per week”, 4 for “I pray every day”. Another dummy is included to account for subjects who agree to answer the question on political orientation, and the political orientation variable takes the value 1 for “extreme left”, 2 for “left”, 3 for “center”, 4 for “green”, 5 for “right” and 6 for “extreme right”. Individualistic social value orientation is defined as a binary variable, equal to 0 when “pro-social” and 1 when “individualistic”. Finally, the control variables include the session size. ***, ** and * indicate significance at the 0.01, 0.05, and 0.1 level, respectively.