

Taxation, observability and cooperation in a social dilemma with heterogeneous populations ^{*}

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Abstract

In the presence of a social dilemma, cooperation can be generally more difficult to achieve when populations are heterogeneous because of potential normative conflicts. 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 two types of policy instruments in this environment. One instrument is based on two variants of a mechanism that taxes extraction and redistributes the tax revenue to group members. The other instrument varies the social observability of individual decisions. We find that both tax mechanisms reduce extraction, increase efficiency and reduce 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 above the social optimum. In contrast, observability impacts only the Baseline condition by facilitating free-riding instead of creating a moral pressure on group members.

Keywords: Social norms; Equity; Experimental Economics; Resource Conservation.

JEL Codes: C92, H23, D74.

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1. Introduction

Often individuals are confronted with situations in which their personal interest are in contradiction with the well-being of a larger collective to which they belong. The tension that arises between private and social interest in such cases is referred to as a social dilemma. Social dilemmas, observed in different areas of society, such as in the environment, in organisations, and in local and global communities, have attracted significant disciplinary and inter-disciplinary interest amongst economists, biologists, psychologists, sociologists, philosophers and political scientists. Researchers and policy makers continue to explore different mechanisms to encourage cooperation in the presence of a social dilemma, which can be particularly difficult to achieve with heterogeneous populations.

This paper studies two mechanisms, in situations where individuals have heterogeneous impacts on the shared resource in a common pool resource ¹. One of the mechanisms is based on centralized and monetary principles of taxation and the other is inspired by non-monetary and decentralized social norms created by the observability of individual actions. Both of these mechanisms are evaluated on their own and in combination so as to examine to what extent they complement each other. An important contribution of our research is that we evaluate the mechanisms based on the criteria of economic efficiency and distributive equality, highlighting the equal importance of the two, hence mitigating the usual tradeoff between these two important criteria. To our knowledge, no studies have yet adopted such an approach when dealing with management solutions in common pool resource environments. The mechanisms we propose manage to address on the one hand the issue of social welfare maximisation and extraction reduction in a common pool resource, but also aim to obtain equal final monetary outcomes between individuals, in spite the initial heterogeneity regarding the impact they may exercise on the resource .

The tension between private and social interests can be even more salient in groups where individuals have heterogeneous characteristics. The normative conflict observed in such groups is well documented (Nikiforakis et al., 2012; Reuben and Riedl, 2013; Weng and Carlsson, 2015).

¹Common pool resource (CPR) dilemmas 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 an individual cannot be used by others. The benefits of extracting an extra unit of the resource are private, however its costs are borne by all individuals involved. Choosing to consume according to their own private interest exhausts the resource, but if individuals extract less than privately optimal the CPR generates future benefits for the whole collective (Ostrom, 2000).

Current policies of managing social dilemmas, such as centrally imposed pricing mechanisms, may trigger an increase in existing inequalities between the group members, thereby raising conflicts between equality and efficiency. We contribute to the literature in this field by proposing monetary and non-monetary mechanisms that have multidimensional effects: maximizing efficiency and also reducing inequality. Both mechanisms have two components: an efficiency maximization element introduced through the form of a Pigouvian tax meant to internalize external costs and attain the Pareto optimal level of welfare, and an inequality reduction dimension that is achieved through an equal redistribution of the collected tax towards all subjects in the group.

Therefore, we assess the effects of two types of monetary instruments, that use Pigouvian taxation and subsequent redistribution as the unifying theme. The two monetary mechanisms proposed represent a variant of two types of pricing schemes referred to as the increasing block rate (IBR) structure and the scarcity-pricing (SP) structure (Dana, 1999; Duke and Ehemann, 2002). The two mechanisms proposed represent an adjusted version of the IBR and SP structure, in the sense that we apply the tax in conformity with the basic principles of functioning of both mechanisms. The scarcity pricing mechanism applies a tax to each unit of resource consumed, whereas for the increasing block rate structure the tax is applied only for the units consumed above the optimal extraction threshold. We select these two instruments because they are common mechanisms to encourage conservation of common pool resources and have different distributional implications. While both mechanisms are expected to attain the same overall optimal efficiency level, the scarcity pricing mechanism is expected to produce higher inequality reduction across subjects' outcomes.

Moreover, we contribute to the literature in this field, by shedding light on the issue of the net effect of a social observability mechanism, consisting on the possibility of receiving feedback on the withdrawal decisions and the payoffs of the other participants in the group. We aim to examine the impact of the public observability of the actions and earnings of the other group members, on cooperative outcomes. While theoretically outcomes are not expected to differ in such situations, there is some evidence (see Section 2) that social observability can either increase or decrease pro-social behavior. One of the main advantages of this mechanism, if it is effective, is that it is relatively inexpensive to implement, compared to other traditional

taxation policies, that imply more costly monitoring and enforcement. Given the political and regulatory challenges with raising prices on natural resources such as energy and water, non-price mechanisms are attractive tools to encourage conservation ². In the context of a social dilemma framed as a public good game, we have evidence showing that if subjects are informed that the others are contributing, they would be likely to reciprocate this behavior or comply to this norm of conduct (Cialdini, 2003; Delaney and Jacobson, 2013). Nevertheless, the net effects of such an instrument are not clearly quantified in the context of a resource consumption in a CPR dilemma with various types of individuals, as fundamental differences could appear due to more destructive framing of the CPR environment (Dickinson et al., 2014).

We examine both the monetary and non-monetary mechanisms using a backdrop of a non-linear common pool resource game with heterogeneous agents, who vary in terms of the maximum amount of resource they are able to extract from the common pool. A common pool resource game is a quintessential example of a social dilemma (Ostrom, 1990). Our goal is to compare the performance of monetary and non-monetary mechanisms with respect to resource conservation, efficiency and distributional equality.

We assess the effects of the instruments proposed individually, but we also examine the consequences of the interaction between the monetary and the non-monetary schemes. Thus, firstly, we propose focusing on the assessment of the impact of the social observability factor, on CPR dilemmas with heterogeneous subjects, that might prove to be quite relevant for designing resource conservation policies as it could throw some light on the interactions that could arise at a community level. Secondly, we examine the performance of the proposed pricing instruments in terms of resource conservation, efficiency and distributional equality, when used in isolation, but also, we aim addressing the question of how such price based instruments could interplay in promoting a sustainable resource management with the above mentioned non-monetary social observability dimension.

We use the experimental methodology to investigate the effects of these alternative mechanisms. Experiments by their very design allow causal interpretations and help us understand the underlying drivers of a policy-behavior relationship. In our setting, experiments are also useful in defining and measuring concepts such as efficiency and equality, which can be difficult

²See Brent et al. (2016) for a review of non-pecuniary policies for natural resource conservation.

to quantify using other empirical approaches. Similarly, experiments help compare outcomes with equilibrium predictions in a controlled environment, allowing us to empirically evaluate theoretical predictions.

Our findings suggest that both monetary mechanisms have a positive effect on reducing extraction reduction, increasing efficiency and reducing inequality. The strongest impact is associated with the scarcity pricing mechanisms, both in terms of resource conservation and decreasing inequality, regardless of the observability condition. Receiving feedback about the decisions and the earnings of others in the group does not significantly change extraction rates when a tax mechanism is in place, and in fact decreases pro-social behavior when there is no tax mechanism.

The remainder of this paper is organized as follows. In section 2 we discuss the literature relevant to this study. We present the experimental design in section 3 and develop the predictions in section 4. Section 5 reports the results and section 6 discusses the implications of our findings.

2. Related Literature

Our paper contributes to two main strands of the literature. First, is the vast and established literature on social dilemmas, in particular common pool resources, and the different mechanisms proposed to mitigate conflicts in resource use. Centralized mechanisms for mitigating social dilemma include structural non-price mechanisms such as restrictions or price instruments. As the non-price mechanisms mainly aim to impose restrictions on consumption, leading to inefficient outcomes ³, most economists therefore advocate for policies using monetary mechanisms that have proven effective at managing scarce resources (Dalhuisen et al. 2003; Olmstead and Stavins 2009; Grafton et al. 2011). One of the most implemented centralized pricing mechanisms to manage social dilemmas such as the common pool resource is the increasing block rate scheme (IBR), in which users pay different amounts for different consumption levels (Ito, 2014; Borenstein, 2012). Although much rarely used in practice, the scarcity-based pricing (SP) instruments according to which prices varies inversely with available supply, in order to reflect

³Imposing such restrictions may lead to substantial losses in consumer welfare (Mansur and Olmstead, 2012) or to free riding behavior (Dixon et al., 1996).

the scarcity value, have been vividly advocated by the economists (Grafton and Kompas, 2007; Hogan, 2013).

When deciding on the amount of the tax to be raised, absolutely pure Pigouvian based taxes are difficult to implemented, mainly due to the practical issues encountered when having to measure the marginal social damage, as well as due to tax aversion issues (Mitchell and Carson, 1999; Bluffstone, 1999; Blackman and Harrington, 1999; Kallbekken et al, 2011; Heres et al, 2013). Nevertheless, given their well-known efficiency properties, the Pigouvian solution seems to be difficult to be abandoned without a struggle, as there is evidence showing that there have been attempts to implement Pigouvian taxes in several countries (McMorran and Nellor, 1994).

An increasing body of evidence shows, however, that such economic incentives are not the sole drivers of individuals' choice and non-economic factors also influence behavior in social dilemmas (Ostrom, 1990; Kerr, 1995; Tyler and Degoey, 1995; Masclet et al., 2003; Dugar, 2013; Peeters and Vorsatz, 2013). Thus, individuals are rational but also have social preferences, which implies that their utility is influenced not only by their own payoff but also by the payoff of others ⁴, such that it is not always the case that resources will be over exploited.

An extensive body of literature acknowledges that providing information on the actions of others might trigger conformity to a social norm of conduct (Allcott and Mullainathan, 2010; Ferraro and Price, 2013), due to various potential reasons: social penalties for noncompliance (Akerlof, 1980); intrinsic utility derived from conforming to an identity (Akerlof and Kranton, 2000), social preferences when dealing with heterogeneous agents or due to cognitive limitations as others' choices might be informative in the face of imperfect information (Banerjee, 1992). Consistent with this, several studies show that individuals are more likely to contribute in a public good game if they are informed about others contributions (Cialdini, 2003; Frey and Meier, 2004 and Shang and Croson, 2004).

In contrast, Noussair and Tucker (2007) and Khadjavi et al. (2014) find that revealing all contribution decisions can have negative impacts on cooperation at the group level. Delaney and Jacobson (2013) show that in a CPR context with homogenous players, information provisions on the congestion situation and the optimality of group actions, lead to an efficiency increase

⁴Such preferences may be driven by altruism (Adreoni and Miller, 2000; Charness and Rabin, 2000), inequity aversion and fairness (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000), reciprocity or reputational concerns (Delmas and Lessem, 2014), assuming it is crucial how individuals interpret the behavior and intentions of others, and respond mainly by reciprocating (Rabin, 1993; Charness and Rabin, 1999; Falk and Fischbacher, 1999).

by reducing over-extraction, but the effect is not persistent. Chaudhuri and Paichayontvijit (2010) show that even when feedback is provided about the actions of others in a coordination game, eventually contributions decay. In cases where there is no feedback, the decay is in fact slower as more time is needed for the agents to realize that free-riding is the dominant strategy. Information about others actions therefore can also create unintended effects on contribution levels ⁵.

Our paper is also related to the recent literature on the impact of heterogeneity and the normative conflict it can potentially create. Most of the proposed mechanisms dealing with social dilemmas provide incentives to maximize efficiency, as efficiency is considered the ultimate criteria for the assessment of a mechanism. However, sole focus on this criterion may result in depriving some individuals from accessing the resource and deepen social inequalities. Criteria of social equality and justice can be of paramount importance as individuals have negative reactions when dealing with unequal distributions. This is particularly so if basic needs are not being met or if there are big disparities among individuals and groups ⁶.

When individuals are heterogeneous a trade-off between efficiency and equality is very likely to appear (Nikiforakis et al., 2012; Reuben and Riedl, 2013; Gangadharan et al., 2015). Various studies have analyzed the effects of heterogeneity on the efficacy of centralized and decentralized mechanisms in public good games (Falkinger et al., 2000; Andreoni and Gee, 2012; Egas and Riedl, 2008) that was introduced through different channels: different endowment levels (Buckley and Croson, 2006) or different yield from the public account (Reuben and Riedl, 2009), but to our knowledge regarding the CPR dilemmas evidence is quite scarce. Results are mixed, some studies show that heterogeneity has a negative effect on cooperation (Anderson et al., 2008), whereas others report a positive impact (Buckley and Croson, 2006; Reuben and Riedl, 2013), and the effects also depend on whether mechanisms for enhancing cooperation are implemented.

⁵In addition to the behavioral impact of the observability of actions, some recent studies have explored the impact of public display of identity (using photos) on pro-social behavior. For example, Andreoni and Petrie (2004) show that making contributions of participants visible in conjunction with their photos leads to a substantial (59%) increase in contributions in public good games. Coricelli et al. (2010) find that displaying the photo of a cheater in a tax experiment deters cheating. Rege and Telle (2004) show that making identity and choices public leads to higher contributions in a one shot public good game. Samek and Sheremeta (2014) show that contributions are affected more by the shame (recognition of the lowest contributor) than by prestige (recognition of the highest contributor). In contrast, Cason et al, 2016 find that social observability has a limited impact on behaviour in an audit and compliance experiment.

⁶There are several situations where such disparities could exist, for example, individuals may live at different distances from dams which are commonly financed, leading to differential costs of assessing water (Kummu et al., 2010; Rockstrom et al., 2009).

3. Experimental Design and Procedures

3.1. Design

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

Baseline treatment with no observability

The main part of the experiment is a CPR game played for 18 periods. We form groups of four subjects who remain matched together throughout the session. 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 are willing 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 notably in Erkal et al. (2011), Charness et al. (2014), and Gangadharan et al. (2015). For ten minutes, subjects have to encode sets of letters into numbers according to a correspondence table that is displayed on their screen.

When performing this task, subjects are not yet aware of the content of the rest of the tasks, but they are informed that the experiment is composed of different parts. Moreover, to avoid introducing wealth effects before the game, the task is not incentivized. Subjects are only informed that their relative performance in this task will affect their maximum earnings opportunities in the next part of the experiment, that they will be placed in groups of four, two of which would be of type A and two of type B, and that these types differ in their earnings opportunities. Once 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 20 units from the CPR, whereas the bottom 50% are assigned to the type that is only allowed to extract up to 10 units. Subjects are informed on their type at the beginning of the CPR game, and they maintain the same type throughout the experiment.

In the CPR game, each subject chooses the number of units he is willing to extract from the common pool, x_i , in each of the 18 periods. This extraction generates a private revenue represented by a concave utility function that increases at a decreasing rate up to a maximum level. Each unit extracted entails an individual fixed and exogenous cost, c . It also generates a negative externality, captured by a variable group cost that depends on the appropriation decisions of all group members. Thus, the payoff function for both types of individuals i 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 the intercept a equal to 9, and the coefficient b equal to 0.2 in the experiment. The third term represents the private extraction cost, with $c=0.1$, meaning that each unit extracted costs 0.1 ECU (Experimental Currency Unit). The last term captures the social cost of extraction, with $d=1$, which depends on the total amount of extraction over 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 ⁷. This setting depicts a social dilemma problem since a subject's extraction decision not only affects his payoff but also the payoff of the other 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. They receive feedback neither on the total extraction by the group, nor on the individual decisions. Of course, the individual's payoff allows a player to draw information on the total amount withdrawn from the common pool. The final earnings in the game are the sum of payoffs in three periods that were randomly chosen at the end of the session.

⁷In the field, heterogeneous extraction capacities might translate through different financial or physical access capabilities to drinking water sources.

Pricing treatments with no observability

The pricing treatments introduce two mechanisms that modify the monetary incentives for cooperation: the scarcity pricing treatment (SP-NO, hereafter) and the increasing block rate treatment (IBR-NO, hereafter). These two mechanisms aim to increase the cooperativeness of the subjects.

The SP-NO treatment introduces a tax and a redistribution mechanism in the previous CPR game. Regardless of their type, subjects have to pay a unitary tax, t , for each unit of resource extracted from the common pool. The value of this Pigovian tax is meant to neutralize 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. Two terms are added to the payoff function (1) and the payoff function for both types of subjects in SP-NO are summarised now:

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

The fifth term 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 represents the individual share of the tax revenue that is redistributed to each subject. At the end of each period, subjects are informed of the amount of the tax paid and on the amount of the tax transferred to them.

Like SP-NO, the IBR-NO treatment introduces both a tax and a redistribution mechanism in the CPR game, but in this case the tax applies only to the units extracted above the social optimum level. Subjects are informed that each unit extracted beyond the 12th one will be taxed. They are not told that 12 corresponds to the social optimum. Thus, this mechanism can only sanction the high-type subjects, since the low-type can only extract up to 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 for both types of subjects in IBR-NO is the following:

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

$$, \text{ where } x_{SO}^* = \frac{a-c-dn}{2b}.$$

The fifth term captures the taxation applied to deviations beyond the optimum level of extraction. The last term represents the individual share of the tax revenue that is redistributed to each subject. At the end of each period, feedback is the same as in SP-NO.

Treatments with observability

We also ran three treatments in which we maintain the same conditions as described above, but in which we allow for social observability; we refer to these treatments as Baseline LO, SP-SO and IBR-SO. At the end of each period in these treatments, subjects are informed about the individual decision and the payoff of each member of their group. A neutral identifier is assigned to each subject (Participant 1, Participant2, Participant 3 and Participant 4) and is kept constant in each period. Thus, since the composition of each group is the same for all periods, subjects are able to keep a track of the decisions of other group member across periods. This non-monetary intervention increases the visibility of each individuals behavior within his group.⁸

Therefore, in total we have three treatments with no observability of others' individual decisions: Baseline-NO, IBR-NO, SP-NO, and three treatments with social observability: Baseline-SO, IBR-SO and SP-SO.

Elicitation of individual characteristics

Since we expect that social preferences may affect both behavior in the CPR game and the reaction to the treatment manipulations, we elicited the subjects social value orientation (SVO) by means of a standard SVO test (Murphy et al., 2011; Hilbig et al., 2014; Murphy and Ackermann, 2014). Subjects are presented six successive decisions, each one consisting of nine different possibilities of distributing different amounts experimental currency between the subject and another person that they do not know and will not meet. The task is to indicate the distribution they prefer most. One decision was randomly selected and implemented for payment. This SVO task was completed online one week before the laboratory session to limit the risk of contamination between this task and the CPR game, with the additional advantage

⁸We also ran a session in which at the end of each period we showed to all the group members the photograph of the subject(s) that extracted the most in that period, but we didn't find a significant impact of this disclosure.

of saving time in the main session.

We also elicited a number of individual characteristics at the end of the laboratory sessions, including age, gender, religiosity, and political orientation, using a post-experimental questionnaire. Risk attitudes were self-reported. 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 to 10 from trying to avoid taking risks to 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 software Z-Tree (Fischbacher, 2007). Subjects were mainly recruited from the student population of local business, engineering, and medical schools by email using the software Hroot (Bock et al., 2012). 144 subjects participated in a total of 15 sessions. Most were undergraduate students (95%) with an average age of 21 years (S.D.=2.34). Table 1 summarizes the characteristics of each treatment. We have collected observations for six independent groups per treatment, i.e. 36 groups in total and 24 subjects per treatment.

Treatment	Monetary Mechanisms	Observability	Number of subjects	Number of sessions
Baseline-NO	N	N	24	2
IBR-NO	Y	N	24	3
SP-NO	Y	N	24	2
Baseline-SO	N	Y	24	3
IBR-SO	Y	Y	24	3
SP-SO	Y	Y	24	2
Total	-	-	144	-

Table 1: Summary of treatments

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 Social Values Orientation questionnaire. Completing this task took less than 10 minutes. Participants were informed that they would learn their payment for this task and receive their payment only at the end

of the session in the laboratory. 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 in an opaque bag. The instructions were distributed for each part after completion of the previous part (see Appendix 1). After reading the instructions, we checked the subjects understanding by means of a comprehension questionnaire. We started the experiment only after all answers were verified and all questions were answered.

The non-linear environment in the CPR game is more realistic than a linear environment but it also makes it more challenging for the participants to identify the value of their payoff associated with every possible decision. Instructions explained the rules that determine payoffs, but to facilitate decision-making, subjects could also use a computer interface to explore how different choices that they and the others in the group could make affect their payoff (see a copy of the screen in the instructions 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 earnings were 24.4 Euros(Std.Deviation.=5.6), including a 5 show-up fee. Earnings were paid in private in a separate room.

4. Predictions

If individuals are self-regarding, they would disregard the negative externality of their extraction decision on others. From (1) for Baseline-NO, we can derive the players best reply function and then infer the symmetric Nash equilibrium, $x_{NE}^* = \frac{a-c-d}{2b}$, that equates the individual marginal payoff with the marginal cost of extraction. In equilibrium, the level of extraction decreases with the individual cost and the coefficient on the quadratic term of the private payoff function. For the parameter values used in the experiment, the dominant strategy Nash equilibrium is for all subjects to extract 19.8 units. However, as the low-type subjects have a capacity constraint, they should extract up to their maximum capacity of 10 units. In equilibrium, each high-type subject earns 38.4 ECU and each low-type earns 9.5 ECU; the total group earnings 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 individual extractions, is attained if the total number of units extracted is $x_{SO}^* = \frac{a-c-dn}{2b}$, i.e. 12.3 units in the experiment. If each high-type subject extracts this optimal amount while the low-type subjects extract their maximum capacity, the total group earnings amount to 118 ECU, with 34.5 ECU for the high-type subjects and 24.5 ECU for the low-type subjects. The degree of inequality between the two types of players would be drastically decreased.

In the SP-NO treatment, due to the introduction of tax and redistribution, the Nash equilibrium now corresponds to the social optimum, $x_{NE}^* = \frac{a-c-dn}{2b}$. The equilibrium level of extraction is 12.3 units. Note that because of the tax and redistribution mechanism, the level of inequality between the two types of subjects is reduced substantially, as the predicted payoff is 31.1 ECU for the high-type subjects and 27.9 ECU for the low-type ones. In equilibrium, the total group earnings are equal to the social optimum of 118 ECU.

In the IBR-NO treatment, the equilibrium level of extraction also corresponds to the social optimum and is again equal to 12.3 units. Since their extraction capacity is bounded below this level, the low-type subjects do not pay any tax. In equilibrium, each high-type subject earns 34.5 ECU, each low-type subject earns 24.5 ECU, and the total group earnings are 118 ECU.

The theoretical predictions are similar for each treatment with and without social observability. Deviations of the extraction behavior from the equilibrium or the social optimum could only be the result of behavioral or cognitive dimensions related to social pressure or inequity aversion. For example, if subjects dislike being identified as a free rider (who extracts a large amount and causes damages to the group) by their group members, they may extract less in a treatment with social observability than in the corresponding treatment with observability.

5. Results

We analyze first the mean extraction levels by type of subject and by treatment, before considering efficiency and, finally, the degree of inequality within groups. Throughout this section, we refer to Table 2 that reports summary statistics by subjects type and by treatment on the mean extraction level, the mean payoff, the mean ratio of actual payoff to the social optimum

payoff as an indicator of efficiency, and the gap between high- and low-type subjects earnings, in %, as an indicator of inequality within groups. Table 2 also reports the significance levels from pair wise Mann-Whitney rank-sum tests (M-W, hereafter) comparing each treatment with the corresponding Baseline treatment, for a given observability condition. In the non-parametric tests, the mean decision or payoff of a group of subjects across periods gives one independent observation. All tests are two-sided. We complement this analysis with an econometric analysis of individual extraction decisions and payoffs.

	Baseline-NO	SP-NO	IBR-NO	Baseline-SO	SP-SO	IBR-SO
<i>Extraction</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>Payoffs</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 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' earnings, in %</i>						
	232.39	23.28	52.50	289.41	15.99	45.09

Note: The Table reports mean values by treatment and standard deviations in parentheses. ***, ** and * indicate significance at the 0.01, 0.05, and 0.1 level, respectively, and ns means non-significance, in Mann-Whitney tests comparing each treatment with the Baseline treatment, for a given observability condition, and the Baseline SO with the Baseline NO, with one value per group taken as an individual observation.

Table 2: Summary statistics

5.1.Extraction behavior

We introduce our first result:

Result 1: *a) The extraction level is significantly reduced by the introduction of the two tax mechanisms (IBR and SP) in both social observability conditions. b) In the absence of a tax mechanism, subjects extract significantly more when the action of each other group member is observable compared to the Baseline with no observability. c) With a tax mechanism, observability does not affect extraction. a), b) and c) hold for the whole group of subjects taken together and for the high-type subjects taken in isolation.*

Support for Result 1. Table 2 indicates that on average subjects extract 13.81 units in Baseline-NO, 11.84 units in SP-NO and 12.02 units in IBR-NO. In Baseline-NO, the mean extraction is higher than the Nash equilibrium (Wilcoxon signed rank test, $p < 0.01$) and exceeds the optimum (Wilcoxon signed rank test, $p < 0.01$). The mean extraction level in Baseline-NO differs significantly from the level of extraction in the two other treatments (M-W, $p < 0.01$ for the two pair wise comparisons). Indeed, the two mechanisms considerably reduce the number of units extracted but the differences between SP-NO and IBR-NO are not significant (M-W, $p = 0.872$).

Similarly, Table 2 indicates that the mean level of extraction is 14.58 units in Baseline-SO, 12 units in SP-SO and 12.12 units in IBR-SO. In Baseline-SO, this level differs from the equilibrium (Wilcoxon, $p < 0.01$) and from the optimum (Wilcoxon, $p < 0.01$). Like in the condition with no observability, subjects extract significantly less units in SP-SO and in IBR-SO, compared to Baseline-SO (M-W, $p < 0.01$ and $p < 0.01$, respectively). We find no significant difference either when comparing the extraction levels under the two tax mechanisms (M-W, $p = 0.748$).

In the absence of a tax mechanism, observability significantly increases the mean level of extraction (M-W, $p = 0.016$ for Baseline-NO vs. Baseline-SO). To further explore the negative impact of observability on cooperation, Figure 1 displays the evolution of the mean extraction over time, by treatment. This figure reveals three interesting findings. First, a significant higher extraction level in the Baseline-SO compared to the Baseline-NO appears as soon as the first

period of the game (M-W, $p=0.017$ in period 1), although at this point, the only difference when making the extraction decision between the Baseline SO and NO, is that in the former the participants know that their decisions will be revealed to the others. One possible explanation for this result may be that some of the participants do not wait for observing the decisions of the others in order to act, but actually may try to use the social observability in order to signal to the others or to impose a norm of high extraction since the beginning, in order to mitigate the potential guilt in case the others show more cooperative intentions.

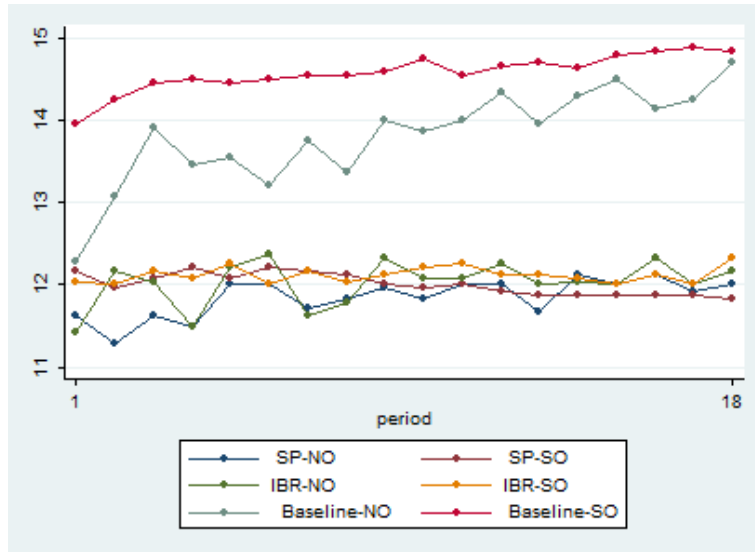


Figure 1: Evolution of the mean extraction level over time, by treatment

In Baseline-NO, the mean individual extraction in the first period corresponds to the optimal level whereas in Baseline-SO individuals free-ride at a higher level since the beginning of the game. Second, Figure 1 shows that free-riding develops over time as a norm of behaviour, that may be due to a social sanctioning mechanism such that, if the others extract a lot, the subject also decides to extract regardless of the consequences, but also due to a learning process such that if it isn't very clear which how to act in order to maximise profit, the subject may decide to copy the behaviour of the others. Extraction converges progressively to the Nash equilibrium and the slope is steeper when subjects are not informed of the individual decisions of their group members. Finally, there are no difference between these two treatments in the last period (M-W, $p=0.719$ in period 18). This evolution over time shows that observability does not create a peer pressure: high-type subjects have no reluctance to show others that they free-ride almost completely since the beginning of the game (see Figure A1 in Appendix 1) and this explains that

the pattern of extraction is relative stable in Baseline-SO.

In contrast to the Baseline treatments, observability has a limited impact when a tax mechanism is introduced. The extraction levels do not differ significantly between SP-NO and SP-SO (M-W, $p=0.335$) nor between IBR-NO and IBR-SO ($p=0.470$). In the SP treatment, the difference is concentrated at the beginning of the game, as visible in Figure 1. It is perhaps not surprising that behavior is not affected by more precise information since people behave optimally even without observability. Figure 2 complements the previous analysis by displaying the mean ratio of extraction to the social optimum for each group within each treatment. It reveals that there is little difference in behavior across groups within a treatment.

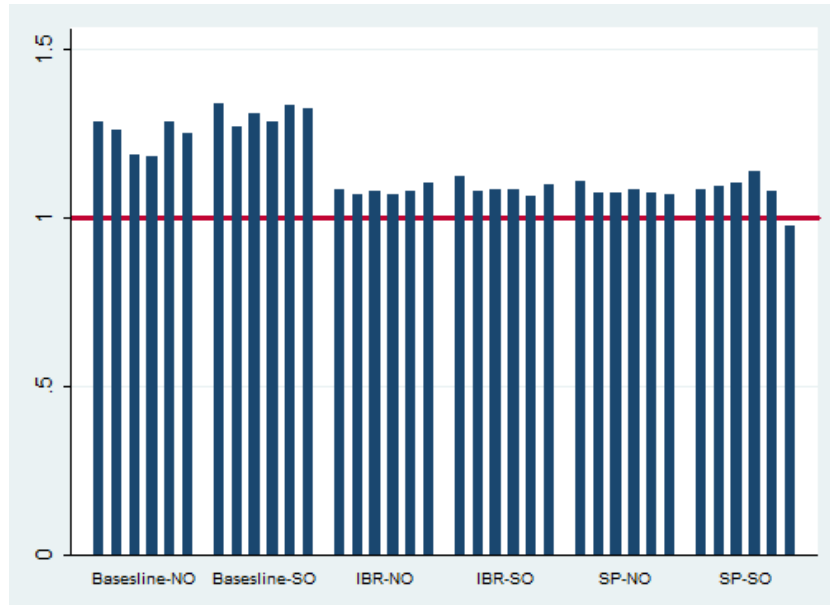


Figure 2: Mean ratio of extraction to the social optimum, by group and by treatment

If we separately examine the behavior of the high-type subjects, we find the same patterns. In particular, high-type subjects extract less in SP-NO and in IBR-NO than in the Baseline-NO ($p=0.003$ and $p=0.003$, respectively). They also extract less in SP-SO and in IBR-SO than in the Baseline-SO ($p=0.003$ and $p=0.003$, respectively). The difference in behavior between Baseline-NO and Baseline-SO is significant ($p=0.016$), but not between SP-NO and SP-SO ($p=0.628$) or between IBR-NO and IBR-SO ($p=0.688$). In contrast to the high-types, as predicted, low-type subjects show little reaction to the treatments. Indeed, 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-SO and SP-SO, nor

between Baseline-SO and IBR-SO ($p=0.187$ and $p=0.144$, respectively). Observability does not make any difference ($p=0.808$ for Baseline-NO vs. Baseline-SO, $p=0.087$ for SP-NO vs. SP-SO and $p=0.259$ for IBR-NO vs. IBR-SO). The evolution of mean extractions over time by the high-type subjects and by the low-type subjects respectively is depicted in the two panels of Figure A1 in Appendix 1. For the high-type subjects the pattern is similar to that described for the whole set of subjects and for the low-type subjects the pattern is flat in all treatments.

We now turn to an econometric analysis to identify the determinants of the individual extraction decision, controlling for subject characteristics and also allowing for clustering at group level. We pool the data of all treatments together. Table 3 reports the marginal effects of variables in six Tobit regressions with bootstrapped standard errors clustered at the group level. These models allow us to control both for the lack of independence of individual decisions within groups and for the censoring of data on the left and on the right. 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 himself) in the previous period, the absolute negative deviation and the absolute positive deviation between the individuals extraction and the mean extraction in the group (excluding the subject) in the previous period.

We also include 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 a possible effect of 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).⁹

Model (1) confirms that in the baseline treatments, subjects extract significantly more when they get feedback about the decisions of the others. It also shows that the two tax mechanisms have a significant negative impact on the amount extracted from the common pool compared to the Baseline-NO treatment. Using equality of coefficients tests to compare the coefficients of SP-

⁹Risk attitude takes a value between 1 and 10; the higher is this value the more the subject is willing to take risks. Religiosity takes value 0 for I don't know or I don't want to answer, 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. Political orientation is defined as 0 for I don't know or I don't want to answer, 1 for extreme left, 2 for left, 3 for center, 4 for green, 5 for right and 6 for extreme right; a higher value of this variable indicating a more right oriented attitude concerning the political spectrum. Individualistic social value orientation (SVO) is defined as a dummy variable in the analysis, with 0 for pro-social and 1 for individualistic.

Dependent variable: Extraction decision	Random-Effects Tobit models					
	All subjects		Hight type subjects		Low type subjects	
	(1)	(2)	(3)	(4)	(5)	(6)
Baseline-SO	.763*** (.233)	.468* (.245)	1.319*** (.378)	.824 (.533)	.208 (.153)	.231* (.130)
IBR-SO	-1.696*** (.246)	-1.440*** (.305)	-3.675*** (.374)	-2.839*** (.437)	.282* (.159)	.251 (.311)
IBR-NO	-1.791*** (.216)	-1.484*** (.310)	-3.574*** (.314)	-2.733*** (.439)	-.009 (.211)	.065 (.271)
SP-SO	-1.810*** (.342)	-1.567*** (.388)	-3.865*** (.611)	-2.893*** (.522)	.245 (.173)	.194 (.235)
SP-NO	-1.969*** (.279)	-1.612*** (.317)	-3.680*** (.370)	-2.674*** (.453)	-.259 (.301)	-.295 (.280)
High type-subjects	6.00*** (.330)	4.779*** (.582)	---	---	---	---
Mean extraction level	---	.283** (.120)	---	.499** (.199)	---	.215** (.089)
Absolute positive deviation	---	.201** (.095)	---	.209** (.100)	---	.053 (.053)
Absolute negative deviation	---	-.291** (.114)	---	-.410 (.987)	---	-.268** (.121)
Period	---	.018*** (.005)	---	.005 (.008)	---	.027*** (.004)
Session size	---	-.033** (.014)	---	-.067* (.040)	---	.014 (.024)
Age	---	-.029 (.042)	---	-.043 (.064)	---	.0003 (.013)
Male	---	-.170 (.139)	---	-.076 (.170)	---	-.127 (.147)
Individualistic	---	-.212 (.173)	---	-.071 (.165)	---	.112 (.120)
Risk attitude	---	-.008 (.045)	---	.043 (.051)	---	-.014 (.013)
Religiousness	---	.006 (.055)	---	-.095 (.076)	---	.026 (.026)
Political orientation	---	.079 (.055)	---	.056 (.064)	---	.018 (.028)
Constant	10.810*** (.277)	8.841*** (1.885)	17.981*** (.313)	13.042*** (2.776)	9.648*** (.151)	7.223*** (1.105)
N	2592	2592	1296	1296	1296	1296
Wald chi2	773.60	2013.62	486.68	2032.92	9.98	206.07
Log-likelihood	-4192.8871	-4077.429	-2283.966	-2230.482	-1690.684	-1592.288

*, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels and in parentheses we indicate bootstrapped standard errors.

Table 3: The determinants of the extraction choice

NO and IBR-NO, and the coefficients of SP-SO and IBR-SO indicates that the two mechanisms have quite similar effects on the extraction behaviour, in the same observability conditions ($p=0.449$ and $p=0.618$, respectively). These tests also show that the impact of the mechanisms isn't significantly different when there is no observability of individual decisions ($p=0.623$ for SP-NO vs. SP-SO, and $p=0.674$ for IBR-NO vs. IBR-SO). Model (2) indicates that the quantity extracted increases with the average extraction in the group and with a positive deviation from

the group average in the previous period. This reveals that cooperation is conditional, as subjects tend to conform to the norm of their group. Extraction also increases significantly over time and decreases with session size. Except the subjects type that is highly significant, no individual characteristics has any effect on the amount extracted.

Models (3) and (4) for the high-type subjects indicate that the same variables are significant than in the regressions on the pooled sample of subjects. In contrast, models (5) and (6) reveal no impact of the treatments on the low-type subjects behavior. This is not surprising as they have limited extraction capacity.

5.2. Efficiency

We now study the impact of our mechanisms on efficiency that we measure by the sum of payoffs within a group. We introduce our second result:

Result 2: *a) The introduction of the two tax mechanisms allows groups to get very close to the maximum efficiency in both observability conditions. b) In the absence of a tax mechanism, efficiency is slightly lower when the action of each other group member is observable compared to the Baseline with no observability. c) With a tax mechanism, observability does not affect efficiency.*

Support for Result 2. As indicated in Table 2, without observability each of the two tax mechanisms increases mean efficiency significantly compared to Baseline-NO (M-W tests, $p=0.003$ for SP-NO and $p=0.003$ for IBR-NO), whereas the difference between the two tax treatments is not significant ($p=0.336$). Similarly, with observability efficiency is improved by both SP-SO ($p=0.003$) and IBR-SO ($p=0.003$) compared to Baseline-SO, with no significant difference between the two tax schemes ($p=0.748$). In the absence of a tax mechanism, mean efficiency is decreased by observability (M-W test, $p=0.025$ for Baseline-NO vs. Baseline-SO). In contrast, observability has no significant impact on efficiency when a tax mechanism is introduced ($p=0.872$ for SP-NO vs. SP-SO and $p=0.374$ for IBR-NO vs. IBR-SO).

Figure 3 displays the ratio of the mean total group payoff to the social optimum for each group, by treatment. It indicates that almost all groups get very close to the maximum efficiency

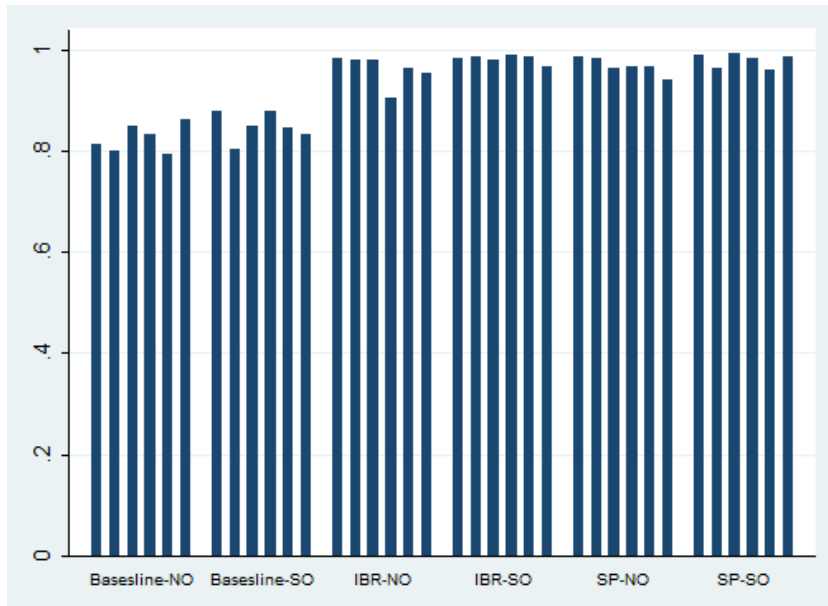


Figure 3: Mean ratio of the total group payoff to the social optimum, by group and by treatment

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-SO (Wilcoxon signed rank test, $p < 0.01$ and $p < 0.01$, respectively).

We complement the previous analysis with a regression analysis of the determinants of individual payoffs in a period. Table 4 (see Appendix 1) reports the results of six linear regressions with robust standard errors clustered at the group level. Like in Table 3, models (1) and (2) pool all the subjects 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 also similar to the corresponding models in Table 2, except that we do not control for the mean extraction in the group and the deviations from the group average in the previous period.

Models (1) and (2) in Table 4 show a significant increase in a subject's payoff when introducing a tax scheme, due to the increased cooperation within groups. T-tests conducted on model (2) indicate that the coefficients do not differ between SP-NO and IBR-NO ($p = 0.380$), SP-SO and IBR-SO ($p = 0.057$), SP-NO and SP-SO ($p = 0.797$), and IBR-NO and IBR-SO ($p = 0.418$).¹⁰ All conditions increase payoffs indifferently. These models also confirm that, in the absence of a corrective mechanism and relative to Baseline-NO, informing the subjects about their group

¹⁰The conclusion does not change if we apply the t-tests to the coefficients of model (1).

members individual decisions decreases payoffs by 1.3 ECU. The time trend is not significant but models (3) to (6) reveal that this results from movements in two opposite directions for the high-type and the low-type subjects.

Considering each type of subjects separately, we find, as expected, 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 ($p < 0.01$) and between SP-SO and IBR-SO ($p < 0.01$); similar tests applied to model (6) for the low-type subjects reach the same conclusion ($p = 0.036$ and $p < 0.01$, respectively).¹¹ This is in line with our predictions since scarcity pricing can only sanction extractions above the maximum extraction capacity of the low-type subjects. We also find that the difference between Baseline-NO and Baseline-SO is negatively significant at the 5% level for the low-type subjects, but not for the high-type subjects, whose payoffs seem to be less affected by the more non-cooperative behaviour of the Baseline SO. In contrast, relative to Baseline-NO, observability does not really impact payoffs when a tax scheme is introduced, except for the case of the SP treatment that seems to significantly increase the payoffs of the low-type and induce a higher decrease in payoffs for the high-type when SO is allowed (t-tests; high-type subjects: $p = 0.051$ for SP-NO vs. SP-SO and $p = 0.668$ for IBR-NO vs. IBR-SO; low-type subjects: $p = 0.076$ and $p = 0.113$, 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 that we introduced endogenously by assigning different extraction capacities to the players. Our last result is as follows:

Result 3: *a) The inequality between high- and low-type individuals is reduced by the two tax schemes with a stronger impact of the scarcity pricing mechanism, 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.*

¹¹The conclusions do not change if we apply the t-tests to the coefficients of models (3) and (5), respectively.

Support for Result 3. By increasing the earnings of the low-type subjects and by reducing that of the high-type subjects, the two tax mechanisms are able to reduce the degree of inequality when considering the earnings of the 18 periods. The decrease is particularly strong under the scarcity pricing mechanism. This pattern is clearly visible in Figure 4 that displays the evolution of mean payoffs over time, by type and by treatment.

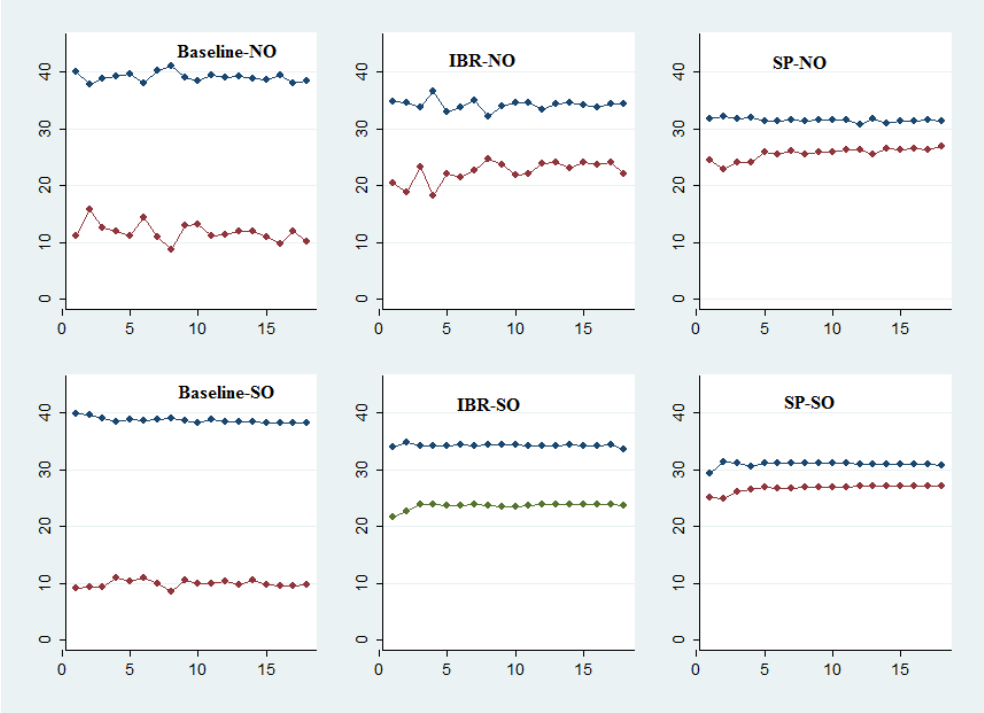


Figure 4: Evolution of mean payoffs over time, by type and by treatment

As indicated in Table 2, while the high-type subjects earn on average 232.39% more than the low-type subjects in Baseline-NO, the earnings gap is only 52.50% in IBR-NO (M-W, $p=0.003$) and 23.28% in SP-NO ($p=0.003$). The difference is even larger under social observability since the gap is 289.41% in Baseline-SO, but only 45.09% in IBR-SO ($p=0.003$) and 15.99% in SP-SO ($p=0.003$). We find a less significant difference both between SP-NO and IBR-NO ($p=0.010$) and between SP-SO and IBR-SO ($p=0.033$).

Finally, observability increases inequality in the Baseline treatments (M-W, $p=0.149$). This is driven by the fact that the loss of efficiency over time is mainly resented by the low-type subjects, as they are more impacted by negative externalities generated by the non-cooperative behaviour of the high-type subjects. Indeed, the ratio of actual earnings to the earnings corresponding to the optimum play is 0.34 in Baseline-NO and only 0.28 in Baseline-SO for the low-type sub-

jects, while it is constant at respectively 1.12 and 1.13 for the high-type subjects. In contrast, observability decreases inequality under the SP mechanism ($p=0.078$), where the ratio is 0.74 in SP-NO and 0.77 in SP-SO for the low-type subjects and 0.91 and 0.90 for the high-type subjects, respectively. Observability has no impact under the IBR mechanism ($p=0.336$), where the ratio is 0.65 in IBR-NO and 0.68 in IBR-SO for the low-type subjects and 0.99 for the high-type subjects in both conditions.

6. Conclusion and discussion

In this study we use an experimental approach to analyze the effects of monetary vs. non-monetary based instruments for improving cooperation and reduction of outcome disparities, in the context of a non-linear CPR game in which individuals have unequal extraction capacities. Both variants of the monetary mechanisms, based on a Pigouvian tax and a secondary redistributive dimension (SP and IBR), confirm the theoretical predictions by reducing extraction and increasing efficiency.

This is consistent with previous studies that confirm the motivating impact of extrinsic monetary incentives (Gneezy and Rustichini, 2000; Benabou and Tirole, 2003, 2006) on cooperation improvement and with the consensus that exists regarding the positive effects in terms of efficiency augmentation generated by the use of Pigouvian based instruments (Plott, 1983; Cochard et al, 2005). In the context of a heterogeneous population in terms of the initial extractive capacities, adding a redistributive dimension to these instruments reduces disparities between the welfare level, especially in the case of the SP mechanism that imposes a tax on each unit extracted.

If we vary the observability degree of individual decisions among the group members, in combination with the tax instruments, we don't register any significant impact of the non-monetary condition on individual extraction behavior. However, the observability level instrument has an impact when used in isolation. Providing feedback is provided regarding the decisions and the welfare level of the others appears to facilitate free riding, which increases extraction, reduces efficiency and increase inequality. However, in spite the results observed, Pigouvian based mech-

anisms might prove to be politically and practically difficult to implement in the field; whereas providing feedback on the behavior of others would be cheaper to put into practice.

Nevertheless, we acknowledge several limitations to our study and several points that leave room for further discussions. Firstly, although the IBR mechanism is effective in increasing cooperation and reducing inequality, announcing the threshold beyond which extraction is taxed, might involuntarily create a kind of reference point that might influence subjects' decisions.

Secondly, instead of creating a higher moral pressure on individuals, as per the evidence provided in other field studies regarding the impact of social comparisons (Allcott, 2011; Ferraro et al. 2011; Allcott and Rogers, 2014), social observability has a rather perverse effect and reduces the willingness to cooperate. In our setting, observability could have less effect due to the fact that type is endogenously assigned after a real effort task and high-types might therefore feel entitled to extract more and take advantage of their earned position (Dickinson and Tiefenthaler, 2002; Gächter and Riedl, 2005). Moreover, the fact that we don't observe any significant differences in the pricing treatments in terms of observability, might be a consequence of the fact that the pricing mechanisms play by themselves a powerful role in making social norms effective (Cooter, 1998). When no observability is allowed, normative conflicts within groups are stronger and especially in the first periods less free riding is observed, but eventually towards the end of the session the non-cooperative norm seems to prevail from the group interaction.

Thirdly, as we draw such results from the context of a restrained group size, it would be interesting to see to what extent the same effects would hold with respect to the observability instrument in larger groups or in the context of extending this to a real life situations. However, in spite such caveats, we believe that the experimental study that we propose is important in order to get a preliminary grasp of the assessment regarding the robustness of the mechanisms we propose and for further deriving policy implications on cooperation improvement in the case of heterogeneous populations in social dilemmas in the field.

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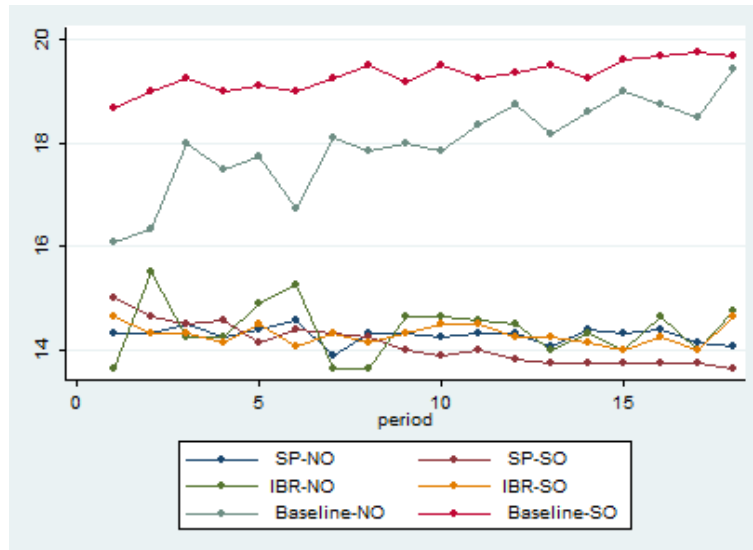
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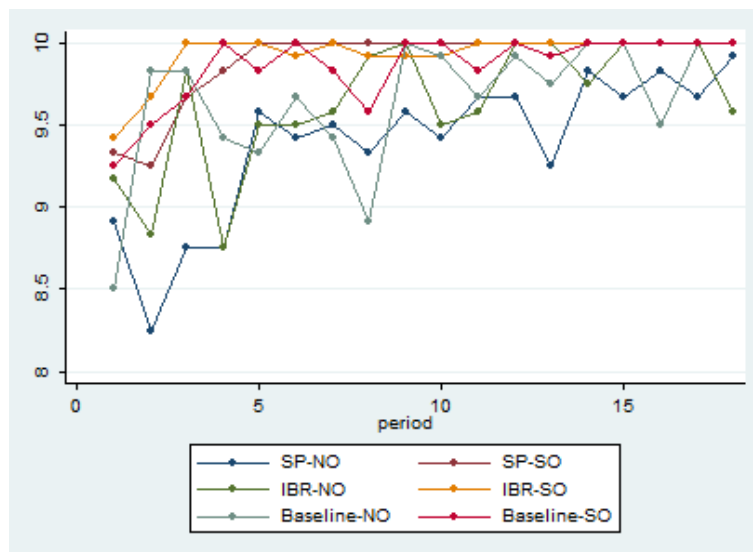
Appendix 1

Figure A1. Evolution of the mean extraction level over time, by treatment and by subject type

a) High-type subjects



b) Low-type subjects



Dependent variable:		All subjects		Hight type subjects		Low type subjects	
Individual Payoff		(1)	(2)	(3)	(4)	(5)	(6)
Baseline-SO		-1.108*** (.351)	-1.308*** (.405)	-.356 (.279)	-.256 (.334)	-1.831** (.738)	-1.467* (.772)
IBR-SO		3.526*** (.210)	3.624*** (.436)	-4.779*** (.287)	-4.694*** (.340)	11.862*** (.572)	12.494*** (.686)
IBR-NO		2.889*** (.376)	3.125*** (.536)	-4.855*** (.269)	-4.704*** (.358)	10.664*** (.924)	11.426*** (.855)
SP-SO		3.425*** (.240)	2.734*** (.480)	-8.078*** (.313)	-8.096*** (.322)	14.957*** (.657)	14.987*** (.648)
SP-NO		3.112*** (.271)	2.596*** (.487)	-7.596*** (.294)	-7.620*** (.342)	13.826*** (.768)	13.627*** (.932)
High type subjects		14.766*** (1.687)	14.443*** (1.623)	---	---	---	---
Period		---	.019 (.014)	---	-.014** (.011)	---	.064** (.029)
Session size		---	.059 (.069)	---	.021 (.019)	---	.180** (.066)
Age		---	-.119 (.185)	---	-1.006 (.048)	---	.039 (.053)
Male		---	-1.275* (.731)	---	.020 (.132)	---	-.607 (.623)
Individualistic		---	-1.021 (.874)	---	.099 (.150)	---	.293 (.567)
Risk attitude		---	-.158 (.193)	---	.003 (.051)	---	-.120 (.091)
Religiousness		---	.115 (.301)	---	-.009 (.077)	---	.046 (.125)
Political orientation		---	.385 (.231)	---	.096 (.109)	---	.011 (.136)
Constant		18.035*** (.877)	21.106*** (4.589)	39.05*** (.249)	40.820*** (.988)	11.758*** (.564)	8.685*** (1.430)
N		2592	2592	1296	1296	1296	1296
R ²		0.61	0.62	0.64	0.64	0.69	0.70

*, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels and in parentheses we indicate robust standard errors clustered at the group level.

Table 4: The determinants of the individual payoff

Appendix 2. Instructions (IBR LSO Treatment)

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.

The experiment is composed of two parts: an online questionnaire that you have already completed and this experimental session. The earnings for the questionnaire will be handed to you in cash, privately at the end of this session.

Today's experimental session comprises two parts. You have received now the instructions for the first part. You will receive the instructions for the second part, after the end of the first one. Your final payoff for this experimental session will be represented by your earnings in part 2. Additionally, 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.

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 left of your desk.

Part 1

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 10 minutes. All group members will be given the same words to encode in the same sequence.

The relative performance of each individual in this part will influence the maximum amount

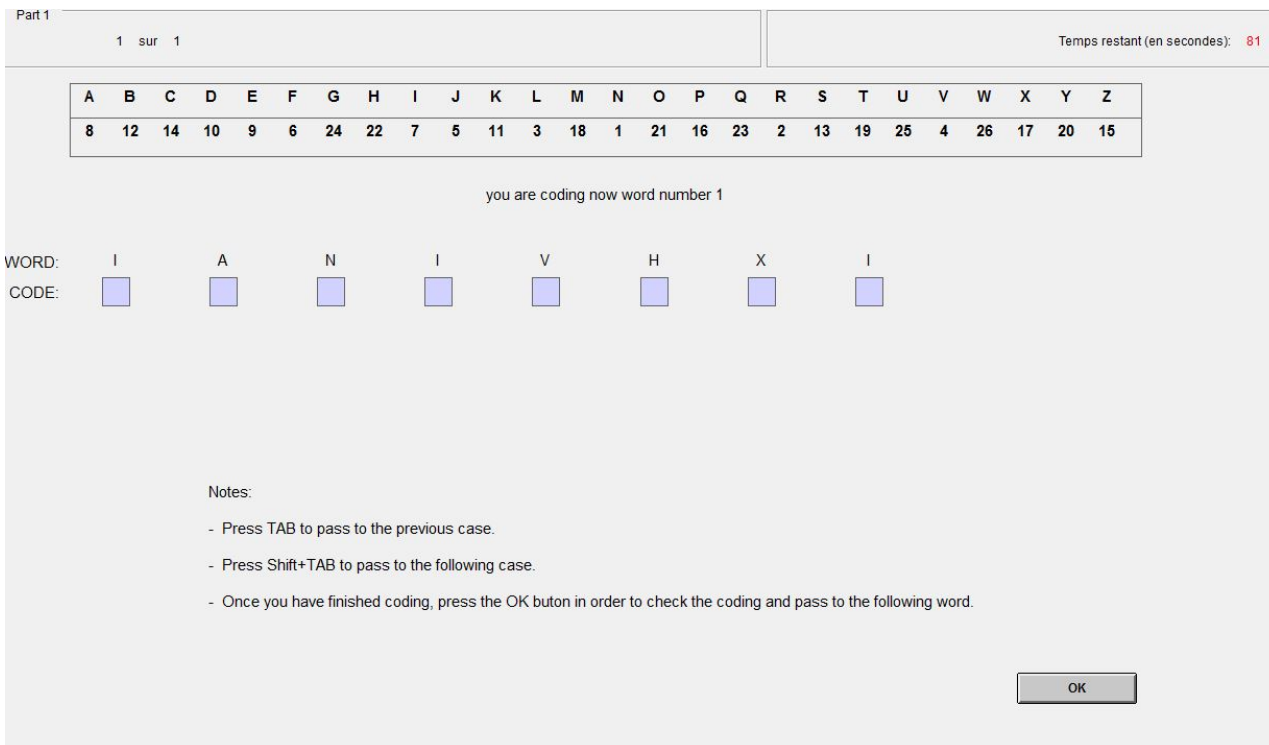


Figure 5: Screen shot of the task in Part 1

they can earn in other parts of the experiment. In some parts, 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 whereas 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 some of the next parts, 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 throughout the experiment. 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

This part consists of 20 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:

$$4.5 \text{ ECU} = 1 \text{ Euro}$$

If this part is selected for the payment, 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 each of these 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 register a negative profit at 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, your loss will be deducted from the value of the show up fee, that 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.

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 20 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. Thus for instance, if everyone in the group decides to withdraw up to their maximum capacity, there will be no unit left in the common account.

How is your payoff for the period determined?

For the type A participants

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 above the 12th unit by the all two type A 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:

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

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. These values result from the application of this formula.

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 in the group:

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

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 each unit withdrawn above the 12th unit, each type A participant has to pay a tax. This tax corresponds to 3 ECU for each unit supplementary unit withdrawn above 12. If the participants withdraw less than 12 units they do not have to pay any tax.

$$\text{Tax} = 3 * W_{12}$$

where W_{12} represents the amount of units withdrawn above the 12th unit

d) The total amount of the tax collected from the two type A group participants for the amount of units withdrawn above 12, is transferred and equally shared 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 one Type A participant withdraws a total of 15 units and the other type A withdraws 20 units. They have to pay a tax of 3 ECU for each unit withdrawn above 12 units.

The number of units taxed for the first type A participant is: $15 - 12 = 3$ units (thus the 13th unit, the 14th unit and the 15th units withdrawn is taxed)

The number of units taxed for the second type A participant is: $20 - 12 = 8$ units (thus the 13th unit, the 14th unit the 20th unit is taxed)

The total tax paid amounts to: $(3 + 8) * 3 = 33$ ECU.

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

For the type B participants

The payoff of the type B participants is computed exactly as the payoff of the type A, with the sole difference that the type B won't pay any tax for the units withdrawn above the 12th unit, as they are able to withdraw only up to 10 units. Your total payoff in each period will depend 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 two type A participants

above the 12th unit

Consequences of type A participants' decisions

On the one hand, the withdrawal decision of a Type A participant determines the payoff associated to their withdrawal and the cost for the group as part of the total withdrawal. 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, and each unit withdrawn above 12 units leads to the payment of a tax of 3 ECU that is then transferred and shared equally between all the four group members.

Example 1:

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

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.

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 as part of the total withdrawal, as each unit withdrawn implies a group cost of 1 ECU for all the four group members.

Example 2: Suppose that one type B participant withdraws 8 units. The decision leads to:

- a payoff for this participant of: $(9 \cdot 8) - (0.2 \cdot 8 \cdot 8) - (0.1 \cdot 8) = 58.4$ ECU
- a group cost for the participant and for the other members of the group of: $8 \cdot 1$ ECU = 8 ECU

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.

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.

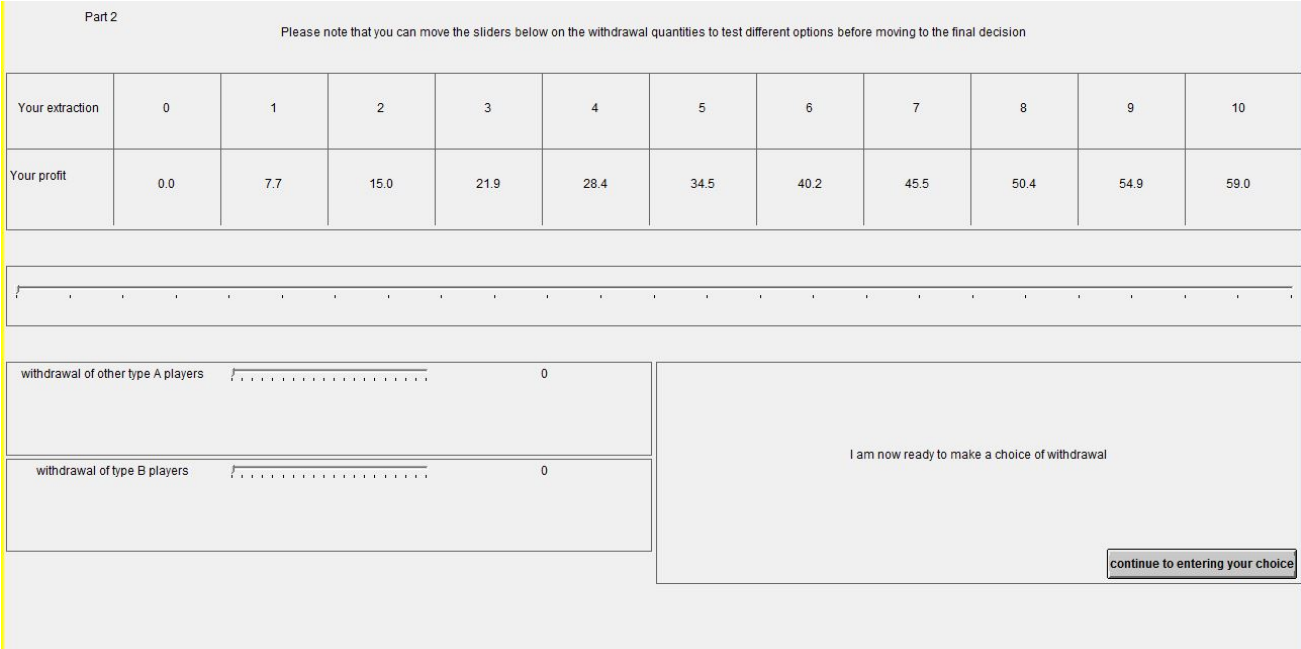


Figure 6: Screen shot of the decision testing in Part 2

End of the period

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

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;

You and the 3 other participants in your group have to choose 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 12 units, each type A participant has to pay a tax and the total amount of taxes collected from the two type A participants is equally split and transferred to the four group members.

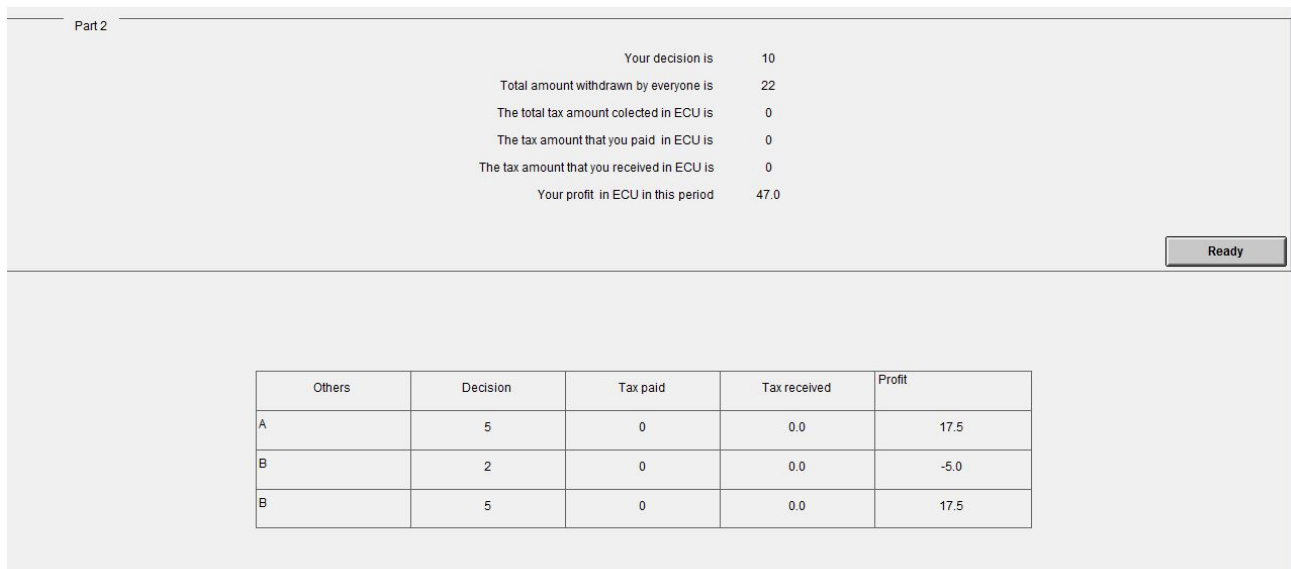


Figure 7: Screen shot of the feedback sequence in Part 2

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.

End of the session

You will see on your computer a questionnaire. We thank you for answering these questions. We remind you that all your answers are anonymous and confidential.

Once all the participants will have completed the questionnaire, your computer screen will recapitulate your payoffs in each paying part in Euros, the selected part for payment will be announced and your payment for that part.

Then, we ask you to remain seated and silent until an experimenter invites you to proceed to the payment room. Please take your ticket and your completed payment receipt with you (except for the amount earned that will be indicated in the payment room).