Information Sharing Is Not Always the Right Option in CPR Extraction Management: Experimental Findings[1]

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Abstract

This paper experimentally investigates the impact of different information sharing mechanisms in a common pool resource (CPR) game, with the aim to find a mechanism that is at the same time efficient and not too expensive for the managing agency. More precisely, we compare the extraction level observed with three mechanisms: a mandatory information sharing mechanism and two voluntary information sharing mechanisms that differ by the degree of freedom given to the players. Our main result is that the mechanism of voluntary information sharing can help achieve a lower average extraction level than that observed with the mandatory one but also that giving actors a lot of freedom introduces strategic considerations that can lessen this positive impact.

Keywords: Common-Pool Resource, Experimental Economics, Voluntary Information Sharing.

JEL Classification: C91; D90; Q50

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1 Introduction

In recent years, the use of collective resources, whatever their form of appropriation and pricing, has been transformed by new techniques which allow users to share and disclose information on their consumption in real time. Based on this information other users can adapt their consumption and resource providers can adapt the amount of resources available to needs.

In the electricity sector, for example, many countries have deployed smart grids to place data flow and information management at the heart of improving supply efficiency. In the case of domestic water use, particularly in Western countries, remote metering allows water services and providers to improve the efficiency of water supply and reduce costs and the leaks. More real-time information on consumption is also provided to water users, who can then adjust their habits and detect possible leaks or abuse, thereby reducing their water bill. In France, 50% of domestic water users should have a remote meter connected within 3 to 4 years (Suez Eau France 2019). These systems do not provide water consumers with information on the consumption of others to date, but initiatives to establish social standards are under study, and benchmarks already exist based on aggregations of macro-data (city, region, nation). In the agricultural irrigation sector, remote measurement systems are still underdeveloped. In the southwest of France, for example, the local water management company (CACG) is implementing a system for remote reading of irrigation water consumption. This system allows the company to have more precise and timely information on the water consumption of irrigators with a double objective of better efficiency in the allocation of water and a stricter control of the respect of the quotas allocated to users. In general, even if well established, like the water and electricity services described here, most regulatory agencies lack information on user consumption and users have little information on the stock of resources and its consumption by others.

In some countries, like United States, India or Maghreb among others, groundwater irrigation has developed rapidly, causing problems with the depletion of aquifers and the sustainability of these systems. In California, the law on sustainable groundwater management (SGMA), adopted by the State in 2004, obliges groundwater sustainability agencies (GSA) to draw up groundwater sustainability plans (GSP) and users located outside of the GSA's management area to report their extraction levels to the State Water Board. Conversely, in countries like Tunisia, Algeria or Morocco, private water wells are proliferating rapidly (Kuper et al. 2016) and information on the extraction of water from these wells is hidden by irrigators to avoid paying fees or penalties. Community management of aquifers has been recognized as one of the possible instruments for groundwater management (Shah 2014), but it can only be achieved if everyone engages in a cooperative scheme and shares information on their private consumption, but the management costs and the feelings of users depend on the policy implemented. Collecting and distributing information is recognized as a necessary precondition in all fields where stock had to be preserved (Liu et al. 2017). Several voluntary information disclosure initiatives have started to develop, like the Carbon Disclosure Program.

These different examples can be modeled as a common pool resource problem (CPR) according to Ostrom, with its two main characteristics; non-exclusion and rivalry. According to the founding article

by Walker et al. (1990), we know that without outside intervention, individuals naturally tend to over-exploit the resource. Several factors can contribute to increasing cooperation within a group, such as communication, reputation or information (Ostrom 2010, Poteete et al. 2010, Janssen 2013). Several recent articles focus on information, and this is also our case in this article. The main result is that having complete information about the actions or benefits of others does not help to improve the average level of cooperation within the group and, therefore, does not solve the problem of overuse of the resource (Apesteguia 2006). Villena and Zecchetto (2011) even show that complete information on the choices of the other members of the group accelerates the learning process and convergence towards the dominant strategy of maximum extraction. This result is also observed when the subjects are placed in a long-term context (Huck et al. 2017).

New technologies, such as smart grids, smartphones, etc., are at the heart of information sharing, whether mandatory or optional. In our opinion, to favor intrinsic motivations, a system based on volunteering is more appropriate. A voluntary information sharing mechanism can be an important tool for regulators as it does not require the collection of private information and, therefore, is much less costly. Its effectiveness has not yet been proven. Our hypothesis is that the voluntary sharing of information on its extraction from the common resource is a prosocial act, and as such, should be done more frequently by prosocial individuals than by selfish individuals. In addition, in a game of social dilemma, a free-rider has no interest in voluntarily disclosing his interested choice. Consequently, since the imitation dynamic is at the origin of the formation of social norms (Goldstein et al. 2008), this could have a positive impact on the use of the resource. In addition, as shown by Fischbacher et al. 2001, most people are conditional cooperators, which means that their cooperative attitude depends very much on the cooperative attitude they observe in the population (see also Keser and Winden, 2002, Frey and Meier, 2004 Janssen et al. 2010).

In a public good game experiment, Kreitmair (2015) shows that the mechanism of voluntary disclosure of their level of contribution by individuals improves overall cooperation compared to the mechanism where individual contributions are automatically and mandatory disclosed. Kreitmair tests three treatments: (i) mandatory, (ii) voluntary ex-post disclosure, (iii) ex-ante commitment to disclose the contribution. Average contribution to the public good is higher in both treatments with voluntary disclosure than in the treatment where decisions are automatically disclosed, despite the absence of any additional effect of the ex-ante commitment. Kreitmair's original research has never been applied to an extraction context, where prosocial behavior is not defined as providing the group with a large amount of private endowment but rather as avoiding overexploitation by choosing a reasonable extraction of the shared resource. As Willinger and Ziegelmeyer (1999) show, framing has important implications for the behaviors observed in public good experiences. Validation of Kreitmar's observations in a CPR context is therefore crucial.

The contribution of our article is twofold. First, we contribute to the literature on the impact of information disclosure in social dilemmas and more specifically in the context of a common resource. Second, we experimentally compare the impact on the extraction levels of two voluntary information sharing mechanisms. Our experience consists of three treatments: (i) Mandatory disclosure (MD), where individual extractions are made public without any agreement from the players, (ii) Voluntary

disclosure (VD), where players are asked to say if they want or not disclose their extraction, and (iii) free disclosure (FD), where players, if agree, declare themselves the amount of extraction that will be made public. The VD mechanism is less costly than the compulsory mechanism if at less one player refuses to disclose its extraction level. In the FD mechanism, the players also decide whether or not to disclose their decision but if agree they declare themselves their level of extraction and therefore the amount that will be made public. This mechanism is free of charge for the regulatory agency because the information is provided by the actors themselves. Our main result is that the voluntary information sharing mechanism can help achieve an average level of extraction lower than that observed with the mandatory one, but also that giving actors a lot of freedom introduces strategic considerations that can mitigate this positive impact.

The rest of the paper is organized as follows. In section 2 we detail the experimental design and present our conjectures, in section 3 we expose the results and we conclude in section 4.

2 Experimental design and conjectures

2.1 Experimental game

In a Common Pool Resource game (thereafter CPR), each player i in a group of N players can extract from $y_i=0$ to $y_i=E$ tokens from a common resource that contains NxE tokens. E is equal to 10 in our experiment. For each extracted token, player i earns 3 ECU[6], but it creates a negative externality for each one of the other group members. In our experimental game the payoff function of player i is given by $\pi_i(y_i, Y) = 3y_i - 0.01875Y^2$ where $Y = \Sigma_i y_i$ and y_i is the individual amount extracted by player i.

To avoid corner solutions, we adapt an existing model (Cox et al. 2013) by transforming the linear payoff functions into a quadratic one. Our game has both features that ensure a social dilemma where individual and collective interests are divergent: (i) whatever the amount extracted by the other group members player i has a higher payoff when he extracts the maximum 10, and whatever the amount extracted by i his payoff is higher when the other group members do no extract any amount from the common resource, the dominant strategy is therefore to extract the maximum possible (10), and (ii) the collective payoff, computed as the sum of individual payoffs, is maximized when the total amount extracted by the group is 20 tokens, with a symmetric issue where each player extracts exactly 5 tokens.

2.2 Treatments

We ran three treatments, in which the parameters of the game were identical but that differed according to the information sharing mechanism. The game played is the one described in section 2.1, with fixed groups of 4 players randomly formed at the beginning of the experiment. Each of the 20 periods of the game is divided into two or three steps depending on the treatment: (i) players decide how many tokens they extract from the CPR, (ii) players decide whether or not they want to make public their extraction

6 Experimental Currency Unit.

decision, and (iii) the summary of the period. From each of the corresponding screen players can access a history screen that displays the information about past periods (decisions, payoffs and so on). The rest of the subsection is dedicated to a more precise description of each of the treatment. Table 1 provides an overview of the treatments' characteristics.

Mandatory Disclosure (MD)

This is our baseline treatment. In this treatment players are informed of each extraction decision made by the other members of their group. Individuals extractions are anonymous, which means that values are displayed without any id attached. This information is given in the summary, so that there are only two steps in this treatment (extraction decision and summary).

Voluntary Disclosure (VD)

In this treatment, each player must decide, in the second stage of the period, whether or not he wishes his extraction decision to be made public in his group. In case of a positive answer, the level of extraction of the player is made public in the group. Specifically, it is anonymously displayed in the summary screen of the period of each member of his group. If the player refuses the information is not displayed.

Free Disclosure (FD)

As in treatment VD the player decides whether or not he discloses his extraction decision to his group members. However, in case of disclosure, the player chooses the amount that is made public. In other words, compared to VD, the player is free to choose the extraction level that is displayed on the screen of the others. He may therefore decide to disclose an amount different from the actual extraction level.

Treatment	# Periods	Group Size	Voluntary Information sharing	Free report of the amount to be disclosed
MD	20	4	No	No
VD	20	4	Yes	No
FD	20	4	Yes	Yes

Table 1: Overview of the treatments

2.3 Practical procedure

The experiment took place at the Experimental Economics Laboratory of Montpellier (LEEM) in France. A total of 104 subjects participated in the experiment[7]. The participants were students from various disciplines of the university chosen at random from a group of subjects of nearly 3,000

7 56.73% of women and 43.27% of men.

volunteers[8]. We made sure that none had previously participated in a common pool resource game. The terminals in the lab are separated by lateral partitions to ensure complete anonymity. The sessions lasted approximately one and a half hours, including initial instructions and payments.

2.4 Conjectures

Conjecture 1: Even without a specific monetary incentive to do so, many players voluntarily choose to disclose their extraction decision to their group members. This is a necessary condition for the mechanism's efficiency to be tested.

Conjecture 2: The voluntary information sharing mechanism (VD) discourages free-riders from disclosing their extraction decision. They should refuse to give their consent for their decision to be made public, and only cooperative players should volunteer. We therefore expect this mechanism to be more efficient, in terms of the average level of extraction observed in the population, than the mechanism that automatically disclose the individual extractions without any prior consent (MD).

Conjecture 3: The effect of the free disclosure mechanism (FD) is more confusing. Two opposing forces are possible. On the one hand, as for the VD mechanism, cooperative players are supposed to consent to make their decision public and to choose the amount actually extracted. In addition, some players can use this freedom to signal the socially optimal solution, even if their actual extraction is a little higher so as not to lose too much money while the (symmetric) cooperative solution is not achieved. Both of these behaviors are likely to lower the average level of extraction observed in the population (*conjecture 3.1*). However, free-riders are no longer discouraged from refusing to make their extraction public. On the contrary, they are encouraged to strategically disclose an extraction level below the actual level in order to benefit from the possible effect on the other members of the group. This strategic lie, if detected, can have a dramatic effect on cooperation within the group, and thus lead to overexploitation worse than mandatory disclosure (*conjecture 3.2*).

3 Results

When voluntary disclosure is offered to players (VD and FD treatment), most of them decide to make their decision public, as shown in Figure 1, in support of our first conjecture. More specifically, in VD treatment, more than 30% of players choose to disclose their extraction decision 100% of the time. This percentage drops to 16% in FD treatment, but as can be seen in the figure, between 5 and 15% of players reveal their decision at least 10 periods out of 20 (50% of the time).

8 The pool of volunteers is handled with ORSEE (Greiner, 2015).

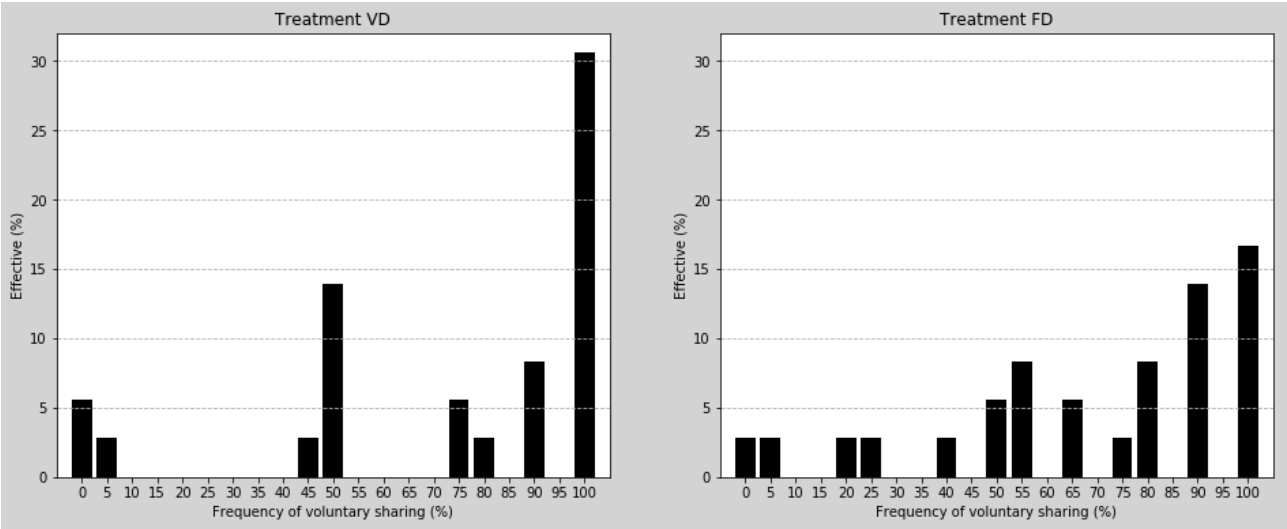

Figure 1: Frequency of agreement to disclose its decision

3.1 Treatment effect

Table 2 provides statistics about the average level of extraction depending on the treatment and Figure 1 displays the evolution of the average extraction of the three treatments. As soon as the first period of play, without any prior information about the other members' behavior in the group, the VD treatment distinguishes with a lower average level of extraction than in MD and FD treatments. This initial effect holds until the end of the game, even if with the repetitions the three treatments converge towards the choice of the dominant strategy, as it is often the case in experimental social dilemma games.

Table 2: Summary statistics

Treatment	# Groups	Av. extraction period 1	Av. extraction periods 1-10	Av. extraction periods 11-20
MD	8	8.06	9.00	9.23
VD	9	7.31	7.84	8.35
FD	9	8.03	8.26	8.66

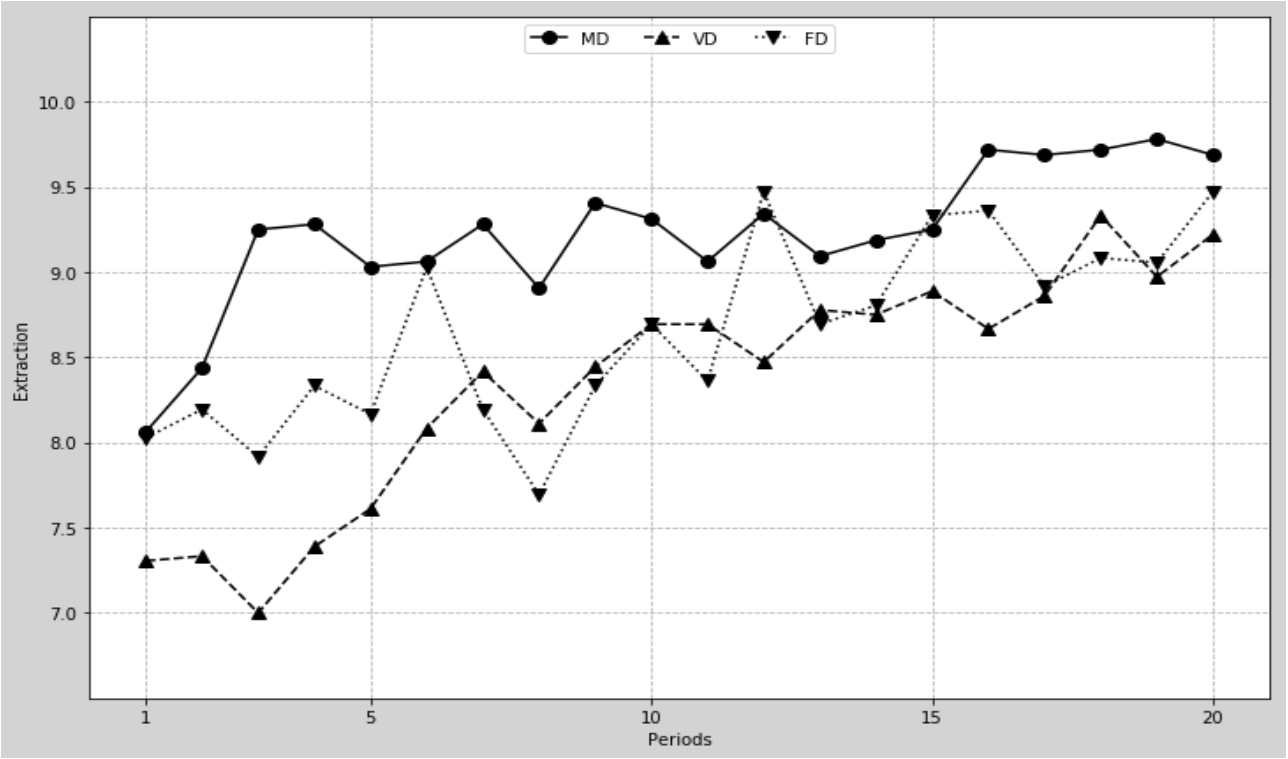

Figure 2: Evolution of average extraction by treatment

To further analyze the data, we consider the following econometric model. Let y_{it} the extraction of player i at period t. This amount is both left- and right-censored, i.e. $0 \leq y_{it} \leq 10$. We have a dynamic panel data model:

$$y_{it} = \rho y i_{,\, t-1} + x'_{it} b + \mu_i + \varepsilon_{it};\ i = 1, 2, ..., N;\ t = 1, 2, ..., T$$

where $y_{i,\ t-1}$ is the extraction of player i at the previous period, x_{it} corresponds to the whole set of explanatory variables including both time-variant variables (total extraction of player i's group in $t-1$, decision-making time, information-related variables such as dummy of information sharing, number of individuals who disclosed their decision in the previous period) and time-invariant variables (treatment dummy variables). The dynamic structure of the model allows us to account for persistence in individual decisions over time. The error term is composed of two parts, an idiosyncratic error ε_{it} and an individual-specific effect μ_i. The dynamic structure is at the origin of the well-known problem of initial observations in econometrics, leading to the inconsistency of traditional estimators. Following Wooldridge (2005), this problem can be fixed by specifying a more general model where μ_i are defined as correlated random effects with the following assumption: $\mu_i \mid y_{i1}, z_i \sim N(\alpha_0 + \alpha_1 y_{i1} + z'_{i\gamma}, \sigma^2\mu)$. This assumption appears to be general enough as it suggests that individual-specific effect depends not only on the initial attracted amount y_{i1} but also on a set of values of explanatory variables ($z_i \equiv x_{i1}, ..., x_{iT}$). The model with this assumption corresponds therefore to a dynamic Tobit model for panel data with

correlated random effects[9]. Table 3 reports estimation results. Both treatments where disclosure of decisions is on a voluntary basis, VD and FD, have a significant negative impact on the amount extracted in the game (both coefficients are however not different from each other, χ^2=0.10, p-value=0.755). This is in line with our second conjecture. Even if at this stage we cannot conclude on which conjecture, 3.1 or 3.2, is prominent in the observations, we nevertheless are able to establish that extraction levels in FD treatment are significantly lower than in MD treatment. So both mechanisms are not only less expensive for the agency than the mandatory one, since they require less data collection, but also more efficient. The estimation further shows that the individual decisions are strongly related to what the players observe from the group during the previous period and that there is, as already indicated in Figure 1, a natural tendency towards higher extraction as the time elapsed.

Variable	Coefficient	Standard errors
Initial individual decision	0.178*	0.095
Individual decision in previous period	0.006	0.061
Group decision in previous period	0.133**	0.030
Decision-making time	-0.049**	0.010
Treatment VD	-1.830**	0.563
Treatment FD	-2.171**	1.040
Time trend	0.163**	0.019
Intercept	-8.229	5.148
Log-likelihood	-2129.767	
Wald test $\chi^2(63)$, for the model's significance	902.19	p-value=0
Number of observations	1976	
Number of individuals	104	
Number of uncensored observations	672	
Number of left-censored observations	26	
Number of right-censored observations	1278	

Notes: Regression of the dynamic Tobit model with correlated random effects with individual extraction decision (y_{it}) as dependent variable. Regression also contains auxiliary regressors (z_i) but their coefficients (without much interest) are not reported here.

Table 3: Estimation results, whole sample

9 Estimation of the latter model, compared to the original model, implies two additional sets of variables: initial decision (y_{i1}) and a set of auxiliary variables (z_i). A likelihood-ratio (LR) test is performed to compare the two models. The null hypothesis corresponds to $\alpha_1=\gamma=0$. For the whole sample (all treatments included), the test statistic is 275.93 and the p-value of the chi-squared distribution with 58 degrees of freedom is almost 0, leading to the rejection of the original model in favor of the dynamic Tobit model with correlated random effects. This test shows the importance of the initial observation problem which has to be controlled for. The significance (at the 10% level) of this coefficient (α_1, Table 3) provides an illustration of this result.

3.2 Information sharing effect

In order to get a better picture on the link between the choice to disclose the decision and the level of extraction, Figure 3 reports, for the VD and FD treatments, the evolution over time of the individual extraction levels according to whether the player consents or not to disclose his decision.

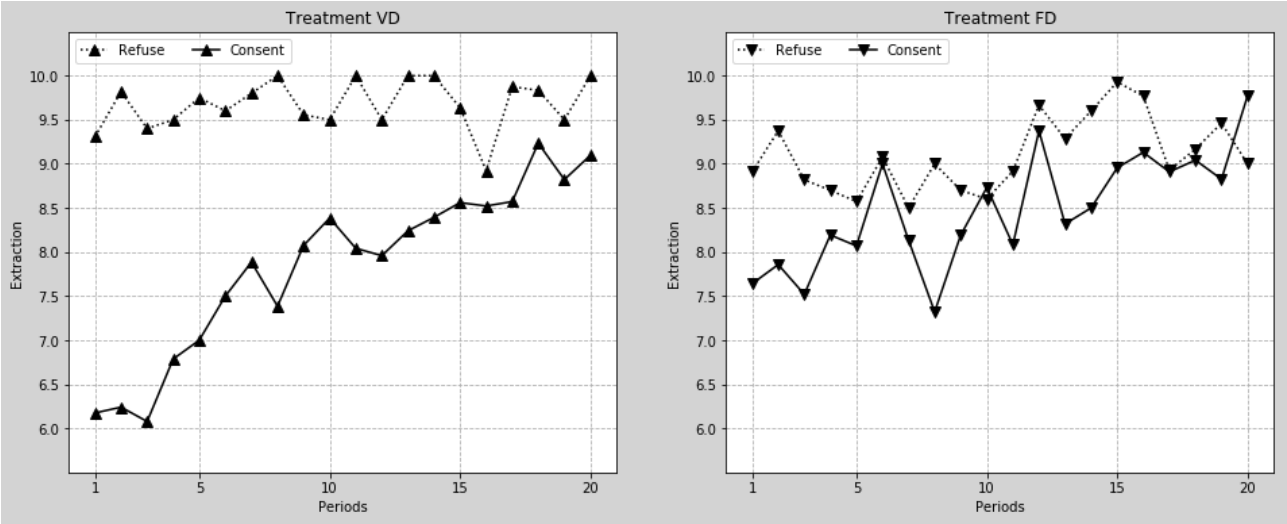

Figure 3: Evolution of average extraction depending on the choice to disclose or not its decision

Clearly, the players that consent to make public their decision extract less than the others, and this is observed in both treatments (Wilcoxon bilateral test VD p-value=0.109, FD p-value=0.066), with a larger difference in VD than in FD. As stated in conjecture 2, our interpretation is that the VD mechanism is more discriminant: free riders have no interest to consent to disclose their decision because their non cooperative behavior may be mimic in the group and therefore favor a quick convergence toward a high level of extraction which would imply a lower benefit for themselves. This is not so clear with the FD mechanism, as it will be discussed in the next paragraph.

Figure 4 shows the evolution of the average amount extracted in the FD treatment depending on whether the player chooses to disclose his decision and whether he is lying or not on the amount he reports. It is clear that players who lie about the amount they report extract far more than those who declare their actual extraction (Wilcoxon p-value=0.008), and also more than those who refuse to make their decision public, even if it is not statistically significant (Wilcoxon p-value = 0.260). In addition, liars, or strategic free-riders, report on average an extraction very close to the social optimum (5, p-value = 0.515). In other words, the freedom given to the players to report their extractions themselves, which is made public in the group, favors the emergence of a strategic behavior consisting in reporting an extraction close to the social optimum but at the same time extracting the maximum to increase their individual benefit, in line with conjecture 3.2.

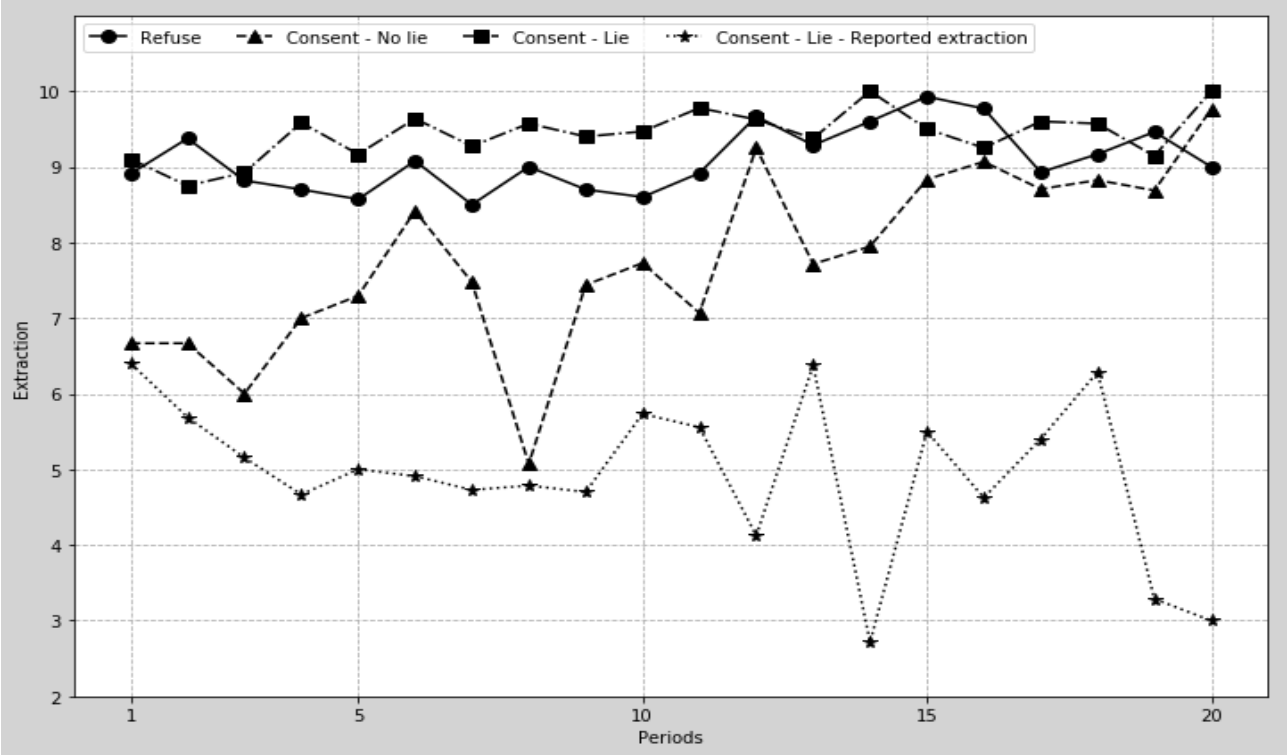

Figure 4: Evolution of extraction (and reported extraction) in treatment FD depending on the choice to disclose or not its decision and on the lying or not in the reported amount

In order to identify the effects of specific explanatory variables (in particular those related to information sharing), estimation is implemented treatment by treatment. Tables 4-6 report estimation results of the same model (dynamic Tobit with correlated random effects) for treatments MD, VD, and FD, respectively[10].

10 As for the case of the whole sample, we perform a LR test to compare the models without and with correlated random effects (i.e. null hypothesis $\alpha_1=\gamma=0$) for each of the three treatments. The result is unambiguously in favor of the dynamic Tobit model with correlated random effects (test statistic is 61.051, 93.543, and 90.688 with a p-value close to zero for treatment MD, VD, and FD, respectively).

Variable	Coefficient	Standard errors
Initial individual decision	0.059	0.253
Individual decision in previous period	0.260*	0.140
Group decision in previous period	0.189**	0.068
Decision-making time	-0.049**	0.018
Time trend	0.133**	0.044
Intercept	-10.860	14.438
Log-likelihood	-470.060	
Wald test $\chi^2(23)$, for the model's significance	165.15	p-value=0
Number of observations	608	
Number of individuals	32	
Number of uncensored observations	133	
Number of left-censored observations	2	
Number of right-censored observations	473	

Table 4: Estimation results for treatment MD

Table 4 provides estimation results for the MD treatment. By definition, the set of explanatory variables does not contain any factors related to the voluntary sharing mechanism. Estimated coefficients are therefore similar to the case of the whole sample presented in Table 3.

Variable	Coefficient	Standard errors
Initial individual decision	0.476**	0.141
Individual decision in previous period	0.217**	0.106
Group decision in previous period	0.065*	0.037
Decision-making time	-0.059**	0.014
Time trend	0.175**	0.029
Information sharing, current period	4.629	3.384
Information sharing, previous period	-3.382**	1.549
Information sharing, number of members in the group	0.013	0.247
Intercept	-6.737**	1.596
Log-likelihood	-783.552	
Wald test $\chi^2(27)$, for the model's significance	534.49	p-value=0
Number of observations	684	
Number of individuals	36	
Number of uncensored observations	270	
Number of left-censored observations	20	
Number of right-censored observations	394	

Table 5: Estimation results for treatment VD

Variable	Coefficient	Standard errors
Initial individual decision	-0.119	0.126
Individual decision in previous period	-0.333**	0.133
Group decision in previous period	0.178**	0.061
Decision-making time	-0.073**	0.021
Time trend	0.139**	0.056
Information sharing & lying, current period	4.530	3.855
Information sharing & non-lying, current period	8.347	5.276
Information sharing & lying, previous period	-2.188	1.748
Information sharing & non-lying, previous period	-4.731*	2.694
Information sharing, number of members in the group	-0.180	0.289
Intercept	-14.047**	4.576
Log-likelihood	-823.005	
Wald test $\chi^2(30)$, for the model's significance	345.13	p-value=0
Number of observations	684	
Number of individuals	36	
Number of uncensored observations	269	
Number of left-censored observations	4	
Number of right-censored observations	411	

Table 6: Estimation results for treatment FD

The models estimated for treatments VD and FD include additional variables linked to the voluntary mechanism. More precisely, for treatment VD, we add two dummy variables to indicate whether the player consented or not to disclose his extraction in the current and in the previous period ("Information sharing, current period" and "Information sharing, previous period"). We also added the number of members in the group who choose to disclose their individual decision. In the FD treatment, as players can report an extraction different from the actual one, there are three possible situations, each of them corresponding to a dummy variable: (i) the player refuses to disclose his decision (the reference) (ii) he consents but reports an extraction different from the actual one ("Information sharing & lying"), and (iii) he consents and reports his actual extraction ("Information sharing & non-lying"). We add the present and the past value for the latter two dummies. The set of regressors also includes the number of members in the group who choose to disclose their individual decisions[11].

11 It should be noted that including the decision to disclose or not its extraction may create an estimation bias. Indeed, an individual can simultaneously make several decisions about (i) his extraction, (ii) his choice to disclose or not his decision, (iii) the amount he reports. This phenomenon urges us to consider the corresponding explanatory variables as endogenous regressors (i.e. variable "Information sharing, current period" for the VD treatment, on the one hand, and variables "Information sharing & lying, current period" and "Information sharing & non-lying, current period" for the FD treatment, on the other hand). For this purpose, we apply the control function approach proposed by Wooldridge (2014), which is particularly suitable for nonlinear models such as our Tobit model with correlated random effects. Tables 5 and 6 provide estimation results which account for this endogeneity bias. The control function approach of Wooldridge (2014), consisting in a two-step estimation, is relatively simple to implement. At the first step, a probit model for the endogenous regressor is estimated in order to obtain a generalized residuals. The second step corresponds to the estimation of the usual nonlinear model (i.e. Tobit model with correlated random effects) with the previously computed generalized residuals as an additional regressor. See Wooldridge (2014) for more computational details. Finally, we perform a z-test for the significance of these

The main result of these estimates is that the level of extraction chosen by the player strongly depends on whether or not he disclosed his decision during the previous period (VD treatment) and if he did, whether declared or not the true value of its extraction (FD treatment).

4 Conclusion

The efficient management of a common pool resource at a reasonable cost is a challenge for several years. The development of new technologies facilitating the transfer and the sharing of information allows to imagine new mechanism for the management of common resources. However, as several previous studies have shown, information, if there is too much without control, can prevent cooperation between actors or accelerate convergence towards non-cooperative solutions (Villena & Zecchetto 2011). In this article, we focused on information on individual extraction levels and investigated how a mechanism based on voluntary choices could improve the usual problem of overexploitation of common resources. To this purpose we experimentally tested two mechanisms. In the first one (VD), the actors are only invited to indicate whether they agree to make public their level of extraction, the agency remaining in charge of data collection. In the second one (FD), the actors are free to disclose or not their level of extraction but they are also responsible for the report of the amount that is made public. Less expensive for the agency than the first mechanism, the latter introduces however strategic considerations, some actors may abuse this freedom by trying to generate more individual profit.

Observations from our experience show that a mechanism based on voluntary sharing is effective, especially when agents are only invited to agree to disclose their individual extraction. Allowing agents to self-report is a mechanism that would likely benefit from the addition of an audit system to (sometimes) monitor reports. This would reduce strategic behavior and thus lead this mechanism being both more efficient and less expensive than other types of procedures.

generalized residuals. For the VD treatment, the z-statistic is -2.08, while for the FD treatment, the z-statistic is -1.20 for the first generalized residuals (corresponding to “Information sharing & lying”) and -1.97 for the second generalized residuals (“Information sharing & non-lying”). This result implies the significance of generalized residuals in the nonlinear regressions, therefore supporting the control for endogeneity of information sharing when using data under the VD and FD treatments.

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