Information disclosure under liability: an experiment on public bads*

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Abstract

We experimentally investigate the impact of information disclosure on managing collective harms that are caused jointly by a group of liable agents. Subjects interact in a public bad setting and must choose *ex ante* how much to contribute in order to reduce the probability of causing a common damage. If a damage occurs, subjects bear a part of the loss according to the liability-sharing rule in force. We consider two existing rules: a per capita rule and a proportional rule. Our aim is to analyze the relative impact of information disclosure under each rule. We show that information disclosure increases contributions only under a per capita rule. This result challenges the classical results regarding the positive effects of information disclosure, since we show that this impact may depend upon the legal context. We also show that while a proportional rule leads to higher contributions than a per capita one, the positive effect of disclosure on a per capita rule makes it as efficient as a proportional rule without information disclosure.

Keywords: Information disclosure; Collective harms; Environmental Regulation; Liability Sharing Rules; Public Bads; Multiple Tortfeasors

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1 Introduction

Programs that disclose information about firms' environmental performance are increasingly used as a "third wave" to regulate pollution, in addition to market-based and command-and-control instruments. Disclosure strategies include public and/or private attempts to make information on pollution available to consumers, workers, shareholders and the public at large (Tietenberg, 1998). These programs are many and varied. Prominent examples of public disclosure include, among others, the Toxic Release Inventory (TRI) and Greenhouse Gas Reporting Program (GHGRP), but other programs have emerged since in many countries, such as in India with the Green Rating Project (GRP) (Powers et al., 2011) or more recently in the European Union.[1] At local level, information disclosure may be public (e.g. livestreaming pollution disclosure, see Huet-Vaughn et al., 2018), or private when disseminated by non-governmental organizations or even citizens (Pien, 2020).

Information disclosure is a particularly interesting tool for several reasons. First, from a political viewpoint, disclosure is more acceptable than some direct regulations perceived as more coercive (Schatz, 2008). Second, the impact of disclosure programs is widely recognized in the literature as a way of decreasing pollution significantly, especially through the enforcement of performance evaluation, rating programs and toxic release inventories. Several studies have highlighted a positive impact of such programs on pollution abatement (see e.g. Blackman et al., 2004; García et al., 2007; Bennear and Olmstead, 2008; García et al., 2009; Powers et al., 2011; Huet-Vaughn et al., 2018). Finally, the cost incurred by countries is low, as the information gathering cost is borne by civil society (Jacquet and Jamieson, 2016). These advantages explain why information disclosure, although underutilized as a policy tool for a time (Schatz, 2008), has been increasingly debated and has often been included in countries' strategies to prevent environmental harms, both at national and local levels.

However, information disclosure mechanisms are additional to existing regulatory measures. In the case of pollution incidents or environmental accidents, information disclosure complements existing regulations based on civil liability. Civil liability in general, and in the environmental field in particular, allows third parties to be compensated and/or the clean-up costs of hazardous sites to be financed *ex post*, as well as providing incentives

[1] See e.g. Directive 2018-851

to invest *ex ante* in safety measures to avoid harms. In practice, two different rules of apportionment of liability exist: a *per capita* rule and a *proportional* rule. According to the *per capita* rule, which is in force in most European countries, each of the n contributors has to compensate for $1/n$ of the common harm. Regarding the *proportional* rule which is used in the US, and especially in CERCLA,[2] the share each contributor has to pay depends on their relative investment in avoiding harm, compared to the investments of the others.[3] The relevant question in this case is whether information disclosure enhances the efficiency of liability rules, and if so, whether this impact is dependent upon the liability rule that applies.

The aim of this paper is to investigate the impact of information disclosure on investments that firms might make to avoid the occurrence of a damage, knowing that if harm does occur, liability rules apply. To this end, we conducted a laboratory experiment to analyze incentives to make investments in safety. We adopted a public bad setting in which players can contribute to reducing the probability of a fixed common loss, which is shared (through the apportionment of liability) among the group members if it occurs. The first two treatments introduced information disclosure through a so-called "identification" mechanism targeting the lowest contributors, under the liability rule in place, *i.e.* either per capita (in one treatment) or proportional (in another one).[4] In order to identify the relative impact of disclosure on investments, we ran two additional treatments with the same two liability rules, but without disclosure. Thus, our experimental design is well-suited to take into account the fact that most environmental harms are caused by a multitude of agents, from local to global pollution and climate change. In such situations, civil liability must apportion liability among the multiple injurers who contributed to a single common damage.

Our results show that while a proportional liability rule leads to higher investments than a per capita rule, introduction of a disclosure mechanism increases investments only under a per capita rule. A per capita rule combined with information disclosure would appear to be as efficient as a proportional rule without information disclosure. The higher impact of disclosure under a per capita rule can be explained by the higher

[2]CERCLA Section 113(f) allows for proportional liability in case of indivisible harm (see Kornhauser and Revesz, 1989; Pinkowski, 1996; Ferrey, 2009). An example is the Colorado vs. ASARCO, Inc case in 1985.

[3]Note here that if each tortfeasor invests the same amount, then the two rules are obviously equivalent.

[4]Note that the terms "recognition mechanism" and "naming mechanism" could also have been used, instead of "identification mechanism".

externality we impose on others when our own investment is low under this rule. When subjects are characterized by moral concerns, and especially when they are sensitive to disesteem, being recognized as a low contributor under a per capita rule can be an important source of stigmatization. A low contribution can be perceived as a signal of being a free rider.

This paper is thus closely related to the recent literature on the effects of information disclosure on firms' environmental performance. Most of them study the enforcement of information disclosure and conclude that there is a positive impact (Blackman et al., 2004; Powers et al., 2011; Huet-Vaughn et al., 2018; Pien, 2020). Foulon et al. (2002) proposed an original contribution by empirically analyzing the impact of fines and penalties on the one hand, and the impact of information disclosure on the other hand. They found that disclosure creates additional incentives for pollution control. Our findings partly challenge this result as we find mixed results as to the impact of disclosure, depending on which liability rule applies.[5] Although field data used in these studies provide useful information, they do not allow endogeneity issues related to the different legal contexts and environmental issues to be avoided. Our experimental design allowed us both to distinguish the impact of disclosure on subjects' behavior and to compare the liability rules with (and without) disclosure. Obviously, such a 2*2 design could hardly be found in the field.

Our paper is also partly in line with the literature on public goods and the identification of contributors, with the latter being enforced through what is referred to as *naming and shaming* low contributors. A series of public goods experiments have shown that naming contributors by revealing their identity affects contribution levels (Andreoni and Petrie, 2004; Rege and Telle, 2004; Soetevent, 2005; Samek and Sheremeta, 2014). Samek and Sheremeta (2014) noted that the shame from being a low contributor is a more powerful motivation for giving than the prestige of being recognized as a high contributor. Although some studies have investigated how players behave in a public bad setting, *i.e.* when the probability or size of a collective event (a loss) is affected by the group's decisions (e.g. Sonnemans et al., 1998; Keser and Montmarquette, 2008; Blanco et al.,

[5]Note also that some papers have investigated the channels through which information disclosure leads firms to reduce emissions. Konar and Cohen (1997) notably identified that a stock price decline due to information disclosure would lead firms to subsequently change their environmental behavior. The impact of such disclosure on firms' financial performance has been analyzed in other papers (see e.g. Capelle-Blancard and Laguna, 2010; Gonenc and Scholtens, 2017).

2016, 2017; Bounmy and Ouvrard, 2019; Flambard et al., 2020), none of them, to our knowledge, has introduced name and shame devices in a public bad setting. Disclosure of low contributors should also play an important role in the avoidance of a collective loss.

Finally, this paper is related to the law and economics literature on liability which has been quite extensively analyzed theoretically (Calabresi, 1970; Brown, 1973; Shavell, 1980) and has been identified as a means of reducing pollution (Kornhauser and Revesz, 1989, 1990; Endres and Bertram, 2006; Endres et al., 2008). Still from a theoretical perspective, some papers on liability have also investigated how this legal framework interacts with moral concerns in providing incentives to manage risky activities (Deffains and Fluet, 2013; Buchens et al., 2019). However, from an empirical perspective, no comparison of liability rules has been made on field data, and few experiments have been performed. Exceptions are Kornhauser and Schotter (1990, 1992), who tested, in a single-actor (unilateral) and double-actor (bilateral) accident framework, the effects of strict liability and negligence on the reduction of a risk of unilateral accident and a risk of bilateral accident respectively. Angelova et al. (2014) also compared strict liability and negligence in terms of efficiency in reducing the probability of an accident. Using two precaution levels (care vs no care), they found that both liability rules provide socially efficient incentives, but that roughly half of the subjects also invested in care under a No Law setting, where subjects cannot be sanctioned for not contributing. Finally, Deffains et al. (2019) compared a no law setting with the two liability rules (strict liability versus negligence) and implemented two legal obligation enforcement levels (mild versus severe).[6] They showed that individuals trade off private benefits, net of legal liability, against the net uncompensated losses caused to others. Finally, on the liability side, the closest paper to ours is Garcia et al. (2021) who experimentally compared the efficiency of two liability rules, *i.e.* joint and several liability and several (only) liability, in terms of incentives for (potentially insolvent) subjects to make investments to reduce the size of a damage which will occur with certainty. Our experiment differs from theirs in several respects. First, and most importantly, information disclosure was not taken into account in their paper which focuses on liability rules only. Second, we adopted a public bad set-

[6] Under severe law, subjects always have to compensate perfectly for any harm caused to others, i.e. the probability of detection is assumed to be 100%; under mild law, the probability of detection is 50% only.

ting, which seems relevant to consider more than two subjects interacting with each other in order to reduce a common harm. Third, we considered that investments reduce the probability (and not the size) of harm, relating to other types of environmental harms. The paper is organized as follows. In Section 2, we display the experimental design and a simple theoretical model that allows us to derive predictions. Section 3 presents the results from our experiment, and Section 4 concludes and discusses the potential implications of this research.

2 Experimental design and hypotheses

2.1 Design

The experiment consists of a repeated game played by groups of four subjects for 20 periods. The composition of each group is randomly changed every five periods. At the beginning of the experiment, each subject is endowed with 200 ECUs so that any group member is able to fully compensate for a potential loss of the same amount. In addition, at the start of each period, subjects receive an endowment of 19 ECUs and have to decide, simultaneously and without the possibility of communicating with the other group members, how many of those ECUs they are willing to invest in order to reduce the probability of a loss of 200 ECUs affecting their group. Note that this loss will be shared between the members depending on the rule in place, as explained below. The probability of occurrence of this loss diminishes as the contributions of the four group members increase, and is given by the following function:

$$p(x_i, x_j, x_k, x_l) = \frac{1}{1 + \alpha(x_i + x_j + x_k + x_l)} \tag{1}$$

where x_i, x_j, x_k, x_l are the individual contributions to decreasing the probability, $i = 1, 2, 3, 4$, $j = 1, 2, 3, 4$, $k = 1, 2, 3, 4$, $l = 1, 2, 3, 4$, $i \neq j \neq k \neq l$ denoting the four subjects, and α is set at 0.19. [7] If none of the four subjects contributes, the probability is 1 and the loss occurs with certainty. On the contrary, if all four subjects contribute their entire

[7] Increasing α leads both to a decrease in the level of the probability (for given contributions), and to a decrease in the marginal benefit from contributing. For α lower than 0.19, the theoretical equilibrium under the *per capita* rule (see later) is the corner solution, *i.e.* contributing 19. $\alpha = 0.19$ leads to an interior solution. Higher values of α lead to closer equilibrium values between *per capita* and proportional rules. So, this value of α was the one which provides both interior solutions and the highest difference in equilibrium values.

endowment (19 ECUs), the probability falls to zero and no harm can occur. In order to facilitate the subjects' decision making, a table displaying the probability for every possible contribution is presented in the instructions.[8] The experiment is completely decontextualized so that only neutral terms such as gain, loss or contribution are used.

We consider four different treatments (see Table 1). In the so-called Per Capita treatment (PC-A)[9], the loss is shared equally between the members of the group. This means that if the loss occurs, each member has to bear 1/4 of the loss, that is to say 50 ECUs.

In the Proportional treatment (PR-A), the share of the loss that each subject has to bear in case of an accident depends on their relative level of contribution (to reducing the probability of the loss occurring). More precisely, the share of the loss for a subject i, denoted γ_i, is given by the ratio of their deviation from the maximum contribution (19 ECUs) to the sum of the four members' deviations. That is:

$$\gamma_i(x_i, x_j, x_k, x_l) = \frac{19 - x_i}{4 * 19 - (x_i + x_j + x_k + x_l)} \tag{2}$$

If all subjects contribute the same amount to the reduction of probability, the individual share of loss simplifies to a per capita one. If a subject i decides not to contribute and if the three others contribute the maximum amount (19 ECUs), subject i bears the entire loss. If a subject i decides to contribute the maximum amount, their share of the loss is reduced to 0.

	Anonymous	Identification
PC	PC-A	PC-ID
PR	PR-A	PR-ID

Table 1: Treatments

We implement the identification mechanism in the treatments PC-ID and PR-ID.[10] We replicate the two sharing rules and, in addition, subjects can be publicly identified for their contributions. We follow Andreoni and Petrie (2004) and Samek and Sheremeta (2014) and use digital photos and first names to identify individuals to one another.[11]

[8] To avoid the subjects needing mathematical skills in order to understand the function of probability, they were not given the functional form of that function but a table of all probabilities instead. See the instructions in the Appendix A.1.

[9] A stands for *anonymous*.

[10] ID stands for *information disclosure*.

[11] As pointed out by Samek and Sheremeta (2014), photos capture and preserve the appearance of the person but do not allow for communication, which may confound the effects of identification alone. In addition to the photo, we therefore included first names.

In the instructions, subjects are told that at the end of the experiment, the picture and the first name of the five worst contributors, characterized by the lowest average contributions over four randomly selected periods, will be displayed on the computer screens of all participants.[12] Since our goal is to work on the subjects' sensibility relative to (dis)esteem (or stigmatization), we show the picture and the name of the five subjects who contribute the least among all the participants of the session whether or not they have been in the same group.[13]

In each treatment, subjects make the same decision, *i.e.* choosing how much they want to contribute to decreasing the probability of a loss. In addition, they are also requested in every period (in addition to the contribution decisions) to indicate their beliefs about the average contribution of the three other members of their group. They are rewarded according to the accuracy of their beliefs.[14] Their gains for each period depend on whether or not the loss occurred. If there was no loss, subjects obtain their endowment of 19 ECUs minus their investment in reducing the probability. In case of a loss, they get their endowment of 19 ECUs minus their investment in reducing the probability and their share of the loss which differs according to the liability rule. At the end of each period, subjects are informed about the total contribution of their group, the resulting probability, the occurrence of the loss and their own payoffs.

In addition to the main game, we also elicit participants' risk attitude using the method developed by Eckel and Grossman (2002). Participants are presented with 5 different gambles and have to select only one of them. Each gamble offers a 50% chance of getting the low payoff and a 50% chance of getting the high payoff. Gamble 1 is a certain gamble (no risk) while Gamble 5 is the riskiest gamble (highest expected return but also highest standard deviation). Highly risk-averse subjects are expected to choose gambles with the lowest standard deviations.

[12] Note that this random draw of four periods implies that a given subject may potentially be identified even in the absence of an accident. Although this might be questionable in terms of external validity, it allows us to reduce both the impact of randomness and a strong path dependency. If a subject were possibly identified only in case of an accident, then a subject making a low investment only once might be identified and a subject making zero investment except once might not be. We therefore give stronger incentives to invest, but avoid too much randomness. This also makes over-investment in the periods following an accident less likely.

[13] Besides the financial impact of bad environmental performances which are disclosed publicly (through consumers' or investors' reactions, as documented by Foulon et al., 2002 or Lanoie et al., 1998), the firms are also sensitive to the opinion of local communities (see Afsah et al., 1996).

[14] We follow Gächter and Renner (2010) for belief elicitation. Subjects earned 6 ECUs if they correctly (± 0.5 ECUs) predicted the average contribution of the three other members and 3 ECUs divided by the (absolute) estimation error otherwise.

2.2 Model and predictions

Here we build here a simple model, which is based on the design introduced above. The aim is to derive some predictions to be tested in the experiment.

We consider a group of four symmetric risk-neutral agents. We note W their initial endowments, and H the loss that can be caused. x_i is the contribution that an agent i can make in order to reduce the probability of causing the loss H, with $i = 1, 2, 3, 4$. Any positive contribution is costly, through a decrease in the additional endowment $R(x_i)$ (with $\frac{\partial R(x_i)}{\partial x_i} < 0$).

Depending on the sharing rule r which applies ($r = PC, PR$), the share γ_i^r of the loss an agent i has to bear is different: it is $\gamma_i^{PC} = \frac{1}{4}$ in case of a *per capita* rule, and $\gamma_i^{PR} = \gamma_i(x_i, x_j, x_k, x_l)$, as defined by (2), in case of a proportional rule. As a result, the agent i's expected payoff depending on the sharing rule r is:

$$E[\Pi_i^r(x_i)] = W + R(x_i) - \gamma_i^r p(x_i, x_j, x_k, x_l)H$$

with $i = 1, 2, 3, 4$, $j = 1, 2, 3, 4$, $k = 1, 2, 3, 4$, $l = 1, 2, 3, 4$, $i \neq j \neq k \neq l$.

Moreover, we suppose that each agent may benefit from social esteem (or suffer from social disesteem) from others, as regards the others' perception of their own ability to be concerned about the loss incurred by others. We note the social (dis)esteem as e, and the agent's sensibility to (dis)esteem β_i (with $\beta_i > 0$). As a result, an agent i utility is :

$$u_i = E[\Pi_i^r(x_i)] + \lambda\beta_i e \tag{3}$$

e can be seen as a coefficient of others' (dis)esteem: $e > 0$ means others have esteem towards agent i, $e < 0$ means disesteem. The higher the absolute value of e, the stronger the (dis)esteem.[15] λ is a dummy variable: $\lambda = 0$ means the agent i is a *homo oeconomicus*, who has no moral concern, and $\lambda = 1$ means the agent i is a *homo behavioris*, who is

[15] As in Deffains and Fluet (2013), (dis)esteem holds through the others' view of the agent's ability to care about the impact of their actions on others. This agent's concern towards others could be included in the model, through an additional cost in (3) such as: $-p(x_i)\theta D^r$, with D^r the loss incurred by others (depending on the rule $r = PC, Pr$), and θ the degree of the agent's concern for the others (with $\theta \geq 0$). (Dis)esteem is based on the underlying rationale that others cannot observe θ, but they try to infer its value, especially through the information disclosed by the identification mechanism. So, esteem (resp. disesteem) plays when others think that we have a high (resp. low) value of θ. Hence, θ is only an instrumental variable, that we choose not to introduce to ease the exposition.

sensitive to (dis)esteem.

Depending on the sharing rule r and the value of λ, we return to the four treatments and can now provide a theoretical basis for the four treatments defined above (see Table 1). Given our specifications, we can complete Table 1 as follows:

	Anonymous	Identification
PC	**PC-A** $\gamma_i^{PC} = 1/4$ $\lambda = 0$	**PC-ID** $\gamma_i^{PC} = 1/4$ $\lambda \in \{0, 1\}$
PR	**PR-A** γ_i^{PR} $\lambda = 0$	**PR-ID** γ_i^{PR} $\lambda \in \{0, 1\}$

Table 2: Treatments and parameters

2.2.1 *Per capita* sharing rule (PC), when agents are *homo oeconomicus* ($\lambda = 0$)

Perfect symmetry between agents implies equal contributions in equilibrium. Below, we introduce the best-response of a given agent i, while the contributions of the three others are given. The utility of an agent i, who is a *homo oeconomicus* under a *per capita* rule is:

$$u_i = E[\Pi_i^{PC}(x_i)] = W + R(x_i) - \frac{1}{4}p(x_i, x_j, x_k, x_l)H \tag{4}$$

The equilibrium value $x_i^{PC}(x_j, x_k, x_l) = x_i^{PC}$ thus satisfies:

$$\frac{\partial E[\Pi_i^{PC}(x_i)]}{\partial x_i} = 0 \Leftrightarrow -\frac{\partial p(x_i, x_j, x_k, x_l)}{\partial x_i}\frac{H}{4} = -\frac{\partial R(x_i)}{\partial x_i} \tag{5}$$

We now turn to the private decision-making of a *homo oeconomicus* under a proportional rule.

2.2.2 *Proportional* sharing rule (PR), when agents are *homo oeconomicus* ($\lambda = 0$)

Again, perfect symmetry implies equal contributions at equilibrium. The utility of an agent i is:

$$u_i = E[\Pi_i^{PR}(x_i)] = W + R(x_i) - \gamma_i(x_i, x_j, x_k, x_l)p(x_i, x_j, x_k, x_l)H \tag{6}$$

The equilibrium value $x_i^{PR}(x_j, x_k, x_l) = x_i^{PR}$ satisfies:

$$\begin{aligned} &\frac{\partial E[\Pi_i^{PR}(x_i)]}{\partial x_i} = 0 \\ &\Leftrightarrow -\left[\frac{\partial \gamma_i(x_i, x_j, x_k, x_l)}{\partial x_i}.p(x_i, x_j, x_k, x_l) + \frac{\partial p(x_i, x_j, x_k, x_l)}{\partial x_i}.\gamma_i(x_i, x_j, x_k, x_l)\right] H = -\frac{\partial R(x_i)}{\partial x_i} \end{aligned} \tag{7}$$

2.2.3 *Homo oeconomicus* ($\lambda = 0$): comparison of sharing rules

We compare incentives to contribute between the two sharing rules, PC and PR, for a *homo oeconomicus* agent ($\lambda = 0$). When comparing (7) with (5), we can see that both marginal costs of contributing are equal, but the marginal benefits are different. In Appendix A.2, we show that for a level of contribution which is equal to the equilibrium contribution under the PC rule (i.e. $x_i = x_i^{PC}$), the marginal benefit of contributing is higher under the PR rule than under the PC rule. This is due to a double marginal benefit of contributing under the PR rule, which allows both the reduction of the probability of an accident and the share of the cost to be paid (all other things being equal). It follows the following prediction.

Prediction 1 *In a symmetric setting, the proportional sharing rule leads to higher contributions than the per capita rule, when agents are not sensitive to (dis)esteem from others ($\lambda = 0$).*

Rule	Equilibrium investment
Per Capita	2.74
Proportional	4.84

Table 3: Equilibrium investments for *homo oeconomicus* agents

In the three next subsections, we study whether (and to what extent) contributions differ when agents are sensitive to (dis)esteem from others.

2.2.4 *Per capita* sharing rule (PC), when agents have moral concerns ($\lambda = 1$)

The fact of being identified as a low contributor provides others with information, from which they infer the extent to which the identified agent cares about the loss borne by the others.

The utility of an agent i, who is sensitive to (dis)esteem, under a *per capita* rule is given by (3) with $r = PC$. Before the disclosure of any information via the identification mechanism, others have a *prior* esteem which is denoted by $\bar{e}$. In the case where the agent is identified as a low contributor, this prior is updated to become e_B^r, with $e_B^r < \bar{e}$, given the rule r. Where the agent is not identified as a low contributor, this prior is updated to become e_G^r, with $e_G^r > \bar{e}$. Denoting by $q^r(x_i, x_j, x_k, x_l)$ the probability of being identified as a low contributor, given a contribution x_i and contributions x_j, x_k, x_l of the others, and a rule r (with $\frac{\partial q^r(x_i,x_j,x_k,x_l)}{\partial x_i} < 0$), the *ex ante* utility for an agent being sensitive to (dis)esteem under a *per capita* rule is:

$$\begin{aligned} & u_i = E[\Pi_i^{PC}(x_i)] + \beta_i \left[q^{PC}(x_i, x_j, x_k, x_l) e_B^{PC} + (1 - q^{PC}(x_i, x_j, x_k, x_l)) e_G^{PC} \right] \\ & \Rightarrow u_i = E[\Pi_i^{PC}(x_i)] + \beta_i \left[e_G^{PC} - q^{PC}(x_i, x_j, x_k, x_l) \Delta^{PC} \right] \end{aligned} \tag{8}$$

with $\Delta^{PC} = e_G^{PC} - e_B^{PC}$

2.2.5 Proportional sharing rule (PR), when agents have moral concerns ($\lambda = 1$)

When a proportional sharing rule is enforced, the *ex ante* utility of an *homo behavioris* agent i is:

$$\begin{aligned} & u_i = E[\Pi_i^{PR}(x_i)] + \beta_i \left[q^{PR}(x_i, x_j, x_k, x_l) e_B^{PR} + (1 - q^{PR}(x_i, x_j, x_k, x_l)) e_G^{PR} \right] \\ & \Rightarrow u_i = E[\Pi_i^{PR}(x_i)] + \beta_i \left[e_G^{PR} - q^{PR}(x_i, x_j, x_k, x_l) \Delta^{PR} \right] \end{aligned} \tag{9}$$

with $\Delta^{PR} = e_G^{PR} - e_B^{PR}$

When we compare (4) with (8), and (6) with (9), we can deduce that the sensitivity to (dis)esteem provides additional incentives to contribute since, whatever the sharing rule, an increase in the level of contribution increases the probability of not being identified as a low contributor, and thus benefitting from a favorable update (or avoiding a detrimental update) of others' esteem (i.e. $\frac{\partial\left[e_G^{PR}-q^{PR}(x_i,x_j,x_k,x_l)\Delta^{PR}\right]}{\partial x_i} > 0$). The following prediction can be made.

Prediction 2 *The identification mechanism should raise the contribution levels chosen by each player, whatever the liability sharing rule: the contribution levels should thus be higher under PC-ID (resp. PR-ID) than under PC-A (PR-A).*

2.2.6 Comparison of sharing rules when agents are sensitive to (dis)esteem

The ID mechanism provides additional incentives to contribute, for a given rule. However, the incentives provided by this mechanism are different between rules.

Recall that (dis)esteem, expressed by others, is the opinion (or belief) that others have towards oneself, in general or as regards a given personal quality. In our analysis, (dis)esteem holds on the agent's ability to care about the impact of their actions (their contributions) on others. However, the impact of contribution x_i on others' utilities differs depending on which sharing rule applies.

In case of a *per capita* sharing rule, a positive contribution leads to a decrease in the probability of causing a loss to others, the magnitude of which is exogenous (equal to $H-\frac{1}{4}H$, i.e., the global harm minus the share paid by the agent). In case of a proportional sharing rule, this effect exists but it is balanced by the fact that the sharing of the loss is also affected by the contribution: increasing x_i reduces the share of the loss to be paid by the agent i, thus increasing the share allocated to others. The impact of x_i on others' utilities is thus ambiguous (while the benefit on agent i's profit - not utility - is higher than under the PC rule).

As a consequence, under the PC rule, being identified as a low contributor provides a clear signal of being little concerned by the consequence of one's contribution on others (relatively to others), while the signal is more "blurred" under the PR rule since a low contributor pays for a larger share of the loss. It follows that: $\Delta^{PR} < \Delta^{PC}$. Then, for similar probabilities of being identified as a low contributor between the sharing rules (i.e. $q^{PC}(x_i, x_j, x_k, x_l) = q^{PR}(x_i, x_j, x_k, x_l)$), we obtain the following prediction.

Prediction 3 *Incentives to contribute provided by the identification mechanism should be higher under a per capita rule than under a proportional rule.*

3 Results

3.1 Procedure

A total of 240 subjects participated in 12 sessions (3 sessions per treatment) in October 2019 and in March 2020 at the Laboratory of Experimental Economics in Strasbourg (LEES). The subjects were recruited from a list of experimental subjects maintained at the LEES using the ORSEE software (Greiner, 2015). The experiment was computerized. Upon arrival, each subject was randomly assigned to a computer. The instructions were read aloud by the experimenter and, before starting, a comprehension questionnaire was administered to check that the rules were well understood. All questions were answered privately. Then the main game took place, followed by the elicitation of risk preferences and finally a post-experiment questionnaire. At the end of the experiment, one period from the main game was drawn randomly for actual payment. A random draw was also made to pick the payoff earned by subjects in the risk elicitation task. The conversion rate was 20 ECUs to 1.5 € for the main game and 4 ECUs to 1 € for the risk aversion elicitation task. Subjects were paid their earnings in a separate room and privately at the end of the session. Average earnings were 19.95 € (std. dev. = 3.04). The experiment lasted 60 minutes on average.

In the treatments PC-ID and PR-ID, we display digital photos of low contributors. Upon arriving in the lab, a digital photograph of each participant was taken by the experimenter. They gave their consent to the use of the picture during the experiment and they were told that all pictures would be deleted at the end of the experiment. They were free to stay to attend the deletion. At the beginning of the experiment, participants also had to enter their first name on the screen so that it could be associated with their picture.

In the following subsections, we present the results in two steps. First, we look at the average contributions to decreasing the probability of a loss and perform a series of non parametric tests. Second, we examine the individual choices of contributing in order to identify the effects of the treatments on subjects' behavior.

Treatment	Average contribution	% of contributions = 0	% of contributions = endowment
PC-A	7.27 (4.24)	7.75% (0.27)	4% (0.20)
PC-ID	9.03 (5.62)	7.25% (0.26)	13.33% (0.34)
PR-A	9.91 (5.10)	3.92% (0.19)	9.58% (0.29)
PR-ID	11.30 (5.25)	2% (0.14)	16.33% (0.37)

Table 4: Mean, minimum and maximum contributions per treatment (std. dev. in parenthesis)

3.2 Average contributions

Table 4 presents the average contributions (and standard deviations) as well as the proportions of minimum (0 ECU) and maximum (19 ECUs) contributions in each treatment. On average, contributions are higher in the Proportional treatments than in the Per Capita treatments (PR-A and PR-ID compared respectively with PC-A and PC-ID). Among the four treatments, subjects contribute the most in PR-ID. When anonymity is fully preserved in the Proportional treatment (PR-A), average contributions are lower but still higher than in the per-capita treatment (PC-A) that displays the lowest level of contributions. In both Proportional and Per Capita treatments, when information disclosure is introduced, average contributions increase.

We first test for the effect of the liability rule and look at the differences between PC-A and PR-A wherein subjects are fully anonymous.[16] The way of apportioning liability appears to affect the contribution levels since the average contribution rises from 7.27 in PC-A to 9.91 in PR-A and this increase is significantly different from zero ($p = 0.0003$). It also significantly increases the proportion of maximum contributions from 4% in PC-A to 9.58% in PR-A (test of proportion, $p = 0.0000$) and decreases the percentage of minimum contributions from 7.75% in PC-A to 3.92% in PR-A (test of proportion, $p = 0.0001$).

The same conclusion applies when contributors can be identified. Here, the average contribution increases from 9.03 in PC-ID to 11.30 in PR-ID ($p = 0.0089$) and the percentage of maximum contributions goes up from 13.33% in the PC-ID treatment to 16.33% in the PR-ID treatment. This rise is significant (test of proportion, $p = 0.0387$), albeit to a lesser extent than in the treatments where contributors cannot be identified. It seems that the impact of the liability rule is mitigated by the effect of identification. The per-

[16] Unless specifically noted, we report the significance levels of a two-sided Mann-Whitney rank-sum test taking individual averages as the unit of observation.

centage of minimum contributions falls from from 7.25% in PC-ID to 2% in PR-ID (test of proportion, p = 0.0000).

In addition to looking at the percentage of maximum and minimum contributions, we can compare the distributions of contributions[17] and determine whether the proportional rule modifies the shape of the distributions. In both cases either with and without anonymity, a Kolmogorov-Smirnov test allows us to reject the null hypothesis of equality of distributions. There is a significant difference between the PC-A and PR-A treatments (p = 0.001), as well as between the PC-ID and PR-ID treatments (p = 0.009).

This supports Prediction 1 according to which the proportional sharing rule leads to higher investments than the per capita rule.

Result 1: Contributions to reduce the probability of a damage are higher under a proportional rule of liability than under a per capita rule.

In order to identify the effect of identification, we now compare treatments for a given liability rule. That is, we look at differences between PC-A and PC-ID and between PR-A and PR-ID. As shown in Table 4, in the Per Capita treatments, when contributors can be identified, it significantly increases the average level of contributions. The average contribution goes from 7.27 in PC-A to 9.03 in PC-ID (p = 0.0384). In the Proportional treatments, allowing for the identification of the worst contributors has a positive impact on the average level of contributions too. The average contribution increases from 9.91 in PR-A to 11.30 in PR-ID but the difference is not statistically significant (p = 0.1076). This finding is consistent with Prediction 2 regarding the PC rule, but contradicts the prediction regarding the PR rule. As a consequence, Prediction 3 is found to be valid, since we find a positive effect of the ID mechanism under a PC rule and no effect of that mechanism under a PR rule. This result can be explained by the fact that when a Proportional rule applies, low contributors bear a greater share of liability than high contributors. Therefore, the externality they impose on others is less important than when a Per Capita rule applies. The stigmatization is lower in a proportional treatment since contributors assume their small contributions by paying a higher part of the loss.

Regarding the proportions of maximum contributions, we find that identification signifi-

[17] See Appendix A.3 for the distributions of contributions per treatment.

cantly increases these proportions in the Per Capita treatments and in the Proportional treatments. The percentage of maximum contributions goes from 4% in PC-A to 13.33% in PC-ID (test of proportion, p = 0.0000) and it increases from 9.58% in PR-A to 16.33% in PR-ID (test of proportion, p = 0.0000). Interestingly when we look at the proportions of minimum contributions, we do not find a significant difference between PC-A and PC-ID (test of proportion, p = 0.6419). However, the percentage of free-riding significantly decreases from 3.92% in PR-A to 2% in PR-ID (test of proportion, p = 0.0056). When we perform a Kolmogorov-Smirnov test, we find a significant difference between the total distributions of PC-A and PC-ID and no difference between those of PR-A and PR-ID. Thus, identification modifies the distribution in the Per Capita treatments (Kolmogorov-Smirnov test, p = 0.016) while it does not in the Proportional treatments (Kolmogorov-Smirnov test, p = 0.378).

Result 2: Recognizing the lowest contributors significantly increases contributions under a per-capita rule of liability but does not increase contributions under a proportional rule.

Figure 1 illustrates the average contributions per period in each of the four treatments. The declining trend we observe is a stylized fact that is consistent with multiple rounds public goods games where contributions tend to decline as the game is repeated (Andreoni and Petrie, 2004). It is also clear from Figure 1 that PC-A is the least efficient treatment in terms of maintaining high contributions while PR-ID seems to be the most efficient one. Also, in PR-ID, the decay of contributions is considerably reduced compared to other treatments. Interestingly, the curves for PC-ID and PR-A are rather close and there is no significant difference between these two treatments (p = 0.2635). This would suggest that it is equally effective, all else being equal, to implement a procedure of identification of low contributors with a per capita rule or to use a proportional rule alone. This result is interesting, especially for public policy. When it is difficult to identify the precise degree of liability of a firm (or when the legal framework does not allow the use of proportionality), a per capita rule where only the worst contributors need to be identified publicly, might prove to be as efficient a solution as a proportional rule. We will discuss this result further in the conclusion.

Result 3: A Per Capita rule combined with an identification mechanism makes it possible to reach the same level of contribution as a Proportional rule alone.

Figure 1 also shows an increase in contributions in the 6^{th}, 11^{th}, and 16^{th} periods. These surges correspond to the reallocation of groups and display a restart effect. To get rid of these reallocation effects, Figure 2 shows the mean contributions combining the four five-round sequences per treatment. The declining tendency seems to be more pronounced in the treatments without identification. In PC-A, the mean contribution starts at 7.96 and ends at 6.39 and in PR-A, it goes from 10.68 to 9.33. The level of mean contributions looks more stable when anonymity is broken. In PC-ID, the mean contribution begins at 9.53 and decreases to 8.65. The effect of repetition seems even less important in PR-ID (11.52 to 10.95). This means that the threat of being exposed may prevent contributions from declining over time as much as when liability applies alone. The comparisons of the treatments with and without anonymity indicate that there is a significant difference between PC-A and PC-ID (p[18] = 0.0372) and between PC-A and PR-ID (p = 0.0669). However, the difference between PR-A and PR-ID is not statistically significant (p = 0.1657) nor is it between PC-ID and PR-A (p = 0.1050).

Result 4: The identification of low contributors reduces the decay of contributions compared to situations in which anonymity is guaranteed.

3.3 Individual decisions

We now turn to the analysis of individual contributions in order to explain the differences between treatments. We first estimate a Tobit model with random effects since our dependent variable (the level of contribution) is left-censored at 0 and right-censored at 19.[19] Table 5 presents the different variables that are used in the regressions and the results are displayed in Table 6. In specification (1), the analysis is based on the pooled data over the four treatments. We identify the treatment effects by using three dummy

[18]The p-value is based on the difference between the average contribution of the first four periods in each group and the average contribution of the last four periods in each group by individuals.

[19]All results are robust to the use of other specifications such as OLS or individual clustered standard errors.

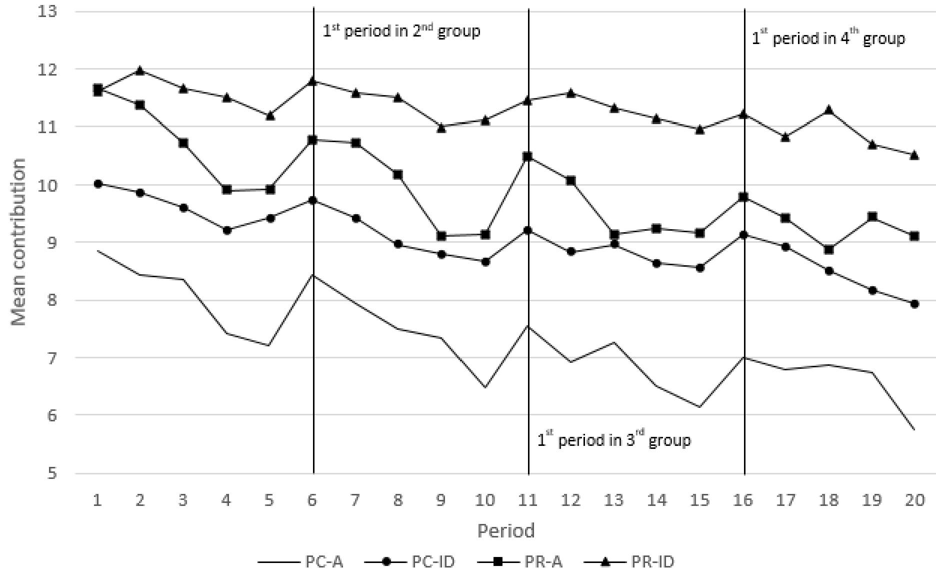

Figure 1: Average contributions over time per treatment

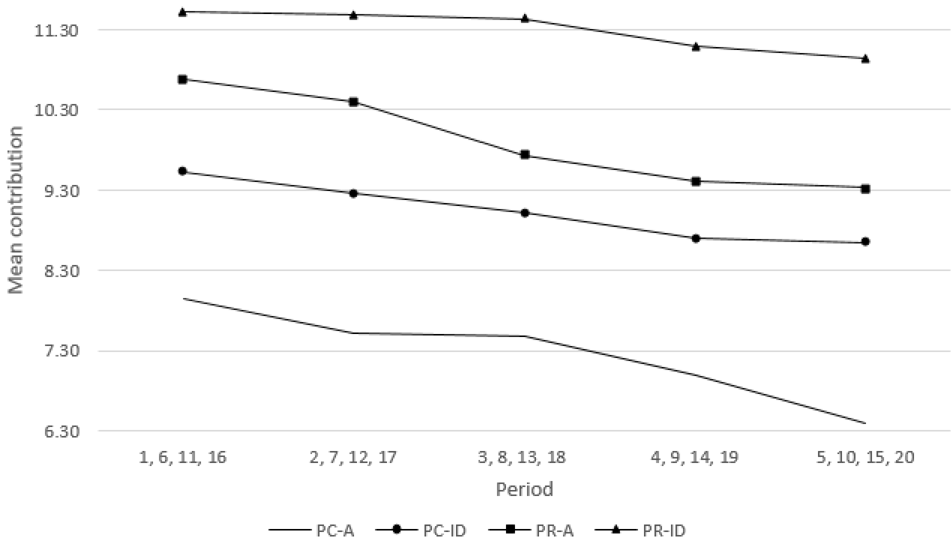

Figure 2: Mean contributions combining all 5-period sequences

variables (the baseline being PC-A). In specifications (2) and (3), we focus on the Per Capita treatments and the Proportional treatments separately in order to isolate the effect of identification. In the last two columns, we estimate logit models to identify the drivers of choice to contribute nothing and to contribute the total endowment.

We see from column (1) in Table 6 that all the coefficients of the treatment variables are positive and statistically significant. The contributions are higher in PC-ID, PR-A and PR-ID than in PC-A, but the highest difference in magnitude is found for PR-ID which is the most efficient treatment to increase contributions. A t-test of equality of

Table 5: Variables definition

Variables	Definition	Mean (std. dev.)
PC-ID	1 if the treatment is PC-ID; 0 otherwise	0.25 (0.43)
PR-A	1 if the treatment is PR-A; 0 otherwise	0.25 (0.43)
PR-ID	1 if the treatment is PR-ID; 0 otherwise	0.25 (0.43)
Loss_{p-1}	1 if a loss occurred in the previous period; 0 otherwise	0.14 (0.34)
$\text{AveragePartners}_{p-1}$	Average contribution of the 3 other group members in the previous period	9.43 (3.82)
Period	1 in period 1, 2 in period 2, ..., 20 in period 20	10.50 (5.77)
Socio-demographic variables		
Gamble	1 if subject chose Gamble 1, ..., 5 if subject chose Gamble 5	3.47 (1.35)
Risk-seeking	Answer from an 11-point Likert scale: 0 standing for a careful person and 10 for a person who loves taking risks	5.37 (2.09)
Female	1 if subject is female; 0 otherwise	0.5 (0.5)
Age	Age of subject	21.40 (2.66)
Econ-manag	1 if subject studies economics and management; 0 otherwise	0.54 (0.5)
Distrust	1 if subject stated that "We must be very careful with people"; 0 otherwise	0.73 (0.45)
Earnings	1 if subject stated that "They only cared about their own payoff during game"; 0 otherwise	0.45 (0.5)

the coefficients of PC-ID and PR-ID indicates that they are significantly different (p = 0.022). However, there is no significant difference between the coefficients of PR-A and PR-ID (p = 0.118) nor between those of PC-ID and PR-A (p = 0.474). This furthermore supports Results 1, 2 and 3 obtained with the non-parametric tests.

Among other results, the occurrence of a loss in the previous period increases the contributions. This can be explained by the availability heuristic (Kahneman and Tversky, 1973). Subjects recall the loss in the previous period perfectly and, therefore, tend to overstate the probability of a loss in the current period. Also, the effect of the average contribution of the other group members in the previous period[20] is positive and highly significant. This means that the higher the average contribution of the other group members in the previous period, the more the subjects will be willing to contribute. As shown

[20]We used this lagged variable rather than the subject's belief about the average contribution of the other group members since we obtain the same result no matter which variable is employed but the effects are more statistically significant with the former.

in Figure 1, the effect of periods is negative which indicates that contributions decrease over time. In the first column of Table A.1 in Appendix A.4, we also present a regression in which we introduce a dummy variable for each period of group reallocation (i.e. the 6th, 11th and 16th periods) and we find a significant and positive reallocation effects suggesting some restart effects.

In the second model in Table 6, we focus solely on the Per Capita treatments to get rid of the effect of the liability rules. The effect of identification appears to be statistically significant ($p = 0.027$) which means that when anonymity is broken in the Per Capita treatments, contributions are higher on average than when it is preserved. Like in regression (1), the occurrence of a loss and higher contributions from the other group members in the previous period increase the individual contributions. The coefficient of Period is also negative and highly significant. However, while Figure 2 seemed to indicate that identification prevented contributions from declining over time as much as when anonymity was preserved, we did not find evidence of this trend. Indeed, in regression (2) of Table A.1 in the appendix A.4, we introduce an interaction variable of Period and PC-ID and it appears not to be statistically significant. This contradicts Result 4 based on the non parametric tests. Regarding the socio-economic variables, we found that subjects who study economics and management contribute less when facing per-capita incentives. It is likely that they have covered this topic in class, so that they might be aware that the optimal strategy is to deviate. Also when subjects are wary of people, they tend to contribute more. They may expect low contributions from the other group members so they invest more to compensate for that. In these treatments, subjects have an incentive to free-ride in order to maximize their payoff. This could explain the negative and significant coefficient of Earnings.

The third regression of Table 6 focuses on the Proportional treatments only. As expected from non parametric tests, the identification of low contributors does not affect the level of contributions, as evidenced by the coefficient of PR-ID which is not statistically significant ($p = 0.098$). The effects of the occurrence of a loss, the contributions of others and time are the same as in the previous regressions. Breaking anonymity still has no effect on the decline of contributions over time as shown by the coefficient of the interaction variable of Period and PR-ID which is not statistically significant.[21] It is still

[21] See column (3) of Table A.1 in Appendix A.4.

Table 6: Tobit and logit estimations

	All	PC	PR	Free-riding	Full contrib.
	(1)	(2)	(3)	(4)	(5)
PC-ID	2.001**	2.073**		-.022	0.048**
	(1.012)	(0.939)		(0.024)	(0.022)
PR-A	2.727***			-.032	0.045**
	(1.015)			(0.023)	(0.022)
PR-ID	4.313***		1.695*	-.051**	0.061**
	(1.021)		(1.024)	(0.022)	(0.024)
Loss_{p-1}	0.512***	0.598***	0.417**	-.012*	0.014*
	(0.131)	(0.161)	(0.208)	(0.007)	(0.007)
$\text{AveragePartners}_{p-1}$	0.277***	0.31***	0.244***	-.000	0.003***
	(0.02)	(0.026)	(0.03)	(0.001)	(0.001)
Period	-.071***	-.077***	-.064***	0.002***	0.001
	(0.008)	(0.01)	(0.013)	(0.000)	(0.000)
Gamble	-.369	-.255	-.254	0.017***	-.008
	(0.288)	(0.369)	(0.427)	(0.006)	(0.007)
Risk-seeking	-.451**	-.327	-.712***	0.002	-.011***
	(0.187)	(0.243)	(0.276)	(0.004)	(0.004)
Female	-2.238***	-1.452	-2.639**	-.005	-.084***
	(0.779)	(0.984)	(1.147)	(0.016)	(0.015)
Age	0.13	0.064	0.137	0.005**	0.007**
	(0.145)	(0.179)	(0.222)	(0.003)	(0.003)
Econ-manag	-.962	-2.907***	1.058	0.015	-.018
	(0.782)	(0.998)	(1.137)	(0.016)	(0.019)
Distrust	0.887	2.307**	-.767	-.02	0.004
	(0.809)	(1.079)	(1.132)	(0.016)	(0.019)
Earnings	-.449	-2.589***	1.728*	0.051***	0.022
	(0.731)	(0.979)	(1.021)	(0.016)	(0.017)
Constant	7.613**	8.142*	10.668*		
	(3.757)	(4.520)	(5.873)		
Obs.	4560	2280	2280	4560	4560
Left-censored obs.	245	177	68	/	/
Right-censored obs.	487	194	293	/	/

Estimated standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Average marginal effects are reported in models (4) and (5).

not in line with Result 4 derived from the non parametric tests. If we look at the socio-economic variables, we observe that subjects who self-identify themselves as risk-seeking persons contribute less. By doing so, they increase both the probability of incurring a loss and their share of liability. There is a gender effect as shown by the negative and significant coefficient of Female. It seems that women tend to contribute less on average, which is consistent e.g. with Brown-Kruse and Hummels (1993) who showed that males tend to contribute more than females in public goods games.

In the last two columns, we estimate a random-effect Logit model to explain the decision to contribute zero ECU or to contribute the total amount of the endowment. In regression (4), the dependent variable equals one when subjects contributed 0 ECU to decreasing the probability and zero otherwise. In regression (5), the dependent variable is equal to one if subjects contributed their 19 ECUs and zero otherwise. Focusing first on regression (4), it turns out that PR-ID is the only treatment that makes free-riding less likely. In other words, identification does not suffice to reduce the chances of free-riding when a per capita rule applies nor does the proportional rule when anonymity of contributors is preserved. However, a t-test of equality of the coefficients of PR-A and PR-ID indicates that they are not significantly different ($p = 0.296$). That means that with a proportional rule, identifying low contributors does not reduce the probability of contributing nothing. The occurrence of a loss in the previous period diminishes the probability of free-riding, although the effect is marginally significant. Subjects may want to avoid incurring a loss again and they are therefore less willing to free-ride. The effect of time is positive as pointed out by the positive and significant coefficient of Period. This is in line with contributions declining over time. As time goes by, subjects may be tempted to contribute nothing to decreasing the probability of a loss. The coefficient of gamble is positive and highly significant, meaning that subjects who chose the riskiest gambles have more chances of free-riding. Subjects who tried to maximize their earnings are also more likely to contribute nothing since it allows them to increase their own payoff by 19 ECUs.

Finally, when looking at the probability of contributing 19 ECUs, we see that the coefficients of the three treatment variables are positive and significant which indicates that the probability is higher in all of these treatments than in PC-A. Nevertheless, the coefficients of PR-A and PR-ID are not statistically different as shown by the t-test of equality of the coefficients ($p = 0.560$). Therefore, when a proportional rule applies, breaking anonymity has no effect on the likelihood of contributing the total endowment. The occurrence of a loss in the previous period affects the probability of contributing 19 ECUs positively, although this effect is only marginally significant. Subjects refer to past decisions of the other group members to make their own. If the other members contributed more in the previous period then it is more likely that subjects will contribute the maximum amount of ECUs. Subjects who stated that they love taking risks show less likelihood of contributing 19 ECUs. There is a strong gender effect which tells us that women are less likely to contribute their entire endowment. This could explain the gender effect we found in the third model of Table 6.

Result 5: Recognizing the lowest contributors increases the proportion of full-contributions when a Per Capita rule applies.

4 Conclusion

In this paper, we run an experiment to analyze the impact of information disclosure on incentives to prevent a damage when several contributors can be held liable if it occurs. Agents decide on their contributions to reduce the probability of harm; in case of occurrence, they share the loss according to the liability sharing rule in force, *i.e.* per capita versus proportional. In order to identify the impact of information disclosure, we run four treatments, by varying both the presence of an identification mechanism and the liability rule. Under a *per capita* rule of apportionment, in case of harm occurring, the damages are split equally between the four players of the group. Under a *proportional* rule, each player is held liable for the harm in proportion to their (lack of) investment to avoid it.

Our theoretical predictions are notably that a *proportional* rule should, everything else being equal, raise higher investments than a *per capita* rule, the intuition being that bearing a share of the harm which depends on relative contributions calls off the free riding implied by a *per capita* rule. Most importantly, we also find theoretically that information disclosure should raise investments to a higher extent under a PC rule than under a PR rule if agents are sensitive to disesteem.

Our results confirm our predictions. We find that information disclosure is efficient under a PC rule, leading to a significant increase in contributions, whereas it has no significant impact under a PR rule. Thus, while a PR rule provides higher incentives to contribute to decreasing the level of expected harm than a PC rule, adding an identification mechanism to the PC rule makes it as efficient as the PR rule. The higher effectiveness of the identification mechanism under a PC rule can be explained by the different moral cost of non-contribution under the two rules. For instance, a zero contribution by one player when the three others contribute their entire endowment has very different consequences depending on the liability rule in place: under a PR rule, zero contribution entails full liability whereas it entails only one quarter of it under a PC rule. So, under a proportional rule, a non contributor is fully liable for payment of the damage and thus, imposes no loss on others while in a per capita regime, they impose a loss to all other players, leading to a higher moral cost.

We believe that the fact that disclosure acts more effectively under a PC rule than under a PR rule is of interest. The first reason is that this result contrasts in a way with the existing literature which concludes that information disclosure systematically has a positive impact on firms' environmental performance (Blackman et al., 2004; García et al., 2007; Bennear and Olmstead, 2008; García et al., 2009; Powers et al., 2011; Huet-Vaughn et al., 2018). A second reason lies in the fact that, although the PR rule is used in some countries, its cost-effectiveness ratio might be questioned, as it requires much more information to be collected than the PC rule, and especially information on the best available technologies or practices, in order to evaluate the firms' deviations with respect to them. Moreover, from a political economy perspective, implementing a *per capita* apportionment of harm could be easier than a proportional one, which could also be seen as a source of uncertainty for firms. In contrast to the PR rule, information disclosure coupled with a PC rule requires less information, as it only needs a ranking of each firm's practices. Such a mechanism is indeed implemented in countries in which enforcement of regulations is weak[22]. This is notably achieved in the environmental field by non-governmental organizations and whistleblowers, which thus play a key role here in terms of information search. Adding information disclosure mechanisms in a PC rule legal context could be a cost-effective alternative to implementing a PR rule and this could be facilitated by public as well as private disclosure.

This paper is, to our knowledge, the first to investigate the impact of information disclo-

[22]See the example of Indonesia in Afsah et al., 1996.

sure by considering different legal contexts. But it is only a first step in that direction. We adopt a liability sharing context, but extensions should consider other contexts in order to determine whether this result may reflect a pattern. In particular, the possibility for victims, or citizens at large, to express disapproval or feel disesteem could be introduced into the analysis as a pushing factor for individual contributions to reduce the expected harm. Moreover, introducing citizens into the analysis could also open the door to the possibility of miscommunication by the agents causing the (expected) harm. As shown in Bramoullé and Orset (2018), firms are able to discredit information revealing their supposed detrimental actions by producing and publicizing scientific evidence which balances it and/or advertising on the virtues of their activities. Such actions might lessen the incentivizing power of information disclosure mechanisms. Faced with the possibility of making a choice between preventive efforts to reduce the expected harm (as considered in our paper) on the one hand, and miscommunication efforts to reduce stigmatization if a harm does occur on the other, the proportional liability sharing rule could regain some virtues, relative to the per capita rule.

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A Appendix

A.1 Instructions

Thank you for participating in this experiment on the economics of decision making. In this experiment you will have the opportunity to make money. The amount of your payoff will depend on **your decisions and the decisions of other participants**. Therefore, we ask you to read these instructions carefully since they will help you understand the experiment. All your decisions are **anonymous**. You will give your choices to the computer in front of which you are sitting your choices.

From now on, communication is no longer permitted. Please switch off your mobile phone as well. If you have a question, raise your hand and an experimenter will come and answer you in private.

This experiment comprises 2 parts. You have received the instructions for part 1. Each time you finish a part, you will get the instructions for the next one. All participants have the same instructions.

The earnings you can collect by taking part in this experiment are expressed in ECUs (Experimental Currency Units). At the end of each part, your earnings, in ECUs, will be converted in euros according to the conversion rate that applies to the part in question. At the end of the experiment, the gains you will have earned, converted into euros, will be paid to you in cash privately.

PART 1

For this part, the conversion rate is **1 ECU = 0.075 €**.

This first part of the experiment comprises 20 periods. During this part, you and 3 other randomly chosen anonymous participants will form a group of 4 persons. However, this group will not remain the same during these 20 periods. Every 5 periods, you will be randomly reallocated to a new group of 4 persons. It is possible that, within this new group, you may interact with participants you have already played with (in a previous group). However, when this happens, you will not be informed.

At the beginning of this part, you will receive 200 ECUs. It is your initial wealth. In addition to your initial wealth, you will receive an endowment of 19 ECUs at the beginning of each period. In each period a loss of 200 ECUs can occur randomly. [PC: If this loss arises, each member of the group will bear $\frac{1}{4}$ of the cost, that is, 50 ECUs.] [PR: If this loss arises, the members of the group will have to bear it collectively.]

Tasks

Task 1) In every period, you will have to choose how many ECUs from your endowment (integer between 0 and 19) you are willing to give in order to decrease the probability of the loss of 200 ECUs occurring; and how many ECUs you want to keep for yourself.

The probability of the loss occurring decreases as your contribution **and** the contributions of the 3 other members of the group increase. Nevertheless when you make your decision, you will not know the choice of the 3 other members and the four of you will make your decisions simultaneously.

In order to help you understand how the probability changes with the decisions of each member of the group, you can refer to Table 1. In this table, your choice of contribution is indicated in the first column. The first line represents the average contribution of the 3 other members of the group. The probabilities of occurrence of a loss according to your contribution (1^{st} column) and the average contribution of the three other members (1^{st} line) are indicated inside the table.

Let us take two examples at random:

Example 1: suppose that one member of the group decided to contribute 4 ECUs, another one 0 ECU and the last one 9 ECUs. Their average contribution is thus 4.3 ECUs (indeed each one of them contributed on average $\frac{4+0+9}{3} = 4.3$ ECUs). If you decide to contribute 14 ECUs, the probability of occurrence of the loss is, in this case, of 16.3%.

Example 2: suppose that one member of the group decided to contribute 10 ECUs, another one 14 ECU and the last one 18 ECUs. Their average contribution is thus 14 ECUs (indeed each one of them contributed on average $\frac{10+14+18}{3} = 14$ ECUs). If you decide to contribute 6 ECUs, the probability of occurrence of the loss is, in this case, of 9.9%.

Note that if the 4 members contribute the minimum amount (0 ECU), the probability of the loss occurring is equal to 100% (the loss occurs with certainty); on the contrary, if the 4 members make the maximum contribution (19 ECUs), the probability decreases to 0% (there is no loss).

Task 2) In every period, once you will have made your contribution decision, you will have to indicate what you think the other members decided. You will indicate what you think the average contribution of the 3 other members (integer between 0 and 19) will be for this period. The closer your answer is to the actual one, the more you earn. If your estimation is correct or not more than 0.5 ECU away from the actual average contribution, you will earn 6 additional ECUs. If your answer is further off than 0.5 ECU, you will earn 3 ECUs divided by the (absolute) distance between your estimation and the actual value.

Let us take two examples at random:

Example 1: you believe that the 3 other members of the group will contribute on average 5 ECUs. Thus, you tell the computer 5. It turns out that the exact answer was 5.3 ECUs. You earn 6 ECUs because your answer is only 0.3 ECU away from the actual one and this gap is lower than 0.5.

Example 2: you believe that the 3 other members of the group will contribute on average 17 ECUs. Thus, you tell the computer 17. It turns out that the exact answer was 12.7 ECUs. You earn $\frac{3}{4.3}$ ECUs (i.e. 0.7 ECU) because your answer is 4.3 ECUs away from the actual one and this gap is higher than 0.5.

Once each member has expressed their belief on the average contribution of the three others, the computer will determine randomly, according to the probability corresponding to the decisions of the 4 members of the group, whether the loss occurs or not.

The periods are independent from each other, meaning that if a loss occurs in a period, it does not affect the probability of occurrence in the next ones.

Earnings

[PR: If a loss of 200 ECUs occurs, you will have to bear a share that depends on your contribution **and** on the contributions of the 3 other members of the group. The more you contribute with respect to the contribution of the 3 other members, the lower this share. If the four of you contribute the same amount, the share you will all have to bear will be identical.

In order to help you understand how your share changes with the decisions of each member of the group, you can refer to Table 2. In this table, your choice of contribution is indicated in the first column. The first line represents the average contribution of the 3 other members of the group. The shares of the loss you will have to bear, if it occurs, according to your contribution (1^{st} column) and the average contribution of the 3 other members (1^{st} line) are indicated inside the table.

Let us take one example at random:

Example 1: suppose that one member of the group decided to contribute 10 ECUs, another one 17 ECU and the last one 5 ECUs. Their average contribution is thus 10.7 ECUs (indeed each one of them contributed on average $\frac{10+17+5}{3} = 10.7$ ECUs). If you decide to contribute 13 ECUs, the share of the loss you will have to bear, if it happens, is, in this case, 38.7 ECUs.]

Your earnings in every period are the sum of two amounts (earnings for task 1 and earnings for task 2) and depend on the occurrence of the loss:

[PC:

19 (your endowment) - your contribution (0, 1, 2, ... 19) - 50 ($\frac{1}{4}$ of the loss) + earnings for task 2 *if the loss occurs*

19 (your endowment) - your contribution (0, 1, 2, ... 19) + earnings for task 2 *if the loss does not occur*]

[PR:

19 (your endowment) - your contribution (0, 1, 2, ... 19) - your share of the loss + earnings for task 2 *if the loss occurs*

19 (your endowment) - your contribution (0, 1, 2, ... 19) + earnings for task 2 *if the loss does not occur*]

At the end of each period, you will be informed of the total contribution of your group, the resulting probability, the occurrence of the loss and your earnings for this period (earnings for task 1 and for task 2).

[ID: At the end of the 20 periods, 4 participants will randomly draw a period and will say it aloud to the other participants. These 4 periods will be used to calculate your average contribution. For example, if you contributed 3 ECUs, 14 ECUs, 0 ECU and 8 ECUs during the 4 selected periods, your average contribution is $\frac{3+14+0+8}{4} = 6.25$ ECUs. The picture and the name of the 5 persons who contributed the least on average (among all the participants) will be **displayed on the computer screen of each participant at the end of the experiment**. If, in case of equality of average contribution, there are more than 5 persons who contributed the least, all of them will be viewed.

At the end of the experiment, only 1 in 20 periods will actually be paid according to the conversion rate in euros. One participant will randomly draw a period in order to calculate the earnings for this first part. Each period has the same probability of being selected.

Therefore, your earnings for this first part are equal to: 200 (your initial wealth) + earnings from the selected period.

PART 2

For this part, the conversion rate is **1 ECU = 0.25 €**.

In this part, you will have only one decision to make. You will have to choose **one** gamble from 5 different gambles. Your earnings for this part will depend on the outcome of the gamble. For each gamble, there are 2 possible earnings: earnings from situation A and earnings from situation B. Each situation has a 50% chance of happening.

In order to determine your earnings for this part, the computer will virtually toss a coin virtually. If it is heads, situation A will happen and if it is tails, situation B will happen. Your earnings will correspond to the earnings of the winning situation of the gamble you will have chosen.

[Displayed on the screen:]

Gamble	Situation A (50%)	Situation B (50%)
1	12 ECUs	12 ECUs
2	18 ECUs	10 ECUs
3	24 ECUs	8 ECUs
4	30 ECUs	6 ECUs
5	36 ECUs	4 ECUs

Table 1: Evolution of the probability of occurrence of the loss according to your contribution (1st column) and the average contribution of the 3 other members (1st line)

Average contribution of the 3 other members

Your contribution	0	0,3	0,7	1	1,3	1,7	2	2,3	2,7	3	3,3	3,7	4	4,3	4,7	5	5,3	5,7	6	6,3	6,7	7	7,3	7,7	8	8,3	8,7	9	9,3
0	100%	84,0%	72,5%	63,7%	56,8%	51,3%	46,7%	42,9%	39,7%	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%
1	84,0%	72,5%	63,7%	56,8%	51,3%	46,7%	42,9%	39,7%	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%
2	72,5%	63,7%	56,8%	51,3%	46,7%	42,9%	39,7%	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%
3	63,7%	56,8%	51,3%	46,7%	42,9%	39,7%	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%
4	56,8%	51,3%	46,7%	42,9%	39,7%	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%
5	51,3%	46,7%	42,9%	39,7%	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%
6	46,7%	42,9%	39,7%	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%
7	42,9%	39,7%	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%
8	39,7%	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%
9	36,9%	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%
10	34,5%	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%
11	32,4%	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%
12	30,5%	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%
13	28,8%	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%
14	27,3%	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%
15	26,0%	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%
16	24,8%	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%
17	23,6%	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%
18	22,6%	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%
19	21,7%	20,8%	20,0%	19,3%	18,6%	18,0%	17,4%	16,8%	16,3%	15,8%	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%

Average contribution of the 3 other members (continued)

Your contribution	9,7	10	10,3	10,7	11	11,3	11,7	12	12,3	12,7	13	13,3	13,7	14	14,3	14,7	15	15,3	15,7	16	16,3	16,7	17	17,3	17,7	18	18,3	18,7	19
0	15,4%	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%
1	14,9%	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%
2	14,5%	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%
3	14,1%	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%
4	13,8%	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%
5	13,4%	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%
6	13,1%	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%
7	12,8%	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%
8	12,5%	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%
9	12,2%	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%
10	11,9%	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%
11	11,6%	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%	7,2%
12	11,4%	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%	7,2%	7,1%
13	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%	7,2%	7,1%	7,0%
14	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%	7,2%	7,1%	7,0%	6,9%
15	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%	7,2%	7,1%	7,0%	6,9%	6,8%
16	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%	7,2%	7,1%	7,0%	6,9%	6,8%	6,7%
17	10,3%	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%	7,2%	7,1%	7,0%	6,9%	6,8%	6,7%	6,6%
18	10,1%	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%	7,2%	7,1%	7,0%	6,9%	6,8%	6,7%	6,6%	6,6%
19	9,9%	9,7%	9,5%	9,4%	9,2%	9,0%	8,9%	8,7%	8,6%	8,5%	8,3%	8,2%	8,1%	7,9%	7,8%	7,7%	7,6%	7,5%	7,4%	7,3%	7,2%	7,1%	7,0%	6,9%	6,8%	6,7%	6,6%	6,6%	0%

N.B. The values indicated on your screen may differ by 0.1 from the ones in the table.

<u>Please do not write on the tables</u>

Table 2: Evolution of the share of the loss (in ECUs) you will have to bear if it happens according to your contribution (1st column) and the average contribution of the 3 other members of the group (1st line)

Average contribution of the 3 other members of the group

Your contribution	0	0,3	0,7	1	1,3	1,7	2	2,3	2,7	3	3,3	3,7	4	4,3	4,7	5	5,3	5,7	6	6,3	6,7	7	7,3	7,7	8	8,3	8,7	9	9,3
0	50,0	50,7	51,4	52,1	52,8	53,5	54,3	55,1	55,9	56,7	57,6	58,5	59,4	60,3	61,3	62,3	63,3	64,4	65,5	66,7	67,9	69,1	70,4	71,7	73,1	74,5	76,0	77,6	79,2
1	48,0	48,6	49,3	50,0	50,7	51,4	52,2	52,9	53,7	54,5	55,4	56,3	57,1	58,1	59,0	60,0	61,0	62,1	63,2	64,3	65,5	66,7	67,9	69,2	70,6	72,0	73,5	75,0	76,6
2	45,9	46,6	47,2	47,9	48,6	49,3	50,0	50,7	51,5	52,3	53,1	54,0	54,8	55,7	56,7	57,6	58,6	59,6	60,7	61,8	63,0	64,2	65,4	66,7	68,0	69,4	70,8	72,3	73,9
3	43,8	44,4	45,1	45,7	46,4	47,1	47,8	48,5	49,2	50,0	50,8	51,6	52,5	53,3	54,2	55,2	56,1	57,1	58,2	59,3	60,4	61,5	62,7	64,0	65,3	66,7	68,1	69,6	71,1
4	41,7	42,3	42,9	43,5	44,1	44,8	45,5	46,2	46,9	47,6	48,4	49,2	50,0	50,8	51,7	52,6	53,6	54,5	55,6	56,6	57,7	58,8	60,0	61,2	62,5	63,8	65,2	66,7	68,2
5	39,4	40,0	40,6	41,2	41,8	42,4	43,1	43,8	44,4	45,2	45,9	46,7	47,5	48,3	49,1	50,0	50,9	51,9	52,8	53,8	54,9	56,0	57,1	58,3	59,6	60,9	62,2	63,6	65,1
6	37,1	37,7	38,2	38,8	39,4	40,0	40,6	41,3	41,9	42,6	43,3	44,1	44,8	45,6	46,4	47,3	48,1	49,1	50,0	51,0	52,0	53,1	54,2	55,3	56,5	57,8	59,1	60,5	61,9
7	34,8	35,3	35,8	36,4	36,9	37,5	38,1	38,7	39,3	40,0	40,7	41,4	42,1	42,9	43,6	44,4	45,3	46,2	47,1	48,0	49,0	50,0	51,1	52,2	53,3	54,5	55,8	57,1	58,5
8	32,4	32,8	33,3	33,8	34,4	34,9	35,5	36,1	36,7	37,3	37,9	38,6	39,3	40,0	40,7	41,5	42,3	43,1	44,0	44,9	45,8	46,8	47,8	48,9	50,0	51,2	52,4	53,7	55,0
9	29,9	30,3	30,8	31,3	31,7	32,3	32,8	33,3	33,9	34,5	35,1	35,7	36,4	37,0	37,7	38,5	39,2	40,0	40,8	41,7	42,6	43,5	44,4	45,5	46,5	47,6	48,8	50,0	51,3
10	27,3	27,7	28,1	28,6	29,0	29,5	30,0	30,5	31,0	31,6	32,1	32,7	33,3	34,0	34,6	35,3	36,0	36,7	37,5	38,3	39,1	40,0	40,9	41,9	42,9	43,9	45,0	46,2	47,4
11	24,6	25,0	25,4	25,8	26,2	26,7	27,1	27,6	28,1	28,6	29,1	29,6	30,2	30,8	31,4	32,0	32,7	33,3	34,0	34,8	35,6	36,4	37,2	38,1	39,0	40,0	41,0	42,1	43,2
12	21,9	22,2	22,6	23,0	23,3	23,7	24,1	24,6	25,0	25,5	25,9	26,4	26,9	27,5	28,0	28,6	29,2	29,8	30,4	31,1	31,8	32,6	33,3	34,1	35,0	35,9	36,8	37,8	38,9
13	19,0	19,4	19,7	20,0	20,3	20,7	21,1	21,4	21,8	22,2	22,6	23,1	23,5	24,0	24,5	25,0	25,5	26,1	26,7	27,3	27,9	28,6	29,3	30,0	30,8	31,6	32,4	33,3	34,3
14	16,1	16,4	16,7	16,9	17,2	17,5	17,9	18,2	18,5	18,9	19,2	19,6	20,0	20,4	20,8	21,3	21,7	22,2	22,7	23,3	23,8	24,4	25,0	25,6	26,3	27,0	27,8	28,6	29,4
15	13,1	13,3	13,6	13,8	14,0	14,3	14,5	14,8	15,1	15,4	15,7	16,0	16,3	16,7	17,0	17,4	17,8	18,2	18,6	19,0	19,5	20,0	20,5	21,1	21,6	22,2	22,9	23,5	24,2
16	10,0	10,2	10,3	10,5	10,7	10,9	11,1	11,3	11,5	11,8	12,0	12,2	12,5	12,8	13,0	13,3	13,6	14,0	14,3	14,6	15,0	15,4	15,8	16,2	16,7	17,1	17,6	18,2	18,8
17	6,8	6,9	7,0	7,1	7,3	7,4	7,5	7,7	7,8	8,0	8,2	8,3	8,5	8,7	8,9	9,1	9,3	9,5	9,8	10,0	10,3	10,5	10,8	11,1	11,4	11,8	12,1	12,5	12,9
18	3,4	3,5	3,6	3,6	3,7	3,8	3,8	3,9	4,0	4,1	4,2	4,3	4,3	4,4	4,5	4,7	4,8	4,9	5,0	5,1	5,3	5,4	5,6	5,7	5,9	6,1	6,3	6,5	6,7
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Average contribution of the 3 other members of the group (continued)

Your contribution	9,7	10	10,3	10,7	11	11,3	11,7	12	12,3	12,7	13	13,3	13,7	14	14,3	14,7	15	15,3	15,7	16	16,3	16,7	17	17,3	17,7	18	18,3	18,7	19
0	80,9	82,6	84,4	86,4	88,4	90,5	92,7	95,0	97,4	100,0	102,7	105,6	108,6	111,8	115,2	118,8	122,6	126,7	131,0	135,7	140,7	146,2	152,0	158,3	165,2	172,7	181,0	190,0	200
1	78,3	80,0	81,8	83,7	85,7	87,8	90,0	92,3	94,7	97,3	100,0	102,9	105,9	109,1	112,5	116,1	120,0	124,1	128,6	133,3	138,5	144,0	150,0	156,5	163,6	171,4	180,0	189,5	200
2	75,6	77,3	79,1	81,0	82,9	85,0	87,2	89,5	91,9	94,4	97,1	100,0	103,0	106,3	109,7	113,3	117,2	121,4	125,9	130,8	136,0	141,7	147,8	154,5	161,9	170,0	178,9	188,9	200
3	72,7	74,4	76,2	78,0	80,0	82,1	84,2	86,5	88,9	91,4	94,1	97,0	100,0	103,2	106,7	110,3	114,3	118,5	123,1	128,0	133,3	139,1	145,5	152,4	160,0	168,4	177,8	188,2	200
4	69,8	71,4	73,2	75,0	76,9	78,9	81,1	83,3	85,7	88,2	90,9	93,8	96,8	100,0	103,4	107,1	111,1	115,4	120,0	125,0	130,4	136,4	142,9	150,0	157,9	166,7	176,5	187,5	200
5	66,7	68,3	70,0	71,8	73,7	75,7	77,8	80,0	82,4	84,8	87,5	90,3	93,3	96,6	100,0	103,7	107,7	112,0	116,7	121,7	127,3	133,3	140,0	147,4	155,6	164,7	175,0	186,7	200
6	63,4	65,0	66,7	68,4	70,3	72,2	74,3	76,5	78,8	81,3	83,9	86,7	89,7	92,9	96,3	100,0	104,0	108,3	113,0	118,2	123,8	130,0	136,8	144,4	152,9	162,5	173,3	185,7	200
7	60,0	61,5	63,2	64,9	66,7	68,6	70,6	72,7	75,0	77,4	80,0	82,8	85,7	88,9	92,3	96,0	100,0	104,3	109,1	114,3	120,0	126,3	133,3	141,2	150,0	160,0	171,4	184,6	200
8	56,4	57,9	59,5	61,1	62,9	64,7	66,7	68,8	71,0	73,3	75,9	78,6	81,5	84,6	88,0	91,7	95,7	100,0	104,8	110,0	115,8	122,2	129,4	137,5	146,7	157,1	169,2	183,3	200
9	52,6	54,1	55,6	57,1	58,8	60,6	62,5	64,5	66,7	69,0	71,4	74,1	76,9	80,0	83,3	87,0	90,9	95,2	100,0	105,3	111,1	117,6	125,0	133,3	142,9	153,8	166,7	181,8	200
10	48,6	50,0	51,4	52,9	54,5	56,3	58,1	60,0	62,1	64,3	66,7	69,2	72,0	75,0	78,3	81,8	85,7	90,0	94,7	100,0	105,9	112,5	120,0	128,6	138,5	150,0	163,6	180,0	200
11	44,4	45,7	47,1	48,5	50,0	51,6	53,3	55,2	57,1	59,3	61,5	64,0	66,7	69,6	72,7	76,2	80,0	84,2	88,9	94,1	100,0	106,7	114,3	123,1	133,3	145,5	160,0	177,8	200
12	40,0	41,2	42,4	43,8	45,2	46,7	48,3	50,0	51,9	53,8	56,0	58,3	60,9	63,6	66,7	70,0	73,7	77,8	82,4	87,5	93,3	100,0	107,7	116,7	127,3	140,0	155,6	175,0	200
13	35,3	36,4	37,5	38,7	40,0	41,4	42,9	44,4	46,2	48,0	50,0	52,2	54,5	57,1	60,0	63,2	66,7	70,6	75,0	80,0	85,7	92,3	100,0	109,1	120,0	133,3	150,0	171,4	200
14	30,3	31,3	32,3	33,3	34,5	35,7	37,0	38,5	40,0	41,7	43,5	45,5	47,6	50,0	52,6	55,6	58,8	62,5	66,7	71,4	76,9	83,3	90,9	100,0	111,1	125,0	142,9	166,7	200
15	25,0	25,8	26,7	27,6	28,6	29,6	30,8	32,0	33,3	34,8	36,4	38,1	40,0	42,1	44,4	47,1	50,0	53,3	57,1	61,5	66,7	72,7	80,0	88,9	100,0	114,3	133,3	160,0	200
16	19,4	20,0	20,7	21,4	22,2	23,1	24,0	25,0	26,1	27,3	28,6	30,0	31,6	33,3	35,3	37,5	40,0	42,9	46,2	50,0	54,5	60,0	66,7	75,0	85,7	100,0	120,0	150,0	200
17	13,3	13,8	14,3	14,8	15,4	16,0	16,7	17,4	18,2	19,0	20,0	21,1	22,2	23,5	25,0	26,7	28,6	30,8	33,3	36,4	40,0	44,4	50,0	57,1	66,7	80,0	100,0	133,3	200
18	6,9	7,1	7,4	7,7	8,0	8,3	8,7	9,1	9,5	10,0	10,5	11,1	11,8	12,5	13,3	14,3	15,4	16,7	18,2	20,0	22,2	25,0	28,6	33,3	40,0	50,0	66,7	100,0	200
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

N.B. The values indicated on your screen may differ by 0.1 from the ones in the table.

Please do not write on the tables

A.2 Proof of Prediction 1

A comparison between x_i^{PR} and x_i^{PC} consists in comparing (7) with (5), that is:

$$\frac{\partial E[\Pi_i^{PC}(x_i, x_j, x_k, x_l)]}{\partial x_i} = 0 \Leftrightarrow -\frac{\partial p(x_i, x_j, x_k, x_l)}{\partial x_i}\frac{H}{4} = -\frac{\partial R(x_i)}{\partial x_i}$$

with:

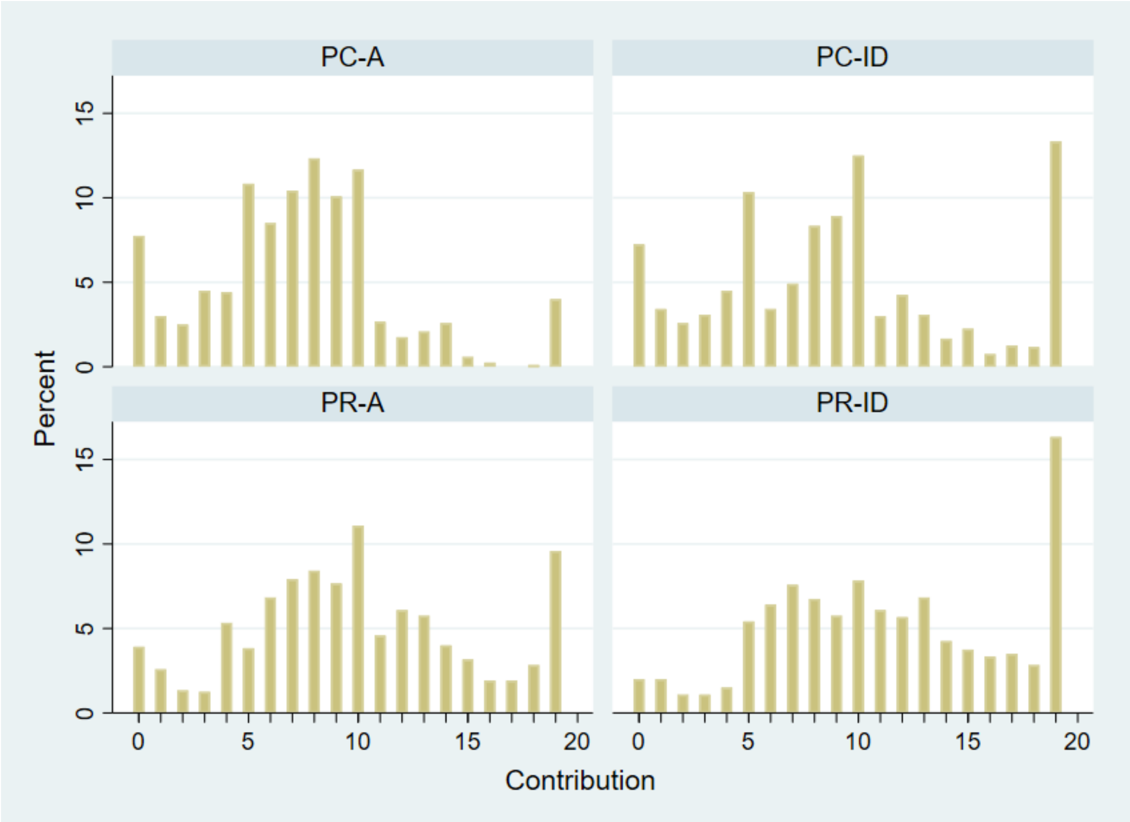
$$\frac{\partial E[\Pi_i^{PR}(x_i, x_j, x_k, x_l)]}{\partial x_i} = 0$$
$$\Leftrightarrow -\left[\frac{\partial \gamma_i(x_i, x_j, x_k, x_l)}{\partial x_i}.p(x_i, x_j, x_k, x_l) + \frac{\partial p(x_i, x_j, x_k, x_l)}{\partial x_i}.\gamma_i(x_i, x_j, x_k, x_l)\right] H = -\frac{\partial R(x_i)}{\partial x_i}$$

We observe that both marginal costs of care are equal, but marginal benefits are different. $x_i^{PR} > x_i^{PC}$ can occur if, for $x_i = x_i^{PC}$, we have :

$$-\left[\frac{\partial \gamma_i(x_i^{PC}, x_j, x_k, x_l)}{\partial x_i}.p(x_i^{PC}, x_j, x_k, x_l) + \frac{\partial p(x_i^{PC}, x_j, x_k, x_l)}{\partial x_i}.\gamma_i(x_i^{PC}, x_j, x_k, x_l)\right] H >$$
$$-\frac{\partial p(x_i^{PC}, x_j, x_k, x_l)}{\partial x_i}\frac{H}{n}$$
$$\Rightarrow -\frac{\partial \gamma_i(x_i^{PC}, x_j, x_k, x_l)}{\partial x_i}.p(x_i^{PC}, x_j, x_k, x_l) > -\frac{\partial p(x_i^{PC}, x_j, x_k, x_l)}{\partial x_i}\left(\frac{1}{n} - \gamma_i(x_i^{PC}, x_j, x_k, x_l)\right)$$
$$\Rightarrow 1 > \frac{-\frac{\partial p(x_i^{PC}, x_j, x_k, x_l)}{\partial x_i}\left(\frac{1}{n} - \gamma_i(x_i^{PC}, x_j, x_k, x_l)\right)}{-\frac{\partial \gamma_i(x_i^{PC}, x_j, x_k, x_l)}{\partial x_i}.p(x_i^{PC}, x_j, x_k, x_l)}$$

Note that this condition is always satisfied whenever $\frac{1}{n} - \gamma_i(x_i^{PC}, x_j, x_k, x_l) \leq 0$, i.e. when, for $x_i = x_i^{PC}$, the share of liability under the proportional rule is higher than or equal to the *per capita* rate. Since the proportional rule reduces to the *per capita* one when the contributions of all agents are equal, we deduce that this condition is satisfied in the symmetric case we consider.

A.3 Distributions of contributions per treatment



A.4 Econometric results

Table A.1: Tobit estimations

	Restart effects	PC	PR
	(1)	(2)	(3)
PC-ID	1.982**	1.736*	
	(1.011)	(0.963)	
PR-A	2.695***		
	(1.014)		
PR-ID	4.268***		1.345
	(1.019)		(1.060)
Loss_{p-1}	0.524***	0.606***	0.433**
	(0.13)	(0.161)	(0.208)
$\text{AveragePartners}_{p-1}$	0.289***	0.309***	0.241***
	(0.02)	(0.026)	(0.03)
Period	-.07***	-.092***	-.080***
	(0.008)	(0.014)	(0.018)
1^{st} period in 2^{nd} group	0.76***		
	(0.2)		
1^{st} period in 3^{rd} group	0.699***		
	(0.196)		
1^{st} period in 4^{th} group	0.694***		
	(0.2)		
Period*PC-ID		0.031	
		(0.02)	
Period*PR-ID			0.032
			(0.025)
Gamble	-.368	-.255	-.254
	(0.288)	(0.369)	(0.427)
Risk-seeking	-.452**	-.327	-.712***
	(0.187)	(0.243)	(0.276)
Female	-2.236***	-1.452	-2.638**
	(0.778)	(0.984)	(1.147)
Age	0.13	0.064	0.138
	(0.145)	(0.179)	(0.222)
Econ-manag	-.963	-2.910***	1.064
	(0.781)	(0.998)	(1.137)
Distrust	0.891	2.307**	-.771
	(0.807)	(1.079)	(1.132)
Earnings	-.443	-2.590***	1.724*
	(0.73)	(0.979)	(1.022)
Constant	7.405**	8.317*	10.866*
	(3.752)	(4.522)	(5.877)
Obs.	4560	2280	2280
Left-censored obs.	245	177	68
Right-censored obs.	487	194	293

Estimated standard errors are in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.