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Abstract

We experimentally investigate cooperative behaviour in a social dilemma situation, where the socially efficient outcome may be encouraged by risk aversion and/or inequality aversion. The first part of our experiment is devoted to the elicitation of subjects' aversion profile, taking care not to confuse the two dimensions. Subjects are then grouped by three according to their aversion profiles, and they interact in a repeated social dilemma game. In this game, agents are characterised by a social status so that the higher the agent's status, the higher her earnings. Cooperation is costly for a majority of agents at each period, but statuses can be reversed in future periods. We show that cooperation is strongly influenced by the group's aversion profile. Groups averse in both dimensions cooperate more than groups averse in only one dimension. Moreover cooperation seems to be more affected by risk aversion, whereas one might interpret cooperative behaviour as an inequality averse or altruistic attitude.

Classification Journal of Economic Literature: C92, D31,D63, D81.
Keywords: Risk aversion; Inequality aversion; Social preferences; Social dilemmas; Experimental economics.

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1. Introduction

In many economic situations, cooperative interactions come from the willingness of some individuals to undertake costly actions in order to achieve social objectives. For example most of the non-profit organizations would not exist without private donations, and some public goods would not be created in the absence of voluntary contributions. Although cooperation is generally efficient for society, it is effective only if individuals who enjoy a financially dominant position act in this way. Social cooperation is sometimes a legal measure imposed by a social choice, collectively approved. The main illustration concerns redistributive taxation schemes which finance, among others, health insurance and unemployment insurance national systems. The scheme structure is usually progressive so that high incomes are taxed proportionally more. Surprisingly, a large majority of citizens recognise the beneficial effects of such redistributive policies, even if advantages are given to a minority.

Thus the question of the motivations for social cooperation often arises. Why do some individuals in an advantageous position collaborate for social objectives by a voluntary and apparently unselfish behaviour, and why do they accept or even encourage redistributive policies? Obviously there is no immediate answer because many factors, sometimes conflicting, can influence decision-making and the weight of each factor depends on the context. In some cases, social cooperation is a purely altruistic attitude. Donations to charities or research associations for example might be placed in this category. By definition altruism consists in helping someone else without receiving benefits. But in most cases, individuals do get something out of unselfish acts, which makes motivations more ambiguous. For example when an individual encourages measures to promote equality, she can be motivated by altruism but also by a kind of risk aversion. A simple explanation is that a reduction of inequalities in society today ensures a diminution of potential risks in the future. First, small inequalities contribute to social cohesion, which is a necessary condition to preserve an advantageous position. Examples of countries where social conflicts, political instabilities and civil wars are correlated with inequalities are extremely large. Second, social positions are not fixed over time, and everyone can fall into poverty or disease. If wealth is equitably distributed in society and if health and unemployment insurance systems are generous, we are sure that the fall will be relatively cushioned. That is, a purely egoistic individual but risk averse and overpessimistic may take part in social programs.

Providing a better understanding of the individual's motivation in situations where risk aversion and inequality aversion can stimulate cooperative behaviour is the aim of this paper. We propose and test by an experiment a simple game which captures such a situation. In this game each agent is characterised by a social status, which represents her capacities to obtain high earnings: the higher the agent's status, the higher her earnings. With status as private information, each agent has to vote for one among two possible earnings distributions, and the majority vote applies. In the first distribution, called cooperative, earnings are more equally distributed and total earnings are greater. But in the second one, called defective, a majority of agents have greater personal earnings. Distributions are of common knowledge so that each agent knows her own potential earnings, depending on her status. That is, choosing cooperative distribution is socially efficient but costly for a majority of people, a situation which constitutes a social dilemma. The game is repeated a finite number of periods. At the end of each period, statuses are completely revised so that someone advantaged by her initial status can loose her privileges, and conversely. An experiment is run to observe the cooperation in this game. Since risk aversion and inequality aversion seem to be the more influential factors of cooperation, we elicit in the first part of the experiment subject's aversion profile. We take care not to confuse the two dimensions, so that inequality is controlled when risk is elicited, and vice versa. Subjects are then grouped by three according to their profile, under a partner matching protocol, and they participate in a twenty periods game. Our main objective is to observe levels and evolutions of cooperation, controlling aversion profile of each group. Intuitively, one may suppose that groups averse in both dimensions are more cooperative, with a reinforcement of the social cooperation across the periods. But the outcome is *a priori* ambiguous for groups averse in only one dimension, or non-averse in both of them.

This paper is organised as follows. We explicit in Section 2 the framework and our objectives, situating our contribution in the literature. We discuss how risk and inequality aversions are traditionally investigated and we specify what risk aversion and inequality aversion mean in our context. Relationships between these two dimensions are then clarified, and we mention some results of empirical works devoted to the influence of risk and inequality perceptions on social cooperation. We present in Section 3 our social dilemma game, which simplifies real economic situations described above. The experimental design is then exposed in Section 4. The strategy used for eliciting subjects' aversion profiles and the parametrization of the game are detailed. Results are proposed in Section 5. First, we present the aversion profiles and we check if aversion in one dimension is correlated with aversion in the other. Then we analyse levels and evolutions of cooperation for each type of group, using simple descriptive statistics and a dynamic probit model. Particular attention is paid to the first period of the game, because all periods but the first are influenced by the cooperation in previous periods. In the first period, a cooperative behaviour only depends on intrinsic characteristics of the subjects. Finally, we conclude by a discussion in Section 6.

2. Framework and related literature

Attitudes towards risk and inequality are two essential components in the – individual and collective – economic decision-making process. In the standard literature, an individual is risk-averse if she is unwilling to accept a risky gamble: she will prefer the expected payment of the gamble for sure to the gamble itself. Symmetrically, an individual exhibits inequality aversion when she is unsatisfied, other things equal, by an unequal income distribution: in her opinion, the social welfare will be maximised if the total income is shared equally among individuals. Literature on risk theory is mainly focused on the modeling of individual preferences faced with risky situations, with applications in insurance and finance. A large number of experimental studies investigated attitudes to risk in such a framework, reported particularly in an extensive survey by Harrison & Rutström (2008). The concept of inequality aversion is echoed in two distinct but closely associated literatures. The first one comes to a large extent from the philosophical theories of justice, their main purpose being the investigation of social choice issues in a normative perspective. Inequality aversion constitutes in this context one dimension of the social planner's ethical preferences, motivated by impartiality and fairness. Several experiments including Glesjer et al. (1977) or more recently Amiel et al. (1999) were run to quantify this aversion precisely. The second one is concerned with game theory, where inequality aversion is used to justify non-self-interested behaviours. Rabin (1993), Fehr & Schmidt (1999) and Bolton & Ockenfels (2000) are usually recognised as the starting-point of this literature. Nevertheless, while the concepts of risk aversion and inequality aversion have received substantial – theoretical and empirical – treatments, only few studies have investigated the link between these two dimensions. More precisely, only few studies have investigated preferences in environments where individuals are simultaneously confronted to risk and inequality.

The first paradox is that formal links between risk theory and inequality theory are well-established. It is well-known that original contributions started in the same period with the same theoretical framework, initiated by the papers of Rothschild & Stiglitz (1970) and Atkinson

(1970), respectively in the fields of risk theory and income inequality. [1] Lotteries (risk), and income distributions (inequality) are treated as random variables with probability densities. Whereas a probability is, in risk theory, a chance of winning particular earnings, it represents in inequality the proportion of individuals having one possible income. Consequently the main tool to compare such random variables is the stochastic dominance theory where, depending on the environment, the variability may be interpreted as risk or inequality. Aversion models consistent with the views captured by the dominance criteria are then proposed, like the so-called expected utility model. Again, depending on the environment, parameters of such models may capture the individual's risk aversion degree, or her aversion to inequality. Similarities between risk theory and inequality theory is emphasised by Rothschild & Stiglitz (1973).

The second paradox is that, as described in the introduction, it is difficult in many economic situations to identify which aversion is the driving force behind the decision-making process. This observation is especially true in interaction situations where a collective decision to reduce inequality implies for each member of the society a diminution of potential future risk (Fafchamps 2004). For example, redistribution policies are not only justified by altruism considerations, but also by the necessity to offer a mutual coverage system of social risks. As mentioned by Cowell & Schokkaert (2001) and Brennan et al. (2008), most of the normative theories explicitly use the insurance analogy to justify their principles of justice. Whereas redistributive policies are mostly imposed on individuals, there exists a lot of economic examples where cooperation – motivated by risk aversion and/or inequality aversion – results from a voluntary and free participation. Mutual-benefit societies, which propose insurance schemes based on a solidarity principle, or cooperative-type associations (for example agricultural or banking cooperatives) which promote the mutual interest of their members, are good illustrations.

Several empirical results tend to corroborate the influence of risk aversion on individual motivations to reduce inequality. For example Schokkaert et al. (2002) proposed a questionnaire study where Belgian respondents were asked their opinion on the unemployment insurance system. Respondents had previously been classified according to their altruism and their subjective perception concerning probability of becoming unemployed in the year to come, on the basis of two simple questions. The authors observe that both the degrees of altruism and income risk have a significant positive effect on the preferences for a more generous system. This influence is clearly confirmed by Ravallion & Lokshin (2000). At the question: "Do you agree or disagree that the government must restrict the income of the rich?", 73.6% of the 7000 Russian respondents opted for redistribution. But responses fluctuate, depending whether respondents expect (*i*) to get a better living standard in the future, (*ii*) to remain at the same level or (*iii*) to get a worse living standard. Whereas relatively rich respondents in groups (*i*) and (*ii*) are less inclined to choose redistribution, more than 80% of the respondents in the highest expenditure decile but in group (*iii*) agree with restriction. Equivalent observations come from the behavioral game theory. For example in the public good game, inequality aversion or altruism constitutes one hypothesis to justify voluntary contributions (see e.g. Palfrey & Prisbey (1996) and Masclet & Villeval (2008)). But Shogren (1987, 1990) showed that these contributions could be positively influenced by an increase of the risk, associated with level at which the good is provided. Consequently, the author argued that voluntary contributions can be explained by the traditional hypothesis on selfish rational behaviour in risky situations, without incorporating such notions as altruism.

Thus a first important question arises: is an individual risk averse automatically inequality averse and vice versa? Following the traditional theories on risk and inequality, there is no objective reason to consider that an individual averse in one dimension is not averse in the

[1] These papers were moreover published in the same issue of the same journal.

other: individual preferences models only differ in the description of the environment. This question has received substantial treatments, including Amiel et al. (2001), Amiel & Cowell (2002), Bosmans & Schokkaert (2004) or Carlsson et al. (2005). In these studies systematic differences between aversions are observed, which suggests that direct transpositions of the measurement tools between risk and inequality are too simplistic. Our first objective in this paper, related to the previous works, is to investigate possible interactions between risk aversion and inequality aversion. Our strategy slightly differs since we focus on social risks, in the sense that risks are commonly borne by society: an individual risk loving behaviour can endanger the situation of other persons. [2] Closer to our concern is the experimental study of Brennan et al. (2008) which analyses connections between other-regarding preferences and aversion to social risks (see also Güth et al. 2008).

In social dilemmas where cooperation, costly for a majority of agents, entails a reduction in inequality and a decrease in social risks, one may reasonably suppose that the agent's aversion profile over risk and inequality influences her motivations to cooperate. Controlling this aversion profile, our second and main objective is to evaluate and distinguish the driving forces which lead to cooperation. Subjects are grouped by homogeneous profiles and interact in a social dilemma game. We note that the investigation of group composition effects on the cooperation is the purpose of recent experiments. Related to our work, Teyssier (2008) showed that disadvantageous inequity aversion and risk aversion decrease the probability of choosing competition between workers in a performance payment scheme. In the public good game, Burlando & Guala (2005) and Gächter & Thöni (2005) showed that cooperation levels are significatively modified if the subjects are associated according to their cooperation profiles.

3. A risk/inequality social dilemma game

We first propose a simple game to capture a social dilemma situation as described above. An *agent* $i \in \mathcal{N} = \{1, 2, \ldots, n\}$ is characterised by a *social status* $s_i \in \mathcal{S} = \{1, 2, \ldots, s\}$. We assume that there exists less social statuses than agents ($s \leq n$) in society, so that two agents can have the same status. The vector of social statuses is denoted by $\boldsymbol{s} = (s_1, s_2, \ldots, s_n) \in \mathcal{S}^n$. Social status s_i represents agent i's rank in the earnings ordinal scale: the higher the agent's status, the greater her earnings. So *earnings* are a correspondence $x : \mathcal{S} \longrightarrow \mathcal{D}$, where $\mathcal{D}$ is a non-empty subset of $\mathbb{R}$, strictly increasing in social statuses such that $x(s_i) < x(s_j)$ for all $s_i < s_j$. Then an *earnings distribution* is a vector $\boldsymbol{x} = \big(x(s_1), x(s_2), \ldots, x(s_n)\big) \in \mathcal{D}^n$. The *mean earnings* of distribution $\boldsymbol{x} \in \mathcal{D}^n$ is defined by $\mu(\boldsymbol{x}) = \sum_{i=1}^{n} x(s_i)/n$.

Consider now that society is faced with two exogenous earnings distributions and has to choose one of them. For example society has the possibility to establish a redistributive scheme or to keep the status quo. Intuitively, two main dimensions will influence the choice, the mean earnings and the degree of inequality in each distribution. We need the following definition:

Definition 3.1 (Social Dominance) *Given two distributions $\boldsymbol{x}, \boldsymbol{y} \in \mathcal{D}^n$, we will say that $\boldsymbol{x}$ socially dominates $\boldsymbol{y}$, denoted by $\boldsymbol{x} \succeq_S \boldsymbol{y}$, if and only if $\mu(\boldsymbol{x}) \geq \mu(\boldsymbol{y})$ and $\boldsymbol{x}$ is more equally distributed than $\boldsymbol{y}$.* [3]

[2] Correlation between preferences over social risks and preferences over individual risks is evaluated by Harrison et al. (2005). Their results suggest no significative differences.

[3] We do not define what "more equally" means, since it requires debatable normative value judgments. For example the Gini index might be used. In our experiment there is no ambiguity because in the more equal distribution, all individuals have the same earnings.

Nevertheless, a redistributive scheme is generally costly for a majority of people. In the case of a poverty reduction policy, for example, a large majority of individuals contribute to helping a small number of people. In the model, the proportion of agents having higher earnings in $\boldsymbol{x}$ than in $\boldsymbol{y}$ is defined by:

$$\varphi(\boldsymbol{x},\boldsymbol{y}) = \#\{i \in \mathcal{N} \mid x(s_i) \geq y(s_i)\}/n\,, \tag{1}$$

where # denoted the cardinality of the set. If the social choice between the two distributions is democratic, one may argue that the value of $\varphi(\boldsymbol{x},\boldsymbol{y})$ will play a crucial role. We introduce the following criterion:

Definition 3.2 (Majority Dominance) *Given two distributions $\boldsymbol{x},\boldsymbol{y} \in \mathcal{D}^n$, we will say that $\boldsymbol{x}$ majority dominates $\boldsymbol{y}$, denoted by $\boldsymbol{x} \succeq_M \boldsymbol{y}$, if and only if $\varphi(\boldsymbol{x},\boldsymbol{y}) \geq 1/2$.*

Using definitions 3.1 and 3.2, we immediately observe that a social dilemma situation emerges if criteria lead to a contradiction:

Definition 3.3 (Social Dilemma) *Given two distributions $\boldsymbol{x},\boldsymbol{y} \in \mathcal{D}^n$, we will say that society faces a social dilemma with socially efficient distribution $\boldsymbol{x}$, denoted by $\boldsymbol{x} \rhd \boldsymbol{y}$, if and only if $\boldsymbol{x} \succeq_S \boldsymbol{y}$ and $\boldsymbol{y} \succeq_M \boldsymbol{x}$.*

In the following, we denote by $\boldsymbol{x}^c \in \mathcal{D}^n$ the *cooperative distribution* and by $\boldsymbol{x}^d \in \mathcal{D}^n$ the *defective distribution*, such that $\boldsymbol{x}^c \rhd \boldsymbol{x}^d$. Each agent has to vote for one of them, with her own social status – and consequently her potential earnings in each distribution – as private information. The *vote of agent i* is indicated by $v_i \in \mathcal{V} = \{0,1\}$, where $v_i = 0$ represents *defecting* and $v_i = 1$ *cooperating*. Then the *voting profile* is defined by $\boldsymbol{v} = (v_1, v_2, \ldots, v_n) \in \mathcal{V}^n$. The winning distribution is obtained by the majority rule, such that $\boldsymbol{x}^c$ defeats $\boldsymbol{x}^d$ if $\mu(\boldsymbol{v}) = \sum_{i=1}^n v_i/n \geq 1/2$. We denote by $I : \mathcal{V}^n \to \{0,1\}$ the *indicator function* defined by:

$$I(\boldsymbol{v}) = \begin{cases} 1\,, & \text{if} \quad \mu(\boldsymbol{v}) \geq 1/2\,, \\ 0\,, & \text{if} \quad \mu(\boldsymbol{v}) < 1/2\,. \end{cases}$$

We are now in position to define the *earnings of agent i* in a one-shot-game:

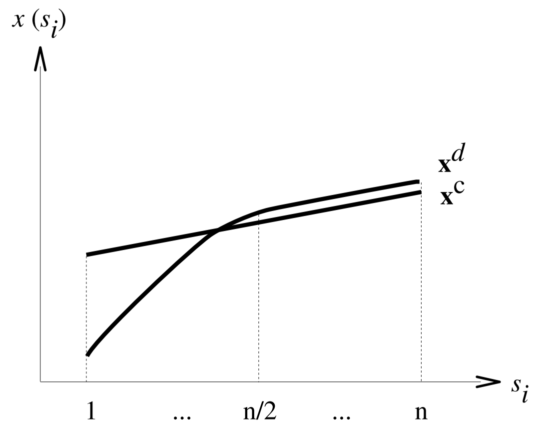
$$\pi_i(\boldsymbol{v}, s_i) = I(\boldsymbol{v})x^c(s_i) + \big[1 - I(\boldsymbol{v})\big]x^d(s_i)\,. \tag{2}$$

In the one-shot-game, a Nash agent simply votes for the distribution in which her own potential earnings are greater. If $\boldsymbol{x}^c \rhd \boldsymbol{x}^d$, a majority of agents have greater earnings in the defective distribution $\boldsymbol{x}^d$. Thus the pure-strategy Nash equilibrium is $\boldsymbol{x}^d$, the socially inefficient distribution.

A graphic representation can clarify this social dilemma context (see Figure 1). To simplify consider that $s = n$ with n an even number, and that $s_i = i$ for all $i \in \mathcal{N}$. Thus, agent 1 with social status $s_1 = 1$ is the poorest in this society, agent 2 with social status $s_2 = 2$ the second poorest, and so on until the richest agent n with social status $s_n = n$. In the graph points $\big(s_i, x(s_i)\big)$ are represented, such that all the adjacent points are joined by a straight line. By definition the curves are increasing, since earnings are increasing with social status. First, the mean earnings are represented by the area below the curve (deflated by n). One observes that this area is greater for $\boldsymbol{x}^c$, so that $\mu(\boldsymbol{x}^c) > \mu(\boldsymbol{x}^d)$. Inequality is then captured by the slope of the curve. The slope is everywhere greater for $\boldsymbol{x}^d$, which implies that:

$$x^c(s_i) - x^c(s_{i-1}) \leq x^d(s_i) - x^d(s_{i-1})\,, \quad \forall\, i = 2, 3, \ldots, n\,. \tag{3}$$

Figure 1: *Social Dilemma Illustration*



This result implies that there is less inequality in $\boldsymbol{x}^c$ than in $\boldsymbol{x}^d$, according to the *absolute differential quasi-ordering.* [4] This extremely demanding inequality criterion is consistent with all standard measures used in the literature, such as the Lorenz criterion. Thus $\boldsymbol{x}^c \succeq_S \boldsymbol{x}^d$. Finally, the intersection point of the curves is before $n/2$, which implies that $\varphi(\boldsymbol{x}^d, \boldsymbol{x}^c) > 1/2$, or equivalently $\boldsymbol{x}^d \succeq_M \boldsymbol{x}^c$. We conclude that $\boldsymbol{x}^c \rhd \boldsymbol{x}^d$.

This social dilemma, limited to one-shot, is not really interesting. A *cooperative behaviour* (the choice of $\boldsymbol{x}^c$) by agents in an advantageous position corresponds to a purely altruistic attitude. There exists in the literature most simple games to observe such a behaviour. Interesting features appear in a repetition of the game, distributions $\boldsymbol{x}^c$ and $\boldsymbol{x}^d$ remaining fixed, but with a possible revision of social statuses. In that sense, a favorable position in the social hierarchy – approximated by a hight social status – is not guarantee over time. For example any worker can loose her job, and fall into poverty. Suppose that there exists a finite number of periods $T \in \mathbb{N}$, indexed by t. The distribution of social statuses at period t is indicated by $\boldsymbol{s}^t = (s_1^t, s_2^t, \ldots, s_n^t) \in \mathcal{S}^n$. We suppose that social statuses are completely revised at each period, such that $\boldsymbol{s}^{t+1} = \Pi^t \boldsymbol{s}^t$ where Π^t is a random $(n \times n)$-permutation matrix. The *voting profile at period* t is denoted by $\boldsymbol{v}^t = (v_1^t, v_2^t, \ldots, v_n^t) \in \mathcal{V}^n$. At the end of the game, agent i is characterised by her *social status profile* over the T periods, that is by the vector $\boldsymbol{s}_i = (s_i^1, s_i^2, \ldots, s_i^T) \in \mathcal{S}^T$. Finally, the *overall voting profile* is defined by $\Phi = (\boldsymbol{v}^1, \boldsymbol{v}^2, \ldots, \boldsymbol{v}^T) \in \mathcal{V}^{n \times T}$. The *overall earnings of agent* i, over the T periods, becomes: [5]

$$\Pi_i(\Phi, \boldsymbol{s}_i) = \sum_{t=1}^{T} \pi_i(\boldsymbol{v}^t, s_i^t)\,. \tag{4}$$

If $\boldsymbol{x}^c$ and $\boldsymbol{x}^d$ remain fixed and $\boldsymbol{x}^c \rhd \boldsymbol{x}^d$, then there exists a unique – and socially inefficient – subgame perfect equilibrium, easily identifiable by backward induction: for each of the T periods, $\boldsymbol{x}^d$ defeats $\boldsymbol{x}^c$.

The strategic component in this model is the overall voting profile Φ, the other variables being exogenous. Contrary to the one-shot-game, a cooperative behaviour by an agent favorably treated through her status, is more difficult to interpret. On the one hand, cooperation in one period may be encouraged by inequality aversion or altruism. On the other hand, such a

[4] See Moyes (1994,1999) for a formal presentation of this inequality criterion.

[5] We implicitly assume that the discount rate is equal to unity.

behaviour may be considered as a self-insurance to cover potential future difficulties, by expecting a reciprocal behaviour. The aim of this paper is to observe experimentally levels and evolutions of cooperation, controlling explicitly for risk aversion and inequality aversion.

4. Experimental design

The experiment was run on a computer network in autumn 2007 at LAMETA-LEEM, University of Montpellier, France. 108 subjects randomly drawn from a pool of 1400 volunteers were recruited and divided into 6 sessions, with 18 subjects each. Participants were students and had never participated in an experiment dealing with inequality or risk aversion. The experiment was divided into three sub-experiments: the first two for eliciting respectively inequality aversion and risk aversion, and the third to implement the social dilemma game. At the beginning of each sub-experiment, a paper version of the instructions was distributed. After a silent reading of the instructions by the participants, an experimenter read them aloud. Participants then had to answer a short questionnaire in order to check their understanding. Subjects' answers were centralised in real time on the server computer, and in case of mistake(s) an experimenter proposed an individual and discreet explanation. An important feature of our design was that subjects were not informed about the outcomes of the first two sub-experiments – and consequently their effective earnings – before playing the social dilemma game. Our objective was to not affect the subjects' initial intentions to cooperate in this game, avoiding to provide information on behaviour of the others. On average, a session lasted 90 minutes including instructions, questionnaires and payment. Subjects were paid according to the total number of *Experimental Currency Units* (ECUs) earned during the experiment. The conversion rate of each sub-experiment was given in the instructions. The average payment by subject was about 25 euros.

4.1. Aversion profile elicitation

The first sub-experiment was devoted to the elicitation of inequality aversion. As rightly mentioned by Kroll & Davidovitz (2003), [6] most empirical studies which investigate inequality aversion do not control the risk dimension. Nevertheless, an inequality reduction diminishes the risk for future periods, particularly to new entrants in the society. For example if an individual has to compare two income distributions with the same mean but one with a lower variance, the choice of the last distribution may capture aversion to inequality and/or aversion to risk. With the objective to keep the risk constant in the elicitation of inequality aversion, we followed the procedure proposed by these authors. Subjects were individually faced with a distribution, [7] composed by three possible earnings with equal probability: $\boldsymbol{x} = (20, 40, 60)$. Each subject had to vote for one of the following alternatives:

Game 1 (Common Game CG) *All subjects sample the same earnings from one mutual gamble.*

Game 2 (Individual Game IG) *Each subject independently draws her own earnings.*

Immediately, we observe that the risk is exactly the same in both games: the subject had a one-third chance to obtain one of the three earnings. But the first game resulted in a perfect

[6] See also Davidovitz & Kroll (2004).

[7] The conversion rate was 1 ECU = 0.1 euros.

equality whereas the second presented an *ex ante* high probability of inequality. Consequently a subject who preferred the common game CG was considered as inequality averse. The game chosen by the majority applied to all participants. If votes were equally shared between games CG and IG, subjects were informed that the winning distribution would be randomly drawn by the server computer.

In the second sub-experiment we transposed the preceding procedure to elicit risk aversion, now controlling for inequality. Subjects were faced with the same earnings distribution $\boldsymbol{x} = (20, 40, 60)$, but the vote was between:

Game 3 (Safety Game SG) *All subjects obtain the expected earnings, namely 40 ECUs.*

Game 4 (Risky Game RG) *All subjects sample the same earnings from one mutual gamble.*

In both games there was perfect equality, since all subjects obtained the same earnings. But there was a risk in the game RG, which was not the case in the game SG. Thus a subject who preferred the game SG was considered as risk averse. Symmetrically, the distribution chosen by the majority applied to all participants, with a random drawn in the case of perfect equality between SG and RG. We note that the risky option entailed a risk borne by all subjects. Thus the subject's strategy provided information on her preferences over social – and not individual – risk. As we have stressed in section 2, a cooperative behaviour in the social dilemma game implies a simultaneous reduction of inequality and social risk. Thus, aversion to social risk is clearly what we want to evaluate here.

The attractiveness of the elicitation procedure chosen in this experiment is to give priority to simplicity – avoiding any bias due to misunderstanding such as indecision and error – with a clear distinction between (social) risk aversion and inequality aversion. But this approach is evidently questionable. First, in each dimension, a subject is binary classified as averse or non-averse. A standard approach consists in evaluating precisely the degree of aversion, supposing that the subject's preferences can be approximated by a particular preference functional such the expected utility model (well-known examples are Holt & Laury (2002) in risk theory and Amiel et al. (1999) in inequality measurement). An important issue deals with the interpretation of this functional: what is the real meaning of the concavity of the utility function? Unfortunately this concavity may capture different features of the preferences – with possible confusions between them – which may depart form risk and inequality aversions. Moreover there is no evidence that a distinction between aversion to risk and aversion to inequality is possible in such a framework. [8] Keeping in mind that our objective is to group subjects with similar risk and inequality aversions, a binary classification is interesting to restrict the number of profiles, under the condition that the preferences are correctly revealed. Second, aversion is captured from only one question. We specify that particular attention in the protocol was paid to ensuring and controlling the comprehension of the subjects. For each of the three sub-experiments, a comprehension questionnaire was proposed before the decisions. At the end of each of them, subjects had to justify by a written comment their choices and strategies. Inspection of these data revealed no comprehension difficulties.

4.2. Social dilemma implementation

The two first sub-experiments enabled us to separate subjects according two their aversion profiles. Four types were observed: subjects inequality and risk-averse, subjects averse in only one

[8] See Gajdos (2001) for a discussion.

dimension and finally subjects prone in both dimensions. Subjects with the same profile were then randomly grouped by three, following a partner matching protocol: groups were fixed for the whole game. The last subjects not affected to a group – because in number less than three with the same profile – were randomly grouped by three in groups called *mixed*. The subject was not informed that the members of her group had the same profile: instructions stated that groups were randomly constituted. Since each session consisted of 18 subjects, 6 groups were formed per session. In the following, we denote the different types of group – apart from mixed groups – as (A,A), (A,P), (P,A) and (P,P) with A for Averse and P for Prone, the first letter of the pair devoted to inequality. [9]

We parameterised the game in the simplest fashion. The game was repeated 20 periods and, at each period, the subject had to vote for one of the following distributions:

$$\boldsymbol{x}^c = (60, 60, 60) \qquad \text{or} \qquad \boldsymbol{x}^d = (10, 70, 70)\,.$$

The winning distribution was chosen by majority vote. Before the vote, each member of the group was randomly affected to one of the three possible ranks, namely A, B or C. Subjects were informed that their potential payoff was correlated to their own rank: 60 or 10 ECUs for rank A, 60 or 70 for rank B and 60 or 70 for rank C. [10] A screenshot is presented in Appendix A.5 (Figure 4). We note that (i) earnings were more equally distributed in the cooperative distribution $\boldsymbol{x}^c$ and (ii) the mean earnings were higher: $\mu(\boldsymbol{x}^c) = 60 \geq 50 = \mu(\boldsymbol{x}^d)$. Nevertheless two subjects out of three have a personal interest to vote for the defective distribution $\boldsymbol{x}^d$. Thus we implemented a social dilemma situation, with $\boldsymbol{x}^c \rhd \boldsymbol{x}^d$. At the beginning of each period, a redeployment of the ranks was randomly drawn. Consequently a subject in position B or C in one period may cooperate, expecting a kind of reciprocity if in a future period she falls to rank A. At the end of each period, subjects were informed about the majority vote in their group, their payoff for the period and their cumulative payoff since the first period. Moreover a history of the past periods was displayed (Figure 5 in Appendix A.5). History was available for consultation at every moment of the game.

5. Results

In this section, experimental results are described. In a first sub-section we expose the subjects' aversion profiles, and we compare the risk and inequality dimensions. The following sub-section is devoted to a description of the cooperation in the first period of the game, and the last sub-section focuses on the dynamics of cooperation over the 20 periods.

5.1. Risk aversion vs. inequality aversion

The first question asked in this experiment deals with the connections between risk aversion and inequality aversion. We report in Table 1 the results of the first two sub-experiments, in which individual aversion profiles are elicited. When we observe the marginal column and row frequencies, we note that a majority of subjects exhibit risk aversion (58.33%) whereas the tendency is inverted for inequality aversion (44.45%). This last result does not corroborate the

[9] We specify that mixed groups can not be interpreted as a benchmark, because we do not control the composition process of these groups. Moreover in this experiment, it appears that players with profile (A,A) are predominantly represented in mixed groups.

[10] The conversion rate was in this last sub-experiment 1 ECU = 0.01 euros. We specify that each period of the game implied effective earnings.

Table 1: *Individual aversion profiles*

	Risk		
Inequality	Prone	Averse	$\sum$
Prone	25.00% (27 subjects)	30.55% (33 subjects)	55.55% (60 subjects)
Averse	16.67% (18 subjects)	27.78% (30 subjects)	44.45% (48 subjects)
$\sum$	41.67% (45 subjects)	58.33% (63 subjects)	100% (108 subjects)

one obtained by Kroll & Davidovitz (2003) in a comparable treatment, where 54.12% of the subjects – 8 years old children – were inequality-averse. Then, the Table shows that aversion in one dimension does not seem to influence aversion in the other dimension. Distribution in each row (resp. column) is consistent with the distribution of the marginal row (resp. column). A Spearman correlation test confirms this hypothesis ($\rho = 0.076$, p-value = 0.437):

Result 1 *Inequality aversion and risk aversion are not correlated.*

We also notice that no dominant profile emerges, but that only few subjects are simultaneously inequality-averse and risk-prone (16.67%). Independence between the two kind of aversion appears to be unsurprising, with regard to related works in the literature. Empirical results reported by Cowell & Schokkaert (2001) suggested systematic differences between inequality and risk perceptions. Brennan et al. (2008), who investigated other-regarding concerns and aversion over social risk, led to similar observations.

In the third part of the experiment, subjects were grouped by three according to their aversion profiles. Table 2 displays the distribution of the 36 groups. Note that in each session, mixed groups were composed only if there was not a sufficient number of subjects with the same aversion profile. Profile (A,P) – inequality-averse and risk-prone – was the least frequently observed, only represented by 4 groups.

Table 2: *Groups repartition*

	Risk	
Inequality	Prone	Averse
Prone	22.22% (8 groups)	25.00% (9 groups)
Averse	11.11% (4 groups)	25.00% (9 groups)

Notes. Mixed groups represent 16.67% (6 groups).

5.2. First period of the social dilemma game

Now we focus on the cooperation in the game, exclusively at the first period. Particular attention has to be paid to the first period because no history of cooperation within the group may disturb the initial motivations of cooperation. [11] We can consider that, at this stage, only the subject's intrinsic preferences can determinate her cooperation decision. The context is modified at the end of this period because the majority vote is publicly announced in the group. Thus, other dimensions such as frustration or reciprocity may affect the motivations of cooperation in the rest of the game.

Average cooperation levels, according to the groups' aversion profiles, are presented in Table 3. A distinction is made for the majority vote in each group, for the vote of subjects in rank A and the vote of subjects in rank B & C. In groups where subjects are averse in both dimensions, more

Table 3: *Average cooperation rates for the first period*

Profile	Majority vote	Rank A	Ranks B & C
(A, A)	77.78%	100.00%	55.56%
(A, P)	50.00%	75.00%	37.50%
(P, A)	66.67%	100.00%	33.33%
(P, P)	50.00%	100.00%	43.75%
Mixed	66.67%	100.00%	41.67%
Average	62.22%	95.00%	42.36%
$\chi^2(4)$	9.326	5.263	6.649
p-value	0.053	0.261	0.156

Notes. For example, (A,P) signifies inequality-averse and risk-prone.

than three-quarters of the majority votes are in favor of the cooperative distribution. This is significantly more than groups where subjects are risk-prone ((A, A) vs. (A, P) and (A, A) vs.(P, P), χ^2 p-value = 0.014 in both cases), but not significantly different compared to the profile (P, A) where two-thirds of the majority votes lead to cooperation (χ^2 p-value = 0.355). Between the profile (P, A) and profiles (A, P) and (P, P), the average cooperation rate does not differ significantly (χ^2 p-value = 0.123), even if the cooperative distribution is chosen only by half of the groups (A, P) and (P, P). Now a distinction by the subject's rank is informative. Whereas there is no objective reason to defect for subjects in rank A, [12] cooperation is costly for subjects ranked B or C. Unsurprisingly the highest cooperation rate is observed for groups averse in both dimensions, up to 55%. This is significantly more than for groups (A, P) and (P, A) (χ^2 p-value = 0.061 and 0.018 respectively), but not significantly higher than the cooperation observed in profile (P, P) (χ^2 p-value = 0.236). As for the majority vote, the average cooperation rate does not differ significantly between the profile (P, P) and profiles (A, P) and (P, A) (χ^2 p-value = 0.488 and 0.235 respectively). A brief overview of these preliminary results shows that aversion in both dimensions leads to the highest cooperation.

In order to corroborate the impact of risk and inequality aversions on cooperation at the first period, we estimate the following *binary probit specification* ($i = 1, ..., N$):

$$P(q_i = 1|\boldsymbol{w}_i) = \Phi(\boldsymbol{w}_i'\boldsymbol{\theta}) \,, \tag{5}$$

where Φ is the cumulative standard normal distribution and q_i denotes the observed choice of player i ($q_i = 0$ if i chooses $\boldsymbol{x}^d$, $q_i = 1$ if i chooses $\boldsymbol{x}^c$). Variables included in the vector $\boldsymbol{w}_i$ are

[11] We also recall that the subjects were not informed about the outcomes of the first two sub-experiments before playing the social dilemma game. So before playing the first period, a subject had never observed the behaviours of her partners.

[12] Cooperation rates in rank A are closed to 100%. We note that 4 groups (A,P) are observed, thus only one subject over the 36 ranked A did not cooperate.

the position of player i in the game (=0 if her rank is A, =1 if B or C) and dummies for her inequality aversion and risk aversion (=0 if prone, =1 if averse). The model does not contain the intercept as we assume that individual behaviour is well balanced, i.e. probabilities of choosing $\boldsymbol{x}^c$ and $\boldsymbol{x}^d$ are equal to 0.5 when individual characteristics are absent.[13]

Estimation results of the probit specification are reported in Table 4.[14] We observe that all explanatory variables are significant at the 5% level. It is useful to interpret the results in terms of marginal effects on the probability of cooperation $P(q_i = 1|\boldsymbol{w}_i)$.[15] All computed marginal effects are also statistically significant, with the expected sign. Change in position of player i,

Table 4: *Probit estimation for the first period*

Variable	Coefficient		Marginal effect	
	Estimate	Std. Err.	Estimate	Std. Err.
Position	-0.768**	0.223	-0.293**	0.082
Inequality aversion	0.579**	0.235	0.226**	0.088
Risk aversion	0.577**	0.208	0.227**	0.079
Log-likelihood	-65.585			
Number of observations	108			

Notes. ** indicates significant values at the 5% level.

from position A to B or C, has a negative effect on the probability of cooperation (up to 30%). This observation seems natural since cooperation is costly for the subject when she is ranked B or C. But surprisingly, we observe that marginal effects of aversion variables are comparable (23%). This result clearly highlights the impact of both inequality and risk aversions on the probability of cooperation. Finally, the effects of inequality and risk aversions are very close (about 0.58). The equality between these coefficients is not rejected by a Wald test ($\chi^2(1)$ statistic = 0.00 and p-value = 0.99).

Result 2 *Inequality aversion and risk aversion have a significant impact on cooperation.*

The above analysis underlines the role of inequality and risk aversions in the cooperation decision of subjects, in the first period of the social dilemma game. Moreover, inequality-prone and risk-averse (P,A) groups seem to be more cooperative than inequality-averse and risk-prone (A,P) groups – even if differences of cooperation appear not to be significant. This observation will be corroborated by the study of the whole game.

5.3. Dynamics of the social dilemma game

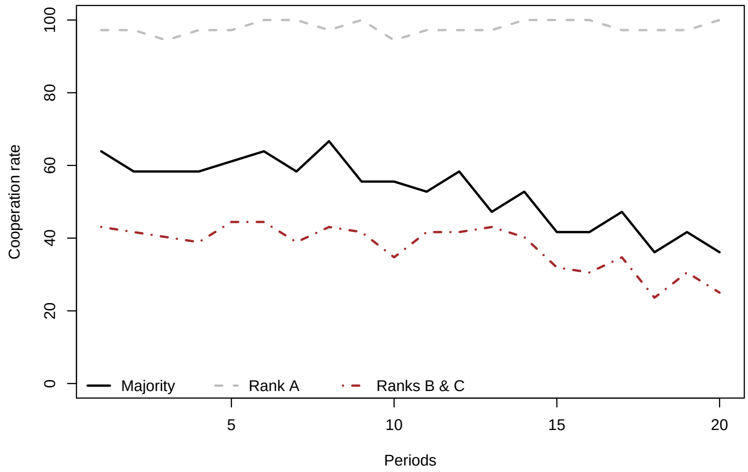
We start by a description of the evolution of choice for the cooperative distribution $\boldsymbol{x}^c$, as depicted in Figure 2. Again we distinguish the majority vote, the vote of subjects in rank A and the vote of subjects in ranks B & C. Unsurprisingly subjects in rank A select almost all the time the cooperative distribution. For the majority vote the average cooperation is around 50%, with a decrease over time. This decrease is significant if we compare the average in the first ten periods

[13] When $\theta = 0$, we get $P(q_i = 1|\boldsymbol{w}_i) = P(q_i = 0|\boldsymbol{w}_i) = \Phi(0) = 0.5$.

[14] Results remain similar for the logit specification, in particular the signs of coefficients.

[15] The marginal effect of a dummy variable is calculated as the discrete change of the probability of cooperation when the dummy variable changes from 0 to 1.

Figure 2: *Evolution of the average cooperation rate*



to the average in the last ten periods (Wilcoxon one-sided p-value = < 0.001). For ranks B & C the average cooperation is around 40% with also a significant decrease between periods 1-10 and periods 11-20 (Wilcoxon one-sided p-value = 0.015).

Result 3 *Average cooperation rate is decreasing over the time.*

Such cooperation evolution is a classical result for repeated social dilemma games (see Ledyard 1995). We also graphically observe a low variability of the cooperation around the decreasing linear trend.

The evolution of the cooperation rates reveals more interesting features if we split groups by aversion profiles, as presented by Figure 3 in Appendix A.5. Whatever the profile, there is a significant decrease in cooperation for the majority vote between periods 1-10 and periods 11-20. [16] This decrease seems to be stronger for profiles where subjects are averse in one dimension and prone in the other (namely (A, P) and (P, A)), especially after the tenth period. For profile (P,A) the average cooperation concerning the majority vote falls from 66.67% to 33.33% and for profile (A,P) it falls from 50% to 0%. In the profiles (A,A) and (P,P), the average cooperation falls respectively from 77.78% to 44.44% and from 50% to 37.5%. This pattern applies also to ranks B & C: the decrease between the two phases is significant for all profiles, except for the profile (P,P). [17] Another interesting feature of the evolution is related to the variability. In groups where the subjects' profiles are either (A, A) or (P, P) the variance of decisions is significantly lower compared to groups where the subjects' profiles are either (A, P) or (P, A). This holds true both for the majority vote and for ranks B & C. [18] To sum up, we observe that:

Result 4 *Aversion or non-aversion in both dimensions leads to:*

[16] Wicoxon one-sided, (A, A) p-value = 0.007, (A, P) p-value = 0.013, (P, A) p-value < 0.001 and (P, P) p-value = 0.033

[17] Wilcoxon one-sided, (A, A) p-value = 0.039, (A, P) p-value = 0.025, (P, A) p-value = 0.019 and (P, P) p-value = 0.239

[18] Majority vote: (A, A) vs (A, P) p-value < 0.001, (A, A) vs (P, A) p-value = 0.070, (P, P) vs (A, P) p-value < 0.001, (P, P) vs (P, A) p-value = 0.098 whereas (A, A) vs (P, P) p-value = 0.424. Ranks B & C: (A, A) vs (A, P) p-value < 0.001, (A, A) vs (P, A) p-value = 0.011, (P, P) vs (A, P) p-value = 0.005, (P, P) vs (P, A) p-value = 0.057 whereas (A, A) vs (P, P) p-value = 0.230.

(i) a lower decrease in the cooperation,

(ii) a lower variability of the cooperation around the decreasing trend.

Since cooperation in one period highly influences cooperation in future periods, it seems natural that decrease and variability are correlated. It clearly appears that non-aversion in one dimension generates a noise which leads to an unstable cooperation.

Table 5 reports the average cooperation by aversion profile over the 20 periods for the majority vote, the vote of subjects in rank A and the vote of subjects in rank B & C. Almost two-thirds of majority votes in the profile (A,A) are in favor of the cooperative distribution. This is significantly more than in the two profiles where subjects are risk-prone (Mann Whitney one-sided [19] (A, A) vs. (A, P) p-value < 0.001 and (A, A) vs. (P, P) p-value < 0.001), but not significantly different from the last profile where subjects are risk-averse (MW, (A, A) vs. (P, A) p-value $= 0.164$). Profile (P,A) cooperates also significantly more than both risk-prone profiles (MW, (P, A) vs. (A, P) p-value < 0.001 and (P, A) vs. (P, P) p-value $= 0.060$). Most of these observations also hold for the average cooperation rates in ranks B & C, except that the rate in profile (A, A) is now significantly higher than in profile (P, A) (MW p-value < 0.001).

Table 5: *Average cooperation rates over the 20 periods*

Profile	Majority vote	Rank A	Ranks B & C
(A, A)	61.11%	97.22%	48.33%
(A, P)	28.75%	97.50%	17.50%
(P, A)	55.56%	100.00%	34.72%
(P, P)	50.63%	95.00%	38.75%
Mixed	55.00%	100.00%	38.33%
Average	50.21%	97.94%	35.53%
$\chi^2(4)$	12.569	0.182	14.296
p-value	0.014	0.996	0.006

Notes. For example, (A,P) signifies inequality-averse and risk-prone.

Before interpreting these results we complete the analysis by the estimation of a probit model, which seems appropriate to our panel data framework. For $i = 1, ..., N$ and $t = 2, ..., T$, we have:

$$P(q_{it} = 1 | q_{i1}, \dots, q_{i,t-1}, \boldsymbol{w}_{it}, c_i) = \Phi(\rho q_{i,t-1} + \boldsymbol{w}'_{it}\boldsymbol{\theta} + c_i) \,, \qquad (6)$$

where c_i, $i = 1, ..., N$, represent individual random effects.[20] As in the analysis for the first period, we think that the current position of player i may affect her current choice. Moreover, as player i observes past decisions of the group to which she belongs, we also think that the majority decision at the previous period of her group may have an impact on her current choice. We can also analyse the persistent behaviour in the decision process by including past value of individual choice $q_{i,t-1}$. The set of explanatory variables contains then the first lag of the dependent variable $q_{i,t-1}$ and time-variant covariates $\boldsymbol{w}_{it}$ (including position of player i at period t, majority choice of the player i's group at period $t-1$, and a time trend).

Model (6) constitutes a *dynamic probit model with random effects* of which Wooldridge (2005) proposed a simple estimation method, by specifying an additional assumption on the distribution

[19] Thereafter MW.

[20] As it is recognised in econometric textbooks, it is cumbersome to consider probit model with fixed effects.

of individual effects. The latter can be written in terms of our variables as follows ($i = 1, ..., N$):

$$c_i = \alpha_1 q_{i1} + \boldsymbol{z}_i' \boldsymbol{\alpha}_2 + \zeta_i, \quad \zeta_i \sim N(0, \sigma_\zeta^2)\,. \tag{7}$$

The distribution of individual effects is then related to the initial observation q_{i1} and the set of time-invariant covariates $\boldsymbol{z}_i$ (which includes player i's inequality and risk aversions).[21] Following Wooldridge (2005), by substituting (7) in (6), we obtain the following equation ($i = 1, ..., N$, $t = 2, ..., T$):

$$P(q_{it} = 1 | q_{i1}, \ldots, q_{i,t-1}, \boldsymbol{w}_{it}, c_i) = \Phi(\rho q_{i,t-1} + \boldsymbol{w}_{it}' \boldsymbol{\theta} + \alpha_1 q_{i1} + \boldsymbol{z}_i' \boldsymbol{\alpha}_2 + \zeta_i)\,, \tag{8}$$

which corresponds to the usual random effect probit model where ζ_i now represents the standard individual random effect and the new set of explanatory variables corresponds to $q_{i,t-1}$, $\boldsymbol{w}_{it}$, q_{i1}, $\boldsymbol{z}_i$.

Estimation results of the model are reported in Table 6. The random effect model is not rejected by the specification likelihood-ratio test. We can be therefore confident about interpretations drawn from this model. As in the previous analysis, the player's position negatively

Table 6: *Dynamic probit estimation for the whole game*

	Coefficient		Marginal effect	
Variable	Estimate	Std. Err.	Estimate	Std. Err.
Past decision	0.449**	0.131	0.164**	0.049
Position	-3.991**	0.191	-0.812**	0.045
Past majority choice	0.632**	0.160	0.228**	0.058
Initial choice	2.745**	0.350	0.826**	0.055
Inequality aversion	0.658*	0.337	0.231**	0.111
Risk aversion	1.395**	0.325	0.492**	0.098
Time trend	-0.026**	0.010	-0.009**	0.004
σ_ζ	1.693	0.184		
Log-likelihood	-489.219			
Number of individuals	108			
Number of periods	19			
Number of observations	2052			
LR test for random effects	282.36**			

Notes. * and ** indicate significant values at the 10% and 5% levels, respectively.

influences the probability of cooperation. Moreover, the signs of position, inequality aversion and risk aversion remain unchanged compared to results obtained only for the first period of the game. The marginal effect of inequality aversion on the cooperation probability is lower than that of risk aversion. We perform the Wald test proposed by Kodde & Palm (1986) for the strict inequality between the two coefficients (i.e. H_0: $\alpha_2^{\text{ineq.}} < \alpha_2^{\text{risk}}$). The test statistic is equal to 0.00, implying that we do not reject the null at the 5% level.[22] If one connects these estimation results with the initial descriptive statistics, one may argue that risk aversion impacts significatively more the dynamic of cooperation than inequality aversion.

[21] We do not use any time-invariant covariate in $\boldsymbol{w}_{it}$ in equation (6) as their coefficients cannot be identified with those of $\boldsymbol{z}_i$ in (7). It should be noted that dummies of sessions, periods, and groups are not included in our model because they create a multicolinearity problem.

[22] Kodde & Palm (1986) provided the upper and lower bounds for the test. The null hypothesis is rejected if the computed statistic exceeds the upper bound value, and is not rejected if the statistic is smaller than the lower bound value. The test is inconclusive for values in between the two bounds. In our case, the lower and upper bounds (the degree of freedom of our test is 1) at the 5% level coincide and are equal to 2.706.

Concerning additional variables (with respect to the first-period analysis), we find that past individual decision positively influences the probability of current cooperation. The choice of group majority at the previous period and the initial individual choice (or choice at the first period) have positive effects on the cooperation probability. Finally, the cooperation slowly diminishes during the game as the marginal effect of the time trend is statistically negative but small (its marginal effect is -0.009). This last observation confirms previous results dealing with the decreasing trend of the cooperation. Thus, the main results of our experimental study are summarised by:

Result 5 *Aversion profile has an impact on cooperation:*

(i) Aversion in both dimensions leads to the highest average cooperation rate.

(ii) Aversion in only one dimension is not sufficient to ensure cooperation.

(iii) Risk aversion has a greater impact than inequality aversion on the dynamics of cooperation.

The first point (*i*) is in line with initial intuition. The game is orientated in such a way that aversion might encourage cooperation, which is corroborated by the experiment. But other information emerges. First we observe that non-aversion in one-dimension leads to a decrease in cooperation. But surprisingly, inequality aversion does not seem to maintain cooperation. Whereas the decrease is not significant from (A,A) to (P,A), the cooperation falls dramatically from (A,A) to (A,P). Second, cooperation for groups (P,P) is relatively higher. On average, this aversion profile cooperates more than profile (A,P). It is important to recall that the expected payment of the cooperative distribution is higher than the defective one. Then a perfect maximizer subject might be inclined to choose cooperation, without social motivations or risk considerations. So there is nothing irrational in obtaining a relatively high level of cooperation for groups (P,P). The cooperation level for groups (A,P) is however really surprising. Many factors can cause such an evolution. Particularly, one does not confuse inequality aversion and altruism. Whereas an altruistic individual is not satisfied if poor people exists, an individual averse to inequality will suffer if some people are better treated than him, without objective reasons. [23] Thus, if in one period an individual in position A remarks that other members of her group do not cooperate, a frustration felling will probably corrupt her cooperative intentions in the future. Even more, she will want to punish them. Such a behaviour is in line with theories of impure or conditional altruism, for example the one developed by Rabin (1993). Since non aversion in one dimension leads to higher variability in cooperation (result 4), combination of such feelings may rapidly damage the social harmony and, as a consequence, cooperation.

6. Overview and discussion

In this paper, we have proposed and tested experimentally a game where social cooperation may be encouraged, simultaneously by inequality and risk aversion. Such situations are widely observed in any human society, as soon as social cooperation for a reduction of inequality today leads to a diminution of potential social risk in the future. A really evocative example is captured by mutual benefit societies, where the aim of cooperation is to provide a mutual insurance coverage following a solidarity rule. Our social dilemma game describes a situation where individuals are *ex ante* unequal in social statuses. Social statuses include all the factors justifying differences in income such as for example health, intelligence, financial inheritance or country

[23] See Fehr & Schmidt (1999) for a distinction between advantageous and disadvantageous inequality.

of birth. Individuals can then cooperate to establish a redistributive scheme. This scheme is costly for a majority of people, but socially efficient in the sense that earnings would be more equally distributed and total earnings greater. The final decision is obtained by a vote, so that redistribution becomes effective if a majority acts in this way. But statuses are not fixed over time, or in other words advantageous positions are not guarantee in the future. Consequently, inequality averse and/or risk averse individuals may be inclined to cooperate. A finite number of periods is repeated to duplicate the social dilemma situation, with at each period a random redeployment of social statuses and the perspective to become richer or poorer.

Before participating in the 20 periods repeated game, the aversion profile of each subject is elicited. Inequality aversion is obtained using the procedure proposed by Kroll & Davidovitz (2003), which we have transposed for risk aversion. Our objective is to clearly distinguish the two dimensions, taking care to avoid possible confusions. For inequality elicitation risk is kept constant, and vice versa. Related works in the literature tend to demonstrate that perceptions on inequality and perceptions on risk display significant differences. The experiment proposed here corroborates these views: we observe that aversions are not correlated. Whereas a majority of subjects exhibit aversion to risk, slightly more than 50% are not inequality averse. Moreover, no dominant profile emerges. Subjects combining inequality aversion with non aversion in social risks are less represented, in comparison with other profiles represented in relatively comparable proportions.

Cooperation in the game is then analysed. We recall that subjects are grouped by three according to their aversion profiles. The average cooperation rate, over the 20 periods and for all the groups, is around 50%. The dynamics of cooperation is in line with standard results in the experimental literature on repeated social dilemma games, with a slightly decreasing trend. But evolution and level of cooperation are significatively influenced by the group's aversion profile. First, aversion or non-aversion in both dimensions leads to a lower decrease and a weaker variability over time. Thus non-aversion in only one dimension seems to create a noise which makes cooperation unstable. Then, in line with our initial intuition, aversion in both dimensions leads to the highest average cooperation rate. Groups averse in only one dimension are less cooperative. Nevertheless consequences are not symmetrically related. Whereas cooperation of non-inequality-averse but risk-averse groups is not significatively different from averse/averse groups, cooperation of non-risk-averse but inequality-averse groups falls dramatically to zero at the last periods. Cooperation for non-averse/non-averse groups is significatively lower than the first two groups, but not to the third.

In a situation where an inequality reduction implies a decrease in social risks, our experimental results suggest that aversion profile has a significant effect on the outcome and the robustness of cooperation. Moreover, it appears that the main driving-force which supports cooperation seems to be risk aversion. Individuals are aware that advantageous positions may be reversed in the future, so they act today to improve the situation of individuals treated less favorably than them. This observation must however be exploited cautiously. An over-interpretation might be to consider that inequality aversion plays a marginal role, so that any cooperative act in order to reduce inequality constitutes a kind of self-insurance. Inequality aversion is in fact a really complex cognitive process which depends on the environment. Initially such an aversion may encourage fairness attitudes, such as cooperation in our game. But if inequality averse individuals are not satisfied with the existence of underprivileged persons, they will also not be pleased if persons better treated than them do not act to improve their own situation. That is, if they notice a cooperation failure when they are underprivileged themselves, a desire for punishment might rule their behaviour in the future. In our opinion, the main conclusion of this paper is twofold. First, it seems imperative to take into account the risk dimension to clearly understand the social motivations to reduce inequality. Second, whereas inequality aversion may favor social cooperation, the existence of "free riders" may damage dramatically the initial cooperative motivations, leading to a punishment behaviour costly for the whole society.

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A. Appendix

A.1. General instructions

(*translated from the french*) You are going to participate in an experiment designed for studying decision process. We ask you to read carefully the whole instructions. These instructions are simple and should help you to understand the experiment. When all participants have read these instructions an experimenter will read it again.

Decisions you will take are anonymously collected by the computer-network.

Your earnings will depend on your own decisions as well as on the decisions taken by the other participants. The monetary unit used in the experiment is the ECU. The conversion rate of the ECUs into EUROs will be specified at the end of these instructions. The total amount of ECUs earned during the experiment will be given to you in cash at the end of the experiment.

The experiment does not contain "good" or "bad" decisions. Every decision may have its own justification.

We ask you not to communicate with the other participants during the experiment. It is a necessary condition for the success of the experiment.

A.2. Instructions dealing with the elicitation of inequality aversion

(*translated from the french*) We are going to describe two games you may participate in. You will have to vote for one of them. Every participant in this room will face the same vote. Only the game having obtained the majority of votes will apply. If there is a perfect equality between the votes for both games, a random draw made by the central computer will determine the game that will apply.

The two games :

Game #
In this game every participant can receive one of the three following earnings: **20 ecus, 40 ecus or 60 ecus**. The central computer makes **one random draw for each participant in this room**. Thus each participant receives her own earnings with respect to the random drawn applying to her.

Game §
In this game each participant can receive one of the three following earnings: **20 ecus, 40 ecus or 60 ecus**. The central computer makes **only one random draw applying for every participant**. Thus each participant receives the same earnings with respect to the unique random draw applying to everyone.

The conversion rate is as follow: 10 ECUs = 1 EURO.

Before the start of the experiment you will have to complete a short questionnaire, in order to check your understanding of the instructions. When every participant has completed the questionnaire, you will have to vote.

A.3. Instructions dealing with the elicitation of risk aversion

(*translated from the french*) We are going to describe two games you may participate in. You will have to vote for one of them. Every participant in this room will face the same vote. Only the game having obtained the majority of votes will apply. If there is a perfect equality between the votes for both games, a random draw made by the central computer will determine the game that will apply.

The two games :

Game #
In this game **every participant receive 40 ecus**.

Game §
In this game each participant can receive one of the three following earnings: **20 ecus, 40 ecus or 60 ecus**. The central computer makes **only one random draw applying for every participant**. Thus each participant receives the same earnings.

The conversion rate is as follow: 10 ecus = 1 euro.

Before the start of the experiment you will have to complete a short questionnaire in order to check your understanding of the instructions. When every participant has completed the questionnaire, you will have to vote.

A.4. Instructions dealing with the social dilemma game

(*translated from the french*) In this experiment all the participants in the room are divided into groups of three. Groups are formed randomly, and will stay fixed for the whole experiment. You can not identify the other members of your group, and the other members of your group can not identify you.

This experiment consists into a repetition of 20 periods. At each period, you will have to vote for one of two earnings distributions. These distributions will remain the same for all the periods. In each period the distribution having the majority vote in your group will apply for the period, and for your group.

At the start of each period a random draw will place each of the three group members in one of the three following position: A, B or C. You will be informed of your position for the period before your vote. Figure 4 is an example of the decision screen.

After the vote of each member of your group, a summary of the period will be displayed, with the following information: your position for the period, your vote, the majority vote in your group and your earnings for the period. Also, you will have information about the past periods. You can consult this history at any moment by clicking on the button "history". Figure 5 is an example of the history screen.

The two earnings distributions:

Distribution #
In this distribution, earnings with respect to the position in the group are the following:

Position	A	B	C
Gain (ecus)	**10**	**70**	**70**

Distribution §
In this distribution, earnings with respect to the position in the group are the following:

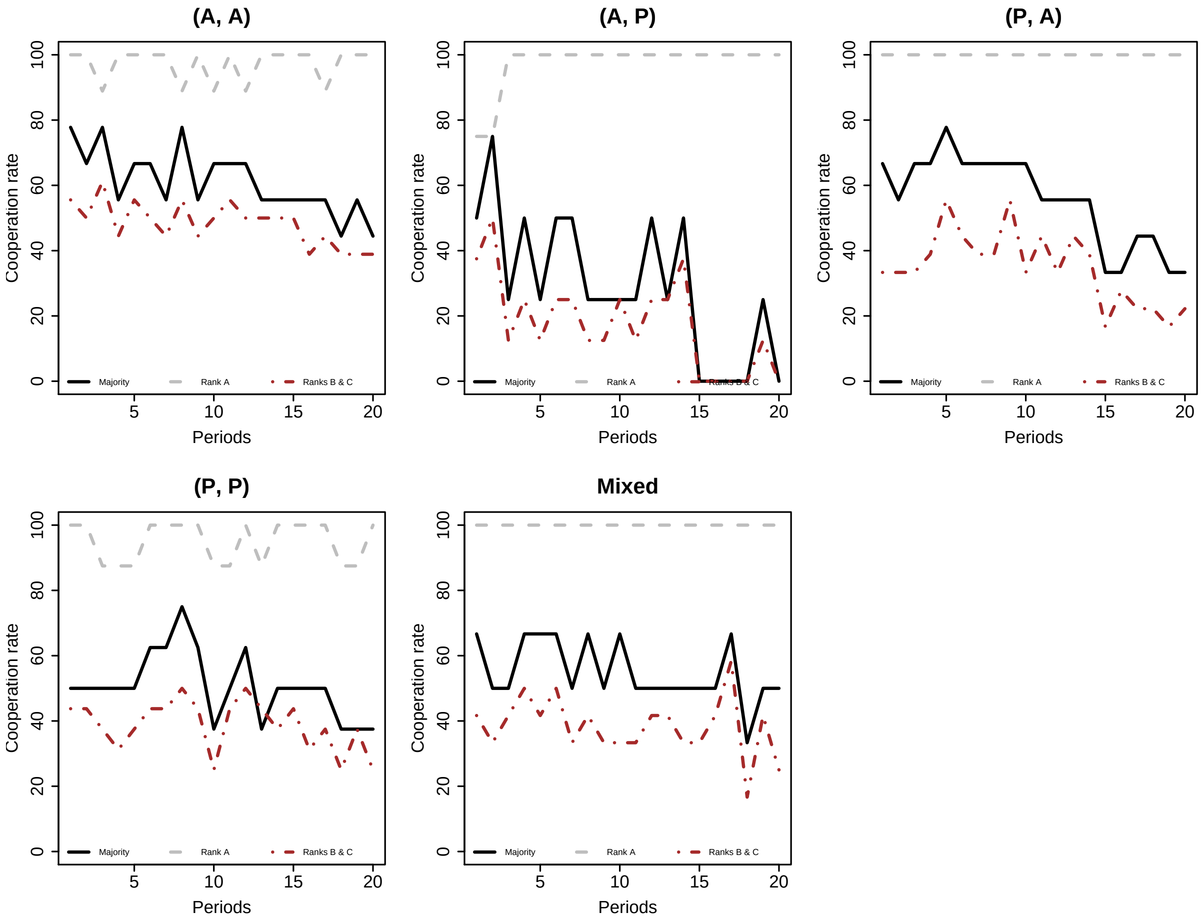
Position	A	B	C
Gain (ecus)	**60**	**60**	**60**

The conversion rate is the following: 100 ecus = 1 euro.

Before the start of the experiment you will have to complete a short questionnaire, in order to check your understanding of the instructions. When every participant has completed the questionnaire, the first period will begin.

A.5. Figures

Figure 3: *Evolution of the average cooperation rate by aversion profile*



Notes. For example, (A,P) signifies inequality-averse and risk-prone.

Figure 4: *Screenshot of decision in the game*

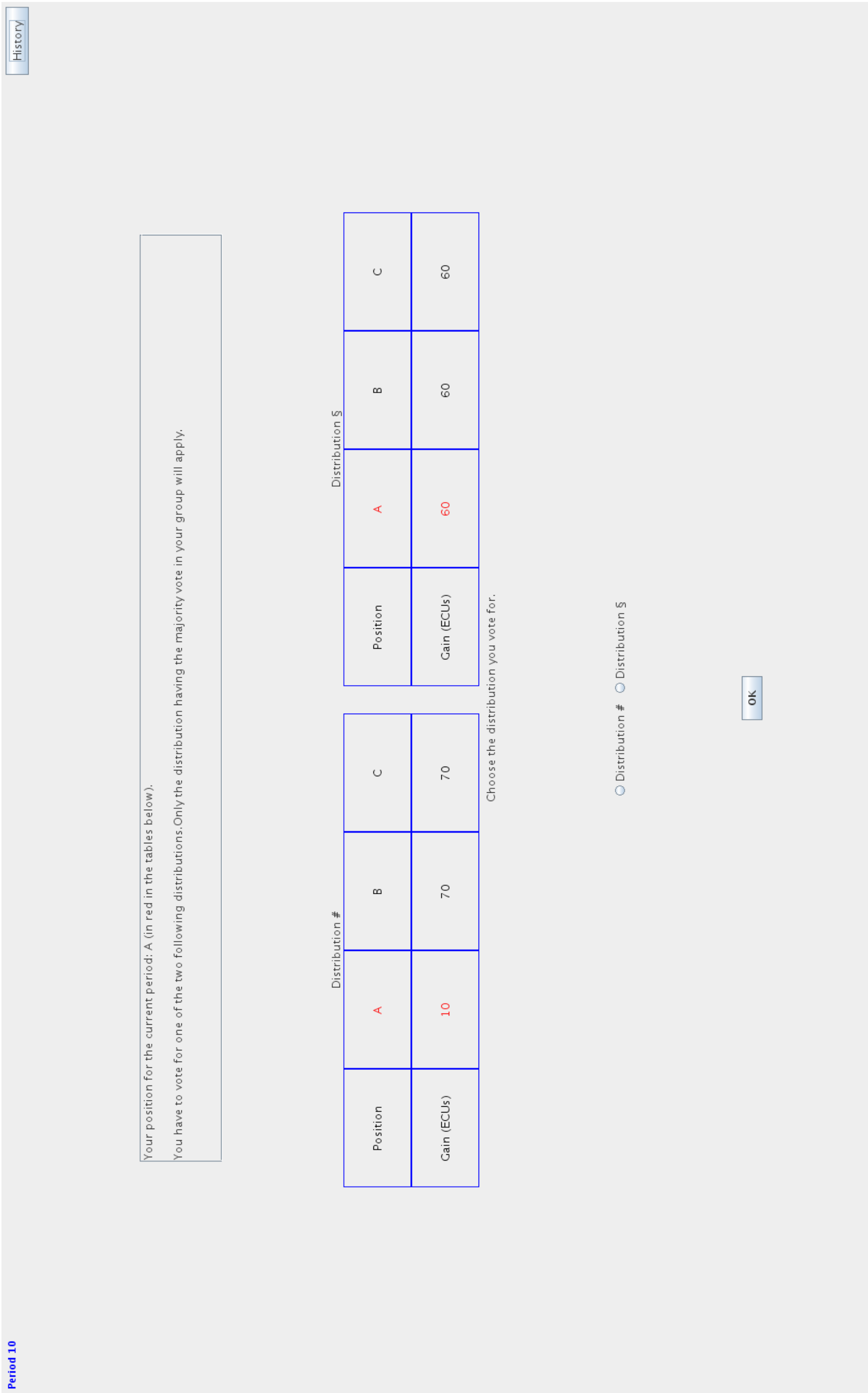


Figure 5: *Screenshot of history*