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« Income Redistribution and Public Good Provision: an Experiment »

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Income Redistribution and Public Good Provision: an Experiment[1]

PRELIMINARY VERSION

COMMENTS WELCOME

Jonathan Maurice[2], Agathe Rouaix[3], Marc Willinger[4]

Abstract

We provide a new experimental investigation of the neutrality theorem of Warr (1983), who states ”when a single public good is provided at positive levels by private individuals, its provision is unaffected by a redistribution of income”. Instead of comparing different income distributions across groups as Chan et al. (1996), in our experiment the total group endowment is redistributed after a 10 rounds sequence. We compare an unequalizing redistribution (EI) and an equalizing redistribution (IE), to two benchmark treatments for which the 10 rounds sequence is repeated, either with an equal distribution (EE) or an unequal distribution (II). The constituent game has a unique interior dominant strategy equilibrium. Our data support the neutrality theorem (after controlling for the restart effect): redistribution has no effect on the total amount of public good in none of the tested treatments. However, the analysis of individual behavior shows that ”poor” subjects over-contribute with respect to their Nash-contribution, while ”rich” subjects tend to play their Nash-contribution or under-contribute slightly. Furthermore, after a redistribution, subjects react asymetrically: subjects who get poorer reduce their contribution of a larger amount than the amount of contribution added by subjects who become richer. And it is shown that the latter do not react enough to the redistribution.

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1 Introduction

Warr (1983) demonstrated that a redistribution of income has no effect on the private provision of a public good when a single public good is provided (positively) by private individuals. His ”neutrality theorem” was extended to more than one public good by Bergstrom, Blume & Varian (1986), BBV thereafter. BBV also showed that if the redistribution of income affects the number of contributors, the amount of public good provided might either increase or decrease, depending on the direction of the redistribution. Income redistribution from rich to poor individuals can lead to a decrease in the amount of voluntarily provided public goods. Symmetrically, a redistribution from poor to rich, might lead to exactly the opposite outcome. Although both these predictions might seem counter-intuitive, they are in line with recent experimental findings about inequality aversion and reciprocal behavior (e.f. Rabin 1993, Fehr & Schmidt 1999, Fischbacher et al. 2001). For instance, individuals who become richer after income redistribution contribute larger amounts to the public goods, reducing thereby the initial income inequality. A similar argument holds for individuals who become poorer. However in BBV's theory, the tendency towards equalization of final net incomes, is obtained under standard behavioral assumptions, i.e. selfish utility maximization. The inequality generated by income redistribution is mitigated by unequal voluntary contributions between rich and poor.

These theoretical findings raise interesting questions from a behavioral point of view. Is it the case that individuals who become richer contribute more, and individuals who become poorer contritute less ? And if true, to what extent do these adjustements cancel out so that neutrality is confirmed ? In this paper, we try to provide answers to these questions, by relying on an experiment based on a voluntary contribution game, in which we implement income redistribution. Our focus is on the neutrality issue raised by Warr's paper.

The only experimental study we are aware off to test this theory was run by Chan et al. (1996). They found that more inequality leads to more public good provision, consistent with BBV (1986). Furthermore at the individual level, in contrast to inequality aversion theories, they observed that the poor tend to over-contribute while the rich tend to under-contribute. But clearly more data is needed to get a clear understanding of how people adjust their contribution after an income redistribution. Chan et al. (1996) actually compared groups of subjects facing different income distributions, ranging from low to high inequality, keeping the aggregate income constant. They did not address the question how a given subject reacts to an income redistribution, which was the original question raised in Warr (1983) and BBV (1996). In order to justify our departure from their experimental design, it is useful to provide some details about their experiment.

The experiment by Chan et al. (1996) involved groups of 3 subjects (1 rich and 2 poors), which they compare to a benchmark treatment, consisting of groups of 3 subjects with equal endowments. For each treatment income distribution was common knowledge and remained unchanged over the 15 rounds of their contribution game. While the constituent game admits a unique Nash equilibrium in agregate group contribution, multiple contribution vectors are compatible with the agregate contribution (due to the integer values restrictions). The multiplicity of Nash equilibria in individual contributions raises therefore a coordination issue, which might possibly have affected subjects' behavior.

Their model[5] predicts that the rich player contributes more than poor players, that "very poor" players contribute zero, and therefore a redistribution from the very poor to the rich increases the level of the public good. If all players contribute a positive amount before and after the redistribution, the level of the public good will be unaffected by redistribution. Besides the coordination issue already mentioned, the model predicts an "extreme" equilibrium in the high inequality treatment: only the rich player contributes. Instead of playing Nash, the rich subject might have felt a moral obligation to contribute with respect to the "very poor" subjects.

In order to overcome the coordination issue raised by multiple equilibria in individual contributions, and to allow for a direct test of redistribution, in the spirit of Warr (1983) and BBV (1986), we propose a new experimental design. First, we choose a quadratic payoff function which implies a unique dominant strategies equilibrium (Keser, 1996). Under

[5] Each player's utility is given by: $u_i(x_i, g) = x_i + g + x_i g$ where x_i corresponds to private goods consumption and $g = \sum_{i=1}^{n} w_i - x_i$ to the consumption of the public good. Player i's budget constraint is given by $w_i = x_i + g_i$ where g_i is his contribution to the public good. His best reply is to contribute $g_i = max(\frac{w_i - g_{-i}}{2}, 0)$.

suitable restrictions only interior solutions exist for a wide range of incomes. Therefore the solutions are clearly independent from income, which establishes directly Warr's result. Second, we choose a within-subject design, for which each subject faces two income distributions. This is done by letting each group play two sequences of 10 rounds. After an initial 10-rounds sequence, income is redistributed and a second 10-rounds sequence is played out. This setting allows us to study the effect of income redistribution within each group, and to identify the reaction of players who become poorer or richer. Furthermore, we consider two kinds of redistributions: an unequalizing redistribution and an equalizing redistribution. In the first case, players belonging to a given group have the same endowment in the initial sequence, but face a unequal distribution in the second sequence. In contrast, the equalizing redistribution starts with an unequal distribution in the first sequence and moves to an egalitarian distribution of income in the second sequence. The comparison of these treatments to the two benchmark treatments (two sequences with uniform income distribution and two sequences with unequal distributions) allows us to isolate the effect of the ordering of the sequences. Finally the benchmark treatments allow us to wipe out the so-called "restart effect" (Andreoni, 1988, Croson, 1996) that might be involved when a new sequence is started unexpectedly for the subjects.

Our main findings can be summarized as follows : i) redistribution does not affect the average amount of public good provided, in accordance with the neutrality theorem of Warr and BBV, ii) subjects who become richer after redistribution tend to under-react, i.e. they increase their contribution but less than predicted, and iii) after redistribution subjects who become poorer tend to over-contribute with respect to their Nash-contribution while subjects who become richer either contribute at their Nash level or slightly below.

The rest of the paper is organized as follows. In section 2 we present the theoretical models of Warr (1983) and Bergstrom, Blume & Varian (1986) and their testable predictions. Section 3 introduces our experimental design. In section 4 we present our results. Section 5 concludes.

2 The neutrality theorem

Two fundamental papers deal with the effect of a redistribution of income on the voluntary contribution to a public good. At first, Warr (1983) concludes in a quite general model that when a single public good is privately provided at positive levels by each individual, an infinitesimal redistribution of income does not affect the private provision of the public good. On the basis of this model, Bergstrom, Blume & Varian (1986) extend the result to non-infinitesimal variations of income and several public goods. They also derive some interesting results concerning the case where the redistribution of income affects the initial set of contributors, i.e. the set of contributors before redistribution. In particular, they show that a redistribution of income from poor individuals to rich individuals increases the private provision of the public good whenever the poor individuals were not contributing before redistribution.

The neutrality theorem of Warr (1983) formally states that "[w]*hen a single public good is provided at positive levels by private individuals, its provision is unaffected by a redistribution of income*". This result holds despite preference heterogeneity in the group of agents, for instance, for heterogeneous marginal propensities to contribute to the public good.

Warr's result applies when "*individuals behave as atomistic utility maximizers in the determination of their provision of a single public good, and where this result is an interior solution to their utility maximization problem*". We provide a brief sketch of the model, underlying the central hypotheses, in order to justify the choices for our experimental design. The model assumes n consumers and m private goods. There is a single public good, the amount of which is noted $g = \sum_{i=1}^{n} g_i$ where g_i is the private contribution by agent i. Utility functions $u_i(c_i, g)$[6] differ among agents. Let w_i be the exogenous income for agent i, p the price vector of private goods and q the price of the public good. The model assumes that each individual behaves as a selfish utility maximizer. A key property is that each individual contributes a striclty positive amount to the the public good, i.e. the solution of the maximization program admits a unique interior solution.

The Nash-equilibrium corresponds to a level of public good provision that is inferior

[6] They are strictly quasi-concave, twice differentiable and increasing in all arguments.

to the Pareto-optimal level. Warr shows that the aggregate demand function for the public good depends only on p, q and w (where w is aggregate income), but not on the distribution of income. In other words, whatever the income distribution, as long as aggregate income is unchanged, the amount of public good will be constant[7]. Identically the result can be restated in terms of aggregate demands for private goods. The latter are functions of p, q and w. Since only aggregate income matters, as demonstrated by Warr, redistribution leaving aggregate income unchanged will generate the same demands for private goods. The intuition behind the result is that agents maximise their utility by choosing optimally their level of consumption of private goods. Their contribution to the public good is therefore "residual". An agent who becomes richer after redistribution spends his extra-income by increasing his contribution to the public good by the same amount. In contrast, an agent who becomes poorer will cut his contribution by the exact amount of his income reduction. As far as his private consumption is not affectd by his income reduction, the increased contribution by the rich is perfectly offset by the reduced contribution of the poor. Seen from the traditional demand side for private goods, as long as redistribution does not affect the individual demand functions for private goods, redistribution has no effect on relative prices and therefore the individual consumption of private goods remains unchanged as well as the agregate contribution to the public good. Furthermore, each individual has exactly the same level of utility before and after income redistribution.

Warr's result depends crucially on the following assumptions : i) each agent is a "*contributor"* before the redistribution occurs , i.e. he contributes a strictly positive amount to the public good , ii) he consumes at least one private good and iii) variations of income are infinitesimal. BBV (1986) consider the more general case where redistribution of income implies non-infinitesimal variations of income and which might affect the set of initial contributors, i.e. after redistribution some of the former non-contributors might become contributors and some of the former contributors might become non-contributors. Their main new assumption is that the redistribution of income among the contributing agents does not lead -at the individual level- to losses that are larger than the original

[7] Warr considers infinitesimal variations of income.

contribution for each consumer. If this assumption is satisfied and consumers'preferences are convex, "*each consumer consumes the same amount of the public good and the private good that he did before the redistribution*". Moreover, BBV also show that their result can be extended to a public good that is a function of the individual contribution[8], "*to more general solution concepts than that of Nash equilibrium*" and "*to more than one public good*".

They only insist on one restriction on this neutrality result. "*The result is sensitive to the assumption that utility depends only on private consumption and the amount of the public good*". If we introduce other arguments, the neutrality theorem will not apply for all functional forms of the utility.

3 Experimental design

In this section we describe our experimental design, by presenting the underlying game, the practical procedures that were implemented in the lab and the treatments that we chose for testing the neutrality theorem.

3.1 The contribution game

In order to avoid difficulties due to the multiplicity of equilibria, like in Chan et al. (1996), we rely on a quadratic payoff function, as in Keser (1996).

$$u_i(x_i, g = \sum_{i=1}^{n} g_i) = 41x_i - x_i^2 + 15\sum_{i=1}^{n} g_i,$$

where x_i represents player i's investment in the private account and $g_i = w_i - x_i$ her investment in the collective account. It is easy to see that player i's optimal consumption of private goods is independent of his income, since : $\frac{\partial U_i}{\partial x_i} = 0 \Leftrightarrow 41 - 2x_i - 15 = 0 \Leftrightarrow x_i^* = 13, \forall i$ and $\forall w_i \geq 13$.

[8]"[...] *there is no loss of generality in restricting ouselves to a public good which is a sum of the individual contributions. If instead $G = f(\Sigma_{i=1}^{n} g_i)$, utility would take the form $u_i(x_i, f(G))$ which is still of the appropriate form.*", BBV (1986), pp. 31.

With our specification, the "residual" contributions to the public good are equal to $g_i^* = w_i - 13\ \forall i$. Therefore, if $w_i > 13$ is satisfied for all players before and after redistribution, each player will invest a strictly positive amount in the public account. Conversely, the equilibrium contribution to the public account depends only on income. The unique interior Nash equilibrium is a dominant strategies equilibrium with $g_i^* = 2$ if $\omega_i = 15$, $g_i^* = 7$ if $\omega_i = 20$ and $g_i^* = 12$ if $\omega_i = 25$. In terms of final payoffs, there is theoretically no difference between rich and poor players. At equilibrium, starting from an unequal distribution, final payoffs are theoretically equally distributed. In fact, at equilibrium poor contribute less than rich after having satisfied their private consumption, and the public good provided is equally distributed among group members. Similarly, at the optimum level of public good provision - which is reached whenever each group member contributes her endowment - payoffs are also equalized within the group. This means that inequality aversion cannot account for the observed departure from equilibrium play, nor from the optimum[9].

The constituent game is based on the above payoff function, although players were not given this formula in the instructions. Instead, each subject received a payoff table indicating the marginal payoff for each token invested in the private account as well as the total payoff as a function of the number of tokens invested in the private account. They were aware that any token invested in the public account gave a payoff of 15 points (for the investor as well as for each other member of the group).

3.2 Practical procedures

We conducted the experiment in a computerized laboratory at the Université de Montpellier 1, with the software z-Tree (Fischbascher, 2007). We run 7 sessions involving 16 subjects and 2 sessions involving 8 subjects. The 128 subjects were randomly selected from a pool of student-subjects containing more than 1 000 volunteers from the Universities of Montpellier. Upon arriving at the experimental lab, subjects were randomly assigned to groups of 4 persons which remained fixed for the whole session. The experiment consisted

[9]TBC Fehr & Schmidt.

in 20 rounds of play of the constituent game. Written instructions were provided for the first ten rounds only. In each round subjects were asked to invest each of their tokens in a private account or in a public account. At the end of each round the following information was displayed on each subject's computer screen : the amount he invested in each of the two accounts, the total contribution to the public account by the group, his earning from the private account, his earning from the public account and his total earnings for that round. Furthermore, the record of previous rounds was also on display.

Subjects were unaware that a second sequence of 10 rounds would be played after the first 10-rounds sequence which was announced in the instructions. At the end of the tenth round, a new sequence of 10 rounds was publicly announced. Subjects were given a new set of instructions, which emphasized the changes with respect to the first sequence, namely the new income distribution among the group members. Each independent group was endowed with 80 tokens. The 80 tokens were split between the four players in an egalitarian way in one of the sequences (20 tokens per player) and in an inegalitarian way in the other sequence (two players received 15 tokens and two players received 25 tokens).

We chose not to announce the redistribution at the beginning of the experiment, in order to avoid uncontrolled effects that could have been generated by differing expectations accross subjects about future endowment after the redistribution. If subjects are more or less optimistic (or pessimistic) about their future income, their contribution to the public good in the first sequence could have been affected. Because of our choice of an unexpected restart of a new sequence after the tenth round of the first sequence, a restart-effect might be present in our data. Such effect was observed earlier by Andreoni (1988) and Croson (1996) under similar circumstances: restarting a new sequence in fixed groups after the last round of the announced initial sequence, tends to increase sharply the contributions of the beginning of the new sequence.

3.3 Treatments

To test the neutrality theorem, we implemented four treatments involving two sequences of 10 repetitions of the constituent game: two benchmark treatments (without redistribution) and two test treatments (with redistribution). The two benchmark treatments are introduced to isolate the restart effect: one for the equal endowment distribution and one for the unequal endowment distribution. For the two test treatments a redistribution of the group tokens endowment was implemened after the first sequence. One of the test treatments started with a sequence of equal distribution and introduced a second sequence with unequal distribution. In the second test treatment, the order of sequences was reversed. The distribution of tokens was common knowledge. Subjects were paid according to their accumulated number of points in one of the two sequences, which was randomly chosen at the end of the session to be paid out for real. Note that this procedure differs from other experiments having a restart of the game (Andreoni, 1988 ; Croson, 1996). We choose this randomly payment procedure to avoid wealth and anticipation effects. The experimental design is summarized in tables 1 and 2.

[Table 1 about here.]

[Table 2 about here.]

To control for the restart effect, we compare the benchmark treatments without redistribution across sequences to the test treatments which involve redistribution after the first sequence: without ambiguity, the benchmark treatments are labelled Equality-Equality (EE) and Inequality-Inequality (II) while the test treatments are labelled Equality-Inequality (EI) and Inequality-Equality (IE), in the order of sequences. For the presentation of the result we use the term ”round” or ”period” indifferently.

4 Results

Our experimental design allows us to make within-treatment comparisons as well as accross-treatment comparisons. Of course we are mainly concerned with the within analysis in order to account for the redistribution effect.

Before presenting our main result, we start with a description of the data, and the presentation of some preliminary results which allow us to guarantee that our main result is not the outcome of some particularities of our data set. Unless otherwise specified, all of our tests are two-sided at the 5% significance level.

4.1 Data

We collected 8 independent data per period for each treatment (8 groups of 4 subjects per treatment).

A first insight of our data is given by figures 1 and 2 that describe the average contributions for test treatments according to endowments. Similar figures for the benchmark treatments can be found in appendix A.

[Figure 1 about here.]

[Figure 2 about here.]

Appendix B details the average group contributions for each sequence of each treatment.

4.2 Preliminary results

4.2.1 Homogeneity

Before testing the potential effect of the redistribution, some preliminary tests[10] are required in order to guarantee that our samples are homogeneous, i.e. that groups involved in the same game behaved the same way. We perform such a test only on the first sequence of each treatment by comparing the first ten periods average contributions of each group. The Mann-Withney test does not detect any significant difference between the first ten periods of the EI treatment and the first ten periods of its benchmark, the EE treatment

[10] We used the software R to analyse our data. This software is available at `http://CRAN.R-project.org/doc/FAQ/R-FAQ.html`

(p-value = 0.753). Similarly, there is no significant difference in average contribution between the first ten periods of the IE treatment and the first ten periods of its benchmark, the II treatment (p-value = 0.329). Note that since we test for the agregate contribution of the group, we do not distinguish between rich and poor subjects. We conclude therefore that for sequence 1, in our two test treatments, EI and IE, the subjects behave as in the corresponding benchmark treatments, EE and II respectively. We therefore assume that observed differences in the second sequence are due to redistribution, acknowledging for the restart effect. Since sequence 1 group behavior does not differ between the test and the benchmark treatments, we pool the sequence 1 data for the treatments EE and EI, and likewise for the sequence 1 data for the treatments IE and II, to test for difference between equality and inequality treatments. There is no significant difference in average contributions between equal and unequal income distributions, according to a Mann-Withney test (p-value = 0.851), a result which is consistent with Chan et al.'s (1996) findings.

The following sections check the compatibility of our data with standard results of the experimental literature on public goods.

4.2.2 Over-contribution

A major finding of public goods experiments - with and without interior equilibria - is that most subjects over-contribute to the public good. Figures 1 to 4 show the average group over-contribution with respect to the Nash-contribution (7 tokens). More details are provided in tables 8 and 9 (see appendix B) which show the average group contribution for each of the 20 periods for each treatment.

Result 1. Over-contribution is frequent but not always significant.

Support for result 1. Average contributions in all groups and all periods are larger than 7 for each treatment (8.74 for EE, 10.07 for II, 9.62 for EI and 8.47 for IE). Note that we only consider the group contribution for the inegalitarian sequences of treatments, without distinguishing between rich and poor subjects. While we observe over-contribution in our data it is not always significant. Table 3 illustrates this result.

[Table 3 about here.]

Overcontribution is significant for three of the sequences out of 8 (Binomial test).

Comment. The above observations are compatible with earlier finding (see Sefton & Steinberg, 1995; Keser, 1996; Laury & Holt, 1998; Willinger & Ziegelmeyer, 2001) that over-contribution is not always significant with interior equilibria. In our experiment it can be explained to some extent by the fact that some groups strongly over-contribute on average, while others are closer to the Nash prediction or slightly under-contribute (see table 8, showing the average contribution per group for the first sequence of each treatment).

> **Result 2.** Poor subjects over-contribute while rich subjects Nash-contribute as predicted.

Support for result 2. (see table 4)

> **Result 3.** After an equalizing redistribution of income, former poor subjects continue to over-contribute and former rich subjects continue to Nash-contribute.

Support for result 3. Inegalitarian sequences allow us to distinguish between poor and rich subjects and compare their amount of over-contribution. Figures 2 to 4 illustrate average contributions of poor and rich subjects following their Nash Equilibrium (2 tokens for poor subjects and 12 tokens for rich subjects). Table 4 details the results of our binomial test on the over-contribution of poor and rich subjects.

[Table 4 about here.]

To build our test, we compute the average contribution of the two poor and the two rich subjects separately for each group and compare each of them to its Nash-prediction: 2 tokens for poor subjects and 12 tokens for rich subjects. Moreover, we can distinguish the average contribution of the former poor subjects to the average contribution of the former rich subjects in the second egalitarian sequence of treatment IE, to detect eventual changes in overcontribution rates.

Comment on results 2 and 3. Table 4 shows a remarkable difference in contribution behavior between rich and poor. Although on average both types of subjects over-contribute with respect to their Nash contribution, over-contribution is significant only for poor subjects. As can be seen from table 4 in every sequence with unequal distribution[11], one observes that rich subjects do not contribute significantly more than their Nash-contribution while poor subjects always over-contribute on average. We conclude therefore that over-contribution asymmetry between rich and poor is not generated by the redistribution of income as such, but merely by the existence of an unequal distribution at the outset of a sequence.

What kind of explanation can be provided for such asymmetry ? The "strength of the social dilemma" might be perceived differently between rich and poor. Willinger & Ziegelmeyer (2001) showed that the stronger the social dilemma the larger the average overcontribution. The strength of the social dilemma is defined as the difference between the equilibrium and the optimum level of contribution. In all of our treatments, and whatever the subjects' income, this difference is always a constant (equal to 13 tokens). Nevertheless, in relative terms, poor subjects have to contribute a very low fraction of their income to reach their equilibrium contribution level ($2/15 = 13.33\%$ of their endowment) whereas rich subjects contribute a relatively large fraction of their endowment at equilibrium ($12/25 = 48\%$ of their endowment). Subjects who needed to contribute a low fraction of their endowment to reach their Nash equilibrium (the poor) might have perceived a relatively stronger social dilemma, than the richer subjects who contribute about half their endowment at their Nash equilibrium.

[11] In sequence 1 of treatment IE, sequence 2 of treatment EI and sequences 1 and 2 of treatment II.

4.2.3 Decay of the average contribution

A stylized fact of voluntary contribution experiments, is the decline of the average contribution over time. This fact is well established in linear public goods experiments (see Laury, Walker & Williams, 1999; Laury & Holt, 1998) but also in public goods experiments with a unique interior Nash-equilibrium, as in Keser (1996).
However, the decay is much less pronounced with an interior Nash equilibrium than in linear public goods experiments (Keser, 1996; Willinger & Ziegelmeyer, 2001). Furthermore, early declines are often followed by temporary increases, the decay becoming sharper towards the final rounds.

> **Result 4.** The average contribution declines slightly over time.

Support for result 4. See our econometric analysis hereafter.

Comment. Our data reveals a slight decrease in average contributions over the 10 rounds of each sequence. The decline is much less pronounced and much slower than in standard linear public good experiments, in accordance with other experiments on interior Nash equilibria (Keser, 1996; Willinger & Ziegelmeyer, 2001). A strong end effect, resulting in a sharp decline towards the end, was also found in these experiments. We observe the same pattern but far less pronounced, probably because we had only 10 rounds per sequence in contrast to the previously cited experiments which had 20 ore more rounds.

4.2.4 The restart effect

> **Result 5.** There is no significant restart effect in the benchmark treatments.

Support for result 5. We first look for an eventual restart effect in treatments without redistribution (EE and II). For each of these treatments, we compare the average contribution of period 11 (first period of sequence 2) and the average contribution of period 10 (last period of sequence 1) at the group level. If the average contribution of period 11 is significantly larger than for period 10 we can reject the null hypothesis of no restart effect (the null hypothesis is that the average contribution of period 11 is equal or lower than in period 10). According to the Wilcoxon signed rank test there is no significant difference between the average group contributions of periods 10 and 11 for the two benchmark treatments (p-value[EE] = 0.3125 and p-value[II] = 0.9441). Since there is no significant restart effect for the benchmark treatments we tentatively conclude that the same holds for the test treatments and that any observed difference after redistribution is attributable to redistribution effects, and not to the restart effect. We now consider within-subjects tests in order to isolate the redistribution effect and state our main results.

4.3 Main results

Result 6. Groups with unequal income distributions after redistribution contribute the same amout than groups with equal income distribution.

Support for result 6. Our accross treatment comparisons confirm the neutrality of the redistribution at the collective level as predicted by Warr. We run a Wilcoxon Mann-Whitney test on the average group contributions observed in sequence 2 of treatments that have the same initial sequence. Both tests confirm that there is no difference in contribution between the average group contributions of second sequences of treatments having the same first sequence (E**E** vs. E**I**: p-value = 0.5054 and I**I** vs. I**E**: p-value = 0.2698). While the restart effect can be isolated in the EE and the II treatments, we cannot control for it in the EI and the IE treatments. We therefore need to assume that the restart effect is independent of redistribution, i.e. there is no interaction between redistribution and restarting a new sequence.

Furthermore, the within-subjects tests confirm that groups contribute on average the same amount before and after redistribution, that is sum up in result 7.

Result 7. The average contribution of sequence 1 is equal to the average contribution of sequence 2 for all treatments.

Support for result 7. We run a Wilcoxon signed rank test to compare the average group contribution of the first sequence with the average group contribution of the second sequence for each treatment. We find that there is no significant difference between the first 10 periods' average contribution and the last 10 periods' average contribution, for the test treatments (p-value[EI] = 0.1953 et p-value[IE] = 0.3828), and for the benchmark treatments (p-value[EE] = 0.8785 et p-value[II] = 0.6363). We conclude therefore that our within-subjects analysis, supports Warr's prediction that income redistribution does not affect the amount contributed by the group to the public good.

Comment. Our results confirm the findings of Chan et al. (1996): the average contribution of groups with unequal income distribution does not differ from the average contribution by groups of equal income distribution. In addition to Chan et al., our design allows us to test the neutrality theorem of Warr by implementing an effective redistribution of income within groups. Our results confirm the prediction that, if the set of contributors is invariant before and after the redistribution, an (un)equalizing redistribution is neutral for the provision of a unique public good. This corroborates the theoretical neutrality result of Warr (1983) at the collective level. However, as discussed previously, at the individual level subjects react differently to the redistribution, depending on whether they get richer or poorer. The behavioral asymetry between rich and poor is further discussed in the next section.

4.4 Individual adjustment

According to Warr's prediction, after a redistribution of income, agents who get poorer decrease their contribution by an amount equal to their income variation, while agents who get richer increase their contribution by an amount equal to their additional income. Both adjustments cancel out, leaving the agregate contribution unchanged.

In accordance with Warr's prediction, we define a suject's individual adjustment as the difference between his average contribution before and after redistribution, for treatments EI and IE. The null hypothesis is that the magnitude of upwards adjustments is equal to the magnitude of downwards adjustments. Given the parametric setting of our experiment, these adjustment should be equal to the income variations induced by redistribution, i.e. $+/-5$ tokens. Although our subjects do not contribute the Nash equilibrium level, we hypothesize that they adjust their contribution as predicted on the equilibrium path. Our data reveals that most subjects do adjust their contribution in the predicted direction, but with a lower magnitude. This is stated as result 8.

Result 8. Subjects under-react to the redistribution (equalizing and un-equalizing)

Support for result 8 In the EI treatment, subjects who become poorer reduce their contribution by 4.53 tokens on average, which is not significantly lower than 5 (Binomial test, p-value = 0.363). On the other hand, subjects who become richer increase their contribution by 2.53 tokens on average, which is significantly lower than 5 tokens (Binomial test, p-value = 0.035).

Appendix C, table 9, summarizes the average contribution per subject for the EI treatment and shows each subject's average over or under-reaction to the redistribution (with respect to the predicted Nash-reaction).

We observe a similar pattern for the IE treatment, except that under-reaction is statistically significant for both types of subjects. While former poor subjects should increase their contribution by 5 tokens and former rich subjects should reduce their contribution by 5 tokens, we observe a significant under-reaction for both types of subjects after the redistribution in comparison to the predicted Nash reaction. The former poor subjects increase their contribution by 2.68 tokens on average, which is significantly less than 5 (Binomial test, p-value = 0.035) and the former rich subjects reduce their contribution by 3.71 tokens on average, which is significantly less than 5 (Binomial test, p-value = 0.035). Appendix C, table 10, summarizes the average contribution of each subject in the

IE treatment and his average reaction after redistribution.

The individual reactions to redistribution are significantly lower than predicted. Since the magnitude of these reactions does not differ signficantly between rich and poor, neutrality hold.

Comment. A plausible explanation for the subjects' under-reaction might be found in the "anchoring and adjustment" heuristics (Kahneman & Tversky, 1974), according to which subjects anchor their adjustment decision on their previous contribution, but adjust insufficiently. Subjects who become richer adjust upwards with respect to their previous contribution while those who become poorer adjust downwards, which is consistent with our data. According to Epley & Gilovich (2006), who studied the origins of insufficient adjustments in many contexts, individuals stop adjusting once a satisfying or plausible value is reached. According to this view, our subjects anchor on their level of contribution preceding the redistribution (e.g. the average contribution level of the ten first periods), and decide about a satisfactory increase or decrease. If this theory can shed lights on the under-reaction of subjects, it does not give the intuition of why it is asymetric.

> **Result 9.** Unequalizing redistribution induces asymmetric adjustements : subjects who become poorer decrease their contribution by a larger amount than the amount by which subjects who become richer increase their contribution. Asymmetric adjustments are visible but not statistically significant after an equalizing redistribution.

Support for result 9.

[Table 5 about here.]

We compare the adjustment of subjects who become poorer to the adjustment of subjects who become richer. The adjustment of the poorer is significantly larger than the adjustment of the richer at the 5% level for the EI treatment (one-sided Mann-Whitney test, p-value = 0.020). There is no asymmetric reactions in the IE treatment (one-sided Mann-Whitney test, p-value = 0.889). We conclude that individuals who become poorer reduce their contribution by a larger amount than individuals who become richer increase their contribution when an unequalizing redistribution occurs. However, the asymetry is not strong enough to contradict the neutrality theorem.

Comment. For the EI treatment, the combined effect of insufficient and asymmetric adjustment between rich and poor is as follows: since both types of subjects tend to over-contribute in the first sequence, the insufficient adjustment for the rich moves their contribution closer to their new Nash contribution of sequence 2. In contrast, since the poor subjects underact, they tend to overcontribute relatively more than in sequence 1. The reason why such asymmetric adjustments between rich and poor occur remains an open question. We note however, that both types seem to privilege their private account after the redistribution, in contrast to the prediction of Warr's theorem.

We summarize our findings for individual behavior as follows. First, independently of redistribution, rich subjects tend to Nash-contribute while poor subjects tend to over-contribute. Second, after redistribution, both types of subjects under-react but asymmetrically : subjects who become richer increase their contribution by a lower amount than subjects who become poorer reduce their contribution. These findings are at odds with Warr's predictions about individual's reactions to redistribution.

In order to confirm the results of the statistical tests we perform an econometric analysis in order to capture possible interactions between the independent variables that account for individual contributions.

4.5 Econometric analysis

In this section we report results of panel-data regressions, in order to account for potential interactions between all the effects isolated previously using averages. A preliminary analysis of the data (F-test) rejects the simple pooled regression favouring a panel model. Furthermore, for most of our model specifications, fixed effects provide a better fit of the data than random effects (Hausman test). The model is estimated by the generalized least squared method with correction for heteroskedasticity. As in the other sections of the paper, we require a 5% significance level for rejecting the null hypothesis for the estimated coefficients.

4.5.1 The data

We take as the dependent variable the contribution of subject i to the public account. Explanatory variables are :

- the contribution of the group at the previous period, named "contribgpp";
- the round number, named "period";
- a dummy for the sequence of the game (before or stricly after period 10), named "redib", taking value 0 before the redistribution and 1 after.
- 8 group dummies named "group i", taking value 1 if the subject belongs to the group and value 0 otherwise.

Group dummys were included in the regression in order to capture a potential group effect[12]. Since these variables are almost never significant, for none of our treatments, we do not report the detailed results about these variables.

The regressions are done on the whole data for each treatment. For each treatment involving unequal income distribution, we analyze separately the data for poor subjects and the data for rich subjects. In the EI and IE treatments, we consider as a poor (rich) player, a player who is poor (rich) in at least one of the 2 sequences. We consequently run 3 separate regressions for the EI, IE and II treatments: one with all subjects, one with only poor subjects and one with only rich subjects. We obtain the same results for all these regressions for each treatment. We report therefore, only the results of the regressions including all subjects.

[12] In the EE treatment, the dummy "group" is significant for three groups and for one group in the EI treatment.

4.5.2 General results

The contribution of the group in the previous period (”contribgpp”) has a positive influence on a subject’s current contribution, in each treatment. Subjects tend to reciprocate the group contribution observed in the previous period. On average subjects’ contributions decay over rounds, as shown by the negative sign of the ”time” variable.
Taken together, our results about these two variables (”contribgpp” and ”time”) are in line with two commonly found facts in experiments on public goods games.

The explanatory variable ”redib” allows to test for two different effects : first, in the benchmark treatments, it allows to test for the presence or absence of a restart effect and second, in the test treatments, it allows to test for the neutrality of redistribution. In the benchmark treatment we confirm that there is no restart effect since the dummy variable ”redib” is not significant. In the test treatment, we conclude that redistribution does not affect individual contributions for the IE treatment but does so for the EI treatment. The latter result diconfirms our main result supported by non-parametric tests.

The significant effect observed for the EI treatment is attributable to the data of one group of players (group 7). In group 7 almost each subject contributes its entire endowment from period 5 to the end of the experiment. If we remove the group dummies from the regression, the variable ”redib” is no longer significant. The data of group 7 increasing sharply the standard deviation of group contributions, compared to the other treatments (see table 8). If we ommit group 7, the standard deviation drops to 1.17, below the standard deviation of other treatments (see table 8). So high variability in this treatment is only due to one group whereas the other groups behave quite similarly contrary to IE treatment. All these factors can explain why the variable ”redib” becomes significant when we introduce the group dummies. Indeed, when we take off the group 7 and when we do not take the group 1 as a reference, we decrease the significance of the dummy ”redib”.

[Table 6 about here.]

4.5.3 Treatments with unequal endowments

For treatments with unequal endowments we further investigate the effects of subjects' endowment on her contribution and her over-contribution. Over-contribution is defined as the difference between the observed contribution of a subject and his predicted contribution (which depends on his endowment: 2, 7 and 12 for endowments of 15, 20 and 25 respectively). We run two regressions -one for the "contribution" dependent variable and one for the "over-contribution" dependent variable- with the following explanatory variables:

- "contribgpp";
- "period";
- "group";
- "endowment (x)", where $x = \{15, 20, 25\}$ is the period endowment of the considered subject. This dummy takes value 1 if the considered subject has an endowment of x and 0 otherwise. The reference endowment is $x = 20$ for the EI et IE treatments and $x = 15$ for the II treatment.

The II treatment allows us also to study the effect of income inequality. The dummy "endowment" indicates that subjects with high endowment contribute more but over-contribute less than subjects with low endowment. These findings are consistent with our previous results.

The two test treatments EI and IE allow us to study the effect of the redistribution. Our regressions confirm the results of our previous analysis. Rich subjects contribute more than subjects who are endowed with 20 tokens and poor subjects contribute significantly less than subjects endowed with 20 tokens, so they adjust their contribution in the predicted direction after redistribution.
Moreover poor subjects over-contribute the same amount (EI treatment) or more (IE treatment) with respect to subjects endowed with 20 tokens, while rich subjects over-contribute

significantly less than subjects who are endowed with 20 tokens. These findings confirms our earlier results:

- After redistribution, subjects adjust their contribution in the right direction. Subjects becoming richer increase their contribution and subjects becoming poorer decrease their contribution ;
- but subjects adjust insufficiently with respect to Warr's prediction. This explains why poor over-contribute more than rich in the EI treatment.

[Table 7 about here.]

5 Conclusion

In this paper, we experimentally investigated the neutrality theorem of Warr (1983) on the private provision of a public good. According to this theorem a redistribution of income among contributors to a public good does not affect aggregate contributions to this public good. We implemented an experimental framework that allows us to make a real redistribution of income in the course of the experiment. We used a quadratic payoff function to ensure that there is a unique interior dominant strategies equilibrium. We controlled for an eventual restart effect after redistribution, which could be a possible confounding factor. Our data supports the neutrality theorem at the aggregate level: a redistribution of income among contributors has no significant impact on the group level of contribution to the public good.

However at the individual level, we find that poor subjects significatively over-contribute to the public good, whereas rich subjects Nash-contribute. The redistribution of income does not affect this asymmetric contribution behavior. Furthermore we observe the same pattern in our unequal income distribution benchmark treatment where no redistribution was implemented. Consequently, only income inequality explains over-contribution differences between rich and poor. Moreover we found that both types of subjects under-react asymmetrically to redistribution: becoming-poorer subjects adjust more strongly than becoming-richer subjects. While under-reaction is compatible with the "anchoring and insufficient adjustment" heuristic, asymmetric adjustement between rich and poor remains puzzling.

Our experiment was a first attempt to isolate the effects of income redistribution on group and individual contributions. We focused on the particular outcome where redistribution is neutral. It would be interesting to contrast these findings to other treatments for which redistribution affects the set of contributors, and therefore neutrality no longer holds (see BBV). This will be a major agenda for future research.

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Appendix

A Graphs of benchmark treatments

[Figure 3 about here.]

[Figure 4 about here.]

B Average group contributions

[Table 8 about here.]

C Individual data: reactions to the redistribution

[Table 9 about here.]

[Table 10 about here.]

List of Figures

Figure 1: Average contribution EI treatment

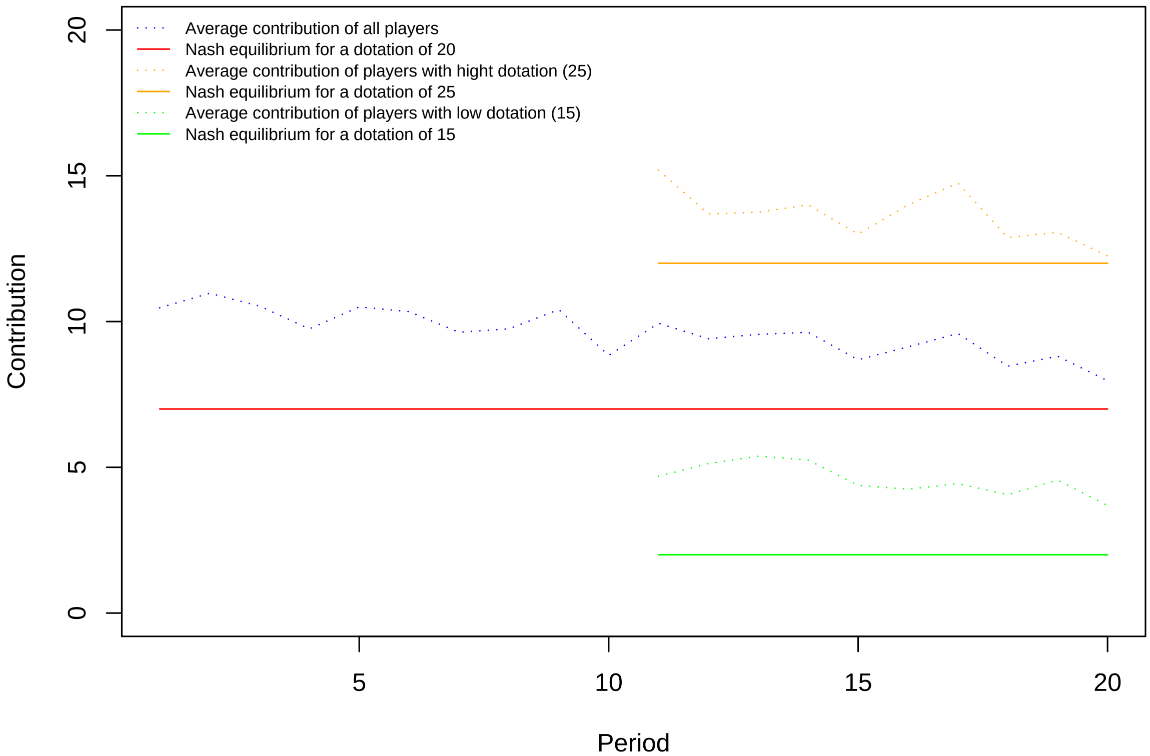


Figure 2: Average contribution IE treatment

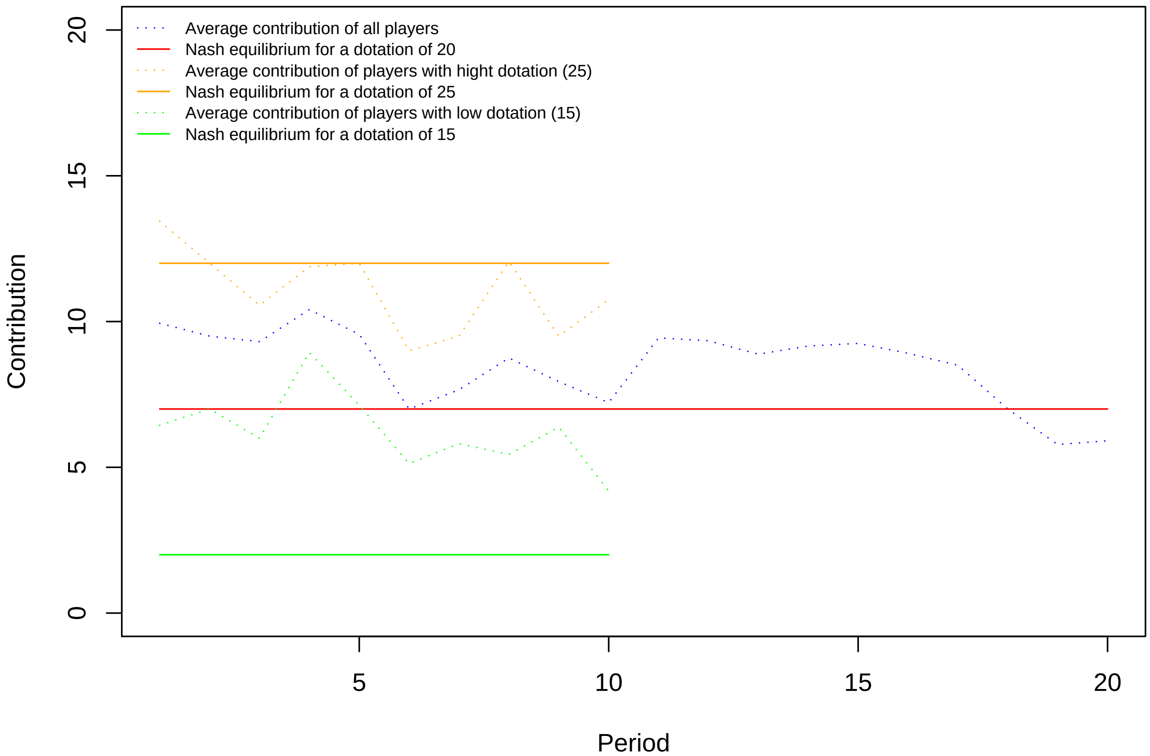


Figure 3: Average contribution EE treatment

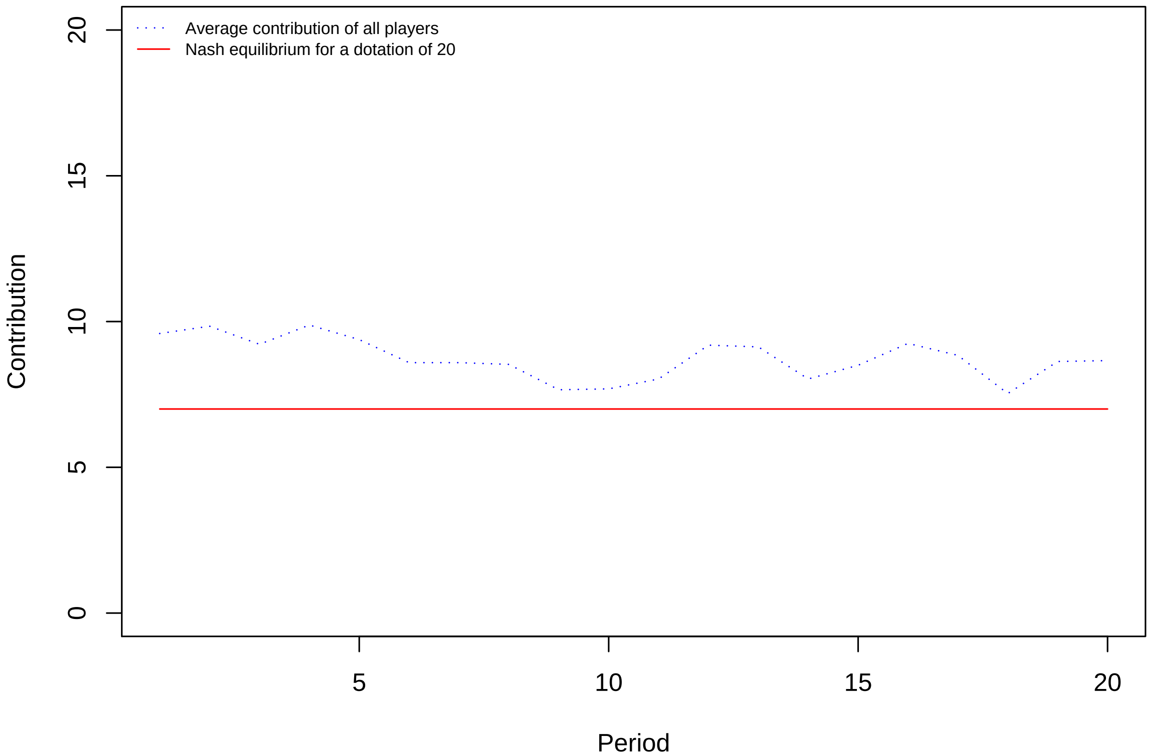
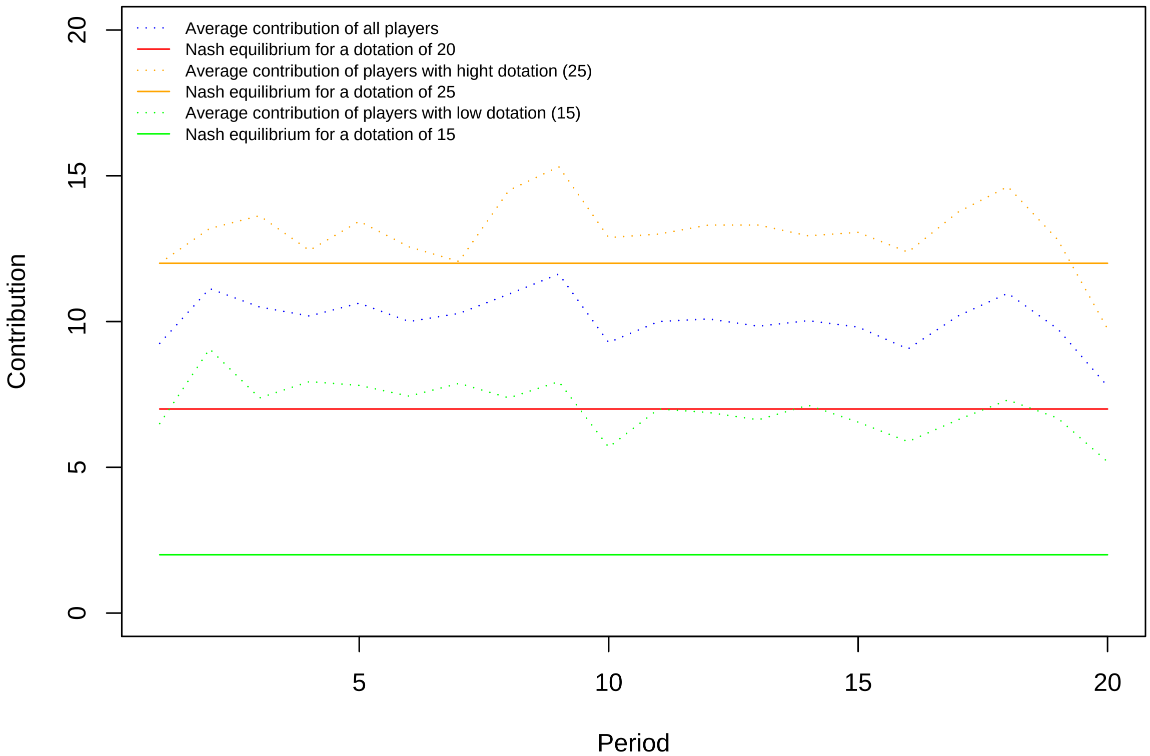


Figure 4: Average contribution II treatment



List of Tables

Table 1: Equality-Equality (EE) and Inequality-Inequality (II) treatments

Benchmark treatments	**EE treatment**	**II treatment**
Endowments for the first ten periods	80=(20,20,20,20)	80=(15,15,25,25)
Nash-contribution	28=(7,7,7,7)	28=(2,2,12,12)
Endowments for the last ten periods	80=(20,20,20,20)	80=(15,15,25,25)
Nash-contribution	28=(7,7,7,7)	28=(2,2,12,12)

Table 2: Equality-Inequality (EI) and Inequality-Equality (IE) treatments

Test Treatments	**EI treatment**	**IE treatment**
Endowments for the first ten periods	80=(20,20,20,20)	80=(15,15,25,25)
Nash-contribution	28=(7,7,7,7)	28=(2,2,12,12)
The redistribution is	Inequalizing	Equalizing
Endowments after the redistribution (last ten periods)	80=(15,15,25,25)	80=(20,20,20,20)
Nash-contribution	28=(2,2,12,12)[a]	28=(7,7,7,7)[b]

[a]Consistent with the neutrality result of Warr and the BBV model.
[b]Consistent with the proposition (i) of the theorem 4 of the BBV model.

Table 3: Aggregate over-contribution (Binomial tests)

Treatment	Periods	Nb of groups above 7[a]	p-value	Result
EE	**1 to 10**	5	0.363	Subjects play Nash
	11 to 20	7	0.035	Subjects over-contribute
EI	**1 to 10**	7	0.035	Subjects over-contribute
	11 to 20	5	0.363	Subjects play Nash
II	**1 to 10**	8	0.004	Subjects over-contribute
	11 to 20	6	0.145	Subjects play Nash
IE	**1 to 10**	5	0.363	Subjects play Nash
	11 to 20	5	0.363	Subjects play Nash

[a]The column reports the number of groups among the 8 groups of the experiment having an average group contribution above the equilibrium 7 (over-contribute) for the corresponding periods.

Table 4: Over-contribution by subjects' type (Binomial tests)

Treatment	Periods	Types	Freq.[a]	p-value	Result
EI	**1 to 10**	Poor[b]	-	-	-
		Rich[c]	-	-	-
	11 to 20	Poor[b]	7	0.035	Subjects over-contribute
		Rich[c]	5	0.363	Subjects play Nash
IE[d]	**1 to 10**	Poor[b]	7	0.035	Subjects over-contribute
		Rich[c]	5	0.363	Subjects play Nash
	11 to 20	Former poor[e]	7	0.035	Subjects over-contribute
		Former rich[e]	4	0.633	Subjects play Nash
II	**1 to 10**	Poor[b]	8	0.004	Subjects over-contribute
		Rich[c]	5	0.363	Subjects play Nash
	11 to 20	Poor[b]	8	0.004	Subjects over-contribute
		Rich[c]	4	0.633	Subjects play Nash

[a]The column reports the number of groups of poor/rich subjects among the 8 groups of the experiment having an average group contribution above their equilibrium (2 for poor subjects and 12 for rich subjects) for the corresponding periods.

[b]The Nash-equilibrium for a poor player is 2 tokens.

[c]The Nash-equilibrium for a rich player is 12 tokens.

[d]We also study the second sequence of this treatment (periods 11 to 20) to distinguish the behavior of the former poor subjects and of the former rich subjects.

[e]The Nash-equilibrium for each player is 7 for periods 11 to 20 in this treatment.

Table 5: Average reactions to the redistribution

Treatment:	EI	IE
Subjects becoming richer[a]	+ 2.53	+ 2.68
Subjects becoming poorer[b]	- 4.53[c]	- 3.71

[a]Rich individuals in EI and poor individuals in IE.
[b]Poor individuals in EI and rich individuals in IE.
[c]The mean reaction is - 4.11 if we eliminate an outlier that clearly over-react to the redistribution.

Table 6: General regressions

	EE	EI	IE	II
contribgpp	0.065***	0.071***	0.104***	0.089***
	(2.67)	(4.5)	(4.46)	(3.99)
redib	-0.178	-0.733***	-0.286	-0.547*
	(-0.56)	(-2.36)	(-0.87)	(-1.79)
period	-0.135***	-0.141***	-0.271***	-0.111*
	(-2.36)	(-2.41)	(-4.13)	(-0.82)

*** p<0.001, ** p<0.005, * p<0.1

Table 7: Regressions in treatments with inequality

		EI	IE	II
Contribution	**contribgpp**	0.063*** (4.09)	0.104*** (4.74)	0.093*** (4.26)
	period	-0.144*** (-2.80)	-0.271*** (-4.51)	-0.103* (-1.69)
	endowment (15)	-4.578*** (-14.24)	-2.707*** (-6.74)	ref
	endowment (25)	3.041*** (7.58)	3.278*** (7.27)	6.102*** (4.92)
Over-contribution	**contribgpp**	0.063*** (4.09)	0.104*** (4.74)	0.093*** (4.26)
	period	-0.144*** (-2.80)	-0.271*** (-4.51)	-0.103* (-1.69)
	endowment (15)	0.422 (1.31)	2.293*** (5.70)	ref
	endowment (25)	-1.959*** (-4.88)	-1.722*** (-3.82)	-3.898*** (-3.14)

*** p<0.001, ** p<0.005, * p<0.1

Table 8: Average group contributions

	Treatments:	EE	EI	IE	II
Sequence 1	Group 1	5.28	6.13	7.90	12.93
	Group 2	6.28	9.60	5.63	8.15
	Group 3	12.58	8.85	8.20	7.78
	Group 4	6.13	9.15	6.13	15.60
	Group 5	8.78	7.88	10.30	10.10
	Group 6	9.85	8.93	14.05	11.48
	Group 7	9.38	18.35	6.40	7.43
	Group 8	12.93	12.08	11.23	9.70
	Mean	**8.90**	**10.12**	**8.73**	**10.38**
	Std. Deviation	**2.71**	**3.48**	**2.73**	**2.63**
Sequence 2	Group 1	5.13	6.73	7.38	13.00
	Group 2	7.63	6.50	5.53	8.73
	Group 3	11.60	6.68	9.40	6.98
	Group 4	7.95	7.53	5.05	12.15
	Group 5	9.53	8.25	10.88	6.98
	Group 6	7.30	8.55	11.73	11.30
	Group 7	9.30	19.55	6.43	7.33
	Group 8	10.20	9.18	9.35	11.58
	Mean	**8.58**	**9.12**	**8.22**	**9.75**
	Std. Deviation	**1.87**	**4.05**	**2.33**	**2.36**

Table 9: Average individual contributions and reactions to the inequalizing redistribution (treatment EI)

Subjects	Endow-ments after the redistri-bution	Mean	Mean of Periods 1-10 (a)	Mean of Periods 11-20 (b)	(b)-(a)	Nash reaction	Over(+)/ Under(-) reaction
1	15	4.75	6.1	3.4	-2.7	-5	-2.3
2	15	0.80	1.8	0.0	-1.6	-5	-3.4
3	15	5.05	6.5	3.6	-2.9	-5	-2.1
4	15	6.70	12.1	1.3	-10.8	-5	5.8
5	15	5.90	9.8	2.0	-7.8	-5	2.8
6	15	4.55	7.1	2.0	-5.1	-5	0.1
7	15	5.65	7.4	3.9	-3.5	-5	-1.5
8	15	4.50	7.0	2.0	-5.0	-5	0.0
9	15	6.40	8.1	4.7	-3.4	-5	-1.6
10	15	4.20	4.3	4.1	-0.2	-5	-4.8
11	15	5.30	8.6	2.0	-6.6	-5	1.6
12	15	9.40	11.0	7.8	-3.2	-5	-1.8
13	15	15.50	17.5	13.5	-4.0	-5	-1.0
14	15	13.25	17.5	15.0	-2.5	-5	-2.5
15	15	4.60	7.2	2.0	-5.2	-5	0.2
16	15	9.95	13.9	6.0	-7.9	-5	2.9
17	25	13.70	11.9	15.5	3.6	5	-1.4
18	25	6.45	4.9	8.0	3.1	5	-1.9
19	25	10.25	9.4	11.1	1.7	5	-3.3
20	25	10.20	10.4	10.0	-0.4	5	-5.4
21	25	9.60	7.5	11.7	4.2	5	-0.8
22	25	11.00	11.0	11.0	0 .0	5	-5.0
23	25	11.70	12.2	11.2	-1.0	5	-6.0
24	25	11.50	10.0	13.0	3.0	5	-2.0
25	25	9.15	10.2	8.1	-2.1	5	-7.1
26	25	12.50	8.9	16.1	7.2	5	2.2
27	25	10.75	9.1	12.4	3.3	5	-1.7
28	25	9.50	7.0	12.0	5.0	5	0.0
29	25	22.50	20.0	25.0	5.0	5	0.0
30	25	21.55	18.4	24.7	6.3	5	1.3
31	25	10.85	8.5	13.2	4.7	5	-0.3
32	25	17.10	18.7	15.5	-3.2	5	-8.2
Mean:		**9.62**	**10.12**	**9.12**			

Table 10: Average individual contributions and reactions to the inequalizing redistribution (treatment IE)

Subjects	Endowments before the redistribution	Mean	Mean of Periods 1-10 (a)	Mean of Periods 11-20 (b)	(b)-(a)	Nash reaction	Over(+)/ Under(-) reaction
1	15	10.00	8.3	11.7	3.4	5	-1.6
2	15	5.55	3.9	7.2	3.3	5	-1.7
3	15	8.25	8.0	8.5	0.5	5	-4.5
4	15	4.15	2.4	5.9	3.5	5	-1.5
5	15	4.90	2.1	7.7	5.6	5	0.6
6	15	9.55	5.5	13.6	8.1	5	3.1
7	15	5.40	4.0	6.8	2.8	5	-2.2
8	15	5.05	4.2	5.9	1.7	5	-3.3
9	15	7.60	6.1	9.1	3.0	5	-2.0
10	15	5.95	4.9	7.0	2.1	5	-2.9
11	15	14.50	15.0	14.0	-1.0	5	-6.0
12	15	9.25	10.8	7.7	-3.1	5	-8.1
13	15	9.65	9.2	10.1	0.9	5	-4.1
14	15	4.30	2.0	6.6	4.6	5	-0.4
15	15	9.40	8.2	10.6	2.4	5	-2.6
16	15	8.85	6.3	11.4	5.1	5	0.1
17	25	2.95	5.5	0.4	-5.1	-5	0.1
18	25	12.05	13.9	10.2	-3.7	-5	-1.3
19	25	6.50	7.0	6.0	-1.0	-5	-4.0
20	25	3.40	5.1	1.7	-3.4	-5	-1.6
21	25	11.65	13.7	9.6	-4.1	-5	-0.9
22	25	9.10	11.5	6.7	-4.8	-5	-0.2
23	25	8.45	11.3	5.6	-5.7	-5	0.7
24	25	3.45	5.0	1.9	-3.1	-5	-1.9
25	25	19.15	18.4	19.9	1.5	-5	-6.5
26	25	9.65	11.8	7.5	-4.3	-5	-0.7
27	25	16.35	17.2	15.5	-1.7	-5	-3.3
28	25	11.45	13.2	9.7	-3.5	-5	-1.5
29	25	2.60	3.3	1.9	-1.4	-5	-3.6
30	25	9.10	11.1	7.1	-4.0	-5	-1.0
31	25	16.15	22.4	9.9	-12.5	-5	7.5
32	25	6.75	8.0	5.5	-2.5	-5	-2.5
Mean:		**8.47**	**8.73**	**8.22**			

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[1] La liste intégrale des Documents de Travail du LAMETA parus depuis 1997 est disponible sur le site internet : http://www.lameta.univ-montp1.fr

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