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SCIENCE DIRECT
European Economic Review 50 (2006) 1197–1222
EUROPEAN ECONOMIC REVIEW
www.elsevier.com/locate/eer

Inequality, cooperation, and growth: An experimental study

Abdolkarim Sadrieh[a], Harrie A.A. Verbon[b,*]

[a]*University of Magdeburg, Magdeburg, Germany*
[b]*Department of Economics, Tilburg University, P.O. Box 90153, 5000 LE Tilburg, The Netherlands*

Received 16 April 2003; accepted 13 January 2005
Available online 28 April 2005

Abstract

In a three player dynamic public goods experiment, social output today determines production possibilities tomorrow. In each period, players choose to sabotage, to cooperate, or to play best response. Sabotage harms social output and growth. Mutual cooperation maximises both. The property rights to social output are distributed unequally. Extent and skew of inequality are varied. We observe equilibrium play in most cases. There is also substantial cooperation, but little sabotage. Our exogenous variations of inequality are neutral to growth, neither negatively correlated to cooperation, nor positively correlated to sabotage. The neutrality result is shown to be sensitive to the dynamic nature of the employed game.

JEL classification: C91; H55

Keywords: Dynamic public goods; Inequality; Reciprocity; Growth

1. Introduction

An issue that has received widespread attention in the literature is the effect that inequality may have on the individual willingness to cooperate with others. The

*Corresponding author. Tel.: +31 13 4662878; fax: +31 134663042.
E-mail addresses: h.a.a.verbon@uvt.nl, verbon@uvt.nl (H.A.A. Verbon).

0014-2921/$ - see front matter
doi:10.1016/j.euroecorev.2005.01.009

importance of this is well acknowledged as it implies that income inequality can negatively affect the growth rate of an economy, if we assume that the social product depends (at least to some extent) on cooperation in the society, e.g. on voluntary (non-contractable) individual contributions of effort. In fact, there is some evidence indicating that low levels of cooperative attitudes in a society are correlated to high levels of inequality and low levels of growth (Knack and Keefer, 1997; Zak and Knack, 2001).

The notion that inequality can impede growth for behavioural or political reasons has been subject to a number of theoretical studies. Persson and Tabellini (1994), e.g., argue that increased income inequality leads to an increased re-allocation of resources from production into distributive conflicts. Alesina and Rodrik (1994) use an endogenous growth model, in which productive government-provided services are financed by a tax on capital income, to show that poor individuals with a high labour income ratio prefer a tax rate above the growth maximising rate.[1]

The empirical studies so far provide interesting, but mixed results concerning the effect of inequality on growth (see Forbes, 2000). Moreover, since all empirical studies are based on macroeconomic data, they can only offer rather coarse tests of the theoretically derived propositions that are based on microeconomic hypotheses concerning individual decisions and preferences (see Aghion et al., 1999; Zweimüller, 2000, for overviews). For this reason it seems to us that the method of economic experimentation, which allows a controlled variation of income inequality, complements the macro data analysis and the micro based theory, giving a better insight into the actual motives driving individual behaviour.

In this paper, we present an experimental study of individual behaviour under controlled variation of inequality that is aimed at understanding the connection between inequality, cooperation, and growth in a dynamic context. In our model, all payoffs are derived from a *social production* function (i.e. we concentrate on the part of the economic activity that requires the cooperation of all individuals). We create inequality in our experimental society by letting some individuals (the ‘‘poor’’) have a smaller share of the property rights to the social output than other individuals (the ‘‘rich’’). Since the provision of effort to the production process is voluntary but costly and since the production frontier depends on capital accumulation, we effectively have a dynamic public good game with voluntary contributions. Note that the individual effort decisions in our model are basically savings decisions, because, as providing efforts today is costly, it leads to lower current consumption, but providing productive efforts enlarges the capital stock tomorrow.[2]

[1]Some studies have cited economic reasons for a negative inequality–growth relation. For instance, in Glomm and Ravikumar (1994), diminishing returns on private capital imply that a more equal distribution of capital across households will lead to a higher aggregate capital stock in the future. In Aghion and Bolton (1997), a mean preserving redistribution of capital towards the poor households removes the credit constraint for some, leading to an increase in the aggregate capital stock.

[2]In this sense our model is both comparable to models of endogenous growth with a productive public good such as those of Alesina and Rodrik (1994) and Glomm and Ravikumar (1994), and to models with voluntary contributions to public goods such as those of Bergstrom et al. (1986), and Glomm and Lagunoff (1999). However, our model does not explicitly include a public good, but the individual efforts of individuals imply strong externalities.

In the basic set-up of our experiment, we examine a 3-player version of the game with four different inequality settings.[3] The degree of inequality is varied on two levels (*low inequality* with a Gini-coefficient of 0.10, *high inequality* with a Gini-coefficient of 0.25), and the skew of the income distribution is varied on two levels (*left-skewed* with 2 poor and 1 rich and *right-skewed* with 1 poor and 2 rich). In each of the five periods of the game, subjects can choose one of three actions: *Sabotage*, *Nash*, or *cooperation*. The strategy combination consisting of Nash action choices by all players in all periods is the sub-game perfect equilibrium of the dynamic game (and thus, also the sub-game perfect equilibrium at any stage in the game). The sabotage action is strictly payoff dominated by the Nash action at any point of the game. Nevertheless, the sabotage action may be attractive to some subjects, because it reduces the payoffs of all players to below equilibrium levels and, thus, reduces the degree of income inequality.[4] The cooperation action is also costly, but—in contrast to sabotage—it increases the payoffs of the others. As in a prisoner's dilemma game, choosing the cooperation action may be attractive to subjects, because the highest payoffs are achieved when all players cooperate in all rounds.

Our experiment is designed to examine whether the extent of cooperation and, hence, the rate of growth vary with the degree or the skew of inequality in our experimental economies. If we observe increased voluntary effort contributions as inequality is increased, we can conclude that inequality is growth enhancing, due to a positive interaction with the provision of productive effort. The reversed conclusion holds, if inequality implies lower individual efforts. By this exercise we are not implying that voluntary contributions to the public output is *the only* factor that determines economic growth in the real world. Economic growth is a complex phenomenon that has many determinants. Our paper can contribute only to the analysis of a single one of these determinants, namely the voluntary provision of socially productive efforts. There are several "real world" examples of such growth-enhancing efforts. Educational investments in human capital constitute such an

[3]We chose to run a 3-player version of the game, because three is the smallest number of individuals with which the desired variations of the inequality setting can be realized. Experimenting with small groups has the advantage that it provides the best conditions for observing reciprocal behaviour, as is predicted by some of the behavioural theories that may apply to our game. In static voluntary contribution games, however, there is evidence that group size has no effect on behaviour as long as the marginal return per capita is not affected, i.e. as long as there is no congestion in the public good (Isaac and Walker, 1988).

[4]A number of experimental studies have shown that subjects are willing to incur a substantial loss, if necessary, in order to avoid a large income inequality. In ultimatum games, for example, responders reject up to 40% of the benefits of trade, just to avoid an *unfair* 40–60% division of the surplus. Although this type of rejection behaviour may be instrumental, in the sense that rejections are used to influence future behaviour of the players making unfair offers by "teaching them a lesson", Abbink et al. (2002) have shown that many subjects have a purely emotional motivation for rejecting unfair offers. The phenomenon that subjects are willing to pay a high price to reduce income inequality is not only observed in the ultimatum game, but also in other games (see e.g. Abbink et al., 2000; Bosman and van Winden, 2002). Moreover, Durham et al. (1998) experimentally show that if in a heterogeneous society individuals can invest their resources in non-productive fighting efforts, in order to get a higher share of total available produced income, inequality will have a negative on total output, since individuals "fight harder" (i.e. are less cooperative), when the resource endowments are unequal.

example, because the individual investments increase social output. Similarly, increased on-the-job effort can lead to increased economic productivity.

The model we employ in our experiments is related to the models of Warr (1983) and of Bergstrom et al. (1986). In those models, like in ours, when the voluntary contributions to the public good are positive in equilibrium, then redistributions of wealth among contributing households leaves the total equilibrium amount of individual contributions unchanged.

There is some experimental evidence on the effect of mean preserving redistributions on voluntary contributions in static public goods games. Chan et al. (1996, 1999) employ experiments to examine whether the neutrality property of income redistribution holds.[5] They conclude that the Nash equilibrium of the game ‘‘on average’’ cannot be rejected as descriptive of the observed behaviour. Yet, they find a small but positive effect of inequality on voluntary contributions to public goods (especially by the ‘‘poor’’).[6]

There is a large body of empirical and experimental research showing that fairness motives may govern economic decisions in the presence of income inequality. These findings have resulted in a number of new theories that propose utility functions incorporating fairness motives. There are two main types of fairness utility theories. The *distributional justice* theories (Akerlof, 1982; Akerlof and Yellen, 1990; Bolton, 1991; Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000) assume that people are interested in equity when comparing their own payoff to that of others. In our setting, these models predict that the poor, who own the rights to only a small (perhaps *unfairly* small) fraction of the total income, may choose to sabotage the social production in order to equalise payoff opportunities. At the same time, these models predict that the rich may be willing to reduce inequality by providing more voluntary effort than in the purely money maximising Nash equilibrium. Although both types of action are predicted to be more frequent with inequality, their implications are contrary: While sabotage reduces growth (implying a negative correlation between inequality and growth), cooperation increases growth (implying a positive correlation between inequality and growth).

The models of *reciprocal behaviour* (Rabin, 1993; Dufwenberg and Kirchsteiger, 2004), on the other hand, are based on the idea that cooperation takes the form of *tit-for-tat* behaviour, rewarding cooperative and punishing non-cooperative actions. Thus, a high provision of effort by one side is assumed to induce more cooperation by the other side, while a low effort choice is assumed to induce sabotage. These theories, however, are silent on the question in which way inequality affects the prevalence of positive reciprocal cycles that lead to sustained cooperation.

We find that most choices correspond to Nash equilibrium behaviour. Those choices that are out of equilibrium are significantly more often cooperation than

[5]There are very few theoretical models where in a dynamic setting voluntary contributions finance a public good. Glomm and Lagunoff (1999) consider the individual location decision when there is a choice between a country where public goods are provided by individual and voluntary decisions and a country where public goods are provided by the government, financed by a compulsory tax.

[6]The same results were found by Cardenas et al. (2002) in the context of the exploitation of a common resource, and by Buckley and Croson (2003) in a static linear public-good game.

sabotage. This is true both for the poor and the rich players, although the poor exhibit significantly more variance in their behaviour. Overall, average behaviour is more cooperative and average growth is stronger than in equilibrium. But surprisingly, neither the degree of inequality, nor the skew of the distribution have a significant effect on cooperative behaviour or growth. Moreover, we find no evidence for reciprocal behaviour.[7]

To infer more clearly the effects of inequality and dynamics in our model we implemented a variant with *very high inequality*, i.e. a Gini-coefficient of 0.50, and a static variant of our model. Extreme inequality does not appear to affect the probability of cooperation, but has a significant negative effect on the probability of sabotage. The static variant reproduces the role played by distributional justice that has been established in many static repeated experiments with voluntary contributions. In other words, the dynamics in our model is crucial for the generation of our 'neutrality' results.

In the next section we present the model and discuss some of the theoretical implications. In Section 3, we describe the experimental parameterisation and, in Section 4, the experimental procedures. Section 5 contains the results of our main experiment. Section 6 describes the procedures and results of the very high inequality treatment. Section 7 reports the results of the control experiment with the static repeated game and Section 8 concludes.

2. The model

We assume there are n individuals $i = 1, \ldots, n$ with exogenously given capital endowments, $\omega_i > 0$. All capital is productive and returns are distributed proportionally to capital endowments (i.e. the endowments are ownership rights to society's production). The social production function $f(\omega, e)$ combines the capital with the efforts e_i that are exerted by the individuals $i = 1, \ldots, n$:

$$f(\omega, e) = \ln\left(1 + \sum_{j=1}^{n} e_j\right) \sum_{j=1}^{n} \omega_j. \tag{1}$$

Effort can be interpreted as the time or attention an individual contributes to the production process. The sum of all individual efforts generates a monetary return on the invested capital. All individual's efforts are perfect substitutes in generating returns on capital, i.e. the marginal productivity of effort is the same for every individual. The individual's effort involves a cost (e.g. a decrease in utility due to the loss of leisure) that is borne by the individual himself. The payoff of individual i is equal to his share $\omega_i / \sum \omega$ of the total production:

$$\pi_i = \left(\omega_i \Big/ \sum_{j=1}^{n} \omega_j\right) f(\omega, e) - \beta e_i^2 = \ln\left(1 + \sum_{j=1}^{n} e_j\right) \omega_i - \beta e_i^2, \tag{2}$$

[7]There is some evidence for a "teaching" effect, however. In some cases, the choice of sabotage by poor is rewarded with cooperative responses of the rich, which make sabotage mildly profitable to the poor.

where $e_j \geqslant 0$, $j = 1, ..., n$, are the individual effort choices. Notice that the individual effort choices have the character of voluntary contributions to a public good: All members of the society gain from effort contributions towards generating a return on the endowment, but the cost incurs only to the individual exerting the effort. Moreover, if no individual contributes to the generation of a return on investment (i.e. $e_j = 0$, $j = 1, ..., n$) everyone's gross and net return will be zero. It can readily be calculated that for given contributions e_j by the other individuals the optimal effort for individual i will be given by

$$e_i\left(1+\sum_{j=i}^{n} e_j\right) - \frac{1}{2\beta}\omega_i = 0. \tag{3}$$

The reaction function of individual i can be obtained from the first-order condition[8] (3) as

$$e_i = -\frac{1}{2}\left(1+\sum_{j\neq i} e_j\right) + \frac{1}{2}\sqrt{\left(1+\sum_{j\neq i} e_j\right)^2 + \frac{2}{\beta}\,\omega_i}. \tag{4}$$

Two things are worth mentioning at the outset. First, according to Eq. (4), it will always be optimal to contribute towards the public good, i.e. $e_i > 0$, irrespective of the contributions by the others.[9] Thus, the Nash equilibrium will not be at a corner of the action space of e_j, $j = 1, ..., n$. Second, from Eq. (3) we find that in equilibrium $e_i/\omega_i = e_j/\omega_j$ always holds. Thus, the contribution to the public good will be some fixed proportion of any given endowment. In this sense, the "neutrality" result of Warr (1983) holds in our model.

Using the fact that all contributions are in the same fixed ratio to the capital endowment, we can easily calculate the Nash equilibrium strategy of player i:

$$e_i^N = -\frac{\omega_i}{2\sum_{j=i}^{n}\omega_j} + \frac{\omega_i}{2\sum_{j=i}^{n}\omega_j}\sqrt{1+\frac{2\sum_{j=i}^{n}\omega_j}{\beta}}. \tag{5}$$

A cooperative solution of the game can be obtained by maximising the sum of the individual payoffs, i.e. $\max(\Omega = \sum \pi_i)$, by using "collective effort" s as the policy instrument. Obviously, from a theoretical perspective, a unique distribution of the efforts among the individuals does not follow from this objective. It seems sensible, though, to assume that cooperating players will split the total effort in fixed proportions of the individual wealth. Thus, we assume that $e_i^C = s/\omega_i$. Differentiating Ω with respect to s then generates the cooperative solution:

$$e_i^C = -\frac{\omega_i}{2\sum_{j=i}^{n}\omega_j} + \frac{\omega_i}{2\sum_{j=i}^{n}\omega_j}\sqrt{1+\frac{2\left(\sum_{j=i}^{n}\omega_j\right)^3}{\beta\sum_{j=i}^{n}\omega_j^2}}. \tag{6}$$

[8]The second-order condition is $-1/(1+\sum_{j=1}^{n} e_j) - 2\beta \leqslant 0$ for all $e_i \geqslant 0$ and $\beta \geqslant 0$.

[9]This holds provided that participation constraint is not binding, i.e. that Eq. (2) generates a positive payoff. For our parameterisations of the model the implementation of Eq. (4) implied positive payoffs, irrespective of the others' effort choices.

Apparently, the only difference between the non-cooperative and the cooperative case is that in the latter case under the square root the term $\sum_j \omega_j$ is replaced by $(\sum_j \omega_j)^3/\sum_j \omega_j^2$. It is easy to see that the latter term is always larger than the former term. This, of course, is due to the fact that the positive external effects of contributions on other individuals' net returns are accounted for. As a result, $e_i^C > e_i^N$ will obviously hold.

We now introduce dynamic considerations by assuming that capital for the next period equals the current capital plus the obtained net returns, defined by Eq. (2). Introducing a time index as superscript, the capital in period $t+1$ is $\omega_i^{t+1} = (\pi_i^t + \omega_i^t)/(1+\rho)$ where ρ is a discount rate. We examine a finite-horizon model with T periods. Each individual i maximises the sum of the instantaneous payoffs $\sum_{t=1}^{T} \omega_i^t$, where ω_i^1 is the exogenous initial capital endowment.

Because we have a finite horizon dynamic game and not simply a finite supergame (i.e. a finitely repeated stage game), it is not straightforward that playing the stage game equilibrium (5) in all periods is an equilibrium of the dynamic game. Under some circumstances a "cooperative phase" in the first few periods may be part of the equilibrium strategies. Especially when the discount rate is low, the marginal benefit of early capital accumulation may be greater than the marginal cost of providing high effort for some periods. When there are no discontinuities, the equilibrium strategies of the dynamic game can at most have one such cooperative phase and this cooperative phase must start in the first period and end before the last period. We will come back to this issue at the end of the next section, once we have presented the specific implementation of the game that we use in the experiment.

3. Experimental conditions in the main experiment

We start by describing the experimental conditions in our main experiment. The additional treatments that we ran are discussed later in Sections 7 and 8. The main experiment consisted of four experimental conditions that differed in the distribution of the players' endowments. As can be seen in Table 1, there were 3 players in every treatment with a total endowment of 300. In two treatments, 2P10 and 2P25, there were two "poor" players and one "rich", while the opposite was true in the other two treatments, 1P10 and 1P25. Moreover, the Gini-coefficient of the distribution of endowments was varied across treatments, with the treatments 2P10 and 1P10 each having a Gini-coefficient of 0.10 and the treatments 2P25 and 1P25 each having a Gini-coefficient of 0.25. By varying across the degree of inequality and the skew of the income distribution, we have tried to span a relatively large range of social environments with our four treatments.

In all treatments, a five period version of the dynamic public goods game was played. In each of the five periods, players first chose their effort levels and then received feedback on all choices and the capital development in their game. Then, the next period began. After the last period had been completed, subjects received their accumulated capital (including the endowment) as payoffs. The cost parameter was set to one, i.e. $\beta = 1$, and the discount factor was set to $\rho = 2.4$ in all treatments.

Table 1
Experimental treatments

Treatment name	Endowments (ω_i)				Number of poor	Gini-coefficient
	Player 1	Player 2	Player 3	Total		
1P10	80	110	110	300	1	0.10
1P25	50	125	125	300	1	0.25
2P10	90	90	120	300	2	0.10
2P25	75	75	150	300	2	0.25

To make the game more easily accessible for the subjects, the set of actions was restricted to only three possible effort levels: *Low* (L), *medium* (M), and *high* (H). The low effort level L is the lowest possible non-zero effort, $e = 1$. Choosing L corresponds to *sabotage*, because it entails the costly destruction of the public good, harming not only one-self, but also all others. Note, that the sabotage action L is a dominated strategy. No matter what action the others choose, the monetary payoff of choosing sabotage is always smaller than that of choosing a different strategy. This is not only true for the payoffs in each stage of the game, but also for the total payoff in the five period dynamic game. However, the structure of the payoffs makes the cost of sabotage smaller for the poor than for the rich.

The medium effort level M is the *Nash* equilibrium effort of the "stage game", as in Eq. (5). This action is *selfish* in the sense that it maximises own monetary payoffs, under the assumption that all other players are also selfish. The high effort level H is the *cooperative* effort that maximises joint profits, as in Eq. (6). Since the game is a social dilemma, payoffs in cooperation are strictly better for all players, but cannot be sustained in a non-cooperative equilibrium. Note that choosing the Nash effort level M in all five periods of the dynamic game constitutes the Nash equilibrium of the dynamic game in our four treatments. In one treatment 1P25, however, there is also a second equilibrium in which the rich always choose the Nash action M, while the poor choose cooperate H in the first period and M in the remaining four periods of the game. We will later notice, that the observed frequencies both of the cooperative and of the sabotage action choices by the poor are especially high in this treatment.

4. Experimental procedure

All sessions of the experiment took place in CentERlab, the computerised economics laboratory of the Center for Economic Research, at Tilburg University in The Netherlands. The subjects were student volunteers that were recruited in classes and on campus. Most of the subjects were first year students of economics and business. Amongst other majors were law and social sciences. Upon entering the laboratory, the subjects were randomly assigned cubicles in which they were seated. The written instructions (included in Appendix) were passed out and read aloud. Questions were answered in private at the cubicle.

The experiment software was written using RatImage (Abbink and Sadrieh, 1995). On screen, each subject's own data was presented in the first position (in red colour). The data on the other two subjects, called "Green" and "Blue," followed in the next columns (see the screen shot in Appendix). Obviously, within a multi-period game, the positions were fixed, so that actions could be attached to player roles unambiguously. Note, however, that the information on which particular subject played which role was never disclosed.

By typing in hypothetical future choices both for themselves and for the other two players, subjects could use the software to "look forward" through all five periods of the dynamic game. It was explained to them that the hypothetical future choices they typed in were not made known to the other subjects (i.e. no signalling was possible) and had no effect on the actual choices made in later periods (i.e. choices were made sequentially as the experiment proceeded). To avoid anchoring subjects' decisions and beliefs, the software was configured in a way that none of the hypothetical choices was pre-selected at the start.

No explicit time limit was given to subjects. However, since subjects had signed up for an experiment with a duration of about 2 hours, they (correctly) perceived the decision time as being limited. In all but one session the subjects managed to complete the four repetitions of the dynamic game that had been planned. Only the session using the treatment 2P10 had to be stopped after the end of the third play of the dynamic game, because the announced experiment time had elapsed. All other sessions took about 90–120 minutes to complete. Payments to the subjects ranged from 12 to 28 Euros with an average of about 20 Euros.

In total 93 subjects participated in the experiment. Since the dynamic game was played more than once, a random rematch of the subjects at the end of each run was necessary. To allow for as many independent observations as possible, the subjects present at a session were divided into cohorts of six. Because all re-matching took place within these cohorts, contagion across cohorts was not possible. Unfortunately, in some sessions not enough subjects showed up to allow for this matching scheme to work perfectly. In these cases, an additional smaller cohort of three subjects was formed in which no re-matching took place. (The number of subjects in all sessions was a multiple of three.) However, it should be noted that subjects were not aware of these details of the matching scheme. They were only told that they will be randomly matched to other subjects in the session. Hence, the subjects both in the re-matched and in the fixed cohorts thought that they are being randomly re-matched. In analysing the data, we have nevertheless checked for possible effects of the small cohorts. No significant differences were found. Thus, we do not report results conditioned on this parameter.

Table 2 summarises the treatment information on subjects, independent observations, and repetitions. The statistical tests that are presented in the next section generally use data on the level of the independent observations.

Table 2
Subjects and observations

	Treatment				
	1P10	1P25	2P10	2P25	Total
Subjects	21	30	18	24	93
Independent observations	4	5	3	5	17
Plays of the dynamic game	4	4	3	4	

5. Results

Table 3 contains our data, aggregated on the level of independent observations and presented as deviations from equilibrium predictions. The first two columns specify the treatment parameters of the observation, i.e. the number of poor and the Gini-coefficient. For each independent cohort, the columns three to five indicate the average action chosen by the poor, the rich, and in total. (Note that for the data analysis the action choices are coded as follows: $sabotage = -1$, $Nash = 0$, $cooperation = 1$. Actual choices were discrete on the three levels, but taking averages leads to non-integer values.) Columns six to eight display the average deviations of observed accumulated capital from the accumulated capital expected in equilibrium. Column nine contains the deviation of the observed from the expected Gini-coefficient. Finally, the last three columns of Table 3, display the average deviation of the observed from the expected growth rates.

Our first important result is that on average total contribution to the public good is above equilibrium. There is only one of seventeen cases in which the average choice of the rich is sabotage and the ratio is four of 17 even for the poor. In total, there are only two cases with an overall negative average action choice, i.e. cases in which slightly more sabotage actions were chosen than cooperative actions. The distribution of action choices shown in Figs. 1a and b indicate that most subjects simply choose the Nash equilibrium action in all treatments. The second most frequent choice in all treatments is the cooperative action. The frequency of cooperative choices ranges from about 35% to about 10% of all choices, depending on the treatment and the player type. Finally, the sabotage action is clearly the one chosen least. In fact, applying the binomial test to the data on the level of independent observations we can reject the null hypothesis that action choices are equally likely to be below or above equilibrium level in favour of the alternative hypothesis that cooperative action choices are more likely. (The binomial test returns a probability of $p = 0.006$, one-tailed, when testing for the rich and $p = 0.071$, one-tailed, testing for the poor.)

Observation 1. Most action choices correspond to the Nash equilibrium strategies. But, when deviating from the equilibrium, subjects exhibit a significant tendency towards cooperation.

Table 3
Deviations of observed variables from equilibrium predictions (data aggregated on the level of independent observations)

Number of poor	Gini of endowments	Mean difference observed to equilibrium action[a]			Mean difference observed to equilibrium capital			Mean obs−eq Gini	Mean difference observed to equilibrium growth		
		Poor	Rich	Total	Poor	Rich	Total		Poor	Rich	Total
1	0.10	0.00	0.05	0.03	2.05	−16.16	−10.09	0.01	−0.15	−0.55	−0.44
1	0.10	−0.25	0.34	0.14	54.83	−3.65	15.84	−0.02	1.71	−0.12	0.37
1	0.10	0.30	0.03	0.12	−7.08	15.75	8.14	0.02	−0.40	0.22	0.06
1	0.10	0.25	0.40	0.35	81.95	58.88	66.57	−0.01	2.60	1.43	1.74
1	0.25	−0.10	0.03	−0.02	−3.15	−4.95	−4.35	0.00	−0.26	−0.18	−0.19
1	0.25	0.58	0.00	0.19	−12.20	10.08	2.65	0.03	−0.64	0.20	0.06
1	0.25	0.18	0.06	0.10	3.80	17.74	13.09	0.01	0.18	0.40	0.36
1	0.25	−0.08	0.16	0.08	21.58	5.03	10.54	0.00	1.06	0.08	0.24
1	0.25	0.43	0.08	0.19	7.75	32.99	24.57	0.02	0.32	0.60	0.55
2	0.10	0.08	−0.20	−0.01	−37.83	−11.30	−28.99	0.03	−1.13	−0.36	−0.82
2	0.10	0.08	0.27	0.15	24.97	−6.83	14.37	−0.01	0.68	0.00	0.40
2	0.10	0.23	0.03	0.17	−0.32	36.07	11.81	0.03	0.03	0.82	0.34
2	0.25	0.08	0.23	0.13	18.79	−5.45	10.71	−0.01	0.72	−0.11	0.30
2	0.25	0.13	0.00	0.08	5.41	30.88	13.90	0.02	0.20	0.50	0.35
2	0.25	−0.06	0.23	0.03	7.95	−42.33	−8.81	−0.02	0.07	−0.77	−0.35
2	0.25	0.33	0.65	0.43	73.83	13.90	53.85	−0.04	2.59	0.22	1.40
2	0.25	0.05	0.10	0.07	16.83	5.80	13.15	−0.01	0.54	0.15	0.35

[a]Action choices were coded: *sabotage* = –1, *Nash* = 0, *cooperation* = 1. Choices were discrete on those levels, but taking averages leads to non-integer values.

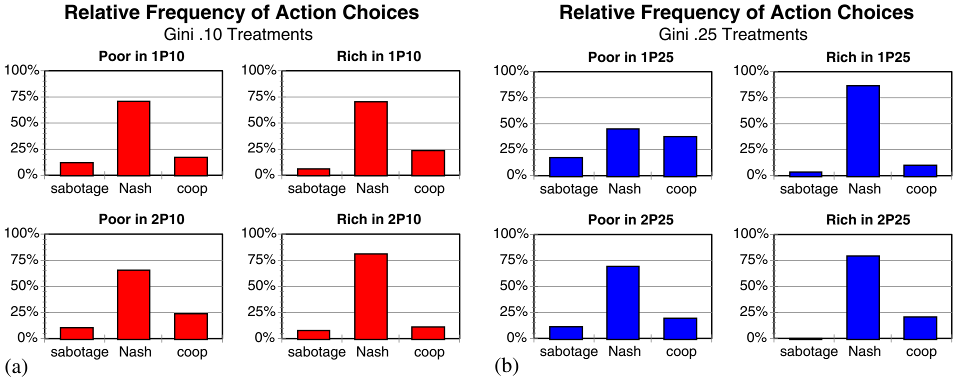

Fig. 1. Distribution of action choices.

Table 4
Decisions as a function of the inequality and time

	Cooperation action choice	Sabotage action choice
Constant	0.6751 (0.3725)[a]	0.2253 (0.4054)
Number of poor	−0.0086 (0.1720)	0.0012 (0.1643)
Gini-coefficient	−0.0057 (0.0123)	−0.0130 (0.0112)
Endowment	−0.0078 (0.0013)[b]	−0.0134 (0.0018)[b]
Round number	−0.0317 (0.0341)	−0.0768 (0.0435)[a]
Period number	−0.2431 (0.0272)[b]	−0.0120 (0.0329)
Number of observations	1770	1770
Number of groups	31	31
Log likelihood	−779.8538	−457.1783
χ^2	99.8	22.9

Probit coefficients are reported with standard errors in parentheses. The probits were run with group level random effects in order to account for the fact that the decisions within each group were not statistically independent. Excluding these random effects (or alternatively including subject fixed effects) does not lead to any substantially different results than reported here.

[a]Coefficient is weakly significant at the 10%-level.

[b]Coefficient is significant at levels below 0.1%.

Observation 1 is also supported by our regression results reported in Table 4. We ran two probit regressions to relate subjects' choices to the exogenous parameters of the game, i.e. the skew of the income distribution measured by the number of poor, the extent of inequality measured by the Gini-coefficient, the experience of subjects in play measured by the round number, the stage in the dynamic game measured by the period number, and the initial wealth of players measured by their endowments. The regression summarised in the second column of Table 4 relates the choice of the cooperative action to the exogenous parameters, while the regression in the third column relates the choice of the sabotage action to those parameters. Since the constant term explaining cooperation action choices is significantly positive, while the constant term explaining sabotage action choices is not significantly different from zero, we conclude that Observation 1 is supported. There are significantly more cooperative action choices than there are sabotage action choices.

Table 4 also shows that neither cooperative nor sabotage action choices are significantly affected by the skew or the extent of inequality. That the action choice distributions are not very different across the treatments can also be visually verified in Figs. 1a and b. Note that there is only one obvious outlier amongst the histograms in that figure, namely the case of the poor in the treatment 1P25. These subjects clearly exhibit the highest frequency of extreme choices. Interestingly, the implementation of the dynamic game in this treatment has two equilibria, the "standard" case in which all players choose the Nash action in all periods and another one in which the rich always choose the Nash action, but the poor start off with a single period of cooperation, before switching and sticking to the Nash action. Although the observed behaviour is not at all in line with either equilibrium play, we can conjecture that the multiplicity of equilibria may be affecting the choices made by the poor.

Observation 2. In general, no significant differences can be found between the distributions of action choices across treatments. Neither the degree of inequality, nor the skew of the income distribution affect the action choices.

The regressions in Table 4, however, also reveal that being wealthy has a significant negative effect both on the cooperation action choice and on the sabotage action choice. The coefficient on endowment is negative and highly significant in both regressions. This means that the poor players choose both cooperation and sabotage actions more frequently than their rich counterparts. In other words, for the complete set of data the decisions of the poor are characterised by a higher volatility than the decisions of the rich. There is some inconclusive evidence, however, that the effect is stronger for the high inequality cases, in which the distance between the poor and the rich is substantial.[10]

Observation 3. The action choices of the poor are more volatile that those of the rich.

The observations above do not consider possible dynamic effects. Figs. 2a and b display the action choices over time for the poor and rich in the four treatments. The graphs clearly show that the pattern of behaviour in our dynamic public good game resembles the well known pattern of voluntary contributions in repeated static public good games: Subjects tend to start with above equilibrium contributions, which they reduce from period to period towards the end of the game. Note that in our dynamic context such behaviour can be "sensible," because early contributions have a higher growth leverage than late contributions, due to the longer duration in which they are effective. The significant negative coefficient of the period number in the cooperation

[10]Using the Mann–Whitney *U*-test to compare the variance of the choices of the poor versus the rich we receive a significant result only for the data of 1P25.

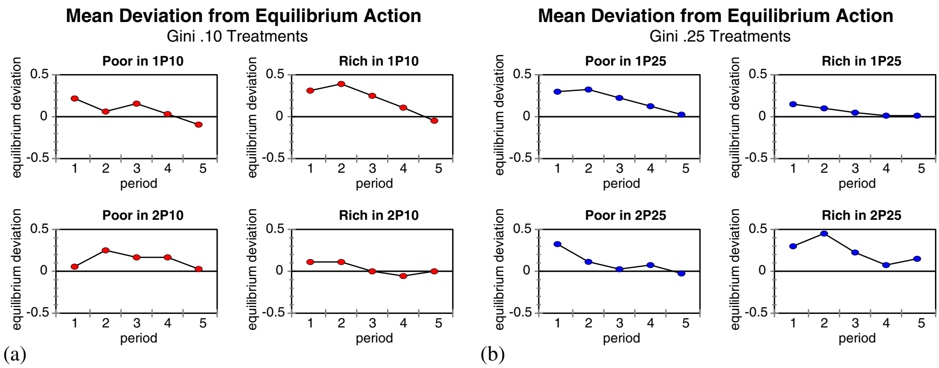

Fig. 2. Development of action choices over the five periods of the game.

probit (second column of Table 4) gives statistical power to the visual impression leading to the following observation:

Observation 4. Subjects in all treatments and in both roles tend to make more cooperative choices in the first periods of the dynamic game than in the last. This decline of contributions to the public good is well in line with the typical declining pattern of contributions found in repeated static public good games. Furthermore, the decline of contributions can be explained by the growth dynamics that provide a higher growth leverage to early cooperation than to late cooperation.

Since we observe a tendency for the poor to behave more volatile than the rich, it is not evident what the effect of the choices on the development of inequality will be. Remember that in our dynamic setting there is a trade-off between current private consumption (i.e. non-cooperative play) and "public saving" (i.e. cooperation). Hence, the degree of inequality will typically be affected by actions chosen. In fact, the Gini-coefficient is predicted to decline slightly in equilibrium for all our treatments.

Column 9 of Table 3 displays the average deviation of the observed Gini-coefficients from the equilibrium predictions. Due to the high prevalence of Nash choices, it is not surprising that the deviations are rather small. Furthermore, the volatile behaviour of the poor is also reflected in the high variation of signs in this column. We find a persistent effect only in the high inequality treatment with one poor (1P25), in which there is a significant tendency for observed inequality to increase over time (sign test at the 5%-level, one-tailed).

How does the action choice behaviour affect growth? There is no clear answer. In each of the four treatments the majority of the cohorts exhibits an overall growth rate that is higher than in equilibrium. However, we also observe at least one (but never more than two) cohort in every treatment exhibiting below equilibrium growth. Comparing the deviation of growth rates from equilibrium growth across treatments, we find no significant differences whatsoever. This is not surprising, since no significance difference was detected in the distribution of action choices either.

Observation 5. While growth rates in all treatments are on average above the rates expected in the non-cooperative equilibrium, a non-negligible number of cohorts falls short of that benchmark. No significant treatment differences in growth are observed. Neither the degree of inequality, nor the skew of the distribution seem to affect the growth of capital.

From the analysis so far it seems clear that issues of distributional justice do not play a prominent role in the decisions of subjects. If distributional justice would have played a role, then we should have observed very different action choices (leading to different growth rates) that depend on the degree of inequality and on the role of the subject. So if distributional issues do not play a role, does reciprocity? We checked whether there is a significant tendency for the poor to react cooperatively to previous cooperative choices of the rich and vice versa. There is no significant tendency of either side to react "kindly" to previous "kind" actions. We also checked for negative reciprocity and, again, found no evidence for a tendency to react with sabotage to "unkind" actions of others. Thus, we find no evidence for "parallel reactions," i.e. "kind" behaviour receiving "kind" responses and vice versa.

We do find some evidence for "teaching" behaviour, however. It seems that in some cases the sabotage action choices of the poor players actually lead to more cooperative action by the rich. Figs. 3a and b show the action to payoff relationships in each of the independent cohorts for the poor and the rich players. For the rich the action to payoff relationship is straightforward: The more cooperative the rich are, the higher their payoffs. Note, however, that this simple positive correlation is not true for the poor players. The graph in Fig. 3a clearly shows a dip in payoffs at the Nash equilibrium action—especially for the low inequality treatments 1P10 and 2P10. In these treatments playing Nash is the worst choice. Playing cooperative clearly yields higher payoffs. But, choosing the sabotage action also leads to higher payoffs than choosing Nash. It seems that the choice of sabotage action by the poor

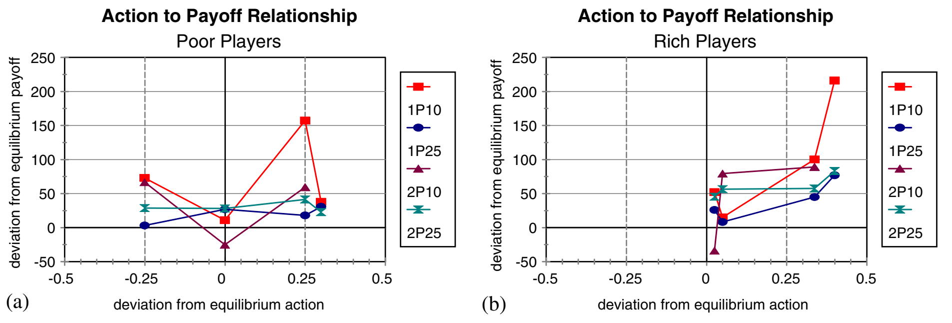

Fig. 3. Action to payoff relationships.

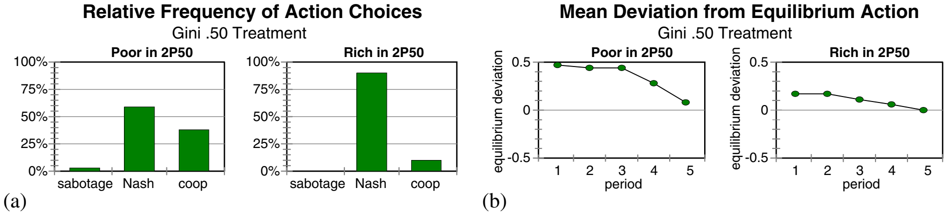

Fig. 4. Distribution and development of action choices in the Gini .50 treatment.

in these treatments "teaches" the rich to be more cooperative and, thus, enhances the payoff of the poor.

Observation 6. Reciprocal action is not observed in any treatment. Neither poor nor rich show a significant tendency to respond to "kindness" with cooperation or to "unkindness" with sabotage. However, in the low inequality treatments (1P10 and 2P10), we observe a tendency for the rich to respond cooperatively to sabotage by the poor. This "teaching" effect—on average—turns sabotage into a mildly profitable action choice for the poor.

6. Increasing the degree of inequality

One rather obvious criticism of our original experiment is that even the high inequality treatment exhibits a "moderate" Gini-coefficient of 0.25, while empirical studies reveal Gini-coefficients that range all the way up to 0.60 in some economies.[11] To address this issue, we ran an additional treatment, 2P50, with a Gini-coefficient of 0.50 in groups of two poor and one rich.[12] Each of the poor in this treatment was endowed with one-sixth of the property rights to the economic output, while the rich was endowed with the remaining two-thirds.

Figs. 4a and b show the results of this increased inequality treatment. Both the distribution of action choices and the development of the choices over the periods seem similar to what was observed in the original treatments. As in the other treatments, the most frequently chosen action is the Nash action, followed by the cooperative action. And, again as before, the poor display substantially more cooperative choices than the rich. However, there is one striking difference to the other treatments: The frequency of sabotage choices seems to be much lower in this very high inequality treatment.

The visual impression is confirmed by running a new set of probit regressions, now including the new data. The results of these regressions are contained in Table 5.

[11]Note that the Gini-coefficient actually underestimates the extent of inequality in small groups due to the rather "chunky" distributions of endowments. A Gini-coefficient of 0.25, for example, corresponds to having 37.5% of the maximum inequality that is possible in a group of 3 players.

[12]Since the other treatments had shown no skew-effects, we did without the corresponding one poor and two rich treatment. In fact, achieving a Gini-coefficient of 0.50 with that skew would have meant giving the poor subject an endowment of zero, which in our game makes little sense.

Table 5
Decisions as a function of the inequality and time—increased inequality

	Cooperation action choice	Sabotage action choice
Constant	0.5666 (0.3113)[a]	0.5327 (0.3679)
Number of poor	−0.0152 (0.1951)	−0.0508 (0.1637)
Gini-coefficient	−0.0045 (0.0066)	−0.0258 (0.0071)[b]
Endowment	−0.0079 (0.0010)[b]	−0.0134 (0.0019)[b]
Round number	−0.0397 (0.0326)	−0.0823 (0.0428)[a]
Period number	−0.2522 (0.0253)[b]	−0.0135 (0.0319)
Number of observations	2040	2040
Number of groups	37	37
Log likelihood	−906.2776	−484.7119
χ^2	128.89	26.3

Probit coefficients are reported with standard errors in parentheses. The probits were run with group level random effects in order to account for the fact that the decisions within each group were not statistically independent. Excluding these random effects (or alternatively including subject fixed effects) does not lead to any substantially different results than reported here.
[a]Coefficient is weakly significant at the 10%-level.
[b]Coefficient is significant at levels below 0.1%.

For the case of the cooperative choice, our additional very high inequality treatment 2P50 confirms the earlier results: There are significant negative effects of the endowment and of the period on the probability of cooperative play. The poor are significantly more cooperative than the rich and the cooperation of both parties falls as the end of the game comes closer. Most importantly, however, we still find no effect of the degree of inequality on cooperation.[13] Hence, our main result that the degree of inequality in our dynamic game setting has no substantial effect on the voluntary provision of effort to social output remains in tact.

Observation 7. Even after including an extreme case of inequality (with a Gini-coefficient of 0.50), no significant effect of the degree of inequality on the probability of cooperation in our dynamic game can be found.

The tendency to sabotage, however, seems to be affected by the degree of inequality. But, to our surprise, the regression results reported in Table 5 show that the effect is negative. This means that increasing inequality in our game setting actually reduces the probability of sabotage significantly. Note that the coefficient of the Gini parameter in the original probit without the new very high inequality treatment was also negative (see Table 4), but not significant. Hence, this effect seems to be systematic and not just due to an idiosyncratic feature of the new treatment.

Observation 8. After including an extreme case of inequality (with a Gini-coefficient of 0.50), the negative effect of the degree of inequality on the probability of sabotage,

[13]When running the probits separately for the poor and the rich the results basically remain unchanged, with the only exception that we find a weak tendency for the rich to cooperate less often when the number of poor is two instead of one.

which was also observed but not significant in the original treatments, turns out to be highly significant.

Admittedly, we can only speculate about the reasons for a negative correlation between the degree of inequality and the probability of sabotage. Our impression from the post-experimental discussions with our subjects is that choosing sabotage when there is a large amount of social tension, i.e. in the cases with the very high inequality, was regarded as "making a bad situation even worse". It seems that the higher the degree of inequality the more the subjects are aware of the need for "social truce" and cooperative actions. But, while they manage to enhance the former, they seem unable to increase cooperation.

7. Behaviour in a static repeated game

It is rather puzzling that issues of distributional justice play almost no role in the behaviour of our experimental subjects, while they have been reported to explain behaviour in other experimental settings well (see e.g. Fehr and Gächter, 2000). One possible reason for this discrepancy may be the fact that the we study behaviour in a dynamic game setting, while the experiments reporting a strong influence of inequity aversion have all focused on static one-shot or repeated games.[14] In this section, we present two additional treatments using a static repeated game version of our original model with two poor and Gini-coefficients of 0.10 and 0.25. These two new treatments, 2P10stat and 2P25stat, will help us distinguish the effect of growth dynamics on behaviour from the effects of other parameters.

In the original game, the players' endowments in each period—except the first—are equal to the accumulated and discounted capital stocks of the period before. This means that capital accumulation in these games follows a typical exponential growth function in equilibrium. The equilibria in the two new treatments 2P10stat and 2P25stat display linear growth paths, because in every period the players' endowments are reset to the initial values at the outset of period one. Hence, the games played in these two treatments are static repeated games, without a dynamic link across periods. This corresponds to the type of set-up often used in the experimental literature on distributional justice.

If the growth dynamics in our original treatments are acting as a constraint to cooperative behaviour, then our new static treatments should induce much more typical behaviour than we have observed so far. Figs. 5a and b display the distribution of action choices and the development of the average observed choices over time, correspondingly. Indeed, it seems rather evident that the frequency of cooperative action choices by the rich in the high inequality setting 2P25stat is greater than in the low inequality setting 2P10stat, just as models of distributional justice would predict. In contrast to what those models predict, however, the poor

[14] We thank an anonymous referee for pointing this out and suggesting the additional treatment we present in this section.

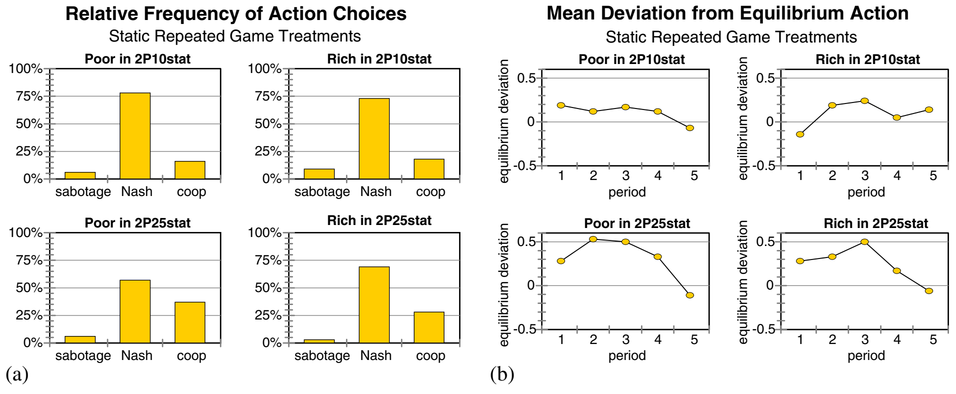

Fig. 5. Distribution and development of action choices in the static repeated game treatments.

also exhibit a higher frequency of cooperative choices in the high than in the low inequality treatment. Moreover, they choose the sabotage action less frequently, which means that there is a tendency for inequality to increase rather than decrease over time. Nevertheless, the increased tendency of subjects in the high inequality treatment towards cooperation can be interpreted as a mutual effort to increase cooperation and to reduce inequality.

The notion that the level of cooperation may be influenced by the degree of inequality is further supported by the pattern of cooperation across periods displayed in Fig. 5b. Both rich and poor subjects in the high inequality treatment start out at very high cooperation levels, only cutting back towards the end of the game. In contrast, the level of cooperation in the low inequality is rather low from the start, without a strong trend across periods.

The visual impression is statistically supported by the two probit regressions analysing the data from the static repeated game treatments, 2P10stat and 2P25stat. The results are summarised in Table 6. While we find no significant effect of the treatment parameters on the probability of choosing the sabotage action, we do find a strong positive effect of inequality and a strong negative effect of the period on the probability of making a cooperative choice. Hence, our static repeated game treatments seem to induce the type of inequality aversion and is often observed in experiments with voluntary contributions in static repeated settings.

Observation 9. In the static repeated game, cooperative actions are chosen significantly more often in the high than in the low inequality treatment and in earlier than in later periods. These game parameters have no significant effect on the probability of choosing the sabotage action.

Since we find that inequality affects cooperation in our static repeated game treatments, we should expect that it will also affect growth in this setting. In fact, a comparison of the two panels on the bottom row of Fig. 6 reveals that the average accumulation of capital in the high inequality treatment is above equilibrium to a

Table 6
Decisions as a function of the inequality and time—static repeated game

	Cooperation action choice	Sabotage action choice
Constant	−0.6983 (0.4217)[a]	−1.285 (0.5130)[a]
Number of poor	–	–
Gini-coefficient	0.0490 (0.0147)[b]	−0.0101 (0.0147)
Endowment	−0.0030 (0.0023)	−0.0015 (0.0035)
Round number	−0.0625 (0.0759)	−0.1023 (0.1037)
Period number	−0.1817 (0.0451)[b]	0.0643 (0.0584)
Number of observations	585	585
Number of groups	13	13
Log likelihood	−281.0698	−130.1287
χ^2	51.59	2.13

Probit coefficients are reported with standard errors in parentheses. The probits were run with group level random effects in order to account for the fact that the decisions within each group were not statistically independent. Excluding these random effects (or alternatively including subject fixed effects) does not lead to any substantially different results than reported here.

[a]Coefficient is weakly significant at the 10%-level.

[b]Coefficient is significant at levels below 0.1%.

much larger extent than in the low inequality setting. The difference is especially strong and striking in the first few periods, when the cooperation is especially high in the high inequality treatment. Despite the clear visual impression, we cannot provide a statistical underpinning, because of our rather small sample sizes in the static repeated game treatments.

8. Concluding remarks

We experimentally implemented a three-person dynamic game, where heterogeneous individuals, by voluntarily providing individually costly efforts, are able to contribute to the social product. Individuals can be poor or rich, dependent on their initial capital endowment, the size of which is linked to the property rights individuals have to total production. The game is dynamic as tomorrow's individual and societal capital stock is determined by the sum of the individual efforts today. Providing individual efforts affects the other persons' wealth positively, and so, in this sense the game has the characteristics of a dynamic public good game.

In equilibrium, both poor and rich players contribute positive efforts. Next to the equilibrium effort choice, the choice set of the players also contains a cooperative and a sabotage action. Cooperation leads to above equilibrium returns for all players, while sabotage reduces the own and the others' payoffs to below equilibrium levels.

The degree of inequality and the skew of the income distribution are our treatment variables. In the basic setting of our experiments, the degree of inequality can be *low*

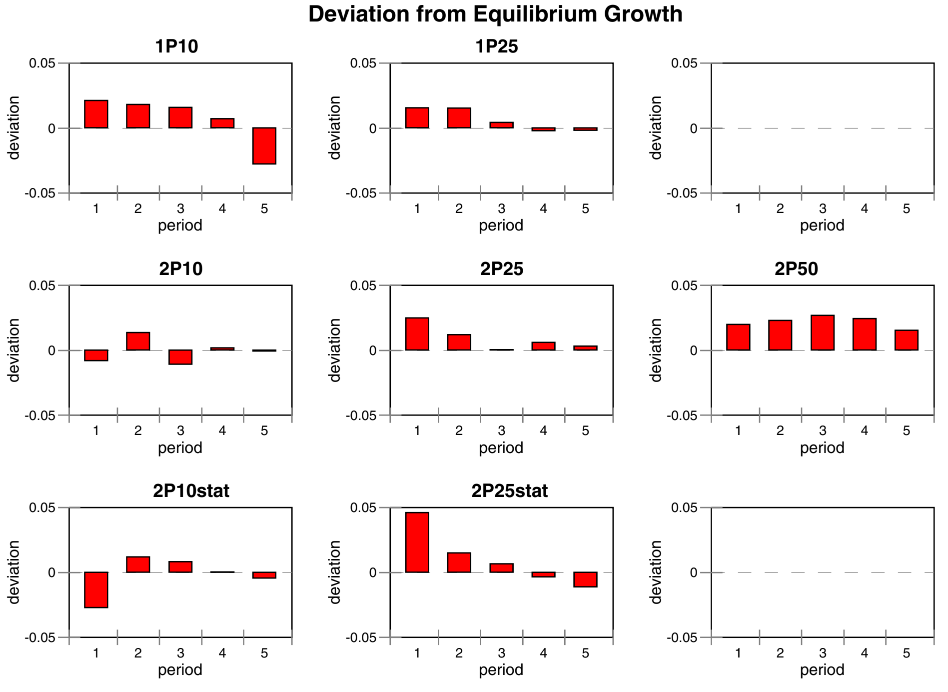

Fig. 6. Observed deviations from equilibrium growth.

with a Gini-coefficient of 0.10, and *high* with a Gini-coefficient of 0.25, and the income distribution can be *left-skewed* with 2 poor and 1 rich and *right-skewed* with 1 poor and 2 rich persons, respectively. Next to the basic setting, we implemented two additional control treatments. In the first control, inequality was *extreme* with a Gini-coefficient of 0.50 in a left-skewed distribution, which implied that the one rich person started with an initial endowment four times as large as the two poor persons. In the second control, we removed the dynamic link in the left-skewed distributions. Obviously, this enabled us to infer more precisely how the dynamic link in our basic setting affected the results.

We observe a substantial amount of cooperation in the basic treatments of our experiments, declining over the periods. As a result, there is significantly more growth than in the non-cooperative equilibrium. This is not very surprising, because such cooperative behaviour has frequently been observed in experiments. The really surprising finding is that the extent of additional growth caused by cooperative behaviour is neither affected by the degree nor by the skew of inequality. Hence, in our basic setting, inequality is neutral to growth, not because the players behave strictly as in the non-cooperative equilibrium, but because their propensity to cooperate is unaffected by inequality.

Comparing this behaviour with the behaviour in the control treatment without the dynamic link between periods, we observe that in the latter treatment inequality (i.e.

the Gini-coefficient) does have a significant positive effect on cooperation, which is in line with earlier studies. Apparently, once the game is enriched by a savings component (as in the basic setting of our experiment), the game dynamics seem to "crowd out" the subjects' fairness concerns.

In contrast to cooperation, sabotage behaviour shows no trend over the rounds in our basic setting. We find that the poor choose the sabotage action more frequently than the rich. Empirically, by choosing the sabotage action they can actually induce more cooperative play by the rich. This leads to above equilibrium payoffs for the poor indicating that the choice of the sabotage action is mainly instrumental.

We checked the robustness of this result by running the extreme inequality treatment, and found the surprising result that the poor mostly refrain from sabotage actions. Extreme inequality affects behaviour even under the dynamic link although subjects do not appear to be able to adequately correct for the inequality. The poor merely choose to destroy less of the potential growth of the capital stock as under less extreme conditions.

Altruism often takes the form of strong reciprocity where cooperative acts by others are rewarded, and violations of cooperative norms are sanctioned. Strong reciprocity, leading to cooperative outcomes, has been established to exist in a large number of well-structured experimental studies (Fehr and Fischbacher, 2003, provide an overview). Moreover, behaviour in the lab often appears to be driven by motives of distributional justice in one-shot or repeated static games. In our basic setting, however, though we found a substantial amount of cooperation among the subjects, we did not find significant evidence for strong or weak reciprocity, nor did we find a clear preference to reach distributional justice. What we carefully conclude from these results is that those motives have a lower probability of getting established in individual behaviour in more complicated dynamic settings. We believe that this is due to the fact that assessing a "fair" allocation is a much more difficult task in a dynamic game with wealth accumulation than in a static game.

It is of some interest to note here that in the context of intergenerational inequality an analogous neutrality result was found (see Van der Heijden et al., 1998). In an overlapping generations experiment the level and stability of an intergenerational transfer system was not furthered by the possibility of rewarding or punishing previous generations, although substantial levels of voluntary transfers could be observed. So this result confirms that dynamics makes it difficult for subjects to identify the nature of the behaviour by others and to assess the effect of their contribution on intragenerational or intergenerational inequality. As a result, subjects behave less in regard of the inequality parameters and the behaviour of others, than if they are engaged in static one-shot or repeated interactions.

Generalizing the results of our micro based experiment to the big macro issue of the explanation of economic growth unavoidably has to rest on some elements of speculation. Especially so because, as we emphasised earlier, we analyse only one single determinant of growth, namely voluntary social cooperation. What we can conclude, though, is that inequality per se is not the microeconomic driving force behind observed growth differences among countries. Instead it seems, that only extreme inequality can make the difference in a dynamic setting. In our experiments extreme inequality implies a lower willingness to destroy capital, especially by the poor. Apparently, the poor do not blame the rich for their own poverty. But, in other circumstances "evident" inequality may be considered to emerge from "unfair" circumstances (e.g. economic discrimination of a minority, or corruption by those in charge), and, therefore, negatively affect the poor willingness to contribute to the social good. The force of this argument should be tested experimentally, perhaps by conducting analogous experiments in societies in which the social history of inequality has been more strongly dominated by extreme forms of inequality, and by discrimination, corruption and segregation than in Western Europe. That will be subject to future research.

Appendix A

A.1. Instructions

This is an experiment on economic decision-making within groups over time. Each group consists of 3 participants, i.e. you are in a group with 2 others. A group remains together for 5 periods. In each period, each of the 3 group members makes exactly 1 decision. After the 5th period, the round ends and the groups are dissolved. For the next round of 5 periods new groups are formed randomly. (This means that the probability of having a former group member in your new group is positive but small.) After the 2nd round, again new groups are formed randomly. In total, you will participate in 4 such rounds, that means in 4 groups for 5 periods each.

At the beginning of a round, each group member has some amount of start capital. On your screen, you will see how much capital each of your group members (including yourself) has. The goal is to increase this capital as much as possible. The amount of capital you have after the 4th round is exchanged at the rate of Dfl 0.01 per point and paid to you in cash. The more capital you have at the end of the 5th period, the more money you will earn.

The development of your capital depends on your own decision and the decisions of the other members of your group. In each period, each group member can choose one of the three options: L ("low cost investment"), M ("medium cost investment"), or H ("high cost investment"). The decisions of all 3 group members influence the development of your capital. The table on the lower part of your screen shows for any possible constellation of decisions how much capital each member of your group will have after the 1st period. Once all 1st period decisions are made, a box will appear to mark the entry in the table that was actually reached. At the start of the 2nd period, the table changes and shows how much capital each member of your group will for any constellation of 2nd period choices. The same procedure applies to the 3rd, 4th and 5th periods.

Instead of just looking at the development possibilities for your capital (and for that of the others in your group) in the current period, you can also check the development possibilities up to the end of the round, i.e. until after the 5th period. To do so, you must first use the buttons on your screen labelled "L", "M", and "H" to enter the hypothetical decisions of yourself and of the others in your group for all the periods that have not passed yet. Next, you can use the buttons on your screen that are label "period 1" to "period 5" to choose the table that shows how much capital each group member will have after the corresponding period, if the corresponding decisions had actually been made. Please, take the time to study the effects of different choices on the development of capital carefully.

Generally, the higher the cost of your investment, the more the capital of all team members (including yourself) will grow. However, since you have to pay the entire cost of your own investment, the capital of the other group members will grow more than you own capital if you invest. This also means that if one of the other group members invests, your capital will grow more than the capital of the investor. Finally, note that the cost of investing more in some cases may be higher than the benefit, while the opposite is true in other cases.

Your own choices and capital are always displayed in red colour on screen. One of the other 2 members of your group is called "Green" and the other is called "Blue". Note that during any round, participant "Green" is always the same actual person and participant "Blue" is also always the same actual person (but a different person than participant "Green"). The actual persons behind these names change when a new round begins and new groups are formed randomly.

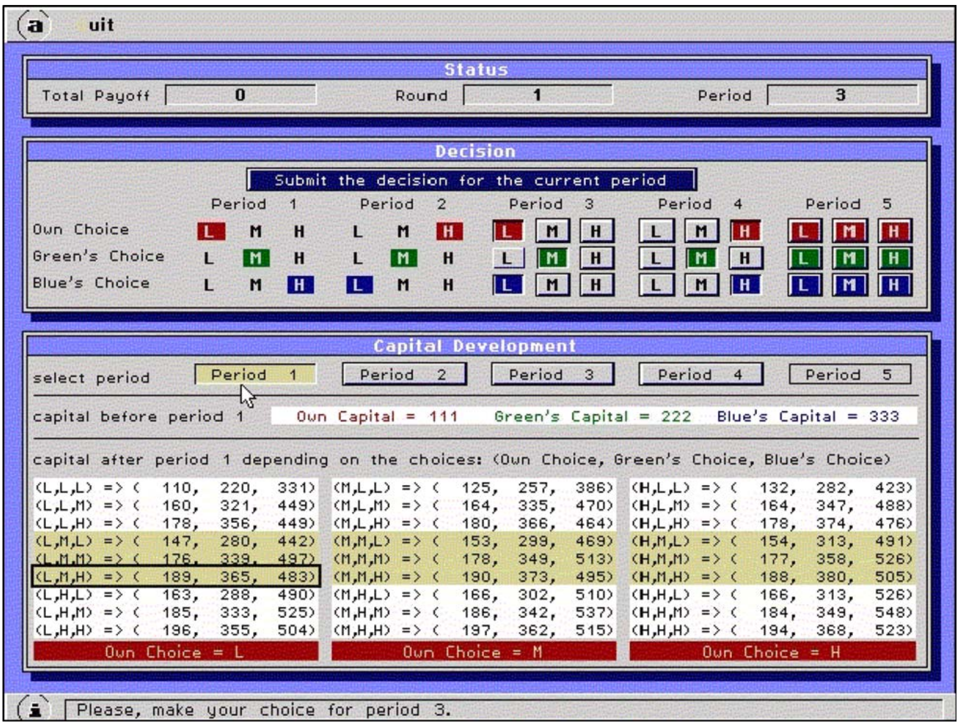

Fig. 7. Screenshot.

A.2. Decision interface (Screenshot)

The screenshot of the subject's decision interface. The presented game is fictitious. The players have the endowments 111, 222, and 333. The game is in round 3 (Fig. 7).

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