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Abstract

A new line of theoretical and empirical literature emphasizes the pivotal role of fair institutions for growth. We present a model, a laboratory experiment, and a simple cross-country regression supporting this view. We model an economy with an unequal distribution of property rights, in which individuals can free-ride or cooperate. Experimentally we observe a dramatic drop in cooperation (and growth), when inequality is increased by a self-serving dictator. No such effect is observed when the inequality is increased by a fair procedure. Our regression analysis provides basic macroeconomic support for the adverse growth effect of the interaction between the degree and the genesis of inequality. We conclude that economies giving equal opportunities to all are not likely to suffer retarded growth due to inequality in the way economies with self-serving dictators will.

JEL codes: C91, D60, K40, O40, P51

Keywords: inequality, corruption, weak institutions, growth, intentions, dynamic public goods

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1. Introduction

The growth of an economy depends – amongst other factors – also on the amount of effort that the individuals provide in the production and development processes. When individual effort contributions create positive externalities for the entire economy (e.g. through technological spillover, increased tax income, etc.), the added benefit typically is divided up according to the distribution of property rights in the economy. Since the provision of effort is costly and to some extent non-observable (or not easily verifiable), there is usually scope both for cooperative behavior that enhances economic output and for free-riding behavior that hampers it. If individuals in this framework condition their effort choices on social parameters – such as the level or the genesis of income inequality –, the societal configuration may have a significant impact on economic growth.

In fact, Knack and Keefer (1998) find empirical evidence for a negative correlation between income inequality and growth. They conjecture that inequality harms growth, because it impairs "social capital," i.e. trust in people and institutions.[1] Glaeser, Scheinkman, and Schliefer (2003), however, argue that inequality is not harmful for social capital *per se*, but only in connection with some form of "institutional weakness". They model a society with a weak legal system and show that inequality may substantially reduce the level of investments, because investors fear the expropriation of their expected returns by the rich who can bribe their way out of the prosecution by the corrupt courts. Hence, the combination of inequality and corruption impedes efficient investments, thus leading to low levels of economic growth.

[1] Although the cross-section studies provide empirical insights on the macro level, they are bound to leave questions concerning the microeconomic foundations unanswered. For a critical assessment of the cross-section analyses and an overview of possible channels of interaction between inequality and growth see Aghion, Caroli, and García-Peñalosa (1999) as well as Barro (2000).

This link between inequality, corruption, and growth finds support in the numerous surveys in which business people sound their concern for corruption and preferential treatment (Lambsdorff 2002).

Without contesting the link suggested by Glaeser et al. (2003), we propose another channel for the negative effect of the interaction of injustice and corruption on growth. Our idea is that the same level of inequality can affect cooperation behavior in different ways, depending on the circumstances under which it has historically emerged. When inequality is perceived as resulting from the unfair actions of a few powerful agents, the level of trust in the society deteriorates, free-riding increases and the willingness of individuals to cooperate declines. But, when inequality is perceived as resulting from a fair procedure (e.g. competition on free markets), we conjecture that trust and cooperation are unaffected. We take three steps to find evidence for our conjecture: We first introduce and analyze a dynamic game that captures the main features of the situation that we have in mind. Next, we report a laboratory experiment of that game, comparing the degree of cooperation in the case when inequality is a consequence of unfair actions to the opposite case. Finally, we run a few simple regression analyses of macro data in the search of some basic empirical support for our main hypothesis.

While close in spirit, there are two key differences between our approach and that of Glaeser et al. (2003). On the one hand, Glaeser et al. compare *equilibrium behavior* in the different settings, showing that equilibrium investments are lowest in the case with corruption and inequality. In contrast, we compare *out-of-equilibrium behavior* by measuring the extent of cooperation in laboratory experiments of the different settings. We observe significantly lower levels of cooperation when self-serving dictators choose high inequality than otherwise. On the other hand, while the poor in the Glaeser et al. model withdraw their investments, because they fear that a part of their investment returns may be expropriated, the poor in our model withdraw their effort, because they feel that they have been treated unfairly. Hence, while the poor in the Glaeser et al. model act in anticipation of future unfair events, our poor react to past unfair events.

The game we introduce is a dynamic 3-person 2-period game with one "rich" and two "poor" individuals. In each period, individuals choose either to cooperate (i.e. increase the total social product), to free-ride (i.e. increase the own relative payoff), or to destroy the current period's payoffs of all the individuals in the economy, including the own. Free-riding is the individually optimal action, while mutual cooperation leads to the efficient outcome. The destruction action is clearly dominated, but provides a strong means of punishment.

There is inequality in the model, because the individual earnings from the social product are proportional to individual endowments, i.e. they are greater for the rich than for the poor. Hence, being poor in this game means having a smaller share of the property rights to the social output than the rich. Just as in Sadrieh and Verbon (2002), the degree of inequality is varied. The important new feature of this study is that, in one treatment, the degree of inequality is chosen by the rich individual (the *dictator*) before the interaction starts. Hence, in our *dictator* treatment we sometimes observe a high inequality economy *DicHi* (Gini-coefficient .6) and sometime a low inequality economy *DicLo* (Gini-coefficient .1), depending on the choice made by the rich individual. Our experimental control treatment consists of two settings where the inequality is fixed by *nature*: in *NatHi* the high inequality economy and in *NatLo* the low inequality economy are implemented at random by the experimenter.

Our main hypothesis is that the cooperation by the poor is on a much lower level when the high inequality setting is chosen by the rich (the *dictator*) than when it is implemented by the experimenters (by *nature*). In contrast, when the rich deliberately choose the low inequality setting, we expect that the poor engage in even more cooperation than in a low inequality setting fixed by nature. Hence, we expect the reciprocal behavior of the poor in the dictator treatment to lead to a clear negative effect of inequality choice on growth, while in the nature treatment we expect to replicate the neutrality finding of Sadrieh and Verbon (2002).

The experimental results are in line with our three hypotheses: When implemented by nature (i.e a random draw), inequality has no effect whatsoever on the level of cooperation. In contrast, when implemented by the choice of the rich dictator, choosing high (low) inequality leads to a significantly lower (higher) level of cooperation by the poor than in the nature treatment. Hence, we find a strong and significantly negative effect of inequality on growth, but only when inequality results from deliberate actions of the rich dictator.[2]

Our experimental results suggest that the willingness to initiate and sustain cooperation in a society crucially depends on the historic process that created the distribution of wealth. This means that simply correlating inequality to growth may miss out on an important aspect of the issue, namely the genesis of inequality. We expect to find a negative correlation between inequality and growth only when inequality has emerged due to discriminating and corrupt actions of the rich and powerful, but not when it is the result of differences in capabilities and preferences in an otherwise just society. Thus, inequality that arises in free market economies where the political systems are perceived as fair has a different effect on the economic development than inequality that arises in corrupt and politically biased societies. We provide basic empirical support for this hypothesis in a simple regression analysis in section 5. Before that, we introduce our model in section 2 and report on the experiment in sections 3 and 4.

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[2] Our results seem related to the literature on reciprocal responses that asserts that an agent's response not only depends on the consequences, but also on the intentions of other agents' actions. Rabin (1993) introduces a first formal model that is enhanced by Dufwenberg and Kirchsteiger (1998). Blount (1995) and Falk, Fehr and Fischbacher (2000) find more reciprocation to human than to the randomized first movers. Fehr and Rockenbach (2003) show that the level of positive reciprocity is higher when punishment is possible, but deliberately not chosen, than when punishment is not possible in the first place.

2. The Model

We assume there are n individuals i = 1,...,n with capital endowments, $\omega_i > 0$. All capital is productive, and individuals can generate a return on the total capital available by exerting effort σ_i ($i = 1,...,n.$). Effort can be interpreted as the time or attention an individual contributes to the production process. 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 efforts σ_i that are exerted by the individuals ($i = 1,...,n.$) are aggregated to form total labor input in production. Total output $f(\omega,\sigma) = \Sigma\sigma_i\Sigma\omega_i$ is distributed in proportion to the capital endowments (i.e. the endowments are ownership rights to society's return on efforts). 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. As in Aghion *et al.* (1999) the cost incurred by individual i is proportional to total capital accumulated in the economy and the squared individual efforts, $c(\omega,\sigma) = \sigma_i^2\Sigma\omega_i / 2$.[3] The payoff of individual i at the end of a period is equal to his share $\omega_i / \Sigma\omega_i$ of the total product minus effort cost:

$$\pi_i = (\omega_i / \sum_{j=1}^{n}\omega_j)\, f(\omega,\sigma) - c(\omega,\sigma) = \omega_i \sum_{j=1}^{n}\sigma_j - \sigma_i^2\Sigma\omega_i / 2 \qquad (1)$$

Notice that the individual effort choices have the character of voluntary contributions to a public good: All members of the society gain when an individual exerts productive effort, but the cost of exerting the effort is borne by the individual alone. Moreover, if no individual contributes to the generation of a return on investment (i.e. $\sigma_j = 0, j = 1,...,n$) everyone's

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[3] We introduce this cost function because it generates a convenient description of Nash behavior. The interpretation for this specification, apart from the familiar U-shaped form, is that as the economy becomes more prosperous the utility loss of providing a certain amount of effort increases.

gross and net return will be zero. It can readily be calculated that for any vector of contributions σ_{j} by the other individuals, the Nash equilibrium strategy of player *i* is:

$$\sigma_{\mathrm{i}} = \omega_i / \sum_{j=1}^{n} \omega_{\mathrm{j}} \tag{2}$$

Notice that, according to equation (2), it will always be optimal to contribute towards the public good, i.e. $\sigma_i > 0$, irrespective of the contributions by the others. Thus, the Nash equilibrium will not be at a corner of the action space. In our experiment, subjects had to choose between playing Nash or playing cooperatively. As is well-known, the literature has not arrived at a unique objective function for cooperation in games like this. This left it up to us to choose a cooperative structure, so we picked a structure that was simple to implement experimentally and led to substantial payoff differences compared to Nash. The following specification, in which a constant amount of effort (.25) is added to every player's Nash equilibrium effort, satisfied these criteria:

$$\sigma_i^C = \sigma_i + 0.25 \tag{3}$$

Next period's endowment is the discounted sum of this period's endowment and payoff that is defined by (1), i.e. $\omega_i^{t+1} = \rho(\pi_i + \omega_i^t)$ where ρ is a discount factor. (For the experiment, we set $\rho = 2/3$). In the next period, with the updated wealth levels, the individual again must decide whether to play Nash, as defined by (2), or to play cooperatively, as defined by (3). The payoff of the new period is again determined by (1), but now for the updated values of the individual endowments. The total payoff of each individual is obtained by adding up all period payoffs. The total payoff, thus, indicates the absolute growth an individual has realized on his initial endowment. The individual rate of growth can then be obtained by simply dividing the total payoff by the initial endowment.

After each period of the game, every individual has the option to destroy the entire current production of the economy. If destruction is chosen by any single individual, the payoffs of all individuals for the current round are zero and the endowments retain the original previous period size. In particular, if in all periods at least one member chooses the destruction option, perfect income equality is established, because the total payoff of every individual is zero.[4]

3. Experimental Conditions and Procedures

The dynamic public goods game described in the previous section was played in four experimental conditions. In every condition, an observation consisted of 3 players (that are called "an economy" in the following) with a total endowment of 300. In the *low inequality* setting, the rich had an endowment of 120, while the endowment of the poor was 90. In the *high inequality* setting, the endowments were 220 for the rich and 40 for the poor. In each session of the *nature* treatment, the experimenter determined one of the two possible distributions of endowments and informed the subjects before the game started. In the *dictator* treatment, the experimenter informed the subjects that the rich individual will choose one of the two possible distributions before the game starts. After this choice was made the subjects were informed on the chosen distribution of endowments and the game started. This method of determining the initial endowments was the only difference between the treatments. Combining the method of distribution selection (nature vs. dictator) with the two possible outcomes (low inequality vs. high inequality) gives us the four experimental conditions NatLo, NatHi, DicLo, DicHi that are summarized in table 1.

[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. E.g. in ultimatum games (Güth 1995; Roth 1995), responders reject up to 40% of the benefits of trade, just to avoid an *unfair* 40%-60% division of the surplus. 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, Irlenbusch, and Renner 2000; Bosman and van Winden 2002).

In all conditions, a two-period version of the dynamic public goods game was played. In each period, players first chose their effort levels. They could choose to act cooperatively or to free-ride (i.e. play Nash equilibrium strategy). After all effort choices were made, subjects received feedback on all choices and payoff consequences in their economy. Then, each subject was given the opportunity to destroy the period's payoffs of all individuals in the economy (including their own payoff). In the second period of the game, the same decisions had to be taken. After the second period had been completed, subjects received their final payoffs. All actions were presented to the subjects in neutral terms: the free-riding and cooperative actions were called "A" and "B," respectively, and the payoff destruction action was called "reset."

Table 1 – Experimental Conditions

Treatment	Distribution is determined	Inequality level (Gini coefficient)	endowments (rich, poor, poor)	number of subjects	Number of independent observations
NatLo	by nature	Low (.10)	(120, 90, 90)	21	7
NatHi	by nature	High (.60)	(220, 40, 40)	24	8
DicLo	by dictator	Low (.10)	(120, 90, 90)	24	8
DicHi	by dictator	High (.60)	(220, 40, 40)	24	8

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All sessions took place at the CentERlab, at Tilburg University. The subjects were student volunteers that were hired via public recruitment on campus. Most of them were first year students in economics, business, and social sciences. Upon entering the laboratory, subjects were asked to draw a card from a covered deck. The randomly drawn card determined the table number at which they were seated. The matching of the tables into economies and the roles of the players had been randomly determined before the experiment started.

The game was extensively explained to the subjects. After subjects had read the instructions (reproduced in Appendix A), they were asked to answer two guided practice questions that tested their understanding of the game. All subjects successfully solved the control questions. In total, 93 subjects (forming 31 economies) participated in the experiment. The distribution of economies over the treatments is given in Table 1. Incidentally, exactly one half of the rich subjects in the dictator treatment opted for the low inequality and one half opted for the high inequality distribution. Each subject participated only in one session. All sessions were held in May, June, and September 2002.

The experiment was run with paper and pencil. Students were seated in cubicles and were asked not to communicate. The payoff information was presented to subjects in tables (see Appendix B). The tables were organized so that each subject saw the own payoffs in the first column and the payoffs of the other players in the other two columns. Using the tables, the subjects could quickly "look forward" through both periods of the dynamic game.

Subjects did not know the identity of the other subjects in their economy, but they were fully informed of the contribution history in their economy. No explicit time limit was given to subjects. Nevertheless, the duration of no session exceeded the two hours that had been announced on the posters. The average duration of a session was about one hour and twenty minutes. At the end of the experiment, subjects received a monetary payment consisting of a show-up fee of 3 Euros plus the experimental payoff that was converted at a rate of 20 Eurocents per point. Payments to the subjects, including show-up fee, ranged from 4 to 44.6 Euros, with an average of 10.10 Euros (1 Euro exchanged at the rate of about $1 at the time).

4. Experimental Evidence

Table 2 contains information on the individual choices regarding cooperative effort and destruction in both periods of the game. In the first part of the table, the cooperative effort choices of rich and poor individuals are given for the first period.

We first check whether the neutrality result found by Sadrieh and Verbon (2002) is replicated, i.e. whether the inclination to cooperate by rich and poor individuals is neutral to the degree of inequality in the nature treatment. According to Table 2, in the nature treatment, 3 out of 7 low inequality economies show cooperative effort choices by the rich, while cooperation is exhibited for the high inequality economies in 5 out of 8 cases. This small difference obviously is not statistically significant. Likewise, the difference in cooperative efforts provided by the poor (5 out of 14 in NatLo and 7 out of 16 in NatHi economies) is not significantly different. This gives support to the finding that inequality – when it emerges from a fair, but random process – is neutral and does not have any growth-enhancing or growth-decreasing effects. This leads to our first result:

Result 1: Inequality given by nature (a fair, but random process) does not have an effect on the level of cooperation by rich and poor individuals

Let us now turn to the dictator treatment. Remember that in that case the rich individual determines which distribution should be put in place before effort choices are made. Notice from table 2 that the rich are not much affected by their own choice of inequality: Only 2 of the 8 rich, who choose low inequality as dictators, also choose the cooperative action. This ratio is not significantly different from the ratio of one out of the 8 rich dictators, who chooses high inequality and cooperation. The behavior of the poor, however, is significantly affected by the distribution that the dictator chooses: While 10 of 16 poor provide cooperatively high effort, when low inequality has been chosen, only 2 of 16 cooperate, when high inequality has been chosen. This difference in the number of cooperative plays is highly significant ($\alpha \leq .01$; two-tailed). Thus, if the rich dictator chooses low inequality, the poor reciprocate by putting more effort into generating returns on the capital stock. Hence, if the poor and powerless in an economy know that those who are in power have actively reduced the inequality, then they provide more effort to the benefit of the entire economy. On the other hand, dictators choosing high inequality seem to signal a self-serving attitude that induces a large majority of the poor to behave non-cooperatively. This is laid down in our second result:

Result 2: In the dictator treatment the poor will provide more cooperative effort under low inequality than under high inequality.

Table 2: Individual choices in the 1st and 2nd periods [a)]

1. First period cooperative effort choices							
	Rich				Poor		
Treatments	Dictator	Nature	Fisher [b)]		Dictator	Nature	Fisher
Low inequality	2 (0.25)	3 (0.43)	.33		10 (0.63)	5 (0.36)	.10
High inequality	1 (0.13)	5 (0.63)	.06		2 (0.13)	7 (0.44)	.05
Fisher	.40	.30			.00	.27	
2. First period destruction choices							
Low inequality	0 (0.00)	0 (0.00)			0 (0.00)	0 (0.00)	
High inequality	0 (0.00)	1 (0.13)			1 (0.06)	1 (0.06)	
3. Second period cooperative effort choices							
Low inequality	2 (0.25)	1 (0.14)	.43		3 (0.19)	4 (0.29)	.28
High inequality	1 (0.13)	3 (0.38)	.25		1 (0.06)	6 (0.38)	.04
Fisher	.40	.29			.25	.27	
4. Second period destruction choices							
Low inequality	1 (0.13)	0 (0.00)			1 (0.06)	1 (0.07)	
High inequality	0 (0.00)	0 (0.00)			2 (0.13)	1 (0.06)	
5. Pay-off points							
Low inequality	73.57	77.50			55.06	60.50	
High inequality	43.13	86.13			21.94	27.50	

[a)] The entries indicate the frequency of cooperative effort choices (sections 1 and 3) or destruction choices (sections 2 and 4). The relative frequencies are given in parentheses. Section 5 indicates average total payoff.

[b)] "Fisher" stands for the Fisher's exact probability test for two independent samples. The entries in the "Fisher" columns (rows) indicate the two-tailed error probability for rejecting the Null hypothesis (H_0 = no treatment differences). A value at or below .10 is considered to indicate a significant treatment difference.

A key issue in this paper is the question whether the way inequality arises has an effect on individual behavior. We can analyze this issue by comparing the effort choices in the *dictator* settings to the effort choices in the corresponding *nature* settings. Comparing across columns in Table 2 shows that under low inequality, the behavior of the rich is the same, no matter whether the distribution was randomly selected or was an explicit own choice: 3 of 7 rich in NatLo and 2 of 8 rich in DicLo provide cooperative efforts. In the case of high inequality, however, the rich are significantly ($\alpha \leq .10$; two-tailed) more cooperative in NatHi, where the income distribution is set by nature (5 out of 8), than in DicHi, where the chose high inequality distribution themselves (1 out of 8). But, of course, there may be a selection bias here, because the rich, who choose high inequality, can be expected to be less cooperative.

For the poor the picture is even clearer. Under high inequality, the poor are significantly less cooperative ($\alpha \leq .05$; two-tailed), if the distribution has come about by willful choice of the rich dictator than if the distribution has been determined by nature: 2 of 16 poor cooperate in DicHi, while 7 of 16 do so in NatHi. Under low inequality we find the reverse: the poor are significantly ($\alpha \leq .10$; two-tailed) more cooperative when the rich choose the low inequality distribution than when it is put in place by nature (10 of 16 poor cooperate in DicLo, but only 5 of 14 poor cooperate in NatLo). This leads to our third result:

Result 3a: The poor are more cooperative when low inequality has been set by the dictator instead of by nature.

Result 3b: The poor are less cooperative when high inequality has been set by the dictator instead of by nature.

Notice that result 3b survives in the second period, but result 3a does not. As can be seen in the third part of Table 2, the case of poor in the DicLo treatment is the only case in which the general level of cooperation actually changes dramatically in the second period. In all other cases, we observe about the same level of cooperation in the second period as we had observed in the first period. Thus, we have no indication of a general “end effect” (i.e.

increased free-riding at the end of a finitely repeated game). The negative effect of a deliberate choice of high inequality on the poor players' willingness to cooperate is so strong that result 3b persists in the second period at the same significance level as in the first: the poor in DicHi economies exert significantly lower cooperative effort than in NatHi economies, both in the first and in the second period. In contrast, the positive effect of a deliberate choice of low inequality on the poor players' propensity to be cooperative is not strong enough to influence behavior in both periods: the frequency of cooperation by poor in DicLo is significantly greater than in NatLo in the first period, but drops to the same level in the second period.

Result 3 makes clear that poor individuals reciprocate the "kind" act of a dictator choosing low inequality by exerting high productive efforts, but punish the "unkind" act of choosing high inequality by exerting low productive efforts. Note that the "punishment" by providing uncooperative efforts is not costly to the punisher, because it is the best response strategy. The destruction option that all individuals in the economy have at the end of each period provides a quite different – and very costly – punishment possibility. If any individual chooses this option the current period payoffs will be lost for all individuals. From the second part of Table 2 it is clear that this option is used rarely. Only 3 of the 93 individuals use this option in the first period and they are dispersed over all treatments.[5] In the fourth part of Table 2, we see that one rich and 5 poor individuals choose to destroy the returns of the second period. Obviously, destruction in this stage has no "educational" effect anymore, but it may be used

[5] Looking at the individual choices in the cases in which destruction took place in the first period, we see the following. The case where the rich individual chose destruction, the first period choice was BAA (where B indicates cooperation, A indicates Nash effort, and the choice of the rich is given first). Apparently the rich was disappointed that both poor chose A. In another case, one of the poor chose destruction, even though the dictator, who had chosen high inequality, showed "remorse" by choosing B in the first period. In the third case, the cooperating poor chose destruction apparently to punish the other poor, who had chosen to free-ride in a *NatHi* session, in which the rich had also chosen to cooperate.

as punishment, because it affects the final payoffs.[6] Apparently, almost all rich individuals choose to safeguard the payoff that they have generated, while some of the poor individuals care less for their final payoffs and remain willing to punish others.[7] Finally, it seems interesting that in three of the five DicHi economies, in which one of the subjects chooses the cooperative effort level, a destruction of the returns occurs. Apparently, when the dictator opts for high inequality, cooperation frequently is followed by destruction, because cooperation by one player tends to stay an isolated act.

Figure 1 shows the observed growth rate of every economy in every treatment normalized to equilibrium growth. To derive the normalized growth rates, we subtract the equilibrium payoff of each individual from the total payoff obtained in the experiment and express the result as a percentage of their endowment (see the fifth part of Table 2). The resulting number indicates to what degree the individuals have been able to realize a higher than equilibrium growth. Figure 1 shows the average normalized growth rates of all economies.

In the dictator treatments positive growth rates are obtained in 2 high inequality economies and 5 low inequality economies. In 3 high inequality economies sizable negative growth rates are observed, while this is the case in only 1 low inequality economy. As a result of these differences the average growth rate over all economies is clearly positive in the low inequality setting, while it is negative in the high inequality setting. In the nature treatments positive growth rates are obtained in 6 low inequality economies and 5 high inequality economies; in 3 high inequality economies negative growth rates are observed, while this is the case in 1 low

[6] It might be noticed here that in no economy the destruction option was chosen twice.

[7] The one rich individual that chose to destroy was a very cooperative one. He opted for the equal distribution first and then chose the cooperative B twice. After he saw that neither of the two poor subjects chose to cooperate in the second period, he decided to destroy their (and his own) returns.

inequality economy. Apparently, in the nature treatment the effect of inequality on growth is inconclusive, although average growth is somewhat higher in the low inequality setting.

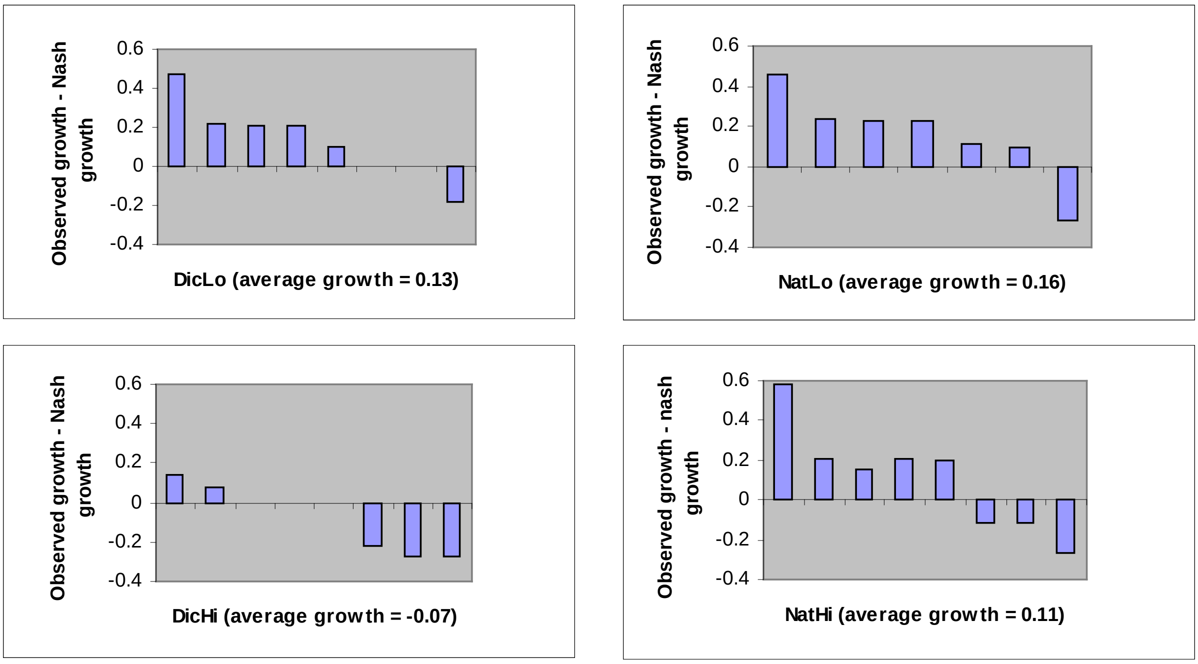

Figure 1 – Total growth for each economy and each treatment*
*) Each bar represents an independent observation of growth per economy, sorted in a descending order.

Comparing the nature and dictator treatments, it appears that the differences in growth for given low inequality are only minor: in the nature treatment 6 out of 7 economies realize positive growth rates, while this holds for 5 out of 8 economies in the dictator treatment. As a result, the average growth rate is slightly higher in the nature treatment (0.16 versus 0.13). In the high inequality setting, however, the differences are clearly discernible: 5 out of 8 economies in the nature treatment realize positive growth rates while in the dictator treatment 2 out of 8 economies realize positive but small growth rates, leading to a sizable difference in the average growth rate. This leads to:

Result 4: Low inequality leads to higher growth than high inequality in the dictator treatment. No such effect can be observed in the nature treatment.

5. Empirical evidence on the growth-inequality relationship

Our experimental results suggest that when free-riding behavior can harm economic development, the adverse effect of inequality on growth depends on the interaction of the degree and the genesis of inequality. In this section, we present very simple cross-section regression analyses that provide some rather basic evidence for the external validity of our experimental finding. Checking our main hypothesis requires a measure of the genesis of inequality to be included in a standard regression of inequality on growth. In principle, the required parameter should represent an evaluation of the "fairness" of the procedure (or the institutions) that historically led to the observed degree of inequality. If the procedure was fair, then we expect growth to be unaffected by inequality. If it was unfair, we expect to observe a strong negative correlation between inequality and growth.

Obviously, there is no simple way to assess the genesis of inequality across countries. The closest (accessible) proxy that we can think of is corruption. It seems straightforward to assume that people perceive the genesis of inequality as especially unfair in societies in which a high degree of corruption governs economic activities. If corruption is a good proxy, then we should observe that the adverse effect of inequality on growth mainly runs through the interaction of inequality and corruption. This is exactly what we find.

The effect of corruption on growth was first measured by Mauro (1995), who finds an adverse effect of corruption. Ehrlich and Lui (1999), in a somewhat more elaborate model, also find significant adverse effects of corruption variables on growth. Neither paper, however, includes an inequality measure in the analysis and neither examines the interaction between inequality and corruption that is necessary for testing our hypothesis.

The analysis that comes closest to ours is provided by Glaeser et al. (2003), who regress GDP growth on inequality and on a binary variable indicating whether a country has a “strong legal system” or not. They find that: “Inequality is bad for growth, but only in countries with poor rule of law.” (p. 215). This result is in line with our experimental results and with the cross-country evidence we provide below, which shows that inequality is bad for growth, but much more so when corruption is high. In this sense, our analysis complements the findings of Glaeser et al. (2003) and extends these to a richer measure of institutional fairness.

The corruption index that we use is constructed by Transparency International.[8] The index describes the level of perceived corruption in each country using of a collection of corruption and political risk indexes for the 1990’s. We transfer the originally negative score into the range from 0 (low corruption) to 10 (high corruption). As a measure of inequality we use the Gini coefficients reported by Deininger and Squire (1996). The measure ranges from 0 (complete equality) to 100 (complete inequality). Our dependent variable is the GDP growth per capita over the period 1991-2001 and is taken from the World Bank’s “World Development Indicators”.[9] We use an average over a relatively long period (ten years) to capture the long-run characteristics of the economies and to avoid cyclic short term effects as far as possible. We were able to construct a full data set for 49 countries.

Before reporting the results, we must note, that we are fully aware of the of econometric difficulties that plague such an analysis (e.g. endogeneity biases, omitted-variable biases, and measurement errors). We therefore see the evidence provided here only as indicative for the empirical prevalence of the conjectured effect. In this sense, our analysis is along the same

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[8] For details see the website: http://www.transparency.org/cpi/2002/cpi2002.en.html

[9] For details see the website: www.worldbank.orghttp://www.worldbank.org/data/countrydata/countrydata.html

lines as the one provided by Glaeser et al. (2003, p. 214), who caution that their cross-country regression evidence should be interpreted as being "only suggestive."

Table 3 displays our regression results. The simple regression in column (1) reproduces the well-known negative effect of inequality on growth. The second regression in column (2) adds corruption as an explanatory variable. Both coefficients have the expected negative signs and the explanatory power increases considerably compared to the simple regression in (1). But, while a highly significant coefficient is estimated for corruption, the effect of inequality is no longer significant. The regression in column (3) includes an interaction term between inequality and corruption. Once again, the explanatory power of the regression increases. Now, the coefficient for the interaction term takes on a negative and highly significant coefficient. The coefficient for inequality remains negative and is significant again, but at only about one-third of the value in (1). The coefficient for corruption has a positive sign, but is far from being significant, which indicates that the effect of corruption on growth only runs through the interaction with inequality. Finally, in the regression (4), we drop the corruption parameter, obtaining a significant intercept, a significant (but positive) coefficient for inequality, and a significant coefficient for the interaction term. This final regression supports the result that the interaction between inequality and corruption is more decisive for growth than either of the two parameters separately. But, the regression also indicates that in absence of corruption, inequality actually has a growth enhancing effect. This is in line with theories that predict investment activity to be positively correlated to inequality, due to the higher marginal propensity of the rich to invest[10]. With all due caution, we note that this result may provide the missing link between the positive investment and the negative social capital approaches discussed in the field (see Aghion et al. 1999; Barro 2000).

Table 3. Inequality, Corruption, and Growth
Dependent variable: Ten year average GDP growth per capita (1991-2001)

	(1)	(2)	(3)	(4)
Constant	3.065 (0.642)	0.607 (0.856)	3.622 (1.380)	2.007 (0.581)
Gini	– 0.031 (0.016)	– 0.006 (0.015)	– 0.088 (0.034)	0.047 (0.021)
Corruption		– 0.295 (0.077)	0.300 (0.233)	
Corruption*Gini/100			– 1.740 (0.648)	– 0.948 (0.203)
Adjusted R^2	0.058	0.270	0.357	0.348

Standard errors in parentheses.

Based on the regression (4) in table 3, we estimate growth for the lowest level (corruption index = 0) and the highest level (corruption index = 10) of corruption combined with the low (Gini = 20) and the high (Gini = 60) income inequality used in our experiment. The result of this estimation is displayed in table 4. Comparing across lines it becomes evident that high inequality can be growth enhancing without corruption, but it is detrimental for the economic development when it goes hand in hand with high levels of corruption.

Table 4. Estimated Effect of Inequality and Corruption on Growth

per capita GDP growth	low corruption (index = 0)	high corruption (index = 10)
low inequality (Gini = 10)	2.48	1.53
high inequality (Gini = 60)	4.83	– 0.86

6. Conclusions

Both the empirical and the theoretical research on the relationship between inequality and growth have come to ambiguous results, sometimes finding a positive, sometimes a negative, and sometimes varying correlations (Aghion et al. 1999; Barro 2000). It seems that more theoretical and experimental work on the behavioral micro-foundations will be necessary to

[10] Our experiment was not designed to check for this effect, because investment decision are not modeled.

untangle the complicated mechanisms that govern the relationship between inequality and growth. In a first paper, we put Knack and Keefer's (1997) conjecture that inequality destroys "social capital" to a direct experimental test, but found no evidence whatsoever in support of it: the observed level of cooperation was independent of the implemented degree of inequality (Sadrieh and Verbon 2002). Given the clear result, it seems evident that something more than inequality by itself is needed to observe the collapse of societal cooperation.

The hypothesis we started this paper with is that the degree of cooperation not only depends on the degree of inequality, but also on its genesis. To be able to examine this hypothesis, we first introduce a model that allows for out-of-equilibrium, but efficient, mutual cooperation in an unequal income setting. We then conduct laboratory experiments using this model in two variants. In the *nature* variant, the degree of inequality – either high or low inequality – is selected by the experimenter at random. In the *dictator* variant, the degree of inequality is selected by the only "rich" individual in the 3-person economy. The results of the experiment are as conjectured: Inequality is only detrimental to cooperation and, thus, to growth, when it is deliberately chosen by the rich dictator. As in the previous experiment, inequality has no effect when it is brought on by a random draw, i.e. by a "fair procedure".

In an attempt to give this micro-foundations result some macroeconomic substance, we run simple regressions of cross-country data on per-capita growth, inequality (Gini coefficients), and corruption ("corruption perception index" of Transparency International). With all due caveats in interpreting such simple regression models, the effect seems to be strong enough to allow confidence in its support for our hypothesis. The adverse effect on growth is entirely captured by the interaction term of inequality and corruption, leaving inequality with a small positive coefficient and corruption without a significant coefficient.

Our result strongly supports the spreading view that the real output effects of inequality are linked to the institutions governing the economy (see Glaeser et al. 2003). The special contribution of our paper is to show a new channel through which this interaction may be effective. The channel we suggest and examine is that of voluntary cooperation in a social dilemma type situation. The idea is that a substantial part of the effort that is put into production by the labor force is non-verifiable and, hence, will dependent on the individual's trust and emotional attachment to the society. Clearly, these may both be severely damaged by inequality that results from the actions of a self-serving dictator, but not by inequality emerging from a fair competition.

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Appendix A – Instructions

This is an experiment on economic decision-making within groups over 2 periods. These instructions explain the workings of the experiment and if you follow them carefully, you may earn a considerable amount of money, which will be paid to you in cash. You are expected to make decisions on your own without consulting other participants. So, please, do not communicate with the other participants. Otherwise, we might have to stop the experiment.

How does this experiment work? Each group consists of 3 participants, so you are in a group with 2 others in the room but you will not be able to identify your group members. The group members will be indicated by a color: Red, Blue, and Green. For the purposes of this instruction we will just talk of "your group members". At the beginning of period 1, each group member has some amount of start capital. At least one of your group members will have a start capital that differs from yours. The start capital that you get can be relatively low, or it can be relatively high. Which of the two will hold for you will be decided by the Red player, who in both cases will have the highest start capital in your group. Of course, if you happen to be the Red player you will decide on your own and the others' start capital.

Whatever your start capital may be you can enlarge your start capital over two periods by making a decision each period. These decisions determine the return that you are earning on your capital. The development of your capital does not only depend on your own decisions, but also on the decisions of the other members of your group. Based on these decisions, at the end of the 2nd period you will have accumulated a certain amount of final capital. From this final capital the start capital will be subtracted resulting in the payoffs that determine your earnings out of this experiment.

In each period, each group member chooses simultaneously one of two options: A or B. As will become clear from the payoff sheets to be discussed in a moment, if all group members choose B, the capital of all group members will grow more than if all choose A. However, if you choose B alone, while the other group members choose A, your capital will grow less while the others' capital will grow more, than if you had chosen A.

Consider the **2** payoff sheets on your desk. These sheets contain important information on your payoff during the experiment. However, if we start playing the experiment, only 1 of the two payoff sheets are relevant for your decisions. Which payoff tables that will be, depends on the Red player's decision. If the Red player chooses the start capital of 220 for him- or herself and 40 for Blue and Green, payoff sheet 1 is relevant to all of you. But if the Red player chooses the start capital of 120 for him- or herself and 90 for Blue and Green, payoff sheets 2 is relevant to all of you.

Let us assume that a payoff sheet 1 is relevant. But, the same reasoning applies if payoff sheet 2 is relevant. For that case, just change in the following, payoff sheet 1 into payoff sheet 2. When you decide on A or B in the 1st period, you do not know your group members' 1st period choices. However, if you choose A in the 1st period, then, whatever the choices of your group members, payoff sheet 1 LEFT is from then on relevant for you. On the other hand, if you choose B in the 1st period, payoff sheet 1 RIGHT is relevant. So, a choice between A or B is a choice between payoff sheets 1 LEFT and 1 RIGHT. The structure of payoff sheets 1 LEFT and 1 RIGHT is identical. It suffices, therefore, to consider one of those payoff sheets only. Let us look at payoff sheet 1 LEFT, where your 1st period decision is A. Omit for a moment the table at the center of the page, saying, “If 1st period choice was Reset”.

Payoff sheet 1 LEFT shows 4 payoff tables. These tables give the possible payoff you and your group members will generate, depending on you and your group members’ 2nd period choices. The letters in the rows of those tables show the decisions of your group (including yourself) in period 2 and the numbers show the final payoff for you and your group members corresponding to these decisions. The first of those numbers is always your final payoff, while the next two numbers are those of your group members. Which of these four tables is relevant for you will depend on the 1st period choice of your group members. If they both choose A, then the first table saying “If 1st period choice was (A, A, A)” is relevant, but if the first other group member chooses A and the other one chooses B the second table saying “If 1st period choice was (A, A, B)” is relevant. The other two tables will be relevant, if the first other group member chooses B, and the other chooses A, or when they both choose B, respectively. In payoff sheet 1 RIGHT you will notice that the first letter in the headings of the payoff tables is not A, but B, corresponding with a 1st period decision of yours of B instead of A.

Once all 1st period decisions on A or B are made, the experimenter will collect all the decision sheets, and return them with the decisions of your group members on A or B included. Then you will know exactly which payoff table on the left-hand side of the payoff sheet is relevant for you. Notice that in your payoff table the payoffs of your group members are shown as well. To help you the experimenter will mark this table with a cross.

After all group members know their payoff table, each group member is given a reset option. If *one* group member chooses to reset, then the capital of *every* group member after the 1st period will be reset to the start capital. What this implies for the payoff is shown by the “Reset” table at CENTER of Payoff sheet 1. You or one of your group members might prefer the Reset option over and above the relevant table at the left-hand side of the Payoff sheet.

The experimenter will communicate to all group members whether there has been a reset, or not. If not, then the table at the left-hand side that was marked with a cross will be the table that is decisive for your final payoff. But, if there has been a reset, table CENTER on the page is decisive.

After the decision whether or not to reset, the 2nd period starts. In the 2nd period again each group member chooses simultaneously from one of two options: A or B. Like in the 1st period, when you decide on A or B, you do not know your group members’ 2nd period choices. If you choose A, then the first four rows in your relevant table shows you the possible payoffs for you and your group members. If you choose B, then the last four rows in your relevant table show you the possible payoffs for you and your group members. Which of those four rows is decisive for your final payoff depends on your group members.

After everyone has decided on A or B, the experimenter will collect the decision sheets and return them with the decision of your group members. Then you will know exactly which row in your payoff table is relevant for you. To help you the experimenter will mark this row with a cross. Again, after all group members have decided for A or B in the 2nd period, each group member is given a reset option. If one group member chooses to reset, then the capital of every group member after the 2nd period will be reset to the start capital of the 2nd period. What this implies for the final payoff is shown by the bottom row of the table saying, “Reset”. You or one of your group members might prefer the Reset option over and above the relevant rows in your payoff table. Notice that if you are already in the Reset table, a reset choice in your group will lead to zero final payoffs for all group members. This is due to a choice for reset in the 1st and the 2nd period, which implies that the final capital for you and your group members equals the start capital. As a result the payoff for any of your group members, including yourself, equals the show-up fee.

The experimenter will collect all decisions on the reset option and thereafter communicate to all group members whether there has been a reset, or not. If not, then the row in the table that was marked with a cross will be decisive for your final payoff. But, if there has been a reset, the bottom row of the table is decisive for your final payoff.

The final payoff will be exchanged into earnings at the rate of 20 cent per point. Your total earnings from the experiment are paid to you at the end of the experiment in cash. Additionally, each of you will receive a fixed payment of 3 Euro for participation in the experiment.

Summarizing. First the Red player decides on the distribution of capital. That choice determines whether the Payoff sheet 1 or Payoff sheet 2 is used. Your own 1st period choice determines whether sheet 1 LEFT or sheet 1 RIGHT (or, sheet 2 LEFT or sheet 2 RIGHT) is decisive for your and the others' payoff. The 1st period choices of your group members fix the table on the left/right-hand side of the relevant payoff sheet. However, if you or one of your group members chooses to reset in the 1st period, the "Reset" table on the center of the sheet is decisive. The 2nd period choices of you and your group members determine which row in the chosen table is going to be decisive for the payoffs. However, if any one in your group (including yourself) has opted for a reset in the 2nd period, the bottom row in the chosen table sets the payoffs for all group members.

Practice rounds. Before running the actual experiments, we give you the opportunity to have some practice. For these practice rounds you can use the payoff sheets on your desk, which are also used for the actual experiment. Moreover, you can use the practice sheets, which are handed out to you now. You will not be paid for the results of these rounds, these rounds are only meant to let you become acquainted with the structure of the experiment. First, we play two practice rounds together for payoff sheets 1. After that, we play two practice rounds together for payoff sheets 2.

During these rounds I announce what you and your group members are hypothetically doing. This information is indicated on your group-practice sheets by A1.1, etc. You indicate on your guided-practice sheets which payoff sheets, tables, or payoffs are relevant behind the questions Q1.1. etc.

Appendix B – Payoff Sheets

Payoff sheet of the rich in the high inequality treatment (Gini = .6).

The other payoff sheets contained exactly the same information, but the columns of the tables were sorted in a way that had each subject's own payoff in the first column.

PAYOFF SHEET LEFT
START CAPITAL (220, 40, 40)
Payoff tables, if your 1st choice was A

If 1st period choice was (A, A, A)

Red	Green	Blue	Red	Green	Blue
A	A	A	44	26	26
A	A	B	84	35	19
A	B	A	84	19	35
A	B	B	123	28	28
B	A	A	36	35	35
B	A	B	76	43	28
B	B	A	76	28	43
B	B	B	116	36	36
	Reset		20	12	12

If 1st period choice was (A, A, B)

Red	Green	Blue	Red	Green	Blue
A	A	A	81	35	19
A	A	B	127	44	11
A	B	A	127	27	26
A	B	B	173	36	18
B	A	A	73	44	26
B	A	B	119	54	18
B	B	A	119	36	34
B	B	B	165	46	26
	Reset		56	18	5

If 1st period choice was (A, B, A)

Red	Green	Blue	Red	Green	Blue
A	A	A	81	19	35
A	A	B	127	26	27
A	B	A	127	11	44
A	B	B	173	18	36
B	A	A	73	26	44
B	A	B	119	34	36
B	B	A	119	18	54
B	B	B	165	26	46
	Reset		56	5	18

If 1st period choice was (A, B, B)

Red	Green	Blue	Red	Green	Blue
A	A	A	119	27	27
A	A	B	171	36	18
A	B	A	171	18	36
A	B	B	223	27	27
B	A	A	110	36	36
B	A	B	162	44	27
B	B	A	162	27	44
B	B	B	215	36	36
	Reset		93	12	12

PAYOFF SHEET CENTER
START CAPITAL (220, 40, 40)
If 1st period choice was Reset

If 1st period choice was Reset

Red	Green	Blue	Red	Green	Blue
A	A	A	20	12	12
A	A	B	56	18	5
A	B	A	56	5	18
A	B	B	93	12	12
B	A	A	13	18	18
B	A	B	50	25	12
B	B	A	50	12	25
B	B	B	87	19	19
	Reset		0	0	0

The tables on the left and right -hand side are decisive for your payoff if there has been no reset in the 1st period. If there has been a reset, the CENTER table determines your payoff. The last row of any table will be the payoff if there has been a reset in the 2nd period. Letters in the rows are 2nd-period choices of you and your group members Green and Blue; Numbers are the corresponding payoffs for you, Green and Blue.

PAYOFF SHEET RIGHT
START CAPITAL (220, 40, 40)
Payoff tables, if your 1st choice was B

If 1st period choice was (B, A, A)

Red	Green	Blue	Red	Green	Blue
A	A	A	39	34	34
A	A	B	78	44	27
A	B	A	78	27	44
A	B	B	117	37	37
B	A	A	32	44	44
B	A	B	71	54	37
B	B	A	71	37	54
B	B	B	110	47	47
	Reset		13	18	18

If 1st period choice was (B, A, B)

Red	Green	Blue	Red	Green	Blue
A	A	A	77	43	27
A	A	B	122	54	19
A	B	A	122	35	36
A	B	B	167	46	28
B	A	A	69	54	36
B	A	B	114	65	28
B	B	A	114	46	44
B	B	B	159	56	36
	Reset		50	25	12

If 1st period choice was (B, B, A)

Red	Green	Blue	Red	Green	Blue
A	A	A	77	27	43
A	A	B	122	36	35
A	B	A	122	19	54
A	B	B	167	28	46
B	A	A	69	36	54
B	A	B	114	44	46
B	B	A	114	28	65
B	B	B	159	36	56
	Reset		50	12	25

If 1st period choice was (B, B, B)

Red	Green	Blue	Red	Green	Blue
A	A	A	115	35	35
A	A	B	166	45	27
A	B	A	166	27	45
A	B	B	217	36	36
B	A	A	106	45	45
B	A	B	157	55	36
B	B	A	157	36	55
B	B	B	208	46	46
	Reset		87	19	19

Payoff sheet of the rich in the low inequality treatment (Gini = .1).

The other payoff sheets contained exactly the same information, but the columns of the tables were sorted in a way that had each subject's own payoff in the first column.

PAYOFF SHEET LEFT
START CAPITAL (120, 90, 90)
Payoff tables, if your 1st choice was A

If 1st period choice was (A, A, A)

Red	Green	Blue	Red	Green	Blue
A	A	A	53	47	47
A	A	B	77	65	39
A	B	A	77	39	65
A	B	B	101	58	58
B	A	A	45	65	65
B	A	B	69	84	58
B	B	A	69	58	84
B	B	B	93	76	76
	Reset		24	21	21

If 1st period choice was (A, A, B)

Red	Green	Blue	Red	Green	Blue
A	A	A	76	65	40
A	A	B	103	86	32
A	B	A	103	56	58
A	B	B	131	77	50
B	A	A	68	86	58
B	A	B	95	107	50
B	B	A	95	77	75
B	B	B	122	98	67
	Reset		44	36	15

If 1st period choice was (A, B, A)

Red	Green	Blue	Red	Green	Blue
A	A	A	76	40	65
A	A	B	103	58	56
A	B	A	103	32	86
A	B	B	131	50	77
B	A	A	68	58	86
B	A	B	95	75	77
B	B	A	95	50	107
B	B	B	122	67	98
	Reset		44	15	36

If 1st period choice was (A, B, B)

Red	Green	Blue	Red	Green	Blue
A	A	A	99	58	58
A	A	B	129	78	50
A	B	A	129	50	78
A	B	B	160	70	70
B	A	A	90	78	78
B	A	B	121	98	70
B	B	A	121	70	98
B	B	B	151	89	89
	Reset		64	30	30

PAYOFF SHEET CENTER
START CAPITAL (120, 90, 90)
If 1st period choice was Reset

If 1st period choice was Reset

Red	Green	Blue	Red	Green	Blue
A	A	A	24	21	21
A	A	B	44	36	15
A	B	A	44	15	36
A	B	B	64	30	30
B	A	A	18	36	36
B	A	B	38	51	30
B	B	A	38	30	51
B	B	B	58	45	45
	Reset		0	0	0

The tables on the left and right -hand side are decisive for your payoff if there has been no reset in the 1st period. If there has been a reset, the CENTER table determines your payoff. The last row of any table will be the payoff if there has been a reset in the 2nd period. Letters in the rows are 2nd-period choices of you and your group members Green and Blue; Numbers are the corresponding payoffs for you, Green and Blue.

PAYOFF SHEET RIGHT
START CAPITAL (120, 90, 90)
Payoff tables, if your 1st choice was B

If 1st period choice was (B, A, A)

Red	Green	Blue	Red	Green	Blue
A	A	A	47	64	64
A	A	B	70	85	56
A	B	A	70	56	85
A	B	B	93	77	77
B	A	A	39	85	85
B	A	B	62	106	77
B	B	A	62	77	106
B	B	B	85	98	98
	Reset		18	36	36

If 1st period choice was (B, A, B)

Red	Green	Blue	Red	Green	Blue
A	A	A	71	82	58
A	A	B	97	106	50
A	B	A	97	73	78
A	B	B	123	97	69
B	A	A	62	106	78
B	A	B	88	129	69
B	B	A	88	97	98
B	B	B	114	120	89
	Reset		38	51	30

If 1st period choice was (B, B, A)

Red	Green	Blue	Red	Green	Blue
A	A	A	71	58	82
A	A	B	97	78	73
A	B	A	97	50	106
A	B	B	123	69	97
B	A	A	62	78	106
B	A	B	88	98	97
B	B	A	88	69	129
B	B	B	114	89	120
	Reset		38	30	51

If 1st period choice was (B, B, B)

Red	Green	Blue	Red	Green	Blue
A	A	A	93	76	76
A	A	B	123	99	67
A	B	A	123	67	99
A	B	B	153	89	89
B	A	A	84	99	99
B	A	B	114	121	89
B	B	A	114	89	121
B	B	B	143	112	112
	Reset		58	45	45