Local Politics and Global Public Goods[1]

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Abstract

The provision of public goods is a major reason for government intervention. Centralized tax policy is in principle capable of providing the efficient amount of the public good. However, if there is a global public good but several local polities determining tax rates in a decentralized manner, an inefficiently low level of the public good will be provided unless it is in the self-interest of a single local polity to provide the public good unilaterally. Our experiments show that this is indeed the case. The political support of the citizens converges towards efficient provision levels if voting takes place in a global jurisdiction while, if there are several local jurisdictions, citizens support only very inefficient levels of the public good. Moreover, we show that the inefficiency of local public goods provision even extends to the case where it is in the self-interest of a singly local jurisdiction to provide the global public good unilaterally. The reason for this is that the unilateral provision of the global good creates large inequalities in income across jurisdictions because the free-riding jurisdictions bear no costs but share the benefits of the public good. Thus, the existence of social preferences considerably strengthens the case for the centralized democratic provision of public goods.

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1. Introduction

Public goods problems are abundant and cover a large variety of scales. Examples range from the production of a joint paper by a team of researchers to the prevention of global warming by international collaboration. Public goods on a smaller scale can often be solved by repeated game incentives and reputation. This is much harder for large-scale public goods. So, the provision of public goods was and is a major reason for institution formation. Almost any kind of human organization solves a kind of public goods problem as hunting in prehistoric societies, or cooperation in firms. Modern national states solve many of public good problems by enacting laws for minimum contribution standards and centralized tax policy to finance public goods. So, communities build traffic systems, fight poverty or set minimal environmental standards. Tiebout (1956) even suggests that if people can migrate they sort into groups with similar preferences for local public goods.

Often though, migration is restricted and the range of the public goods does not coincide with the authority that decides on the level of cooperation that should be provided. Most frequently, this problem occurs on the international level. The most prominent example – and the most global – is probably global warming caused by the emission of carbon dioxide. In this case, national governments decide on the environmental policies for reducing the emissions but the problem is a global one. The effort to reach transnational agreements as the Kyoto protocol shows that it is recognized that the problem is hardly solvable at the national level. The situation of an incongruity between the range of a public goods and the jurisdiction that decides on how much of it is provided, occurs in many places around the world and is often accompanied by international conflicts. The protection of the Caspian Sea environment is difficult to achieve because the sea is surrounded by five nations, which decide independently on the use of it. For instance, the over fishing problem is first a prisoner's dilemma between different fishing companies. If there is only one nation that borders a lake, this nation can enact restrictions that allow a sustainable use of the lake. If different nations decide on the use of the lake, the prisoners' dilemma on the level of the fishing companies can be solved but a new prisoners' dilemma between the nations appears. Sinn (1997) shows that the prisoners' dilemma that exists between the individuals, when there is no state to enforce an efficient level of the public goods, can translate into a prisoners' dilemma between the jurisdictions that decide on the enforced contribution level. As long as the range of the public goods does not coincide with the jurisdiction that decides on the level of contribution, there

are externalities, which usually result in an inefficient level of enforcement and therefore in an inefficient level of cooperation.

Since many people have social preferences and are in particular willing to cooperate if others cooperate as well, they might be able to overcome the problem. Even if people have heterogeneous preferences, a majority of cooperative individuals could overrule selfish individuals in a majority vote. Unfortunately, this is not the only possible outcome of social preferences. A community that decides to provide a high level of the public good has to bear a higher cost than a community that does not. If the members of the more cooperative community dislike the unequal distribution of cost, it can restrain them from cooperation even if it would be in their material interest to enforce higher levels of the public good. So, if the other country would not exist, a higher level of the public good would be provided.

In reality it is very hard to measure cost and in particular the benefit of a public good. For this reason, we investigate this question in an experiment. In our experiment subjects decide in different jurisdictions on a minimum level of contribution to a public good. This minimum level has to be provided by the members of the jurisdiction that implemented this rule. The important variation in our experiment is the range of the jurisdiction that decides on the minimum contribution. There is a "global treatment" in which the group that benefits from the public good coincides with the group that decides on the enforcement. In the other treatment, called "local treatment", two jurisdictions decide autonomously on an enforced minimum contribution level for their domain but both jurisdictions contribute to the same public goods. We find that in the global treatment, subjects vote for the efficient outcome while in the local treatment, they clearly fail to provide an efficient level of the public good. Even in a case in which it was materially beneficial to enforce the efficient level of the public good, subjects' contribution was much lower. The reason for this is that the unilateral provision of the global good creates large inequalities as explained above.

Our study relates to a large literature of experimental studies on public goods games (see e.g. Ledyard 1995). First studies focused on voluntary cooperation. They found significant but diminishing cooperation. This evidence can well be understood by the assumption of heterogeneous preferences with conditional cooperation (Keser and van Winden 2000, Fischbacher, Gächter and Fehr 2001). If some subjects are conditionally cooperative and some are selfish, then the conditionally cooperative subjects initially cooperate but they learn that other subjects do not and, henceforth, correct their contributions downwards. Facing the instability of cooperation, many researchers investigated the question how cooperation can be increased and stabilized. Based on selfish actors, mechanisms, as the

Groves-Ledyard mechanism, were designed to create incentives for selfish actor to contribute efficiently. Chen and Plott (1996) and Falkinger et. al. (2000) found that these mechanisms are indeed capable to support efficient outcomes. In these designs the experimenter exogenously implements the mechanism. So, it is natural to question what kind of mechanisms people would choose if they could make binding agreements. Walker et. al. (2000) addressed this question in the context of a common-pool resource game (CPR). They found that voting on the use of a CPR could lead to socially efficient outcome. Margreiter, Sutter and Dittrich (2005) confirm these results by investigating CPRs with heterogeneous agents. A similar enforcement technology as in our experiment was used in Sutter and Weck-Hannemann (2003). In their non-linear public goods game subjects could choose whether to implement a particular minimal contribution level or not. They found no significant increase in cooperation when the enforcement level that could be implemented was below the Nash equilibrium and a significant increase when the enforcement level was between Nash equilibrium and efficient level. Our study differs in three dimensions from the other designs. First, we allow for different levels of enforcement. So, we can address the question what level of enforcement subjects choose, and how it relates to the level of cooperation. Second, in our design enforcing higher levels of contribution is costly. This feature creates an interesting tension between spending the cost for enforcing high levels of cooperation and hoping for voluntary cooperation. The main distinctive feature of our design is, though, that we compare behavior in environments in which global enforcement is possible with behavior in environments where decisions are decentralized. We will show that local enforcement of an efficient contribution level is not possible – even in a case where cost are low and the enforcement of an efficient contribution level is individually profitable.

In Section 2, we introduce the game and we develop the standard prediction assuming rationality and selfishness in Section 3. Section 4 presents the experimental setup and introduces the parameters used, Section 5 derives predictions based on fairness, Section 6 presents the results and Section 7 concludes.

2. The local-global game

In this section, we explain the basic structure of the game. There are n players in m jurisdictions of k players ($n=mk$). The game has two stages. In the first stage, the voting stage, the players decide in each jurisdiction on a minimum contribution to the public goods. In the second stage, the contribution stage, they choose individually how much to contribute from an

endowment *E*. This contribution has to be at least as high as the level decided in one's own jurisdiction. Let us now explain the stages in detail.

In the first stage, the players decide in their jurisdictions on the level of contribution they want to enforce. Each player announces a desired enforced contribution level v_i. We call this the vote of player *i*. Then, in each jurisdiction *J*, the median of all votes v_i in this jurisdiction is implemented as the rule r_J.[4] If r_J is the rule in a jurisdiction, then each player in this jurisdiction must contribute at least r_J, so possible contributions are between r_J and the endowment *E*. Enforcement is not costless. If enforcement is enacted costs for this enforcement accrue. Because higher levels of enforced contribution are usually achieved by implementing different steps, costs increase in the level of the enforced contribution. Think for instance of environmental policy. The higher the standard of air quality that has to be implemented, the more laws have to be enacted. So, catalytic converter can become mandatory, regulations for private heating installation can be enacted, filters for power plants can be enforce or low emission power plants can be subsidized. In our experiment, the costs are linear in the rule, so costs are cr_J for every individual in the jurisdiction. Note that the individual vote is irrelevant for the incurred cost. The implemented level of enforcement determines the cost. So, at the voting stage, there is no prisoners' dilemma between the voters within a jurisdiction.

In the second stage, the players decide how much to contribute to a linear public goods game (Ledyard 1995). The players get an endowment E and they contribute an amount g_i to the public goods. The return from the public goods is $a\sum_{j=1}^{n} g_j$ for all players. The factor *a* is the marginal per capita return (MPCR) of the public good. We assume that $1/n<a<1$ which implies that on the one hand choosing the lowest possible contribution, i.e., r_J, is a dominant strategy and that on the other hand maximum contribution is efficient. We say that the public good is global since we sum up over all *n* players. So, we get the following payoff function for subject *i*

[4] If the median vote of an odd number of players is used, then the implemented rule is supported by a majority if we assume that the players support any enforcement level up to their vote v_i and vote against every level above of their vote. If there is an even number 2N of players, then the decision depends on the starting point of the legislation. If the question is whether to introduce new laws, then the (N+1)th vote from the bottom decides. If the question is whether to abolish laws, then the (N+1)th vote from the top decides. Since we did not want to use any level of contribution as reference, we decided to use the median vote as a decision rule.

$$\pi_i = E - g_i + a\sum_{j=1}^{n} g_j - cr_i .$$

3. Standard predictions

We first derive the standard prediction assuming selfish and rational individuals (and common knowledge of it). Since $a<1$, selfish players contribute r_J. This means that contributions above r_J are "**voluntary contributions**". To avoid many nonsensical equilibria, we only consider trembling hand perfect equilibria, i.e., we assume that there is some probability that the decision of a player is actually implemented.[5] If a vote of a player is not implemented as a rule, is has no impact on the player's payoff, so we have only to consider the incentives if the player's vote is actually implemented. In this case, he will vote for the maximal enforcement level if $1+c<ka$ and for no enforcement if $1+c>ka$.[6] On the left hand side of the inequality, 1 is the marginal cost of the enforced own contribution if the minimum contribution is increased by one point and c is the marginal cost of enforcement; on the right hand side ka is the marginal benefit of the additional contributions of the k players in the own jurisdiction. This inequality reveals that the condition for maximal enforcement is easier to satisfy if costs are low and if the jurisdiction is large.

4. Parameters and experiment setup

In the experiment there was always a group of n=6 players. The marginal per capita return of the public goods, a, was set to 0.4 and the players received an endowment of 20 points. We varied the range of the jurisdiction, which decides on the level of enforced contribution. There was a **global treatment** in which the jurisdiction was the whole group, i.e., $k=6$. In the **local treatment**, we had two jurisdictions of three players, which decided autonomously on the enforcement level. Independently of the size of the jurisdiction, we varied the cost of the enforcement. There was a **low cost treatment with *c=0.15***. In both the low cost global as well as in the low cost local treatment, standard theory predicts that full contribution is enforced. There was also a **high cost treatment with *c=0.5***. In the high cost global treatment, theory also predicts that full contribution is enforced. In the high cost local treatment, standard theory predicts zero enforcement and cooperation.

[5] Otherwise, any strategy combination in which all players vote for the same rule is an equilibrium. In this case, a single player cannot change the rule by changing the vote because the other players are in majority. If there is no incentive for a particular vote, the player has no incentive not to follow the majority.

[6] In the case of equality, he is indifferent between all the votes.

The first best solution is based on voluntary cooperation: If no contribution is enforced and all players contribute, the average payoff equals *naE*, which is greater than *E* by assumption on *a*. If costs are not too high then the payoff that results if the players enforce full contribution equals *(na-c)E* and is still grater than E. In the global treatment, enforcing full contribution is individually optimal if and only if it is more efficient than no contribution. For both cost levels this is actually the case. Also in the local treatments, it is more efficient to enforce contributions than not to contribute at all. However, it is only individually optimal in the low cost treatment. Since, in this situation, enforcing higher contribution levels is not in the selfish self-interest of the subjects, we call enforcement in this case **voluntary enforcement**. It expresses the fact that the jurisdictions face a prisoners' dilemma on the enforcement stage in this case.

Behavior in this experiment depends crucially on how the subjects assess the other subjects' behavior. For instance, if they expect that the other subjects cooperate independent of the enforcement level, then enforcement is useless. So, to allow subjects to learn about the other players' behavior, the game was played 10 times. To avoid contribution or its enforcement for strategic reasons only, we changed group composition from period to period. In every period, players first chose their vote. Then they got to know the result of the vote in their own jurisdiction. In the local treatment they also got to know the result of the ballot in the other jurisdiction in their group. At the end of the period, after having decided on the individual contribution level, subjects got to know the average contribution in the own jurisdiction. In the local treatments they also got to know the average contribution in the in the other jurisdiction in their group.

In total 174 subjects from the University of Zurich and from the Swiss Federal Institute of Technology Zurich participated in 8 sessions. In each session, subjects received written instructions for the first experiment. When everybody had finished reading the instructions and had correctly answered the control questions, a public oral summary was given. Then the first treatment was started for 10 periods. After each period the group composition changed. The sessions lasted about two hours and on average subjects earned about 43 SFR (about 25$ at the time of the experiment), including a show up fee of 10 SFR. The experiment was programmed and conducted with the software z-Tree (Fischbacher 1999).

In 5 sessions 24 subjects participated and in 3 sessions 18 subjects participated. In the session in which 24 subjects participated, we formed matching groups of 12 subjects, i.e., groups were formed within these smaller subgroups. In Table 1, we list the number of

sessions and matching groups. Since we expected an uninterestingly high cooperation rate in the low cost global treatment, we did not conduct sessions with this treatment type.

Table 1: List of session types.

Sequence of treatments	Number of sessions (matching groups)	Number of subjects
High cost; first global, then local	2 (4)	48
High cost, first local, then global	3 (5)	66
Low cost, first local, then global	3 (4)	60

5. Fairness hypothesis

We know from many experiments that not all people are selfish. For instance, we know from public goods experiment that people cooperate more than predicted by assuming selfish preferences (see e.g. Ledyard 1995). More generally speaking, people reward kindness (Berg et al. 1995, Fehr et. al. 1993) and punish unkindness (Güth et. al. 1982, Fehr and Gächter 2000). This evidence motivated the development of theories of fairness (e.g. Fehr and Schmidt 1999, Bolton an Ockenfels 2000, Dufwenberg and Kirchsteiger 2004, Falk and Fischbacher, forthcoming). These theories assume that in addition to the selfish motive given by the material payoff π_i, there is a fairness motive in the utility function U_i. The models differ in the details how this fairness motives are defined but in the case of public goods games they make comparable predictions. Therefore, we use the Fehr and Schmidt (1999) [FS] model because it is the easiest to apply. The FS model assumes that players have disutility from inequality in the following form:

$$U_i = \pi_i - \frac{\alpha_i}{n-1}\sum_j \max[\pi_j - \pi_i, 0] - \frac{\beta_i}{n-1}\sum_j \max[\pi_i - \pi_j, 0]$$

There are two parameters in the model. The parameter α_i measures players *i*'s aversion against disadvantageous inequality and β_i measures player *i*'s aversion against advantageous inequality. The model assumes that $\alpha_i \geq 0$, $1 > \beta_i \geq 0$, and $\alpha_i \geq \beta_i$.

In the appendix, we characterize the equilibria that result if players have preferences according to this model.[7] The derivations show that players voluntarily contribute, i.e. they contribute more than the chosen minimum, if players sufficiently dislike advantageous

[7] We consider also in the analysis of the FS model only trembling hand perfect equilibria.

inequity and if they belief that others contribute as well. However, the propositions also show that the conditions for voluntary cooperation are quite demanding. In the case of the global treatment, voluntary cooperation will be very unlikely. If we assume complete information, i.e. players know other's preferences, there is voluntary contribution only if all players are sufficiently non-selfish. If only one player has a β_i value below 0.6, then there is no voluntary contribution. With the distribution of types as assumed in Fehr Schmidt (1999), the probability that all player have $\beta_i \geq 0.6$ is less than 1 percent, i.e., the probability that an equilibrium with voluntary contribution exists, is very low. If players do not know each other's type, i.e., in a game with incomplete information, there is no equilibrium with voluntary cooperation. Since players cannot rely on voluntary cooperation, they have to vote for the enforcement even though no enforcement and voluntary cooperation would be the efficient outcome. So, in the global treatment, the FS model makes the same prediction as the standard theory: Players enforce the contribution and there is no voluntary contribution.

In the local treatment, the situation is more complex. If the two jurisdictions choose different enforcement levels, then the players in the group with the lower level know that the three players in the other group will surely contribute at a higher level. So the condition for voluntary cooperation is easier to satisfy since only three players have to satisfy the condition $\beta_i \geq 0.6$. Given the type distribution in Fehr, Schmidt (1999), this condition is satisfied with a probability of about 6 percent.[8] Thus, we expect more voluntary cooperation by the group with the lower enforcement level.[9] However, also in the local treatment, we expect voluntary cooperation to be low and unstable.

In the local treatments, fairness plays also an important role at the voting stage. If the other jurisdiction decides differently than the own jurisdiction, different cooperation levels and therefore different income levels result. If players sufficiently dislike inequity, they prefer that their own jurisdiction chooses the same enforcement level as the other jurisdiction. In our experiment, it implies that in the high cost local treatment, there are equilibria with voluntary enforcement, i.e., equilibria with a higher level of enforcement than predicted by selfish preferences. If in both jurisdictions a majority of players has a sufficiently high aversion

[8] Because the player in the jurisdiction with the higher enforcement level had higher enforcement costs, inequity seeking players would even contribute more to the public goods than the players in the groups with the higher enforcement level. This is shown in Proposition A4 in the appendix.

[9] There is a counteracting effect, though. If more selfish players choose the lower enforcement level, then the composition of the group with the lower enforcement level is biased towards selfish types and, therefore, contribution will be lower in this jurisdiction.

against advantageous inequity (β_i>1/2), then for any enforcement level *r*, there is an equilibrium in which in both jurisdictions, a majority of player chooses *r*. There are two reasons why voluntary enforcement is more likely to be an equilibrium than voluntary cooperation. First, in the case of voluntary enforcement, the selfish players in the own jurisdiction can be forced to cooperate. So, there are cooperative equilibria even if there are selfish players. Second, the free-rider incentive is smaller for enforcing cooperation compared to voluntary cooperation because the members in the own jurisdiction have to contribute as well. However, there is also a reason why also voluntary enforcement might be difficult to achieve. The marginal disutility from choosing a slightly higher level of enforced contribution is always greater that the marginal disutility from choosing a slightly lower level. So, if people make errors in applying their best reply, they prefer to make downward errors.

In the low cost local treatment, the selfish equilibrium implies enforcing the highest possible contribution level. In this treatment, fairness can have a negative impact on the level of enforced contribution. If the enforced contribution level is lower in the other jurisdiction than in the own jurisdiction, then reducing the enforced contribution reduce the payoff but it also reduces inequality between the own income and the income of the players in the other jurisdiction. Players who sufficiently dislike disadvantageous inequality will therefore choose the same low enforcement level as the other jurisdiction. It is shown in the appendix that player with $\alpha_i \geq 1/12$ prefer to choose the same enforcement level as the other jurisdiction. Therefore, if a there is a majority of players with $\alpha_i \geq 1/12$ in both jurisdictions, then any level of enforced contribution can constitute an equilibrium. Intuitively, if players envious, they do not enforce the maximum level because it is much more profitable for the other jurisdiction than for the own jurisdiction. The critical value of 1/12 is very low; subjects with $\alpha_i < 1/12$ accept an offer as low as 8% in the ultimatum game. In the appendix, we also analyze the disutility from deviation from the enforcement level of the other jurisdiction. It is shown that choosing a marginally lower enforcement level creates a smaller disutility than choosing a marginally higher enforcement level if $\alpha_i - \beta_i > 1/6$. In the parameterization given in Table III the FS paper, this condition is assumed for all non-selfish types and only 30 percent are assumed to be selfish. So there is good reason to assume that there is a downward trend in enforcement in this treatment although selfish preferences predict full contribution.

Due to the multiplicity of equilibria, we cannot make point prediction based on fairness predictions. Nevertheless, we formulate the following hypotheses based on material and inequity incentives. First we state hypothesis about the behavior in the different treatments;

then we list hypothesis about the comparative static between the treatments, and finally, we list hypothesis about voluntary cooperation.

H1: In the (high cost) global treatments, cooperation as well as enforcement is high.

H2: In the high cost local treatment, there is voluntary enforcement, i.e. there is cooperation, which is based on enforcement.

H3: In the low cost local treatment envious behavior prevails, i.e., enforcement and cooperation are below standard prediction.

H4: Votes and the actual contributions are higher in the global treatments compared to the local treatment. In the global treatments, full enforcement is the only trembling hand perfect equilibrium for selfish as well as for fair players (if we assume that there is no voluntary cooperation). In the local treatment equilibria with lower contributions are possible – at least if some players have social preferences.

H5: Votes and the actual contributions are higher in the low cost treatments compared to the high cost treatment. This hypothesis simply states that players respond to the price of enforcement.

H6: In the local treatments, subjects' voluntary contribution is higher in the group with the lower enforcement level.

6. Results

As we have seen in the theoretical predictions, the treatments have very different motivational structures. Therefore, we present the treatments one after the other before comparing them. First, we will present results on the global treatments. Then, we analyze the high cost local treatment and finally, we discuss the local low cost treatment. In the global treatments, theory predicts full cooperation based on enforcement. Nevertheless, subjects might be tempted to save the enforcement costs and rely on voluntary cooperation. The following result summarizes behavior in the high cost global treatment, confirming hypothesis 1:

Result 1: *In the* ***high cost global*** *treatment cooperation increases and approaches the maximum possible level. Cooperation is based on enforcement.*

Figure 1 shows the time path of the high cost global treatment. Theory, assuming selfish individuals, predicts an enforcement level of 20 and cooperation at the enforced level. The figure shows average contribution as well as the average enforcement level (not the average vote). Subjects start with low enforcement level and with some voluntary

cooperation. It seems as if subjects try to achieve the first best solution – cooperation without enforcement. However, voluntary cooperation is low from the beginning. Subjects even reduce voluntary cooperation and switch to an enforcement strategy. Enforcement and cooperation increase and approach the maximum level of 20. This result can also be confirmed statistically. In Table 2, we show Tobit regressions of the decision in the high cost global treatment. Standard errors are corrected for the potential dependence of observations within matching groups. We use *contribution minus 20* as dependent variable and *period minus 10* as regressor. Since the constant in a regression measures the deviation from the dependent variable when all regressors equal zero, the constant in our regression can be interpreted as the difference of the contribution from 20 in period 10. The significance of the period regressor shows that contribution is significantly increasing in time and the insignificance of the constant shows that in period 10, the estimated contribution is not different from 20.

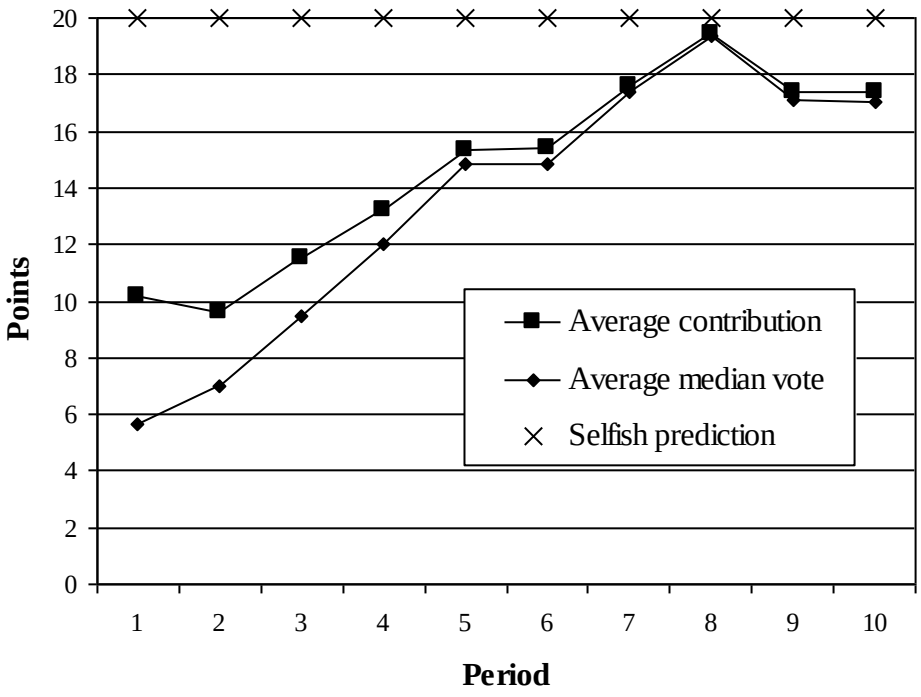

Figure 1: Time path of the high cost global treatment.

Table 2: Tobit regression in the high cost global treatment. Dependent variables are *contribution minus 20* and *vote result minus 20*.

	(1) Contribution minus 20	(2) Vote result minus 20
Period minus 10	1.517	1.969
	(0.238)***	(0.293)***
const	3.376	3.937
	(2.438)	(2.793)
Observations	480	80
Prob > X^2	<0.0001	<0.0001.

Robust standard errors taking the dependence of decision within matching groups into account in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

In the high cost local treatment zero contribution is predicted. From many other public goods experiments, we know that subjects cooperate, but that cooperation declines over time. In this treatment it is particularly interesting how cooperation is achieved since both voluntary cooperation and enforcement are not in the subjects' self interest. The following result summarizes behavior in the high cost local treatment. It is in line with hypothesis H2 insofar as voluntary cooperation vanishes and cooperation has to rely more on enforcement.

Result 2: *In the* ***local high cost*** *treatment there is a significant amount of cooperation but this cooperation declines over time. Cooperation is based more on voluntary cooperation than on enforcement. Over time enforcement becomes more important.*

As Figure 2 reveals, there are considerable but declining contribution levels. This is in line with the well-established observation that people cooperate in public goods games but that cooperation declines over time. In this experiment, cooperation can be based on enforcement or on voluntary cooperation. Initially, subjects rely on voluntary cooperation. In the first 5 periods, less than one third of the resulting cooperation was enforced. However, this share increases, mainly because cooperation decreases. Table 3 shows a Tobit regression with *period minus 10* as regressor. In column (1) cooperation and in column (2), the vote result, i.e., the enforced level of cooperation, are the dependent variables. The regression reveals decreasing cooperation and an insignificant increase in enforcement. The regression also shows that cooperation and enforced cooperation level are both not significantly positive in period 10. The constant in the enforcement regression is even negative. This is due to the fact that a majority of zero vote result drives this result. Cooperation is significantly positive in the

first period but cooperation declines over time and enforcement is not sufficiently high to establish a significant level of cooperation.[10] Although the vote result is not significantly positive in the Tobit regression, on average 28 percent of the groups enforced a positive cooperation level (and even 41 percent in the last period). So there were groups who voluntarily cooperated in the prisoners' dilemma between the jurisdictions by choosing a positive enforcement level. At the beginning, subjects tried to rely on voluntary cooperation but as usually observed in public goods games, cooperation declined. Since enforcement increased (though not significantly), the share of cooperation that is based on enforcement increases over time. So as predicted by the fairness theory, subjects relied more on enforcement. However, also voluntary enforcement was not very strong. As mentioned above, in the last period, 60% of the votes (as well as of the vote result) were equal to zero.

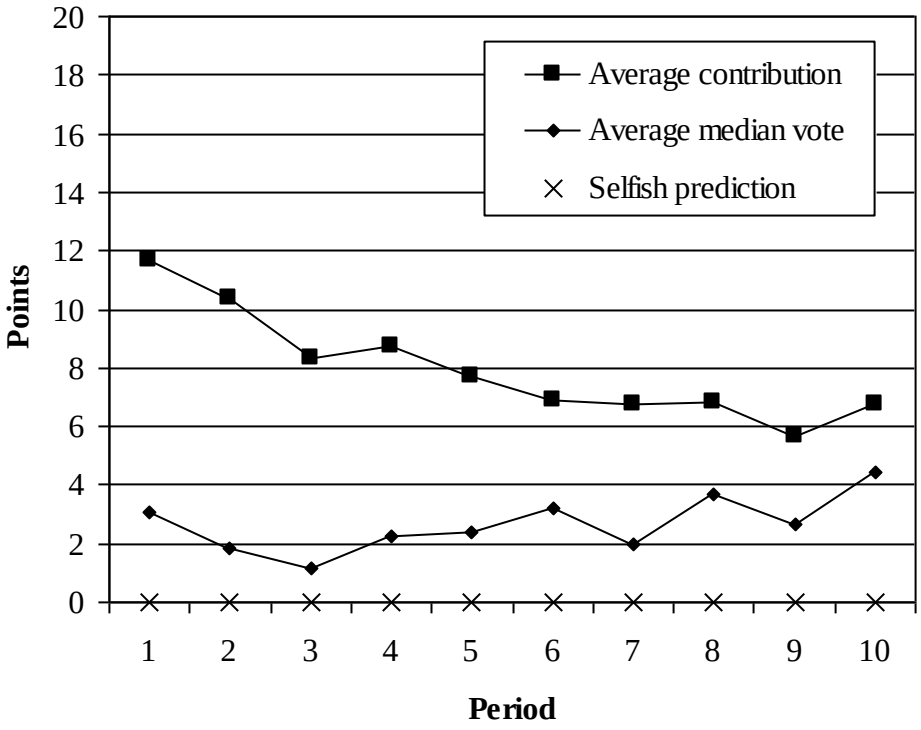

Figure 2: Time path of the high cost local treatment (average of the decisions in the first run).

[10] In an ordinary regression, not taking into account that contribution cannot be below zero, the regression returns significantly positive constants, both for cooperation and for the enforcement.

Table 3: Tobit regression in the high cost local treatment (first run). Dependent variables are contribution, and vote result, and the percentage of cooperation that is enforced.

	(1)	(2)
	Contribution	Vote result
Period minus 10	-1.047	0.616
	(0.304)***	(0.602)
Constant	1.478	-6.662
	(1.729)	(3.916)*
Observations	660	220
Prob > X^2	<0.0006	0.3060

Robust standard errors taking the dependence of decision within matching groups into account in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

In the low cost local treatment the selfish equilibrium implies full enforcement. As we have seen in the predictions section, the benefit of enforcement accrues to a much larger extent to the other jurisdiction than to the own jurisdiction. So envy can lead to lower than materially optimal enforcement levels. First, we state the main results in the low cost local treatment. It confirms hypothesis 3 and hypothesis 4 with respect to the votes; it contradicts hypothesis 4 with respects to cooperation.

Result 3: *In the* ***local low cost*** *treatment there is a significant amount of cooperation but this cooperation declines over time. Cooperation is slightly higher than in the high cost local treatment, but the decline over time is similar. Different from the high cost treatment, in this treatment, cooperation is primarily based on enforcement from the beginning.*

Figure 3 shows that even though the selfish equilibrium prediction was full contribution, contribution was not very high, and even more remarkable, cooperation declined over time. Comparing the two local treatments, it is surprising that the time trend of cooperation is much alike in the two treatments. Table 4 presents a Tobit regression of the decisions. There is data from all three treatments in this regression. Since the high cost local treatment is the baseline in this regression the dummy for "low cost" measure the difference between the two local treatments. The dummy for "global" measures the difference between the two high cost treatments. We use *period minus 1* as a further regressor to control for time trends. *Period minus 1* equals *0* in period 1, so the coefficients of the dummies can easily be interpreted as the difference in the treatments in the first period. The first column shows the

regression with the contribution as the dependent variable. It reveals that the decline in cooperation is not significantly different between the local treatments and that also the absolute difference is only marginally significant. The enforcement behavior is very different between the two local treatments, both with respect to the behavior in the first period as well as with respect to the time trend. While in the high cost treatment subjects try to rely on voluntary cooperation, the subjects in the low cost treatment vote for rather high enforcement levels – compared to the high cost treatment.

As a side note, Table 4 also reveals how the high cost global treatment differs from the high cost local treatment. It reveals that initial cooperation does not differ between the high cost global treatment and the high cost local treatment. However, time trends are completely different resulting in a significant difference in the last period (not shown in the regression). Enforcement is different from the start and also has a significantly different time trend, all confirming hypothesis 4.

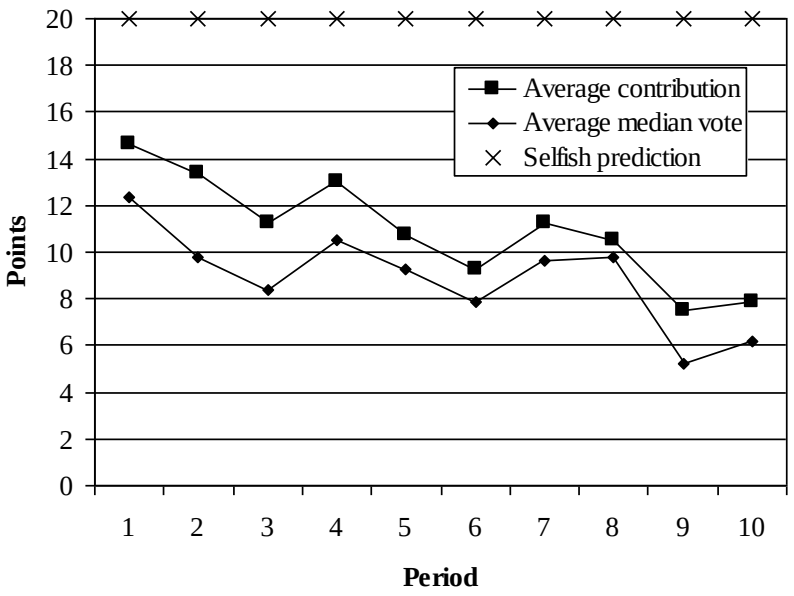

Figure 3: Time path of the low cost local treatment.

Table 4: Tobit regression; high cost local treatment is the baseline.

Dependent variable	Contribution	Vote	Vote result
Constant	10.797	-12.877	-9.304
	(2.515)***	(4.370)***	(4.201)**
Period minus 1	-0.929	0.704	0.534
	(0.258)***	(0.402)*	(-0.443)
Low cost dummy	5.73	22.888	20.942
	(2.951)*	(5.040)***	(4.904)***
(Low cost)*(period minus 1)	-0.15	-1.294	-1.391
	(-0.338)	(0.443)***	(0.521)***
Global dummy1	-1.135	18.824	14.915
	(-2.601)	(4.336)***	(4.174)***
(Global)*(period minus 1)	2.778	1.682	1.959
	(0.389)***	(0.366)***	(0.538)***
Observations	1740	1740	500
Prob > X^2	<0.0001	<0.0001	<0.0001

Robust standard errors taking into account dependency within matching groups in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

It is remarkable that in the low cost local treatment, subjects did not enforce higher levels of cooperation although it was materially worthwhile doing so. In the predictions section, we showed that fairness preference could explain this behavior. If subjects dislike disadvantageous inequity, they experience disutility if their group enforces a higher level of cooperation than the other group.

Envious subjects do not vote for a high level of cooperation if they fear that the other group does not enforce a high level of cooperation. If there is conditional cooperation between the jurisdictions with respect to the enforced level of cooperation, then pessimistic beliefs can cause low enforcement levels and therefore low cooperation. First evidence on this mechanism is presented in Table 5. It analyses the reason for why subjects change their voting decision. The dependent variable is the difference between a subject's vote in the current period compared to the vote in the previous period. As regressors, we used a dummy for whether the own group has chosen a higher rule than the other group and a dummy for whether the own group has chosen a lower rule than the other group. The regression shows that subjects are more likely to decrease their vote if they belonged to the jurisdiction that has chosen a higher vote. Those belonging to a jurisdiction that has chosen the lower vote and those in a situation where the votes were the same in the two jurisdictions increased their vote.[11] This means that conditional enforcement was important. Interestingly, conditional enforcement was stronger in the downward direction.

[11] For the subjects in the group with the lower enforcement, the increase in the vote was significant only in the high cost treatment – even though the coefficient is higher in the low cost treatment than in the high cost treatment.

Table 5: OLS regression with the change of the vote as a dependent variable.

	high cost treatment	low cost treatment
Dummy that equals 1 if subject belonged	-4.674	-4.044
to the group with the higher rule	(0.323)***	(0.226)***
Dummy that equals 1 if subject belonged	0.05	-1.149
to the group with the lower rule	(-0.522)	(0.260)**
Constant	1.08	1.843
	(0.172)***	(0.229)***
Observations	594	540
R-squared	0.1	0.06

Robust standard errors taking into account dependency within matching groups in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

The envy experiment

Even though the regression is evidence in favor of conditional voting, we cannot be sure that the motive of envy causes the decline in enforcement and cooperation. Since the material incentives for enforcing contribution are low, it is not completely obvious that envy is responsible for the decline of enforcement.[12] For that reason we conducted a direct test of the envy hypothesis. If envy causes the low enforcement level, then enforcement should be higher in a treatment in which contribution has no positive externality onto the other jurisdiction.[13] We conducted an experiment with the same structure as above, with very low enforcement costs of 0.05 points per enforced point. In this treatment envy is possible which is why we call this treatment the "envy" treatment. In another treatment called the "no envy" treatment the range of the public goods coincided with he range of the jurisdiction of 3 players. Since we use the same MPCR of $a=0.4$ in this treatment, much lower efficiency gains are possible. But on the other hand, envy with respect to the other jurisdiction does not exist either. Therefore, envious subjects are willing to enforce higher levels of contribution in the "no envy" than in the "envy" treatment. The experiments were also conducted in Zurich with the same subject pool and procedure as in the experiments described above. In total 93 subjects participated in 4 sessions, which lasted about 1 hour and 25 minutes. Subjects earned on average 24 SFR (about 18 US$ at the time of the experiment) including a show up fee of 10 SFR.

This experiment allowed confirming the envy hypothesis unambiguously:

[12] . For instance, there could a general decline in cooperation (and enforcement) and a positive effect after being in the jurisdiction with the lower enforced contribution.

[13] We thank Dirk Engelmann for suggesting this control experiment.

Result 4: *Envy causes the decline in cooperation in the local low cost treatment.*

Figure 4 shows the result of this experiment. In both treatments subjects start with the same contribution level but the behavior diverges. While in the no envy condition, where the public goods covers only the group of three, cooperation slightly increases, it declines in the envy condition. So, cooperation significantly differs in the last period between the two treatments. (This result is statistically confirmed with an Tobit regression and by a Mann Whitney rank sum test on matching groups average. For all x, the cooperation averages of the last x periods is higher in all of the 4 “no envy” matching group compared to the 4 "envy” matching groups which gives a significance of p=0.028, two-sided.) This is clear evidence in favor of the envy hypothesis. If subjects can enforce a contribution level in their own group, they achieve a higher level of contribution even if the prospects of cooperation are not very high. If their contribution has a strong positive externality onto the other group, envy creates an environment that discourages cooperation.

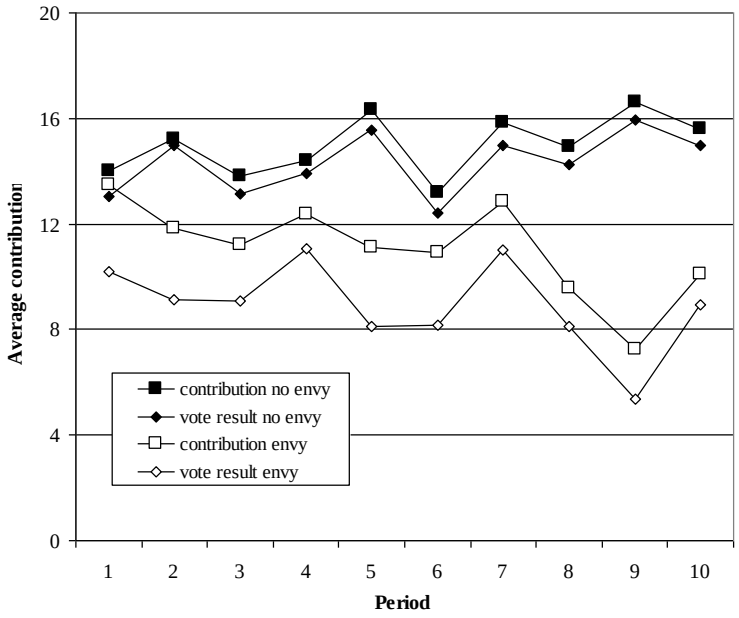

Figure 4: Time path of the envy control experiment.

We have seen in the introduction that the prisoners’ dilemma on an individual level may translate into a prisoners’ dilemma between jurisdictions if the range of the public good does not correspond with the range of the jurisdiction. The evidence of our experiment goes even further. In this situation, selfish player would enforce full cooperation in their jurisdiction. However, since many subjects are envious, they do not enforce high levels of

cooperation. The loss in income caused by this behavior is considerable and summarized in result 5.

Result 5: *In the global treatment income increase over time; in the local treatments they decrease. In later periods, profits are higher in the global treatment than in the local treatments. In the low cost local treatment, earnings are higher than in the high cost local treatment.*

The first best solution (all cooperate voluntarily) gives a payoff of 48 points. The second best solution (maximum contribution is enforced) creates an income of 45 in the low cost treatments and an income of 38 in the high cost treatments. Figure 4 shows the time path of the payoffs in the three treatments. As expected from Figures 1 to 3, the time trend is positive only in the global treatment. Regression results as well as a Mann Whitney rank sum test reveal that in the last period, payoffs are higher in the high cost global treatment than in the low cost local treatment.[14] It is stunning how badly subjects perform in the low cost local treatment. While 45 points could easily be achieved, subjects earn only about 30 point at the end of the run.

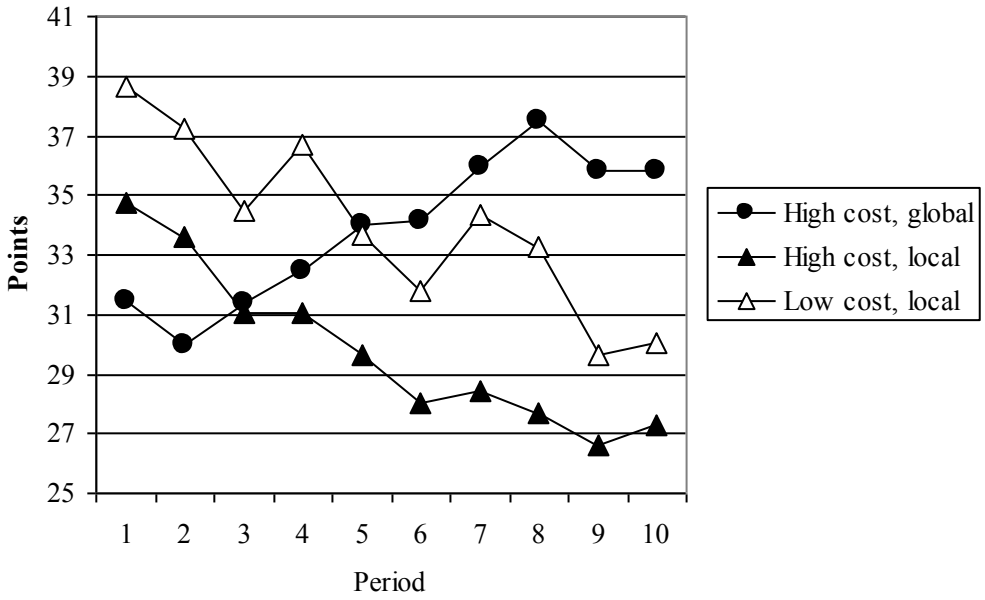

Figure 5: Average period earnings per subject.

[14] In the last two period, payoffs of matching groups were higher in the global treatment than in the local treatments and there were lower in high cost local treatment than in the low cost local treatment. This yields p-values of 1/35 and 1/63 for the two-sided test.

Envy occurs due to a coordination problem. The two groups cannot communicate and therefore different enforcement levels result, causing envy for the subjects in the jurisdictions that decides on the higher level of enforced contribution. Since voluntary cooperation was possible, this problem could be mitigated considerable if all subjects would comply with the higher standard. If subjects are sufficiently inequity averse against advantageous inequity, subjects should do so. Result 6 presents evidence on this question, which confirms hypothesis 7 for the high cost local treatment and mildly rejects it for the low cost local treatment.

Result 6: *In the high cost local treatment, jurisdictions with lower enforcement levels have higher voluntary cooperation, voluntary cooperation does not offset the lower enforcement level and voluntary cooperation is highest when both jurisdictions choose the same enforcement level.*

In the low cost local treatment, voluntary cooperation is low and not very sensitive to the difference between the enforcement levels of the two jurisdictions.

In Figure 5, we plotted voluntary cooperation dependent on the difference between the enforcement level in the own jurisdiction and the enforcement level in the other jurisdiction. We first consider the high cost treatment. For instance, the subjects in a jurisdiction, which enforced 11 to 15 points less than the other jurisdiction voluntarily contributed about 8 points, while the members of the other jurisdiction contributed less than 1 point. This example illustrates result 6: those in the lower jurisdiction contribute more but this cooperation is lower than the difference in the enforcement level. Figure 5 also shows that the voluntary cooperation is always lower than the amount the jurisdiction is behind with respect to the enforcement. For example, if the difference in enforced contribution is between 11 and 15, then the jurisdiction with the lower enforcement level contributes on average 7.67 and the other jurisdiction contributes on average 0.38, resulting in a total average of 4.02. This is lower than the average of 6.88 if they enforce equally. It is not always true that those in the jurisdiction with the lower enforcement level contribute more. If in the high cost treatment the difference between the two jurisdictions ranges between 1 and 5, then the jurisdiction with the higher enforcement level has a higher cooperation level. On average, though, the slope of the graphs is downward sloping. But this could be due to the following restriction. If the difference in the enforcement is, say 15, then no voluntary cooperation above 5 is possible. For that reason, we show in Figure 6 the voluntary cooperation in percent of the potential voluntary cooperation dependent on the same difference as in Figure 5. Figure 6 shows that the basic feature addressed in result 6 are also valid for percent voluntary cooperation. This

evidence is statistically supported in the regression in Table 6. The regressions show that voluntary cooperation (whether we measure it in points or in percentage of potential voluntary cooperation) depends significantly the difference between own and other group's enforcement. Furthermore, there is a significant discontinuity at the difference of 0 where voluntary cooperation is particularly high (significantly, though, only in the high cost treatment). The significance findings are also supported in an ordered probit regression.

In the low cost treatment, voluntary cooperation is lower. A Mann Whitney rank sum test on matching group averages shows a weakly significant difference in the absolute level of voluntary cooperation ($p=0.063$, two-sided) and an insignificant difference in voluntary cooperation in percent ($p=0.190$, two-sided). As Figure 5 and Figure 6 as well as the regression in Table 6 reveal, voluntary cooperation is less sensitive to the difference in enforcement levels. One reason is the generally lower voluntary cooperation in this treatment. While in the high cost treatment, in 48% of the decisions, there was voluntary cooperation; this number is 24% in the low cost treatment. A second reason can be found in the different motivations for the choice of the enforcement level in the two treatments. In the high cost treatment, many subjects choose a low enforcement level because it is expensive but they are willing to cooperate voluntarily. When they see that the other group even takes high enforcement costs into account, they like cooperating. On the other hand subjects who choose a low enforcement level are likely do so because of envy or the fear of being exploited. In cooperation decision such subjects have the same problem. Other subjects, in particular those in the own jurisdiction, benefit much more from their cooperation than they themselves.[15]

[15] Actually they have a net loss for cooperation.

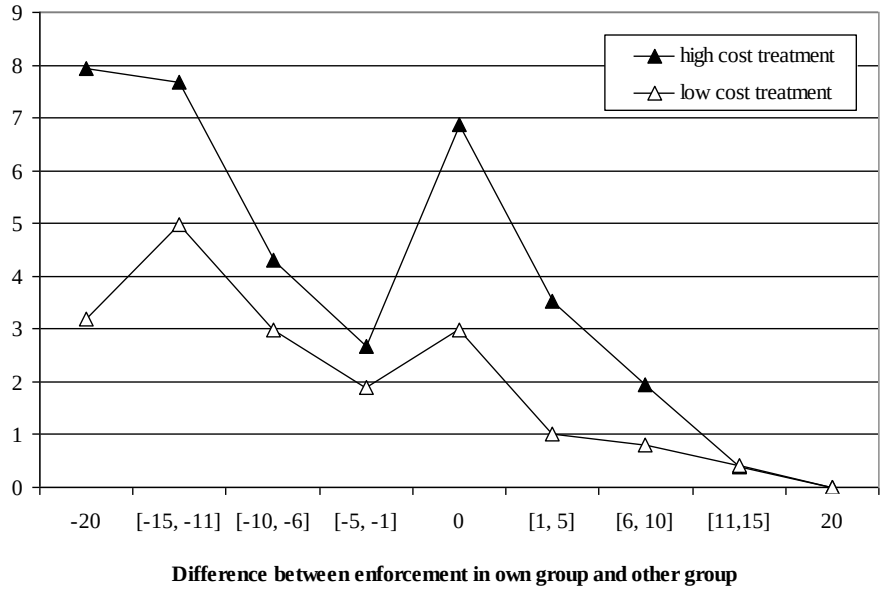

Figure 6: Average voluntary cooperation in points conditioned on the difference between the enforcement level in the own jurisdiction compared to the one in the other jurisdiction.

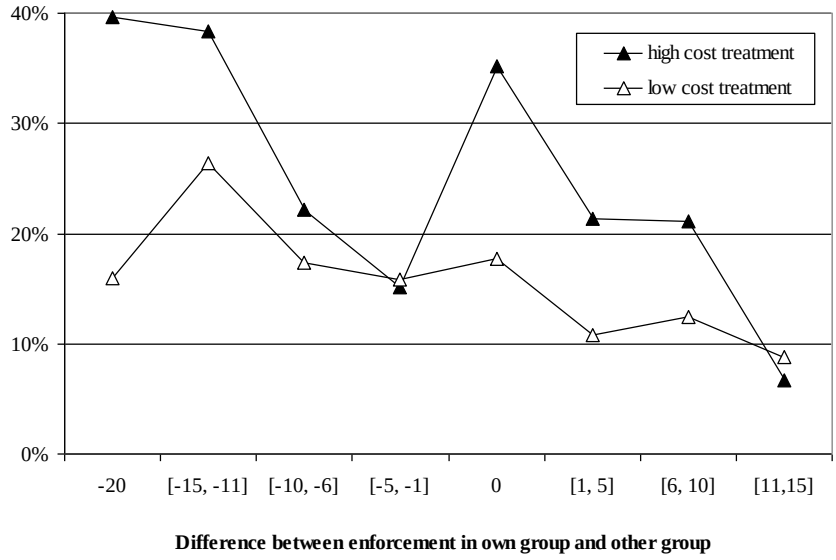

Figure 7: Average voluntary cooperation in percent conditioned on the difference between the enforcement level in the own jurisdiction compared to the one in the other jurisdiction.

Table 6: OLS regression of voluntary cooperation in the local treatments. (Tobit regression unfeasible; ordered probit regressions yield the same significances.)

	(1) Low cost	(2) High cost	(3) Low cost	(4) High cost
Difference between own enforcement level and enforcement level of other jurisdiction	-0.109 (0.032)**	-0.177 (0.041)**	-0.003 (0.002)	-0.005 (0.002)**
Both jurisdictions choose same enforcement	1.163	3.551	0.035	0.143

level (dummy)	(1.099)	(1.056)**	(0.064)	(0.054)*
Constant	1.811	3.327	0.142	0.209
	(0.552)**	(0.786)**	(0.019)***	(0.046)**
Observations	600	660	474	636
R-squared	0.07	0.09	0.01	0.04

Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%; dependent variable is absolute voluntary cooperation in column (1) and (2) and voluntary cooperation in percent of possible voluntary cooperation in column (3) and (4).

7. Conclusion and discussion

We investigated local and global enforcement of cooperation in public goods experiments. Theory predicts that if enforcement costs are sufficiently high in the local enforcement situation, the prisoners' dilemma between the individuals translates into a prisoners' dilemma between the jurisdictions. We have shown that the problem is more serious than theory predicts. Even when it is materially beneficial for the individual countries to enforce higher levels of a public good, people in the county might oppose such a decision because they are envious that the other counties benefit much more, Felder and Schleiniger (2002), for instance, show for Switzerland that a policy to reduce CO_2-emissions will have sufficient positive effect on local environmental quality to justify a unilateral reduction of emissions. However, people are reluctance against a unilateral reduction since people feel unfairly treated – resulting in sayings like: "Why should we contribute to the public good if the other country does not." So, our paper provides a possible answer why a community implements inefficiently low environmental standards and it shows that multinational agreements are even more important than predicted by theory.

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Appendix

In this appendix, we derive the Fehr-Schmidt predictions for the local-global game. We consider trembling hand perfect equilibria.

We first study the global game with complete information, i.e. the situation in which all players know other's preferences.

Proposition A1 (global game with complete information, contribution game): Consider the subgame in the global treatment in which a minimal contribution M is enforced. If there is at least one player with $\beta_i<0.6$, then there is only one equilibrium. In this equilibrium, there is no voluntary contribution. If $\beta_i \geq 0.6$ for all players i, then there is an equilibrium for all $x \in [M, E]$ in which all players contribute x. There are no other equilibria.

Proposition A2 (global game with complete information, full game): Consider now the full game of a global treatment with na>1+c. If there is at least one player with $\beta_i<0.6$, then there is only one equilibrium. In this equilibrium all players vote for E. If $\beta_i \geq 0.6$ for all players i, then there are many equilibria. In all these equilibria, players coordinate on a contribution level in the contribution subgame. The decision in the voting stage is determined by the material optimum given the contributions in the contribution subgames.

Remark: If na<1+c and $\beta_i<0.6$ for at least one player, then player will vote for zero. na<1+c and $\beta_i \geq 0.6$, then there are many equilibria as in the last case of the proposition.

Proposition A3 (global game with incomplete information): If $\beta_i \leq 1-a$ for all player and if there is a positive probability that there are players with $\beta_i < 1-a$, then players vote for full contribution and do not voluntarily contribute (in any subgames).

Proof: First, we will show that a player with $\beta_i \leq 0.6$ will not contribute more than the lowest contribution that occurs with positive probability. Assume that all other players contribute x and there is a positive probability p that some players (assume k players) contribute less. In this case the marginal utility from contributing less that x equals

$$1-a+\frac{pk\alpha_i}{n-1}-\frac{(p(n-k-1)+(1-p)(n-1))\beta_i}{n-1}=1-a+\frac{pk(\alpha_i+\beta_i)}{n-1}-\beta_i \geq 1-a-\beta_i \geq 0.$$

If $\beta_i > 0$ the second last inequality is strict, otherwise the last inequality is strict. Therefore, also player with $\beta_i = 1-a$ will not voluntarily contribute if there is a positive probability that there is a player who does not voluntarily contribute. This is indeed the case since there are players with $\beta_i < 1-a$ who never voluntarily contribute.

Hence, voluntary contribution can only occur in a group of players with $\beta_i = 1 - a$ where this is also common knowledge. However, there is no way to signal this successfully: After the voting stage, only the median vote is revealed. Therefore, there is always a positive probability that there is a player with $\beta_i < 1 - a$ in the group. Q.e.d.

Proposition A4 (local game with complete information, contribution game): Let L and H be the minimal contributions in the jurisdictions 1 and 2. We assume without loss of generality that L<=H.

a) If at least one player in group 1 a beta<0.6 then nobody voluntarily contributes.
b) If in group 1, all players have a beta of exactly 0.6 and at least one player in jurisdiction 2 has a beta below 0.6, then the players in jurisdiction 1 contribute an equal amount x between L and H+c(H-L) and players in jurisdiction 2 contribute H
c) If in group 1, all players have a beta of exactly 0.6 and all players in jurisdiction 2 has a beta of at least 0.6, then the players in jurisdiction 1 contribute an equal amount x between L and 20 and players in jurisdiction 2 contribute max(x–c(H-L),H)
d) If in group 1, all players in jurisdiction 1 have a beta of at least 0.6, at least one player in jurisdiction 1 has a beta above 0.6 and at least one player in jurisdiction 2 has a beta below 0.6, then the players in jurisdiction 1 contribute H+c(H-L) and players in jurisdiction 2 contribute H
e) If in group 1, all players in jurisdiction 1 have a beta of at least 0.6, at least one player in jurisdiction 1 has a beta above 0.6 and all players in jurisdiction 2 have a beta of at least 0.6, then the players in jurisdiction 1 contribute the same amount x between H+c(H-L) and 20 and players in jurisdiction 2 contribute x–c(H-L).

If there is voluntary cooperation, many equilibria exist. In the following, we concentrate on the situation where the players do not voluntarily contribute.

Proposition A4 (high cost local game with complete information, full game): Assume that players do not voluntarily cooperate. If there is a majority of players with $\beta_i \geq 0.5$ in both jurisdictions, then there are many equilibria. In theses equilibria, these player vote for the same $x \in [0, E]$. If there is not majority of players with $\beta_i \geq 0.5$ in both jurisdictions, then all players vote for zero.

Proposition A5 (low cost local game with complete information, full game): Assume that players do not voluntarily cooperate. If there is a majority of players with

$\alpha_i \geq \frac{1}{12}$ in both jurisdictions, then there are many equilibria. In theses equilibria, these player vote for the same $x \in [0, E]$. If there is not majority of players with $\alpha_i \geq \frac{1}{12}$ in both jurisdictions, then all players vote for E.

Deviation incentives

Proposition In the local high cost treatment, choosing a marginally lower enforcement level creates a smaller disutility than choosing a marginally higher enforcement.

In the local low cost treatment, choosing a marginally lower enforcement level creates a smaller disutility than choosing a marginally higher enforcement level if $\alpha_i - \beta_i > 1/6$.