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An experimental test of the public-goods crowding-out hypothesis when taxation is endogenous*

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Abstract

Andreoni (1993) has shown in an experimental study that crowding-out is incomplete when an involuntary lump-sum tax is levied exogenously on individuals to finance the provision of a public good. In this paper, we (i) replicate Andreoni's experimental conditions, (ii) introduce treatments where subjects vote on a tax, which is (iii) either below or above the Nash equilibrium. We find almost complete crowding-out with exogenous taxation. Voting behavior on the tax in the endogenous treatment has high predictive power for voluntary contributions, but only when voting on the tax which is below the Nash equilibrium of the game.

JEL classification: C72, C91, D70, H30, H41

Keywords: taxation, public goods, crowding-out, voting, experiment

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1 Introduction

The theoretical models of Warr (1982, 1983), Roberts (1984, 1987), Bergstrom, Blume and Varian (1986) or Bernheim (1986) show that government provision of privately provided public goods can crowd out private contributions dollar for dollar. However, empirical studies do not support the neutrality of government provision. Field studies of charitable giving by Abrams and Schmitz (1978, 1984), Clotfelter (1985), Kingma (1989) or Brunner (1997) find that crowding out is quite small, with estimates ranging from about 5% to 28%. These empirical findings can better be accounted for by Andreoni's (1990) theory of warm-glow giving, which states that if the act of giving itself has some private value ('warm glow'), then neutrality breaks down, and government contributions to charity will incompletely crowd out private contributions, implying that the total provision of public goods can be increased by taxation.

In an influential paper Andreoni (1993) has examined the public-goods crowding-out hypothesis in an experiment. Although in the controlled and anonymous setting of the laboratory social commitment or peer pressure – factors which might influence contributions to public goods - are absent, Andreoni finds incomplete crowding-out (at about 71%) when an involuntary transfer resembling a lump-sum tax is levied on individuals. In a subsequent study, Chan et al. (2002) have also found incomplete crowding out, but only when comparing contributions to a public good with zero minimum contributions with total contributions given that a strictly positive, mandatory contribution below the Nash equilibrium is required. However, raising the mandatory contribution to the Nash equilibrium, Chan et al. find complete crowding out when comparing total contributions to those in the treatment with a mandatory contribution below the Nash equilibrium. Hence, the study of Chan et al. confirms, in general, the existence of incomplete crowding out, but acknowledges the possibility of complete crowding out of voluntary contributions to a public good through (increased) taxation.

A common feature of Andreoni (1993) and Chan et al. (2002) is that taxation is exogenous, meaning that experimental subjects have no influence on the level of the involuntary contribution, i.e., on the lump-sum taxation for the provision of the public good. In most (representative) democracies decisions on taxation and on the use of tax revenues are taken by representatives and not directly by citizens. Hence, citizens have no direct influence on the level of taxation, but rather face an exogenous determination of taxes. This kind of situation is adequately captured by the experimental designs of Andreoni or Chan et al..

However, in a system of direct democracy like, for instance, in Switzerland, citizens can often vote directly on the introduction of taxes or a change of existing taxes in a popular referendum (Frey, 1994). Since some of these taxes are used to finance otherwise privately provided public goods citizens can both decide on their mandatory contributions (via taxes) as well as their voluntary contributions (through charity) to the public good. Given that voluntary and involuntary contributions to public goods are not independent from each other in many cases[1], we extend the experimental analysis of the crowding-out hypothesis to the case of endogenous taxation. Subjects have to vote, first, by simple majority on whether there shall be an involuntary minimum contribution to the public good for all group members, and, second, they have to decide how much they would like to contribute voluntarily. Through our endogenous treatments we can test

[1] In line with the terminology of Andreoni or Chan et al., mandatory contributions through taxes will also be referred to as 'involuntary' contributions in the following. Note, however, that in a system of direct democracy, where citizens can vote on taxes, contributions through taxes are not strictly involuntary, since the level of taxation has been determined endogenously. Clubs provide another example for the endogenous determination of 'involuntary' contributions. Typically, all members of a club have to approve (for instance, by simple majority) changes in membership fees proposed by the club's board. In addition, they are sometimes requested to give voluntary contributions to improve, for instance, the club's assets, like a tennis court or a sauna facility.

whether the opportunity to vote on a mandatory minimum contribution to a public good increases the amount of overall contributions and how voting behavior and contribution behavior are related.

Naturally, if simple majority is applied in the vote on minimum contributions, some group members may be voted down. Our experimental design allows to examine the influence of being voted down on voluntary contributions to the public good. In particular, we are able to investigate whether voting behavior on the involuntary contribution has any explanatory power for the extent of free-riding on voluntary contributions.[2] Since many regional or global public good or public bad problems – such as local waste disposal, rain forest destruction or global warming – are nowadays tackled through negotiations and formal votes in regional or international political bodies, it seems to us a relevant question whether voting behavior is indicative of the willingness to actually contribute to a public good or to prevent a public bad.

Another common feature of Andreoni (1993) and Chan et al. (2002) is that the level of taxation, i.e. of involuntary contributions to the public good, is *below* the (interior) Nash equilibrium in their non-linear public goods games. But in many cases, negotiations on public goods provision – like preserving the world's ozone layer or fighting the extinction of animal species – focus on minimum contributions *above* the level which would prevail in case of pure self interest.

Therefore, we have set up two different treatments with endogenous taxation, which differ in the level of the mandatory minimum contribution. Comparing behavior in treatments with mandatory contributions below, respectively above the Nash

[2] For a theoretical model of identifying free-riders see Andreoni and McGuire (1993). A recent paper by Brosig (2002) studies in a face-to-face experiment whether individuals who possess a willingness to cooperate can credibly signal it and whether it is recognizable by the partner. Brosig finds that relatively more cooperative subjects are better at predicting their partner's cooperation level in a one-shot prisoner's dilemma game than are relatively egoistic subjects.

equilibrium could yield insights into the effects of more or less ambitious targets in negotiations on public good provision.

A third common feature of Andreoni and Chan et al. is the fact that taxation is always symmetric for all group members. In a companion paper to the present one, Sutter and Weck-Hannemann (2003) have introduced asymmetric taxation in the sense that group members face different mandatory minimum contributions (below the Nash equilibrium).[3] They show that asymmetric taxation has no influence on a group's overall contribution. Yet, asymmetric minimum contributions interact importantly with the way of determining minimum contributions. If minimum contributions are determined exogenously, subjects with higher minimum contributions give, on average, considerably more than those with lower minimum contributions. Yet, if minimum contributions are determined endogenously, the reverse holds true: Subjects with the higher tax burden contribute in total less than subjects with the lower tax burden. Endogeneity crowds out cooperation of those subjects with the relatively higher tax burden.

The rest of the paper is organized as follows. Section 2 introduces the experimental design. Section 3 presents our results. A conclusion is drawn in Section 4.

2 Experimental design

Our experimental design builds on Andreoni (1993). Groups are composed of three subjects. Each subject is endowed with 7 tokens which can be contributed simultaneously in integer numbers to a public good. The combination of own

[3] Variations in income tax systems, for instance, can lead to different (i.e. asymmetric) tax liabilities for tax payers with the same income. Married single earners have to pay lower taxes in a system of family based taxation with income splitting, like in Germany, than under an income tax system where each taxpayer is treated separately and family status plays no role, like in Austria.

contributions and the sum of contributions of the other two group members determines a subject's payoff per round according to Figure 1.

Figure 1 about here

The payoff-matrix in Figure 1 has a unique Nash equilibrium for each subject to contribute 3 tokens with a resulting payoff of 61 Taler per round. The symmetric Pareto efficient point is where each subject contributes 6 tokens with earnings of 109 Taler per round.

The experiment consists of five phases with four rounds in each phase. Subjects are informed that within each phase the group composition is fixed (partner matching). Between phases, however, group composition changes in such a way that each subject is paired with another participant at most in one phase (perfect stranger matching).

We have set up four different treatment conditions. The baseline treatment is the *no-tax* treatment which has no mandatory minimum contribution to the public good. In the *exo-tax* treatment subjects have to contribute at least 2 tokens to the public good. This treatment is identical to Andreoni's tax-condition. Subjects in the exo-tax treatment are informed that payoffs in rows labeled '0' to '3' and columns labeled '0' and '1' are not feasible, because each group member has to contribute at least 2 tokens.

The two further treatments are denoted *endo2-tax* and *endo4-tax*, respectively. The distinctive feature of both treatments is that the mandatory minimum contribution of 2 tokens in endo2-tax, respectively 4 tokens in endo4-tax, is endogenously determined.[4] At the beginning of each phase there is a secret vote in which all members of a group have to vote with 'Yes' or 'No' whether there shall be a mandatory minimum contribution of 2 (4) tokens for all group members for the whole phase (i.e., for the next 4 rounds). If a simple majority of group members votes in favor of a mandatory minimum contribution then it applies. Otherwise, there is no mandatory minimum contribution and the whole range of contributions from zero to seven tokens is permissible in the respective phase. Votes have to be cast simultaneously and group members are informed about how many group members have voted for the minimum contribution and whether the minimum contribution applies in this phase. Individual voting behavior remains anonymous for other group members and cannot be linked to individual contribution decisions later on in a phase.

Note that in case the simple majority is passed in the endo2-tax treatment, then the same contribution conditions as in the exo-tax treatment apply. If the minimum contribution is rejected (in either endo2-tax or endo4-tax), subjects face the same conditions as in the no-tax treatment. This experimental design allows to test for the effects of endogeneity by controlling for the size of the minimum contribution.

If we expect subjects to play the Nash equilibrium of Figure 1, our prediction is that contributions should not differ between no-tax, exo-tax and endo2-tax, since in these three treatments the involuntary contribution is in any case below the Nash equilibrium. This would imply that positive involuntary contributions crowd out voluntary contributions completely, as in the standard model of Warr (1982). The theory of warm glow giving by Andreoni (1990) would predict incomplete crowding-out of voluntary contributions through involuntary contributions. The theory of social ties formation and public good provision by van Dijk and van Winden (1997) would predict just the opposite. Positive social ties provide individuals with additional resources in times of need, and, thus, increase cooperation levels in public goods games. Government

[4] A translation of the instructions for the endo2-tax treatment can be found at

provision impedes the development of social ties and, therefore, leads to a decrease of total provision of a public good, i.e. to over-crowding-out.

The effects of endogeneity are hard to predict. In the context of a linear public good game, Tyran and Feld (2002) have shown that voting for the imposition of a mandatory minimum contribution (above the Nash equilibrium of contributing nothing) can serve as a signal to be willing to cooperate, i.e. it can activate the social norm of cooperation. In our non-linear setting, the effects of voting are more difficult to assess. In the endo2-tax treatment, the outcome of the vote on the tax plays no role at all, provided that subjects are willing to play Nash, i.e. contribute 3 tokens each. As a consequence, we expect no systematic bias of voting in favor or against the mandatory minimum contribution in endo2-tax.[5]

In endo4-tax, groups accepting the minimum contribution of 4 tokens can enforce contributions above Nash. If a subject expects the other group members to contribute 3 tokens in case of no mandatory minimum contribution, it is a weakly dominant strategy to vote for the minimum contribution of 4 tokens. The voting stage, then, has several Nash equilibria in which either group members vote unanimously for or unanimously against the tax, or in which two out of three members vote for the tax.[6]

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http://homepage.uibk.ac.at/~c40421/research.html.

[5] The endogenous treatments can be described as two-stage games with perfect information about payoffs, with voting as the first stage and contributions as the second stage. The voting stage in endo2-tax is, basically, a cheap talk game, since the tax – if it is accepted – constitutes no binding limit for a rational and self-interested subject. Nevertheless, voting may convey private information (similar to the private provision games studied by Gradstein, 1992) about the degree of conditional cooperation, warm-glow or inequity aversion, for instance. Yet, for our theoretical prediction of voting behavior in endo2-tax we take as a benchmark for behavior in stage 2 of the game the Nash equilibrium, which makes the voting outcome irrelevant, because the tax is below the Nash equilibrium.

[6] If we consider these Nash equilibria to be equally likely, we should observe, on average, 60% of subjects to vote for the tax. Note that voting in the endo4-tax treatment is no cheap talk game because accepting the tax excludes self-interested behavior in the form of playing Nash in the contribution stage.

3 Experimental results

The experiment was run computerized with the help of Z-Tree (Fischbacher, 1999) in January and March 2001 as well as March 2003 at the University of Innsbruck. For each treatment, we had 36 participants. On average, a session lasted 50 minutes, with subjects earning about 140 Austrian Schillings (about 10 Euro).

In discussing the results we, first, re-examine the crowding-out hypothesis by comparing subjects' contributions in the no-tax and exo-tax treatments. Second, we investigate the effects of endogeneity. Third, we analyze the relation between voting behavior and contributions in the endogenous treatments.

3.1 Exogenous taxation and crowding-out

Table 1 reports average contributions to the public good in the no-tax and exo-tax treatments, as well as the difference between both treatments. Overall averages – including the mandatory contribution of 2 tokens in exo-tax – are 3.18 tokens in the no-tax treatment, respectively 3.23 tokens in the exo-tax treatment. The difference in averages is not statistically significant. The slightly higher mean in exo-tax implies that, on average, crowding-out is almost complete with 97.5%.

Table 1 about here

Taking overall averages, our result is consistent with the neutrality theories referred to in the introduction, but at odds with Andreoni's main result of incomplete crowding-out. In order to resolve the origin of the difference to Andreoni, we compare data across both experiments, finding that the difference lies in the no-tax treatments, but not in the tax-treatments. Whereas subjects in Andreoni's no-tax treatment contribute on average

2.78 tokens with a standard deviation of 0.65, our subjects contribute significantly more with 3.18 tokens and a standard deviation of 0.61 (*t*-value = –2.69)[7]. Contributions in the exo-tax treatments, on the contrary, do not differ: 3.35 tokens (standard deviation of 0.77) in Andreoni's experiment versus 3.23 tokens (standard deviation of 0.72) in our experiment (*t*-value = 0.68). Of course, we do not argue that Andreoni's conclusion of incomplete crowding-out is wrong, but we are not able to replicate his finding when looking at overall means.

Table 2 about here

Therefore, we take a closer look at a more disaggregated level by comparing relative frequencies of contributions at all possible levels between the no-tax and the exo-tax treatment (see Table 2).[8] Recall that subjects in the exo-tax treatment are forced to contribute at least 2 tokens, which is their actual choice in about a third of cases. By collapsing relative frequencies into three categories (0-2 tokens, 3-6 tokens, 7 tokens), we can check whether the frequency of choosing contributions in these three categories differs across treatments. In fact, we find that distributions are significantly different between the no-tax and exo-tax treatments ($\chi^2 = 6.3$; $p < 0.05$; $df = 2$). The difference is caused by the frequencies in the tails: Subjects in the no-tax treatment contribute more often 7 tokens, but less often below 3 tokens, than subjects in the exo-tax treatment.[9] Contributions from 3 to 6 tokens are very similar across both treatments.

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[7] Even though we do not have the individual raw data of Andreoni's experiment, average contributions and the corresponding standard deviations suffice to perform a t-test, which, however, is not strictly applicable since it assumes a normal distribution.

[8] For the sake of expositional brevity, relative frequencies for the endogenous treatments discussed in subsection 3.2 are already included in Table 2.

[9] One might wonder why subjects choose contributions below the Nash equilibrium of 3 tokens. Besides considering the possibility of subjects making mistakes, contributions below Nash could be rationalized by optimistic expectations about the other group members' total contributions. Given that a subject expects the others to contribute at least 7 tokens in total, then contributing 3 tokens is strictly

Hence, even though contribution levels do not differ *on average* between no-tax and exo-tax, taxation has an influence on the distribution of *individual* contributions. We may conclude that taxation leads to a significant shift in individual behavior, which is in line with the previous results of Andreoni (1993) and Chan et al. (2002).[10]

3.2 The effects of endogeneity on contributions

Table 3 reports contribution and voting behavior in the five phases of our endogenous treatments, with data for endo2-tax in the upper half and for endo4-tax in the lower half. The column labeled 'Overall' considers the contributions of all 36 subjects, irrespective of the outcome of the vote on the tax. The next three columns present average contributions, conditional on the tax applying or not, and the difference between both conditions. The two columns on the right hand side indicate the number of subjects voting for the tax in a given phase, respectively the number of subjects for which the tax applies.

We start by presenting results for contribution behavior in endo2-tax (see upper half of Table 3), where the tax (if it applies) is below the Nash equilibrium. The overall average contribution of 3.03 tokens in endo2-tax is not significantly different from the overall averages in no-tax (3.18) or exo-tax (3.23).[11] Given that the minimum contribution is not binding in any of these treatments, the lack of significant differences is not unexpected. Hence, in our non-linear public goods game endogeneity per se does

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dominated by contributing 2 tokens. The same reasoning can be applied to why subjects contribute 1 token or zero.

[10] Note that the shift in individual behavior is inconsistent with Warr's (1982, 1983) theory and is suggestive of some social motives – like the warm glow of giving (Andreoni, 1990) – playing a role for behavior in the exo-tax treatment. Since taxation has basically increased the spread in the data, without changing the mean, we have not found any differences in means between both treatments.

[11] With respect to the relative frequencies of individual contributions, given in Table 2 above, we find no significant differences between the exo-tax and endo2-tax treatments. Frequencies differ in the same way, i.e., in the tails, between the endo2-tax and no-tax treatment as they do between the exo-tax and the no-tax treatments.

not raise cooperation by activating social norms as observed in the linear public good setting of Tyran and Feld (2002).[12]

Looking at contributions in endo2-tax, conditional on the tax applying or not, we find that subjects contribute on average 3.17 tokens, if the tax is accepted, but only 2.53 tokens, if the tax is rejected in a group. We tested for a significant difference between these two means by considering only those 25 out of 36 subjects who faced both conditions (rejection and acceptance of tax) at least in one phase, and then applied a Wilcoxon signed ranks test ($p < 0.01$). The fact that contributions are lower without the tax than with the tax is another indication of incomplete crowding-out of 68%, which is quite close to Andreoni's degree of incomplete crowding-out and inconsistent with Warr's results.

Table 3 about here

Next, we look at contributions in the endo4-tax treatment (see lower half of Table 3), where the possible tax is above the Nash equilibrium. The overall average of contributions is 3.90 tokens, which is significantly larger than in any other treatment ($p < 0.01$ for any pairwise comparison; Mann-Whitney U-test). Therefore, we may conclude that the opportunity to implement a binding limit for purely self-interested behavior by voting for a mandatory contribution above Nash raises overall efficiency significantly.[13] This overall result is driven by the cases where the tax is successfully implemented. Given the tax applies, average contributions are 4.41 tokens, compared to

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[12] In the first phase of the experiment, contributions in endo2-tax are even significantly smaller than in the exo-tax treatment (3.12 versus 3.48; $p < 0.05$; Mann-Whitney U-test, $N = 24$ groups). Phase 1-contributions in the no-tax treatment (3.36) are not significantly larger than in the endo2-tax treatment. From the second phase on, there are no significant differences between contributions in any pairwise comparison of no-tax, exo-tax and endo2-tax.

2.79 tokens when the tax is rejected ($p < 0.01$; Wilcoxon signed ranks test; $N = 29$ subjects who faced both acceptance and rejection of the tax).

3.3 Voting behavior and contributions

Looking at voting behavior in our endogenous treatments (see the right hand side of Table 3), we find that in endo2-tax 71% of subjects vote for the tax at the beginning of each phase, on average, yielding an average of 9.4 out of 12 groups (i.e. 28.2 out of 36 subjects) to accept the tax of 2 tokens. In endo4-tax, support for the tax is lower, but not significantly different. 62% of subjects vote for the tax and 8.2 groups, on average, accept the tax of 4 tokens.

According to the theoretical benchmark there should be no systematic bias of voting in favor or against the tax in endo2-tax, since the outcome of the vote does not affect subjects' opportunity to play the Nash equilibrium. If subjects had randomized voting behavior with equal probability, each subject would have voted, on average, 2.5 times for the tax. Actually, 10 out of 36 subjects voted less than 2.5 times 'Yes', but the other 26 subjects voted 'Yes' more often ($p < 0.05$; binomial test). In endo4-tax, we cannot reject the hypothesis that subjects vote for the tax with a probability of 60%, which would apply in case all Nash equilibria of the voting stage would be equally likely. But neither can we reject the hypothesis that voting is random with probability of one half.

Looking at individual voting patterns, we find that only 2 (3) subjects vote in all five phases against the tax, but that 15 (12) subjects vote always for the tax in endo2-tax (endo4-tax). In the course of the experiment, support for the tax is growing in both

[13] This can also be checked by looking at subjects' average profits, which are the following. 133 ATS in no-tax; 135 ATS in exo-tax; 124 ATS in endo2-tax; 164 ATS in endo4-tax.

treatments.[14] In order to examine voting behavior more carefully, we run a logit regression where we regress a subject's voting decision on the tax ('Yes' = 1, 'No' = 0) in phase $t + 1$ on the following independent variables: *diff* denotes the difference between a subject's own contributions and the average contributions[15] of the other two group members in previous phase t; *min* is a dummy variable for the acceptance (rejection = 0) of the tax in phase t. We also include a dummy variable *phaseX* for each of the phases 3 to 5 in which the vote is cast.

Table 4 about here

The upper (lower) part of Table 4 shows the results of our logit regression for the endo2-tax (endo4-tax) treatment. In endo2-tax the variable *diff* is significantly positive. A one unit increase in the difference between own contributions and the other group members' contributions raises the probability of voting for the tax by 15.5 percentage points, where the marginal effect is evaluated at the mean of the dependent variable (0.72). The variable *min* is negative, but insignificant. Thus, whether or not the tax has been accepted in phase t has no systematic effect on voting behavior in phase $t + 1$. Finally, the dummies for phases 4 and 5, respectively, are significantly positive, implying that the likelihood to vote for the tax in these phases is significantly larger than in phase 2.

Interestingly, results in our endo4-tax treatment are clearly different from those in endo2-tax. Most notably, the variable *diff* is not significant any longer, neither are the

[14] Aggregating 'Yes'- and 'No'-votes of phases 1-3, respectively those of phases 4 and 5, we find that the distribution of votes is significantly different between the early and the final phases ($\chi^2 = 7.5$ in endo2-tax; $p < 0.01$; $\chi^2 = 4.3$ in endo4-tax; $p < 0.05$; $df = 1$).

[15] Note that participants in the experiment were only informed about the sum of contributions of the other two group members. Hence, a subject could only compare his own contribution to the average contribution of the other two group members.

dummies for the later phases of the experiment, even though they are positive. Only the variable *min* is significantly positive, meaning that if the tax has been accepted in the previous round, then the likelihood of voting for the tax in the current round is higher by 12.5 percentage points.

Particularly striking is the different influence of the variable *diff* in both treatments. Whereas the significantly positive coefficient in endo2-tax indicates a significant relation between voting and contribution behavior, in endo4-tax there seems to be no systematic relationship between both variables. In the following, we would like to explore this difference from another angle by looking at the effects of being voted down on contribution behavior. Applying simple majority rule in groups of three persons implies that one group member may be voted down and has to bow to the will of the majority. This happened in 38 (44) out of 60 possible cases in endo2-tax (endo4-tax).

Starting with endo2-tax, there are 12 cases where one group member votes for the tax, but the other two members against it. The subject being voted down contributes on average 0.40 tokens more than the other two group members. Even though the difference is not significant at conventional levels ($p = 0.15$; two-sided Wilcoxon signed ranks test), one may cautiously interpret the evidence such that voting 'Yes' is an indication for relatively more cooperation. With respect to those 26 cases where one group member has to comply with the tax although he has voted against it, the subject being voted down contributes on average 0.21 tokens less than the other two group members. This difference is weakly significant ($p < 0.1$; two-sided Wilcoxon signed ranks test), implying that subjects voting against the tax contribute, in fact, also relatively less to the public good. Hence, voting 'No' is on average correlated with more free riding.

In endo4-tax, voting behavior when being voted down is no longer a significant indication of (more or less) cooperation: Subjects voting for the tax (of 4 tokens) when it is rejected in the group contribute on average even 0.16 tokens less than the other two group members ($p > 0.5$; Wilcoxon signed ranks test; $N = 16$). Subjects voting against the tax in case it is accepted in the group contribute on average 0.01 tokens less than the supporters of the tax ($p > 0.5$; Wilcoxon signed ranks test; $N = 28$).

Hence, our treatment variation when taxation is endogenous offers an interesting insight. Whereas voting behavior is not correlated in any way with contributions when the tax is *above* the Nash equilibrium (endo4-tax), supporting a tax *below* the Nash equilibrium (endo2-tax) is correlated with higher contributions, in particular when the tax is accepted. Note that in endo2-tax the voting stage offers no opportunity to signal high cooperation (above the Nash equilibrium) since the vote is only on a minimum contribution below the Nash equilibrium. Yet, if the tax of 2 tokens applies, the room for exploitation by the other two group members is restricted (since they have to contribute in sum at least 4 tokens). Therefore, cooperation in the form of higher contributions is less risky. Those voting for the tax of 2 tokens (in case it is accepted) are obviously more willing to bear that risk by contributing more than those voting against the tax.[16] It seems that voting against a tax below the Nash equilibrium can be tentatively interpreted as a willingness to try to exploit the other group members. This is not the case in the endo4-tax treatment, where the tax is above the Nash equilibrium. In this case, voting against the tax does not necessarily imply that a subject has a tendency to exploit the others (by contributing below Nash), since it is still possible – and rational – to choose the Nash equilibrium in case the tax fails. In addition, voting for the tax in case the tax is accepted does not imply higher contributions of tax supporters compared

[16] Higher cooperation in case the tax of 2 tokens is accepted may be explained by the concept of conditional cooperation, which states that people are willing to contribute more to a public good the more others contribute (see Brandts and Schram, 2001; Fischbacher et al., 2001; Keser and van Winden, 2000). In our case, the tax guarantees a positive minimum contribution of other group members which puts a floor on their minimum contribution. This might raise the willingness of other group members to contribute more since they are less likely to be exploited.

to tax opponents. One possible explanation for the insignificant relation between voting and contribution behavior might be that contributing 4 tokens when a tax of 4 tokens applies is a strictly dominant strategy.[17]

4 Conclusion

Our experimental results indicate that voluntary contributions to the provision of a public good can be completely crowded out in the aggregate by involuntary contributions through lump-sum taxation. Although this result has been established in a variety of theoretical papers from the 1980s, field studies as well as experimental studies have so far – to the best of our knowledge – only found incomplete crowding-out. Compared to the prominent study of Andreoni (1993) who has found crowding-out of about 71%, we find almost complete crowding out of 97.5% in the aggregate when taxation is imposed exogenously. As such, our results are similar to Chan et al.'s (2002) findings of complete crowding out when raising the level of taxation from below the Nash equilibrium to the Nash equilibrium of a non-linear public goods game. On the individual level, however, we find that taxation leads to a shift in the frequencies of individual contributions which is in line with Andreoni's observations and the observations of Chan et al. where they compare contributions without a minimum contribution to those when a tax below the Nash equilibrium applies.

The main innovations of this paper have been the introduction of treatments where (i) subjects determine endogenously whether a tax is imposed as a mandatory ('involuntary') contribution to the public good and where (ii) the level of involuntary contributions is either below or above the Nash equilibrium of the game. These features are common in direct democracy and in negotiations of regional and international

[17] In fact, 70.5% of subjects facing the minimum contribution of 4 tokens contribute exactly 4 tokens.

committees tackling public goods problems like local waste disposal, rain forest destruction or global warming.

When the endogenous tax is below the Nash equilibrium, endogeneity per se has no influence on the level of cooperation. There is no significant difference in average contributions between our no-tax, exo-tax or endo2-tax treatments. Yet, voting behavior and voting outcomes in our endo2-tax treatment provide some interesting insights. First, failing a simple majority to impose a lump-sum tax of 2 tokens on all group members crowds out cooperation, to about 15% below the Nash equilibrium, compared to a situation where the tax is accepted by a simple majority. Second, subjects' voting behavior is closely related to their contributions. If a subject votes for the tax, its total contributions are about 15% higher than if it votes against the tax. If a subject has to bear the tax although having voted against it, the contributions of this very subject are significantly below the other group members' contributions, thereby impairing the provision of a public good.

When the endogenous tax is above the Nash equilibrium in our endo4-tax treatment, overall average contributions are significantly larger than in any other treatment. Therefore, we may conclude that the opportunity to implement a binding limit for purely self-interested behavior by voting for a mandatory contribution above Nash raises overall efficiency significantly. Even though the simple majority for the implementation of the tax is slightly, but insignificantly, less often reached in endo4-tax than in endo2-tax, from the perspective of social efficiency it seems clearly preferable to vote on a relatively more ambitious tax, i.e. mandatory minimum contribution. Whether this conclusion prevails also with even more ambitious tax targets would be an important question for international negotiations on global warming, for instance, but awaits further studies.

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Tables and Figures

Figure 1. The payoff matrix

Your contribution

Total contributions by the other two group members	tokens	0	1	2	3	4	5	6	7
	0	0	1	3	6	9	10	11	10
	1	1	4	8	11	14	15	15	14
	2	5	9	14	18	20	21	20	17
	3	12	17	22	26	28	28	25	22
	4	21	28	33	36	37	35	32	27
	5	34	40	45	48	47	44	39	32
	6	49	56	60	61	59	54	47	38
	7	68	74	77	76	72	64	55	44
	8	90	95	96	93	86	76	64	51
	9	115	118	117	111	102	89	74	58
	10	143	144	140	131	119	103	85	66
	11	175	173	166	153	137	118	97	75
	12	210	205	193	177	157	134	109	84
	13	248	239	223	203	178	151	122	93
	14	290	276	256	230	201	169	136	103

Table 1 – Average contributions to the public good in the no-tax and exo-tax treatments

Phase (Rounds)	No-tax ($N = 36$)	Exo-tax ($N = 36$)	Difference Exo-tax – no-tax
1 (Rounds 1-4)	3.36	3.49	0.12
2 (Rounds 5-8)	3.35	3.23	-0.12
3 (Rounds 9-12)	3.15	3.35	0.20
4 (Rounds 13-16)	3.06	3.06	0.00
5 (Rounds 17-20)	3.00	3.04	0.04
Average	3.18	3.23	0.05
std. deviation	0.61	0.72	

Table 2 – Relative frequencies of total contributions to the public good

	contribution							
treatment	0	1	2	3	4	5	6	7
no-tax	0.060	0.078	0.174	0.304	0.192	0.114	0.046	0.033
exo-tax			0.346	0.315	0.183	0.086	0.054	0.015
endo2-tax	0.036	0.026	0.317	0.283	0.226	0.063	0.036	0.013
endo4-tax	0.036	0.038	0.064	0.081	0.531	0.165	0.060	0.026

N = 720 in each treatment

Table 3 – Average contributions to the public good in the endogenous treatments

Phase (Rounds)	Overall	Average contribution with tax	Average contribution without tax	Difference with tax – without tax	*N* (vote 'Yes' for tax)	*N* (with tax)
endo2-tax						
1 (Rounds 1-4)	3.12	3.33	2.69	0.64	23	24
2 (Rounds 5-8)	2.85	3.12	2.33	0.79	21	24
3 (Rounds 9-12)	3.08	3.36	2.22	1.14	24	27
4 (Rounds 13-16)	3.15	3.17	2.92	0.25	30	33
5 (Rounds 17-20)	2.97	2.94	3.25	-0.31	29	33
Average	3.03	3.17	2.53	0.64	25.4	28.2
endo4-tax						
1 (Rounds 1-4)	3.99	4.69	3.02	1.67	19	21
2 (Rounds 5-8)	3.81	4.60	2.70	1.90	19	21
3 (Rounds 9-12)	3.88	4.37	2.42	1.95	22	27
4 (Rounds 13-16)	3.88	4.25	2.75	1.50	26	27
5 (Rounds 17-20)	3.94	4.27	2.94	1.33	25	27
Average	3.90	4.41	2.79	1.62	22.2	24.6

Table 4 – Determinants of voting on the tax

Logit estimates

Endo2-tax

Variable	Coefficient		Z-value	Marginal effect
diff	0.78	**	3.18	15.5%
min	-0.17		-0.70	-3.3%
phase3	0.38		0.74	7.5%
phase4	1.39	**	2.37	27.9%
phase5	1.25	**	2.17	25.1%
constant	-0.34		-0.50	
N	144		Mean dependent variable	0.72
Log Likelihood	-75.33		Level of significance **	$p < 0.01$.

Endo4-tax

Variable	Coefficient		Z-value	Marginal effect
diff	0.03		0.11	0.6%
min	0.54	**	5.14	12.5%
phase3	0.01		0.01	0.0%
phase4	0.63		1.12	14.6%
phase5	0.47		0.83	10.7%
constant	-1.60	**	-2.29	
N	144		Mean dependent variable	0.64
Log Likelihood	-77.30		Level of significance **	$p < 0.01$.

Notes:

Dependent variable is voting for (= 1) or against (= 0) the tax in phase $t + 1$.

diff denotes the difference between own contributions and average contributions of other group members in phase t.

min is a dummy variable with value 1 if the tax has been accepted in phase t.

phase denotes the phase $t + 1$ in which the respective vote is cast.

Appendix (for referees' use only; conditional on acceptance of the paper, the experimental instructions will be made available on the following website: http://homepage.uibk.ac.at/homepage/c404/c40421/research.html)

A1. Instructions for the Endo2-tax treatment

The following instructions are translated from German. Instructions for the other treatments are available upon request from the authors.

Welcome to the experiment!

Please, do not talk to any other person than the experimenter until the end of the experiment.

In this experiment, you can earn money through a contribution to a common project. How much money you will earn depends upon your own contribution as well as the contributions of two other participants with whom you form a group of three persons.

The experiment has 5 phases. Each phase has 4 rounds. That means there will be 20 rounds in total, after which the experiment will be terminated.

Within each phase, the group composition is fixed. Between phases, group composition changes in such a way that you will never be in a group together with any participant with whom you have been in a group in an earlier phase.

Each phase and each round follow the same procedure.

In each round, you are requested to decide on your contribution to the common project. Your contribution can range from 0 tokens to 7 tokens.

At the beginning of each phase there is a secret vote in which all members of a group have to vote with 'Yes' or 'No' whether there shall be a mandatory minimum contribution of 2 tokens for all group members for the whole duration of this phase (i.e., for the next 4 rounds).

After all group members have cast their votes you will be informed about the number of 'Yes'- and 'No'-votes and about the collective outcome. If two or more group members vote 'Yes', then the mandatory minimum contribution applies. Otherwise, there will be no mandatory minimum contribution.
After 4 rounds group composition changes and the next phase starts with another secret vote on the minimum contribution.

The following table shows the income in Taler you get from a given combination of your own contribution and the sum of contributions of the other two group members. The payoff table is identical for each participant in this experiment.
In the top row of the table (light colored) you see your possible contribution levels from 0 to 7 tokens. If a mandatory minimum contribution applies in a certain phase, you have to contribute at least 2 tokens. That means that the payoffs in columns '0' and '1' are not possible in this phase.
The first column on the left (dark colored) shows the sum of contributions of the other two group members. The sum can range from 0 to 14 tokens. In case the minimum contribution applies, the sum of both members' contribution is at least 4 tokens. That means that the payoffs in rows labeled '0' to '3' are not possible in the respective phase.

Your income in a certain round can be found at the intersection of the column with your own contribution and the row with the sum of contributions of the other two members. Your income in each round will be added up. Your total income will be paid to you anonymously by a cashier who is not present during the experiment. For exchanging Talers into Austrian Schillings we apply the following exchange rate:

10 Taler = 1 Austrian Schilling

Before the experiment starts, there will be 2 trial rounds with a vote before the first trial round. The purpose of the trial rounds is to make you acquainted with the computer screens you will face during the experiment. Income from trial rounds will not be considered for your total income at the end of the experiment.

Table: Your income in Taler

Your contribution in tokens (column)

Total contributions by the other two group members (row)

tokens	0	1	2	3	4	5	6	7
0	0	1	3	6	9	10	11	10
1	1	4	8	11	14	15	15	14
2	5	9	14	18	20	21	20	17
3	12	17	22	26	28	28	25	22
4	21	28	33	36	37	35	32	27
5	34	40	45	48	47	44	39	32
6	49	56	60	61	59	54	47	38
7	68	74	77	76	72	64	55	44
8	90	95	96	93	86	76	64	51
9	115	118	117	111	102	89	74	58
10	143	144	140	131	119	103	85	66
11	175	173	166	153	137	118	97	75
12	210	205	193	177	157	134	109	84
13	248	239	223	203	178	151	122	93
14	290	276	256	230	201	169	136	103

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