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Mandatory minimum contributions, heterogeneous endowments and voluntary public-good provision

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Résumé/abstract

In a public-good experiment with heterogeneous endowments, we investigate if and how the contribution level as well as the previously observed "fair-share" rule of equal contributions relative to one's endowment (Hofmeyr et al., 2007; Keser et al., 2014) may be influenced by minimum-contribution requirements. We consider three different schedules: FixMin, requiring the same absolute contributions, RelMin, requiring the same relative contributions, and ProgMin, requiring minimum contributions that progressively increase with the endowment. We find that minimum contributions exert norm-giving character and may lead to an increase in average group contributions. This is especially true for the progressive schedule. On the individual level, this schedule leads to higher relative contributions by the wealthier players and thus violates the "fair-share" norm. On the group level, it leads to the highest contribution level and the lowest inequality in total profits as measured by the Gini index.

Mots clés /Key words : Experimental economics, public goods, heterogeneous endowments, mandatory minimum contributions, norms.

Codes JEL *:* C92, D63, H41

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1. Introduction

When it comes to their funding, several public institutions, such as, for example, museums, theaters, and operas, rely on a two-tier model. They apply mandatory admission charges that may be voluntarily supplemented by charitable donations. Given that these institutions provide merit goods, their two-tier funding situation may be modeled in a public-good game, where mandatory levies are requested and additional contributions are possible. Such a model has been introduced by James Andreoni (1993) to investigate crowding-out effects of public intervention in a laboratory experiment. He observes that voluntary contributions are partially crowded out by a lump-sum “tax”. It still remains an open question, though, how such mandatory levies should be designed to maximize the revenues of public institutions, taking into account that agents possess unequal economic possibilities (wealth) and differ in their willingness to pay.

An extensive experimental literature on the voluntary contribution mechanism (VCM) finds that behavior in public-good games cannot solely be explained by standard economic preferences. Contributions, though declining over time, are generally higher than the Nash-equilibrium prediction. This is true whether the dominant strategy is to contribute nothing (e.g., Marwell and Ames, 1979, 1980) or whether it lies in the interior of the strategy space (e.g., Keser, 1996). Survey studies suggest that, when the dominant strategy is to contribute nothing and participants are equally endowed, initial contributions typically lie between 40 and 60 percent of the endowment but decay over time. In the last round about 70 percent of subjects contribute nothing (e.g., Davis and Holt, 1993; Dawes and Thaler, 1988; Ledyard, 1995; Ostrom, 2000). Although contributions are higher than theoretically predicted, they are at a considerable distance from the social optimum. There is ample evidence that subjects tend to coordinate their contributions by conditional cooperation, i.e., they begin cooperatively and reciprocate depending on the actions of others (e.g., Keser and van Winden, 2000; Fischbacher et al., 2001). How such cooperation is affected by an inequality in endowments (wealth) is, however, not yet well understood. John Ledyard’s conjecture that homogeneity in endowments has a positive effect on group contributions, or in other words, that heterogeneity has negative effects (Ledyard, 1995), has only partly been confirmed in the recent literature. Group contributions in weakly asymmetric environments tend to be equal to those in symmetric settings, where the same total endowment is allocated evenly over all group members. Thereby, players tend to follow a “fair-share” rule, where they coordinate on equal relative contributions of the endowment (Hofmeyr et al., 2007; Keser et al., 2014; Keser and Schmidt, 2014). The “fair-share” rule has its limitations, though. When the asymmetry in the endowments becomes so large that one of the players loses interest in the group optimum, the norm shifts from equal relative to equal absolute contributions and the group contribution level declines significantly (Keser et al., 2014).

In this study, we consider an environment with heterogeneous endowments where the "fair-share" norm applies (the AsymWeak treatment of Keser et al. (2014)) and investigate if and how this norm as well as the group contribution level may be influenced by minimum contribution requirements similar to the "taxes" in Andreoni (1993). In our experiment, we implement various minimum-contribution schedules (MCS) charging subjects with different endowments with different levies. These levies are compulsory minimum contributions. The staggering of our MCS is motivated by common tax structures to be found in real-life settings. We consider a treatment with a lump-sum "tax" (FixMin), requiring the same absolute minimum contributions from all players, a treatment with a flat "tax" rate (RelMin) that requires the same minimum contribution relative to their respective levels of endowment from all players, and a treatment with a progressive "tax" schedule (ProgMin), where the more wealthy players are requested to provide a higher minimum contribution relative to their endowment than the less wealthy ones. The AsymWeak treatment of Keser et al. (2014) serves as the baseline treatment (NoMin) without any minimum-contribution requirement.[1] We do not see the mandatory levies in our study as taxes in the strict sense. Tax burdens impose tax levels, which are not intended to be overspent by taxpayers. Our minimum-contribution schedules more closely resemble the mandatory admission charges mentioned above. We consider them as a policy tool to potentially impose norms.

Despite the fact that in our experimental game there are no "standard economic" incentives for contributions above the compulsory minimum values, we expect our different minimum contribution schemes to exert "expressive power" (e.g., Cooter, 1998; Galbiati and Vertova, 2008), while driving contributions beyond the enforced minima due to incomplete crowding-out (Andreoni, 1993). Thereby, we anticipate that the miscellaneous schedules differently affect the sense of justice and the willingness to contribute among the group members. To investigate this, we define a measure of motivational crowding-out for our experimental setup. This measure relates to the classic crowding-out in the analysis of public policy (Andreoni, 1993; Andreoni and Payne, 2011) but it is different in that it considers the percentage of the freely disposable endowment that is contributed, rather than the absolute amount contributed. The motivational crowding-out measure indicates zero crowding-out if subjects that contribute, for example, 50 percent of their endowment in the absence of mandatory minimum contribution requirements will still contribute 50 percent of their freely disposable endowment (endowment beyond the mandatory contribution) in the presence of such requirements. Full motivational crowding-out implies contributions equal to the mandatory contribution levels.

In the choice of the different minimum-contribution schedules, we pay attention to two features. Firstly, the total amount of minimum contributions is constant across all treatments. Secondly, minimum contributions for the individual player types are lower

[1] The differentiation of mandatory contribution levels in the treatments with the relative and the progressive MCS can be seen as a kind of third degree price discrimination, where the levies vary by wealth status.

than the respective average contributions in the baseline treatment (without mandatory minimum contributions) and thus sum up to less than the (unenforced) average total group contribution in the baseline treatment.[2] This is necessary, since we are not interested in increasing contributions to the public good by mandatory contributions that are high enough to exceed the amount that people would contribute voluntarily, anyway. We strive to investigate if and how different distributions of a given total mandatory levy may change individual and group contribution patterns.

As discussed above, our study relates to two literature strands. The first one deals with the "expressive power" of law and is thus particularly relevant to the part of our study that deals with the impact of the various minimum contribution schemes on contribution norms. Law can be defined as an obligation, and, according to the expressive-power hypothesis, it might have psychological effects on individual preferences. In other words, actors might view an obligation as an internal value. Law can thus create a focal point by creating values (e.g., Cooter, 1998; Galbiati and Vertova, 2008). The second literature strand deals with the impact of external interventions on intrinsic motivation with respect to crowding-out or crowding-in (e.g., Deci et al., 1999). Given the finding of incomplete crowding-out of voluntary contributions by minimum-contribution requirements (Andreoni, 1993; Chan et al., 2002), we expect our tax systems to increase group contributions. Both literature strands are presented in more detail in Section 2.

The main findings of our experiments can be summarized as follows. We find that mandatory minimum contributions do have a norm-giving character (expressive power). Group contribution levels are significantly higher in ProgMin than in NoMin and FixMin. On the individual level, we observe in all treatments that individuals with higher endowments make on average higher contributions than those with lower endowments. Furthermore, in RelMin, we replicate the "fair-share" rule observed in NoMin (Keser et al., 2014). In FixMin, we find relative contributions to be higher for the less than for the more wealthy players, but we observe the opposite in ProgMin. This suggests that the contribution norm can indeed be influenced through a deliberate intervention like a minimum contribution requirement. As a consequence, the progressive contribution schedule leads to a significant increase in average group contributions relative to the baseline treatment without minimum contribution requirements. While we observe motivational crowding-out in FixMin, we have no evidence for motivational crowding-out in ProgMin and RelMin.

The remainder of this paper is structured as follows. Section 2 gives a short overview over the related literature. Section 3 presents the experimental design and derives

[2] To investigate crowding-out, Andreoni (1993) chooses a "tax" below the interior solution of the non-linear public-good game. Our linear public good game does not have an interior Nash equilibrium but has a dominant strategy solution to contribute nothing. The outcome of the baseline treatment, however, lies in the interior of the strategy space and can be presented as a quantal response equilibrium under the assumption of altruism and error making (Anderson et al., 1998).

testable hypotheses. Section 4 reviews these hypotheses in the face of the experimental results. Section 5 provides a summary and conclusions.

2. Related literature

We consider two ways how mandatory minimum contributions schedules could impact voluntary contributions to a public good. The first is derived from the literature on expressive law that hypothesizes that obligations have a potential to influence behavior. They may create focal points or norms, which channel individuals' beliefs about the behavior of others and act as coordination devices (Cooter, 1998; Galbiati and Vertova, 2008; McAdams and Nadler, 2005). Rational individuals internalize a norm (i.e., change their behavior) when commitment promises an advantage (Cooter, 1998). A norm set by the mandatory minimum contribution levels that is perceived as appropriate to enhance one's profit is hence potentially able to increase individual and group contributions.

Galbiati and Vertova (2008), for example, study expressive law with weakly incentivized non-binding obligations in a public-good game. These obligations are presented as minimum contributions that are not mandatory and thus leave the players' decision spaces unaffected. However, participants know that they will be probabilistically audited and penalized or rewarded if they have under- or over-fulfilled their obligations. In a repeated linear public-good game with groups of six equally endowed subjects, Galbiati and Vertova test whether different obligation levels imply different levels of cooperation. They find that obligations in repeated interactions significantly affect the average level of individual contributions and the rate of decrease in cooperation over time. Higher obligations reduce the pace of the decline in average contributions. Unexpected changes in the level of minimum contributions have asymmetric effects on the level of cooperation: "a reduction does not alter the pattern of deterioration of cooperation over time, whereas an increase triggers a re-start in cooperation" (p. 148). In a follow-up study, Galbiati and Vertova (2014) disentangle the effects of obligations and incentives. They consider non-binding incentives (such that zero contribution to the public good still remains the dominant strategy for risk-neutral players) with a low and a high probability of an audit. They find obligations and non-binding incentives to be complementary, jointly supporting high levels of contribution. Incentives alone do not significantly increase contributions, while high obligations in the form of recommendations moderately increase them.

In a similar study, using a repeated public-good game with groups of two identically endowed subjects, Riedel and Schildberg-Hörisch (2013) find that obligations increase contributions in the first rounds. Contributions toward the end of the game, however, are not statistically distinguishable to the case without obligations. Individual contributions are affected by the own obligation but independently from the partners obligation. For a given obligation, behavior is not significantly different between symmetric and asymmetric obligation treatments. However, the fraction of non-compliers is higher for subjects with higher inflicted obligation. Given that the decline in contributions is only significant for individuals with high obligations, subjects seem to incur non-monetary costs while disobeying obligations. People are not more likely to violate an obligation if it is perceived unfair.

The three studies above differ from our study in that the therein employed obligations, i.e., minimum contributions, are not binding. That means that in these studies participants face the same decision space whether obligations are imposed or not, i.e., under- or over-fulfillment of the obligation is possible. In our study the decision space is reduced by the minimum contribution requirements in the MCS treatments such that only over-fulfillment of the obligation is possible.

The second potential impact channel of minimum contributions relates to the literature on the impact of external interventions on intrinsic motivation. According to Ryan and Deci (2000) "[i]ntrinsic motivation is defined as the doing of an activity for its inherent satisfaction rather than for some separable consequence. When intrinsically motivated a person is moved to act for the fun or challenge entailed rather than because of external prods, pressures, or rewards" (p. 56). It is argued that, given a task that is performed voluntarily or for the sake of its own, any form of outside interference may affect the intrinsic motivation on which the initial action is based and thus change the amount of effort exerted in the task. Crowding-out of intrinsic motivation is reinforced, when the external intervention is perceived as controlling (Falk and Kosfeld, 2006) or when it has a negative effect on people's feeling of self-determination, competence and self-esteem (Deci, 1971; Nyborg and Rege, 2003; Rotter, 1966).

Titmuss (1970) was the first to establish the hypothesis that monetary rewards may crowd out intrinsic motivation. He came up with the example of blood donations, where present donors may reduce donations, if they perceive that their intrinsic motivation is not appreciated, when monetary incentives for their donations are offered. The result is what Condry and Chambers (1978) call "hidden costs of reward" as rewards tend to distract attention from the process of the task activity itself to the goal of getting a reward. This hypothesis was confirmed by Uptom (1973). Since Titmuss (1970) a large body of literature found indication for his hypothesis in a variety of other circumstances[3]. Note, however, that in contrast to the said, interventions, might also be perceived as supportive and promote self-esteem. If this is the case, they might even crowd in intrinsic motivation (Frey and Jegen, 2001).

In the case of the funding of a public good, a specific additional factor could play a crucial role: the perception of one's moral responsibility for the provision of the good. If the government enforces minimum contribution levels, individuals may perceive a decay of

[3] See, for example, Deci (1971, 1972), Deci et al. (1999), Frey (1993, 1994, 1997a, 1997b), Frey et al. (1996), Frey and Oberholzer-Gee (1997), Frey and Goette (1999), Frey and Jegen (2001), Gneezy and Rustichini (2000a, 2000b), and Lepper et al. (1973).

their responsibility for the provision, leading to a crowding-out of (additional) voluntary contributions. If however, the intervention is able to communicate morally ideal contribution levels, which are perceived as symbolic, even a crowding-in is possible (Brekke et al., 2003; Nyborg and Rege, 2003).

Theoretical models on government intervention in the provision of public goods, for models with an interior equilibrium, predict complete crowding-out of private voluntary by public contributions (e.g., Warr, 1982, 1983; Roberts, 1984, 1987; Bergstrom et al., 1986; Bernheim, 1986). Indeed, crowding-out of voluntary public-good provision by governmental provision is found in several empirical studies. In the context of charitable giving Abrams and Schmitz (1978, 1984) find crowding-out of about 30 percent and that in addition to governmental charitable payments the need of the recipients plays a crucial role in the decision for private charitable donations. Payne (1998) observes crowding-out of about 50 percent of private donations to non-profit organizations (NGOs) with increased government funding. In a laboratory experiment, based on a public-good game with an interior equilibrium, Andreoni (1993) finds crowding-out of about 70 percent by mandatory contributions. In a similar study Chan et al. (2002) also find that crowding-out is incomplete and that enforced contributions significantly increase total contributions to the public good.

3. The experiment

3.1. The game

In our public-good game n players form a group. Each player i ($i = 1, \dots, n$) is endowed with a number of tokens, e_i, which have to be allocated between a private and a public investment. Let x_i denote the amount allocated to the private investment and y_i the amount allocated to the public investment by player i, with $x_i, y_i \geq 0$. The investments have to be in entire tokens and have to add up to the endowment. Furthermore, there is a minimum contribution requirement to the public investment c_i, with $c_i \geq 0$. Thus, $0 \leq x_i \leq e_i - c_i$, $c_i \leq y_i \leq e_i$, and $x_i + y_i = e_i$. The profit of each player i depends on his individual private investment and the sum of all public investments in his group. Each token that he allocates to the private investment yields him an individual return of α, while each token that he allocates to the public investment yields him and each other group member a return of β, with $\alpha > \beta$ and $n\beta > \alpha$. The profit function of player i can thus be written as:

$$\pi_i\left(x_i, \sum_{i=1}^{n} y_i\right) = \alpha x_i + \beta \sum_{i=1}^{n} y_i \tag{1}$$

Since a player's individual return in the private investment is larger than in the public investment ($\alpha > \beta$), the game has an equilibrium in dominant strategies, where each player contributes the required minimum to the public investment and all remaining tokens to his private investment ($x_i^* = e_i - c_i,\ y_i^* = c_i$). If this game is played over a finite number of T rounds, the subgame perfect equilibrium solution prescribes, based on backward induction, that in each round $t \in (1, \dots, T)$ each player contributes the required minimum to the public investment and all remaining tokens to his private investment ($x_{it}^* = e_i - c_i,\ y_{it}^* = c_i$).

Given that $n\beta > \alpha$, the sum of profits of all n players is maximized if all tokens are allocated to the public investment. Hence, in the social optimum all players allocate in each round their entire endowment to the public investment. The game-theoretical solution (subgame-perfect equilibrium) is thus collectively inefficient.

Given the evidence from earlier experiments on this kind of linear public-good game, where contributions, significantly deviate from the Nash equilibrium solution, also other equilibrium concepts are conceivable. For example, the so-called quantal response equilibrium, which is based on the assumption that subjects' decisions are determined by altruism and decision-error, can explain why mean contributions deviate from the Nash equilibrium (Anderson et al., 1998). Based on the quantal response equilibrium concept, the crowding-out measure by Andreoni (1993), which is based on the assumption that the Nash equilibrium (before and after taxation) lies in the interior of the decision space and that the lump-sum tax is smaller than the equilibrium contribution, can also be used in the context of our study to evaluate the impact of our minimum contribution schedules on individual and group contributions.

3.2. Procedure

We conducted the computerized experiment in the Göttingen Laboratory of Behavioral Economics at the University of Göttingen, Germany, based on the z-tree software package (Fischbacher, 2007).[4] Participants were 160 bachelor and master students from various disciplines (mostly economics and business administration). Recruited via ORSEE (Greiner, 2004), they had previously volunteered to participate in decision-making experiments. On average, a roughly equal number of female and male students participated in the experiments; the number of women and men approximately balanced during all sessions. According to subject availability, we conducted sessions with three to four groups each, implying three to four independent observations per session. In total 40 independent observations were collected in four different treatments.

The procedure of the experiment was as follows. Upon arrival in the meeting room each participant got a randomly assigned participation number corresponding to a computer

[4] The lab consists of 24 computers in isolated booths, such that vision of someone else's computer screen or verbal communication with other participants is highly restricted.

terminal in the lab. As soon as the required number of participants had shown up, the experimenter distributed written instructions (a translation of these is provided in Appendix B) and read them aloud to all participants.

Participants were informed that they would be randomly assigned to groups remaining unchanged during the entire experimental session (partners design). Participants, however, did not get to know the identity of the participants with whom they interacted. Each player in a group was randomly assigned a player number from one to four, which was individually communicated at the beginning of the experiment and remained unchanged. Each player number was associated with a certain fixed endowment and minimum contribution requirement per round. At the end of each round, participants were informed about the contributions to the public investment by each of the other players in the group (identified by their player number but otherwise anonymous), the total group contribution, the profit for the current round, and the total profit so far. Moreover, all participants were provided with a history of all previous rounds, containing the same information, on the screen.

After the reading of the instructions participants were seated at their respective computer terminals. Before the experiment started, we used computerized control questions with regard to the understanding of the instructions. The experiment did not start until all participants had provided correct answers to all questions.

The participants were informed in the instructions that the profits gained in the course of the experiment were measured in Experimental Currency Unit (ECU) and that these profits were to be multiplied by a conversion factor of 0.01 € per ECU (which is the same for all players) for the final payment, in addition to a show-up fee of 3 €. The cash payment was conducted anonymously after the experiment.

An experimental session lasted on average around 75 minutes. The average payoff earned was about 15.50 € (including a 3 € show-up fee).

3.3. Parameters and treatments

Participants are assigned to groups of four ($n = 4$), the game is played for 25 rounds ($T = 25$), and the parameters of the profit function are $\alpha = 2$ and $\beta = 1$ (which implies a constant marginal per capita return (MPCR[5]) of 0.5 for the investment in the public account). Furthermore, participants are informed that Player 1 (Type 10) is endowed with 10 ECU, Players 2 and 3 (Type 15) are endowed with 15 ECU, each, and that Player 4 (Type 20) is endowed with 20 ECU. In each round, each participant has to make an allocation decision, conditioned on his minimum contribution requirement to

[5] The MPCR is defined as the ratio of the private value of one token invested into the public investment to the private value of one token invested into the private investment.

the public good (c_i). Minimum contribution requirements of all player types are common knowledge.

Table 1 presents the individual minimum contribution requirements (c_i) for the three player types in our four treatments: (1) NoMin, (2) FixMin, (3) RelMin, and (4) ProgMin. Under NoMin no participant is forced to contribute a mandatory levy; under FixMin every participant is forced to contribute a mandatory levy of 6 ECU; under RelMin each participant is forced to contribute a mandatory levy of 40 percent of her/his endowment; and under ProgMin each Type 10 player has to contribute 2 ECU, each Type 15 player has to contribute 6 ECU, and each Type 20 player has to contribute 10 ECU. The amounts of 2 ECU, 6 ECU, and 10 ECU in ProgMin correspond to progressive MCS rates of 20, 40, and 50 percent, for the three player types. The FixMin treatment is in principle a regressive MCS system, in that poorer individuals have to contribute relatively more of their endowment. The amounts of 6 ECU correspond to a regressive MCS regime with rates of 60, 40, and 30 percent for the three player types, respectively. In all treatments the total endowment of the four players is equal to 60 and in all MCS treatments the total mandatory levy is equal to 24.

Table 1:
Treatment overview

Treatment no.	Label	Minimum contributions (c_i)				$\sum_{i=1}^{4} c_i$	# Obs.
		Type 10	Type 15		Type 20		
		Player 1	Player 2	Player 3	Player 4		
1	NoMin	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	10
2	FixMin	6 (60%)	6 (40%)	6 (40%)	6 (30%)	24	10
3	RelMin	4 (40%)	6 (40%)	6 (40%)	8 (40%)	24	10
4	ProgMin	2 (20%)	6 (40%)	6 (40%)	10 (50%)	24	10

3.4. Hypotheses

To facilitate the illustration of the results in the following section our analysis focuses on two hypotheses.

Hypothesis 1: *Minimum contribution requirements incompletely crowd out voluntary contributions implying that we observe higher group contributions in the MCS treatments than in NoMin.*

Andreoni (1993) and Chan et al. (2002) measure crowding-out by $(\bar{Y}_0 + C - \bar{Y}_C)/C$, where $\bar{Y}_0$ is the average group contribution to the public good in NoMin, C is the sum of minimum contributions of all group members, and $\bar{Y}_C$ is the average group contribution to the public good in the respective MCS treatment. Thus, crowding-out is 0 percent if $\bar{Y}_C = \bar{Y}_0 + C$ and it is 100 percent if $\bar{Y}_0 = \bar{Y}_C$. Based on this measure, they find that crowding-out is incomplete and, thus, that their public policy interventions by enforced minimum contributions significantly increase total contributions to the public good. Therefore, we expect that the three minimum contribution schedules increase group contributions above the level of NoMin, but not by the full amount of the contribution requirements.

Hypothesis 2: *Players follow a simple "fair-share" rule of equal relative contributions of the endowment in RelMin but not in FixMin and ProgMin.*

Keser et al. (2014) have shown that players in NoMin tend to coordinate their contributions by using the simple "fair-share" rule, where they contribute equal amounts relative to the endowment. Since in RelMin mandatory contributions are staggered relative to the endowment, we expect contributions to follow this rule as well. However, we expect that Type 10 players contribute a higher (lower) share of their endowment than both other types in FixMin (ProgMin), and that Type 20 players contribute a higher (lower) share of their endowment than both other types in ProgMin (FixMin). In other words, we expect the proportional mandatory contributions in RelMin, the regressive mandatory contributions in FixMin, and the progressive mandatory contributions in ProgMin, respectively, to exert their "intended" influence by pushing individual contributions in the direction in which the minimum contribution requirements are staggered). We derive support for this conjecture from the literature on expressive law. This literature suggests that mandatory minimum contributions schedules may exert "expressive power" through the imposed obligations by expressing certain levels of "fair contribution" (Galbiati and Vertova, 2008; Riedel and Schildberg-Hörisch, 2013).

4. Results

Beyond the analysis of group contributions in Subsection 4.1 (Hypothesis 1) and individual contributions in subsection 4.2 (Hypothesis 2), we shall investigate reciprocity in Subsection 4.3 and profits in Subsection 4.4. All nonparametric tests presented in the following subsections are two-sided. We shall denote the Mann-

Whitney U test as U test and the Wilcoxon matched-pairs signed-rank test as signed-rank test.

4.1. Group contributions

Figure 1 presents the development of the average group contributions to the public investment ($\bar{Y}_t$) in the four treatments over the 25 rounds. As can be seen, the ProgMin treatment exhibits the highest contributions.[6] Due to the large end-game effect in NoMin (in approximately the last five rounds), which is impeded by the minimum contribution requirements in the MCS treatments, we report only figures for rounds 1 to 20 in the forthcoming analysis. For this game interval, average group contributions are 36.4 in NoMin, 38.7 in FixMin, 40.2 in RelMin, and 44.7 in ProgMin.[7] This indicates that the mandatory contributions only partially crowd out voluntary contributions. Following Andreoni (1993), crowding-out is 90.2 percent in FixMin, 83.8 percent in RelMin and as little as 65.0 percent in ProgMin. Pairwise treatment comparisons, based on U tests, show that average group contributions in ProgMin are significantly higher than those in NoMin ($p = .0343$) and FixMin ($p = .0963$); no other pairwise comparison shows a statistically significant difference.

It is important to mention that group contributions in ProgMin do not start from the beginning on a higher level than in the other two MCS treatments. They rather rise during the first rounds of the game and then remain nearly constant until the end-game. In the first round, we find that average group contributions do not differ between the MCS treatments, with respective figures of 39.0, 36.5, and 38.5 in FixMin, RelMin, and ProgMin. The average first-round contribution in NoMin is 30.8; it is significantly lower than in FixMin ($p = .0884$) and in ProgMin ($p = .0487$), when compared by U tests.[8]

Result 1: *Group contribution levels are significantly higher in ProgMin than in NoMin and FixMin. For ProgMin, this confirms Hypothesis 1 that crowding-out is incomplete.*

[6] Over rounds 1-25, the mean group contributions are 43.5 in ProgMin compared to 33.1 in NoMin, 37.7 in FixMin, and 39.8 in RelMin. The respective average standard deviations are 7.5, 12.4, 5.9, and 6.1.

[7] Average standard deviations of total group contributions for rounds 1-20 are 9.9, 5.3, 5.4, and 6.8 for NoMin, FixMin, RelMin, and ProgMin respectively.

[8] Average standard deviations of total group contributions for round 1 are 9.0, 7.4, 6.9, and 7.9 for NoMin, FixMin, RelMin, and ProgMin respectively.

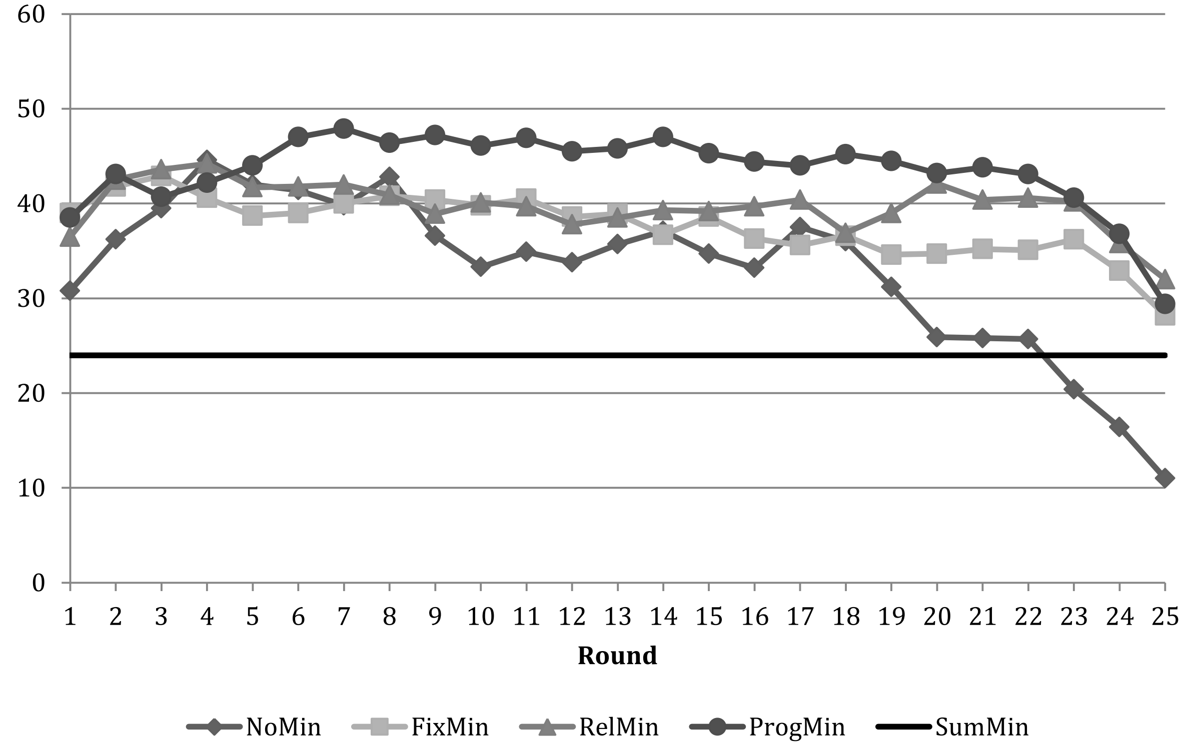

Figure 1: Average group contributions per round (by treatment)

Net relative group contributions and motivational crowding-out: To compare voluntary contributions in the NoMin treatment to the contributions in the MCS treatments, while taking into account the different sizes of strategy sets in these two kinds of treatments, we calculate for each round *t* the *net relative group contribution*:

$$Y_t^{Net} = \frac{\sum_{i=1}^{4} y_{it} - \sum_{i=1}^{4} c_i}{\sum_{i=1}^{4} e_{it} - \sum_{i=1}^{4} c_i} = \begin{cases} \frac{Y_t}{60} & \text{for NoMin} \\ \frac{Y_t - 24}{36} & \text{otherwise} \end{cases} \tag{2}$$

Y_t^{Net} captures, for round t, the group contribution above the sum of mandatory contributions (group contribution minus sum of mandatory contributions) relative to the net endowment of the group (group endowment minus sum of mandatory contributions). This measure ranges from zero to one. It is zero, when only the mandatory levies are contributed (which are zero in the case of NoMin) and one, when the entire net endowment is contributed.

This measure allows a more flawless comparison of the treatments in our study since it takes into account that players with different endowments and different minimum contribution requirements have different strategy sets. Based on this measure we define a "*motivational crowding-out* or *crowding-in*" of voluntary contributions, which is different from the classic definition of crowding-out by public policy (Andreoni, 1993). If we observe that in a MCS treatment groups contribute a lower (higher) percentage of their freely disposable endowments (net endowments) than the groups in the NoMin treatment, we interpret this observation as motivational crowding-out (crowding-in) of contributions by the minimum contribution requirements. Motivational crowding-out is, in contrast to the classic crowding-out, not measured token by token but in percent of the endowment that is at free disposal. While we define that net relative group contributions at the same level as in the NoMin treatment imply zero motivational crowding-out, full motivational crowding-out is defined by zero net relative group contributions. Both definitions are different from the classic definitions in Andreoni (1993).

Figure 2 shows the development of the average net relative group contributions in the four treatments. Visual inspection suggests two distinct contribution levels over rounds 1 to 20: NoMin and ProgMin show average contributions of 60.6 percent and 57.6 percent, respectively, while FixMin and RelMin show average contributions of 40.8 percent and 45.1 percent, respectively.[9, 10] Pairwise comparisons, based on U tests, indicate significant differences between NoMin and FixMin as well as ProgMin and FixMin ($p = .0963$, for both comparisons). Thus, we find on average small and statistically insignificant motivational crowding-out of 4.9 percent in ProgMin and higher but still statistically insignificant motivational crowding-out of 25.5 percent in RelMin. Only the motivational crowding-out of 32.6 percent in FixMin is statistically significant.

Result 2: *Motivational crowding-out of group contribution is statistically significant in FixMin. There is no significant motivational crowding-out in ProgMin and RelMin.*

[9] The corresponding average standard deviations of Y_t^{Net} for rounds 1-20 are .1645, .1478, .1503, and .1885, for NoMin, FixMin, RelMin, and ProgMin respectively.

[10] The overall negative time trend is moderate and seems to be, except for the first periods, not different between the treatments.

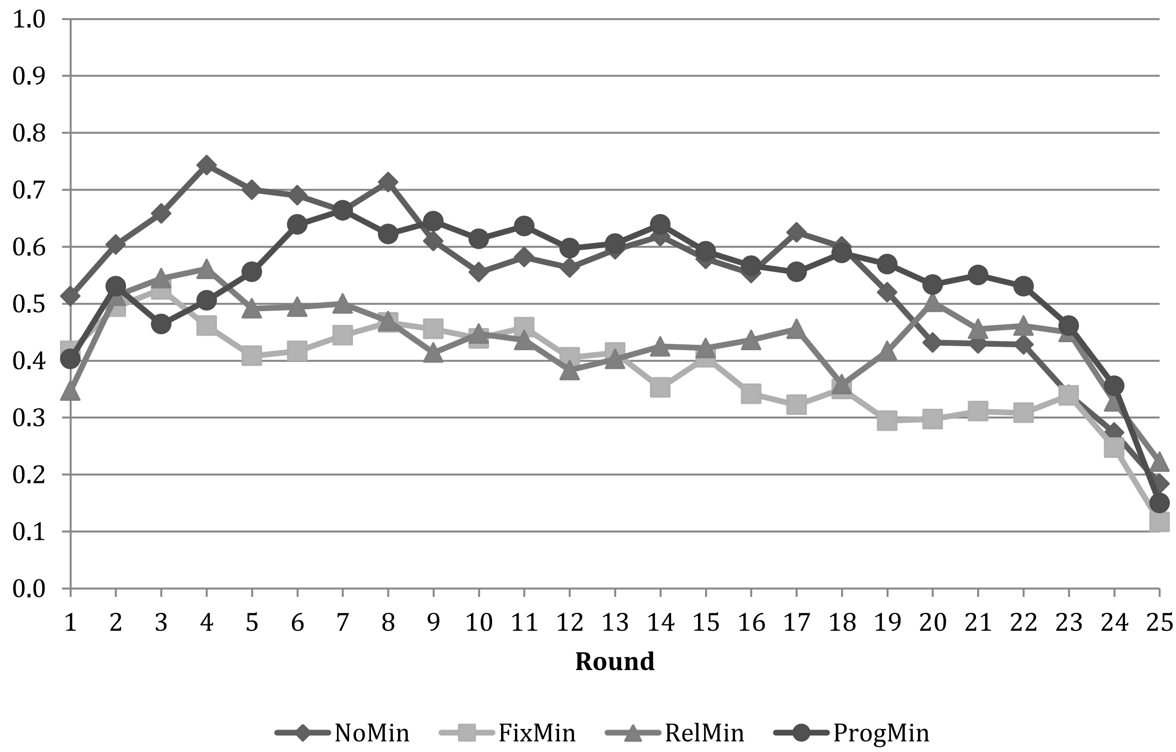

Figure 2: Average net group contributions (by treatment)

4.2. Contributions by player types

4.2.1. Comparison within treatments

To compare the contributions of the different player types within each treatment, differences in the end-game effects for the player types play a minor role. We thus consider averages over rounds 1 to 25 in this analysis.

Figure A.1 in Appendix A presents the development of average contributions of the three player types (Type 10, Type 15, and Type 20) in the four treatments over the 25 rounds.[11] We find the non-surprising tendency for more abundantly endowed players to contribute more in absolute terms. Table A. 1 in Appendix A shows that, with the exception of two comparisons, all pairwise comparisons, based on signed-rank tests, show significant differences with $p \leq .0593$.

Given the asymmetry in endowments, we consider two "relative contribution measures" to compare the contributions of the poor (Type 10), wealthy (Type15), and rich (Type 20) players. The first measure goes back to the fair-share rule in Hofmeyr et al. (2007) and Keser et al. (2014); it measures the absolute contributions of the player types

[11] For Type 10 (player 1) and Type 20 (player 4) the averages are based on ten players for each average, each. For Type 15 (players 2 and 3), the averages are based on twenty players.

relative to their individual endowment (relative contribution). Figure A. 2 in Appendix A presents the development of average relative contributions for the three player types in the four treatments. As can be seen, there are no significant differences in the average relative contributions between the player types both in NoMin (AsymWeak treatment of Keser et al. (2014)) and RelMin. For RelMin, where the mandatory contributions push contributions toward the "fair-share" rule with equal relative contributions, this result is highly plausible. In FixMin average relative contributions significantly differ between the player types such that relative contributions to the public good decrease with the endowment level. For ProgMin, on the other hand, the contribution hierarchy is reversed such that the wealthier players contribute relatively more. Table A. 2 in Appendix A provides the p-values of the pairwise comparisons of contributions by player type in the four treatments (signed-rank tests). These widely confirm the previous statement: all differences in NoMin and RelMin are insignificant, and (almost) all differences in FixMin and ProgMin are significant ($p \leq .0745$, the unique exception is the difference between Types 15 and 20 in ProgMin that is not statistically significant). We may conclude that the proportional mandatory contributions in RelMin, the regressive mandatory contributions in FixMin, and the progressive mandatory contributions in ProgMin, respectively, exert their "intended" influence. RelMin leads to equal relative contributions, FixMin to higher relative contributions by the less wealthy players, and ProgMin to higher relative contributions by the more wealthy players.

Result 3: *In RelMin players follow the simple "fair-share" rule of equal relative contributions of the endowment. However, this rule does not apply in FixMin and ProgMin: average relative contributions are higher for the less wealthy players in the regressive FixMin treatment and higher for the more wealthy players in the progressive ProgMin treatment. These results confirm Hypothesis 2.*

The second relative-contribution measure, y_{it}^{Net}, essentially calculates Y_t^{Net} on an "individual" basis for each player type $i \in \{Type\ 10, Type\ 15, Type\ 20\}$:

$$y_{it}^{Net} = \frac{y_i - c_i}{e_i - c_i}, \tag{3}$$

where c_i is treatment dependent. It captures for each player type i the average individual contribution net of the mandatory contribution (absolute contribution minus mandatory contribution) relative to the net endowment (individual endowment minus mandatory contribution).

Figure A. 3 in Appendix A presents the development of average y_{it}^{Net} for the three player types in the four treatments. Table A. 3 in Appendix A shows the p-values of the pairwise comparisons based on signed-rank tests. As can be seen, there is only one difference that is statistically significant ($p = .0745$, Type 10 players contribute significantly more than Type 20 players in FixMin). None of the remaining comparisons yields statistical significance. We conclude that players tend to follow a modified "net fair-share" rule of equal relative contributions of the disposable endowment in FixMin and ProgMin. The "net fair-share" rule also applies in NoMin and RelMin, since it coincides with the original "fair-share" rule.

Result 4: *Players follow in all treatments a "net fair-share" rule of equal contributions relative to the decision space.*

4.2.2. Comparison between treatments

So far, we have focused our analysis on the differences between the player types within each of the four treatments. For a deeper understanding of the mechanics that might be at work in the various treatments, i.e., how the norms might be set by the different MCS regimes, we compare the behavior of each player type across the four treatments. If we observe differences in behavior, these differences could ultimately lead to differences in group contributions between the treatments. Due to the strong end-game effect in NoMin, which is impeded by the minimum contribution requirements in the MCS treatments, we report only averages over rounds 1 to 20 in this analysis.

Figure 3 depicts that, on average, relative contributions (and thus also absolute contributions) of Type 10 are highest in FixMin, where also the mandatory minimum contribution relative to the endowment is highest for this player type. The trajectories in the other treatments are not clearly distinguishable. Contributions of Type 15 are clearly highest in ProgMin and lowest in NoMin; the trajectories in FixMin and RelMin lie in between. Contributions of Type 20 are highest in ProgMin and lowest in FixMin. NoMin shows a clear decline that, toward the end of the game, even undercuts the level of FixMin. Contributions in RelMin lie between those in FixMin and ProgMin.

Considering contributions in the first round, we find that, on average, Type 10 players contribute 6.3, 7.2, 6.4, and 5.7; Type 15 players 6.9, 9.4, 9.3, and 9.7; and Type 20 players 10.7, 13, 11.6, and 13.5 in NoMin, FixMin, RelMin, and ProgMin, respectively. For Types 10 and 20, the differences between the treatments are never statistically significant. For Type 15, differences are significant between NoMin and all three MCS treatments ($p \leq .0698$, U tests); comparisons between the MCS treatments yield no significant differences.

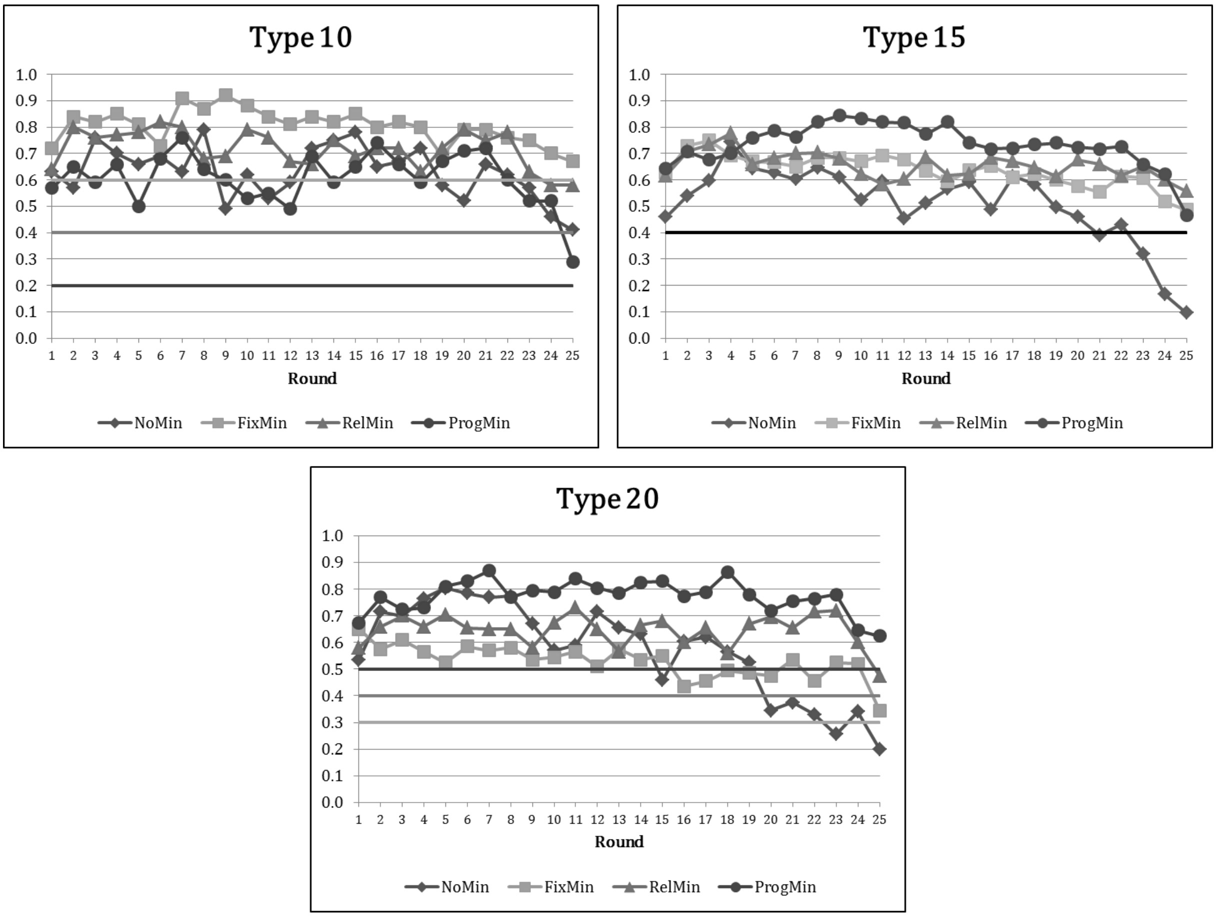

Figure 3: Average relative contributions (by treatment)

For contributions in rounds 1 to 20, Table A. 4 in Appendix A shows the p-values of the pairwise comparisons of average absolute [and net] contributions for the three player types (U tests). As can be seen, Type 10 players contribute on average most in FixMin and least in ProgMin and NoMin; contributions in RelMin lie in between. However, only the difference between ProgMin and FixMin is statistically significant ($p = .0257$). Type 15 players contribute in all MCS treatments on average more than in NoMin but only the difference between ProgMin and NoMin is significant ($p = .0232$). Although differences between the MCS treatments are not significant, the average figures indicate that contributions are highest in ProgMin, followed by RelMin, and then FixMin. Type 20 players contribute on average least in FixMin and most in ProgMin; contributions in NoMin and RelMin lie in between. Contributions in ProgMin are thereby significantly higher than in all other treatments ($p \leq .0696$), between which there is no statistically significant difference. For Type 20 we observe motivational crowding-out in FixMin and RelMin ($p \leq .0696$, for both). For no other player type do we observe motivational crowding-out. To conclude, for player types 15 and 20 but not for player type 10, ProgMin leads to the highest contributions to the public good. Given that Type 10 players have a lower leverage on group contributions than Type 15 and Type 20 players, this explains why we observe the highest group contribution level in ProgMin, which is significantly higher than in NoMin.

Result 5: *Type 10 and Type 20 players contribute most, when they are facing relatively high mandatory contributions (FixMin and ProgMin, respectively) and contribute least, when they are facing relatively low mandatory contributions (ProgMin and FixMin, respectively). Type 15 players contribute most in ProgMin and least in NoMin.*

One might argue that contributions in the MCS treatments increase merely due to the enforced increase in the contributions of uncooperative subjects, while the cooperative subjects' contributions might have remained the same. To test for this eventuality, we use a simple approach. For each player type and treatment, we order average contributions from the lowest to the highest, and divide this ordering by half. We can thus distinguish between more and less cooperative subjects and compare the behavior of the more cooperative subjects' in the various treatments. The average contributions are presented in Table A. 5 in Appendix A. Tests for differences across the treatments, based on U tests, confirm for both Type 15 and 20 players that the increase in contributions in ProgMin is not solely driven by the higher contributions of uncooperative subjects.[12]

Additionally, we find that in ProgMin lower-bound contributions of Type 15 players ($y_i = c_i = 6$), for which mandatory contributions are equal in all MCS treatments, exhibit with 19.8 percent the lowest proportion of all MCS treatments ($p \leq .0030$, U tests). In NoMin, we observe 38.3 percent of contributions of six or below. Furthermore, we also find that in ProgMin Type 15 and 20 players display the highest proportion of full contributions ($y_i = e_i = 15$ and $y_i = e_i = 20$, respectively) compared to all other treatments ($p \leq .0225$, U tests); for Type 10 players differences in the proportions of full contributions between the treatments are insignificant. The respective figures for lower-bound and full contributions are presented in Table A. 6 in Appendix A.

The results concerning contributions by cooperative players and concerning lower bound and full contributions indicate that the ProgMin treatment leads to a norm shift, not just to higher group contributions due to a higher constraint for the wealthier players.

[12] Cooperative Type 15 players significantly contribute more in ProgMin than in RelMin and FixMin ($p \leq .0413$); all other differences are not significant. Cooperative Type 20 players contribute significantly more in ProgMin than in NoMin and FixMin ($p = .0413$, for both comparisons); all other differences are not significant. For Type 10 players, contributions of cooperative players are not significantly different between all treatments.

4.3. Reciprocity

As known from the literature (e.g., Keser and van Winden, 2000; Fischbacher et al., 2001), subjects behave reciprocally and make contributions that depend on the actions of others. Keser and van Winden (2000) argue that players, if they change their contribution from one round to the next, tend to increase (decrease) their contribution, if in the previous round their contribution was below (above) the average of the group. Given the different endowments of player types in our experiment, we examine reciprocity in terms of changes in relative contributions. In other words, we examine how players react if their own relative contribution has been lower (higher) than the average of the relative contributions of the other group members in the previous round.

Table 2 presents the results of a regression on the reaction of the individual relative contribution to the average relative contribution of the other group members in the previous round. The dependent variable is the individual change of the relative contribution to the public investment from the previous to the current round (Δy_{it}^{Rel}). The major explanatory variable is the lagged difference between the relative contribution of the player and the average relative contribution of the other group members ($L.Diff2MeanOthers$). Additionally, we control for player-type and treatment effects by using dummy variables (and interactions), considering Type 10 and NoMin as the respective reference group.

Table 2 indicates that $L.Diff2MeanOthers$ is significantly negative and thus provides clear evidence for reciprocity. Another important finding concerns the ProgMin treatment and potentially explains why it shows the highest group contribution level. On the one hand, we observe that Type 10 players behave most reciprocally (the interaction term *ProgMin × L.Diff2MeanOthers* is significantly negative) and, on the other hand, that Type 15 and Type 20 players behave least reciprocally (the interaction terms *Type 15 × ProgMin × L.Diff2MeanOthers* and *Type 20 × ProgMin × L.Diff2MeanOthers* are significantly positive). These findings are consistent with our previous results. As it seems, Type 15 and Type 20 players choose their contributions in this treatment "irrespective" of the contributions by Type 10 players. The two wealthier types seem to accept the low contributions by Type 10 players and "simply follow" the contribution norms set by the ProgMin schedule. This may, at least partially, explain why contributions of both player types in ProgMin are highest in this treatment, despite the fact that Type 10 players exhibit their lowest contributions of all treatments. Additionally, we find that the change in relative contributions is becoming more negative during the course of the game ($Round$ is significantly negative).

Result 6: *Players generally behave reciprocally. In ProgMin, Type 10 players behave more and Type 15 and 20 players less reciprocally.*

Table 2:
Regression for comparisons of reciprocity

Dependent variable:	Δy_{it}^{Rel}	
Constant	.0378	(.0251)
L.Diff2MeanOthers	-.3268***	(.0552)
Round	-.0021***	(.0007)
Type 15	-.0390	(.0291)
Type 20	-.0043	(.0295)
FixMin	.0437	(.0288)
RelMin	.0201	(.0294)
ProgMin	-.0855**	(.0340)
Type 15 × FixMin	-.0267	(.0343)
Type 15 × RelMin	-.0001	(.0352)
Type 15 × ProgMin	.1312***	(.0389)
Type 20 × FixMin	-.1372***	(.0387)
Type 20 × RelMin	-.0417	(.0367)
Type 20 × ProgMin	.0981**	(.0398)
Type 15 × L.Diff2MeanOthers	-.1285*	(.0703)
Type 20 × L.Diff2MeanOthers	-.0313	(.0823)
FixMin × L.Diff2MeanOthers	.0601	(.0765)
RelMin × L.Diff2MeanOthers	-.0355	(.0800)
ProgMin × L.Diff2MeanOthers	-.2083**	(.0849)
Type 15 × FixMin × L.Diff2MeanOthers	.0072	(.0991)
Type 15 × RelMin × L.Diff2MeanOthers	-.0576	(.1030)
Type 15 × ProgMin × L.Diff2MeanOthers	.1995*	(.1078)
Type 20 × FixMin × L.Diff2MeanOthers	-.1446	(.1244)
Type 20 × RelMin × L.Diff2MeanOthers	-.0840	(.1183)
Type 20 × ProgMin × L.Diff2MeanOthers	.3226***	(.1151)
R^2	.2346	
N	3040	

Notes: OLS-regressions with robust variance estimates. Standard errors in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

4.4. Profits and Gini indices

Table 3 illustrates the average profits per round over rounds 1 to 20 for the three player types and the resulting average group profits in the four treatments. Pairwise comparisons, using U tests, show that solely the differences in average group profits between ProgMin and NoMin ($p = .0343$), and ProgMin and FixMin ($p = .0963$) are significant.

Table 3:
Average profits per round

	NoMin	FixMin	RelMin	ProgMin
Type 10	43.30	42.30	45.60	52.23
Type 15	49.33	49.03	50.31	52.04
Type 20	50.75	57.07	54.27	53.19
Group profit	192.70	197.41	200.48	209.49

Notes: Averages for rounds 1 to 20. Social optimum sum of profits per round = 240. Equilibrium sum of profits per round = 120, 168, 168, 168. Equilibrium profit per round for Type 1 = 20, 32, 36, 40; equilibrium profit per round for Type 2 = 30, 42, 42, 42; equilibrium profit per round for Type 3 = 40, 52, 48, 44 (NoMin, FixMin, RelMin, ProgMin). Social optimum profit per round = 60 (for all types).

Comparisons for the player types between treatments based on U tests show that Type 10 players earn on average significantly more in ProgMin than in all other treatments, between which there are no significant differences ($p \leq .0343$). For Type 15 players, profits in ProgMin are significantly higher than in NoMin ($p = .0989$) and FixMin ($p = .0498$); for the other differences, we cannot reject the null hypothesis of no significant difference. For Type 20 players, profits in FixMin are significantly higher than in NoMin and ProgMin ($p \leq .0172$); all other differences are statistically insignificant.

Given that players in all four treatments start with different endowments, and that contributions to the public investment tend to result in an equalization of total profits through a redistribution of wealth, we analyze, based on the Gini index, the differences in inequality between the initial distribution of endowments, the distribution of total profits in equilibrium, and the actual distribution of total profits over rounds 1 to 20 in the four treatments. Table 4 displays the respective figures.

Average total profit Gini indices are smaller than Nash-equilibrium Gini indices for NoMin ($p = .0051$) and FixMin ($p = .0284$), using MPSR tests; for RelMin the difference is almost significant ($p = .1141$). For ProgMin, on the other hand, total profit Gini indices are significantly higher than Gini indices in equilibrium ($p = .0218$).

Furthermore, the comparison of average total profit Gini indices discloses that ProgMin exhibits significantly smaller Gini indices than all other treatments. Based on U tests, we find significant differences between NoMin and ProgMin, and FixMin and RelMin ($p = .0284$, respectively), and also between FixMin and ProgMin, and RelMin and ProgMin ($p = .0065$, respectively).

Table 4:
Gini indices

Treatment	Gini index for endowments [net of MCs] (1)	Gini index in Nash equillibrium (2)	Gini index for total profits (3)	Differences in percent (3)-(1)/ (2)-(1)/(3)-(2)
NoMin	.1250 [.1250]	.1250	.0561	-55.1/-0.0/-55.1
FixMin	.1250 [.2083]	.0893	.0674	-46.1/-28.6/-24.5
RelMin	.1250 [.1250]	.0536	.0471	-62.3/-57.1/-12.1
ProgMin	.1250 [.0417]	.0179	.0279	-77.7/-85.7/+55.9

Notes: Gini indices for total profits over rounds 1 to 20.

Result 7: *ProgMin leads to the lowest inequality in total profits of all treatments. Although, the inequality in total profits is larger than in equilibrium, the average group profit in ProgMin is the highest of all treatments.*

5. Conclusion

We investigate whether and how cooperation and the previously observed "fair-share" norm in public-good experiments with asymmetrically endowed players are influenced by enforced minimum-contribution schedules. We consider schedules, where all players face the same absolute minimum contribution irrespective of their endowment (FixMin), where all players face the same minimum contribution relative to the endowment (RelMin), and where a player with a higher endowment faces a higher minimum contribution relative to the endowment than a player with a lower endowment (ProgMin). Our mandatory minimum-contribution schedules relate to the literature on tax fairness or "vertical equity". In taxpayer surveys, Gerbing (1988) and Roberts and Hite (1994) find evidence of a preference for progressive tax rates. For upper-income taxpayers, however, Gerbing finds that they perceive flat tax rates as more fair. In the context of a public-good game, where participants can vote for several minimum contribution schemes, which are intended to provide a jointly agreed minimum group provision level, Gallier et al. (2014) find that the scheme which equalizes payoffs (similar to ProgMin) is mostly chosen by less wealthy players, while rich players mostly chose the scheme which equalizes contributions (similar to FixMin). Given this evidence and the pervasive calls for fairer tax systems implying tax breaks for lower and middle income classes together with tax increases for upper income classes, it is possible that an as fairer perceived distribution of mandatory minimum contributions (as, for example, in ProgMin) exerts a positive effect on individual and consequently total group contributions.

The results of our experiment suggest the potential of mandatory minimum contributions to exert expressive power. We observe them to exert a norm-giving character. They seem to communicate relations of fair contributions by the different player types and thus might increase group contributions relative to the situation without minimum-contribution requirements. It turns out that this is particularly true for our ProgMin treatment, which is likely perceived as the most fair among all mandatory contribution systems considered. ProgMin is the only treatment, where the crowding-out of voluntary contributions to the public good by mandatory contributions is significantly incomplete, when we use the measure by Andreoni (1993). For RelMin and FixMin the crowding-out is close to complete. When we consider motivational crowding-out as defined in this paper, it is statistically significant only in FixMin. ProgMin exhibits hardly any motivational crowding-out.

On the individual level, we find support for the "fair-share" rule in RelMin. This rule cannot be detected in FixMin and ProgMin due to the norms set through the (inverted) progressivity in both treatments. In the regressive FixMin treatment average relative contributions are higher for less wealthy players and in ProgMin average relative contributions are higher for more wealthy players. As we see, the "fair-share" norm can be eroded through a deliberate intervention. In particular, in ProgMin, the norm of what is a player's fair share is adapted in the "intended" direction. Players in FixMin and ProgMin seem to coordinate on a modified fair-share rule of equal contributions relative to the decision space, which we call the "net fair-share" rule. Average relative contributions to the available decision space are equal for all player types in FixMin and in ProgMin.

Type 15 players, for which mandatory contributions are the same in all three MCS treatments, contribute most in ProgMin and least in NoMin. The other two player types contribute more, when they are facing relatively high mandatory contributions (FixMin for Type 10 and ProgMin for Type 20) and contribute less, when they are facing relatively low mandatory contributions (ProgMin for Type 10 and FixMin for Type 20). We also find Type 10 players to behave most and Type 15 and Type 20 players to behave least reciprocally in ProgMin. As it seems, Type 15 and Type 20 players choose their contributions in this treatment "irrespective" of the lower contributions by Type 10 players. This may, at least partially, explain why contributions of both player types in ProgMin are the highest of all treatments, despite the fact that Type 10 players exhibit their lowest contributions of all treatments. Thus, the observation that group contributions are significantly higher in ProgMin than in the other three treatments can potentially be explained by the acceptance of the norm of progressive contributions among the Type 15 and Type 20 players in this treatment, rendering their contributions unconditional on the contributions by Type 10 players. Furthermore, we find that ProgMin exhibits the lowest inequality in total profits of all our treatments in terms of the Gini index.

In spite of these strong results, we advise caution generalizing our findings, in particular with respect to public policy. The response of contributions in a public-good game with heterogeneous endowments to mandatory minimum contributions may not be the same as the response of real economic factors as, for example, labor supply on an intervention in this sphere (Lindsey, 1987). In our experiment, heterogeneous endowments were randomly allocated to all participants in a group. Thus, participants neither had to supply their endowments by themselves nor to work for them. Even though neither Clark (2002) nor Cherry et al. (2005) find that these origins of the endowments, compared to cases where participants are provided with windfall endowments, have an effect in their public-good experiments, we believe that at least some caution is advised concerning possible effects of the endowment origin. This might be particularly true, when the asymmetry in the endowment distribution becomes more important. For example, Cherry et al. (2002) find an effect of endowment origin on behavior in a dictator-game setting. If endowments had to be earned, our mandatory contributions could likely exert similar effects as taxes and lead to a decline in the work effort, which would be in keeping with the Laffer curve hypothesis. Note, however, that for almost all types (with the exception of Type 10 in FixMin and Type 20 in ProgMin) our tax rates are well below the empirically observed tax-revenue-maximizing rates of 50 to 60 percent (e.g., Sutter and Weck-Hannemann, 2003). Although our study is able to show that the progressive minimum-contribution schedule performed best in our public-good setting in terms of overall contribution rates, we are not able to predict, which degree of progression would work best in a public-good environment, where endowments must be earned.

With respect to our initial example of public institutions, which rely on two-tier financing models based on mandatory admission charges plus voluntarily charitable donations and/or employ third degree price discrimination by setting admission fees that vary by status (e.g., regular tickets and reduced tickets for children, students, retirees, unemployed etc.), the increase in average group contributions in ProgMin compared to NoMin and FixMin suggests that progressive tariff structures can indeed be used to improve the financing of such institutions.

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Appendix A

Additional Tables and Figures

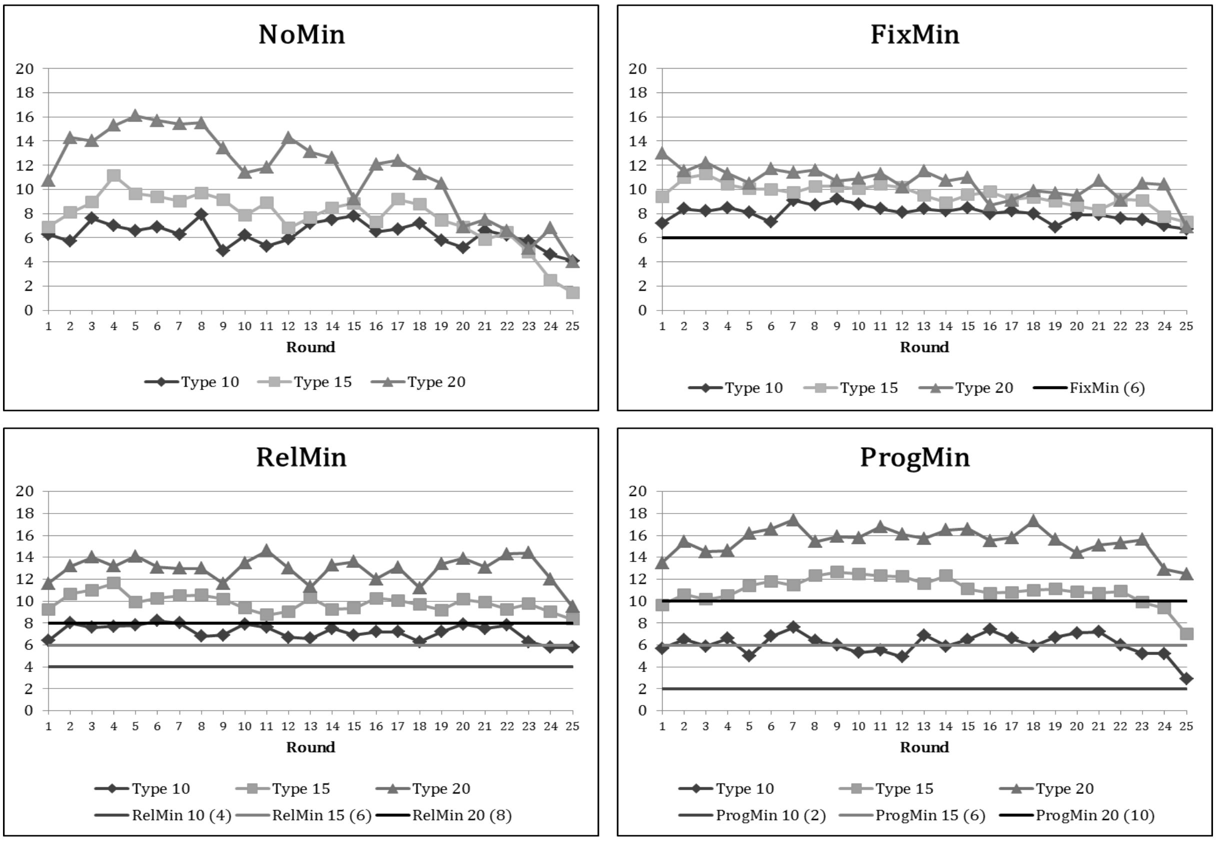

Figure A. 1: Average absolute contributions by player type

Table A. 1:
Comparisons of average absolute contributions between player types
(p-values of two-sided signed-rank tests)

	NoMin				**FixMin**		
	Type 10 (6.31)	Type 15 (7.65)	Type 20 (11.44)		Type 10 (8.03)	Type 15 (9.54)	Type 20 (10.56)
Type 10 (6.31)	-	.2845	**.0218**	Type 10 (8.03)	-	**.0593**	**.0284**
Type 15 (7.65)	-	-	**.0051**	Type 15 (9.54)	-	-	.2411
Type 20 (11.44)	-	-	-	Type 20 (10.56)	-	-	-
	RelMin				**ProgMin**		
	Type 10 (7.18)	Type 15 (9.82)	Type 20 (12.92)		Type 10 (6.07)	Type 15 (11.00)	Type 20 (15.48)
Type 10 (7.18)	-	**.0166**	**.0069**	Type 10 (6.07)	-	**.0051**	**.0051**
Type 15 (9.82)	-	-	**.0069**	Type 15 (11.00)	-	-	**.0051**
Type 20 (12.92)	-	-	-	Type 20 (15.48)	-	-	-

Notes: Comparisons and average contributions involve rounds 1 to 25. Averages for the player type are given in parentheses.

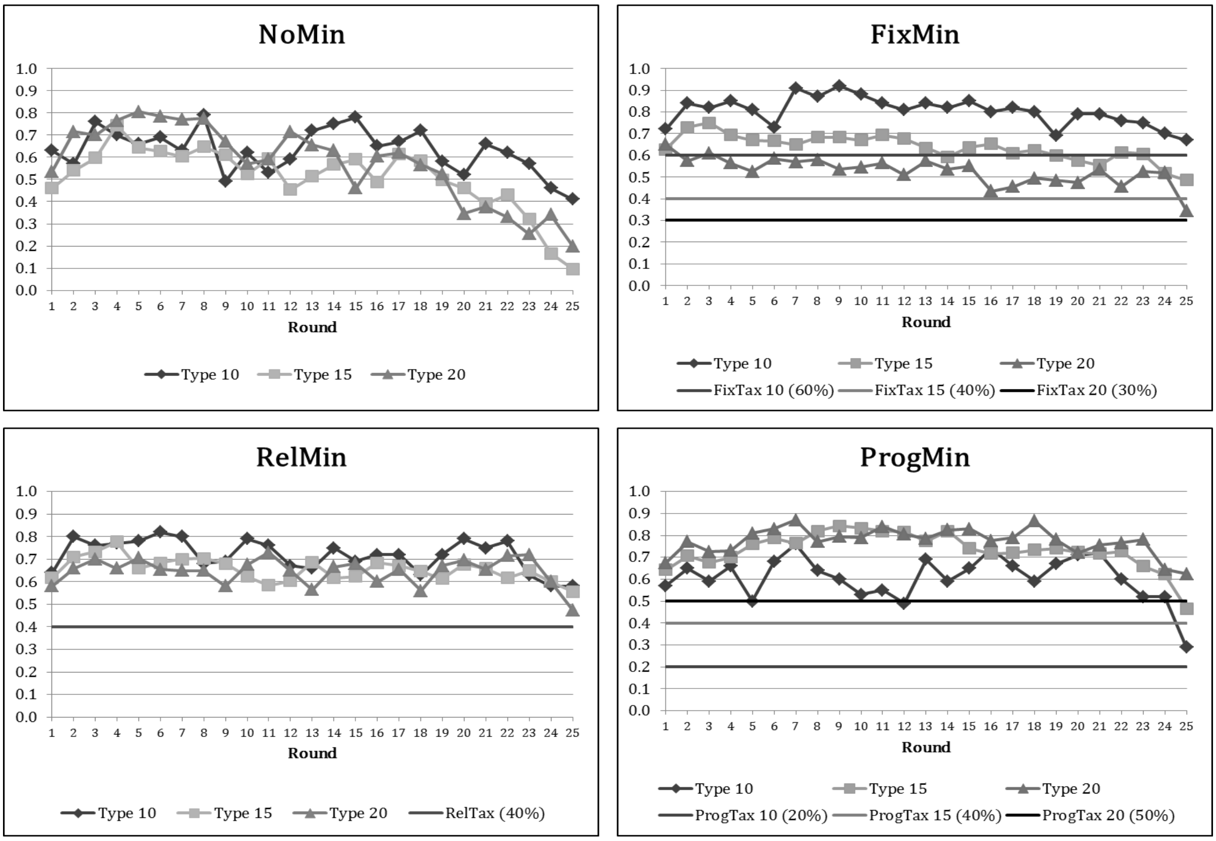

Figure A. 2: Average relative contributions by player type

Table A. 2:
Comparisons of average relative contributions between player types
(p-values of two-sided signed-rank tests)

	NoMin				**FixMin**		
	Type 10 (.6308)	Type 15 (.5101)	Type 20 (.5720)		Type 10 (.8032)	Type 15 (.6359)	Type 20 (.5280)
Type 10 (.6308)	-	.2411	.6465	Type 10 (.8032)	-	**.0166**	**.0093**
Type 15 (.5101)	-	-	.1394	Type 15 (.6359)	-	-	**.0593**
Type 20 (.5720)	-	-	-	Type 20 (.5280)	-	-	-
	RelMin				**ProgMin**		
	Type 10 (.7184)	Type 15 (.6549)	Type 20 (.6460)		Type 10 (.6068)	Type 15 (.7332)	Type 20 (.7740)
Type 10 (.7184)	-	.1394	.2845	Type 10 (.6068)	-	**.0593**	**.0745**
Type 15 (.6549)	-	-	.2411	Type 15 (.7332)	-	-	.3329
Type 20 (.6460)	-	-	-	Type 20 (.7740)	-	-	-

Notes: Comparisons and average contributions involve rounds 1 to 25. Averages for the player type are given in parentheses.

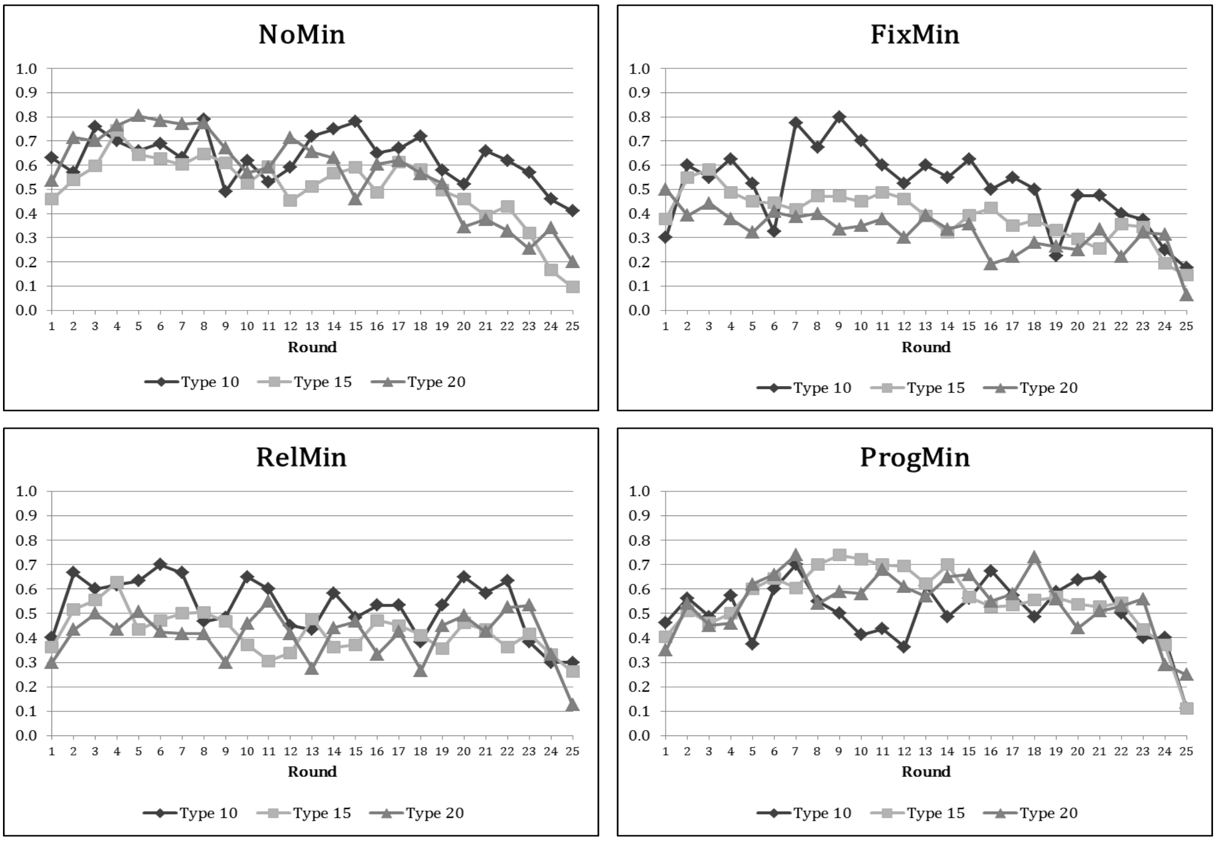

Figure A. 3: Average net contributions by player type

Table A. 3:
Comparisons of average net contributions between player types
(p-values of two-sided signed-rank tests)

	NoMin				FixMin		
	Type 10 (.6308)	Type 15 (.5101)	Type 20 (.5720)		Type 10 (.5080)	Type 15 (.3931)	Type 20 (.3257)
Type 10 (.6308)	-	.2411	.6465	Type 10 (.5080)	-	.1394	**.0745**
Type 15 (.5101)	-	-	.1394	Type 15 (.3931)	-	-	.5076
Type 20 (.5720)	-	-	-	Type 20 (.3257)	-	-	-

	RelMin				ProgMin		
	Type 10 (.5307)	Type 15 (.4249)	Type 20 (.4100)		Type 10 (.5085)	Type 15 (.5553)	Type 20 (.5480)
Type 10 (.5307)	-	.1394	.2845	Type 10 (.5085)	-	.5076	.7213
Type 15 (.4249)	-	-	.2411	Type 15 (.5553)	-	-	.9594
Type 20 (.4100)	-	-	-	Type 20 (.5480)	-	-	-

Notes: Comparisons and average contributions involve rounds 1 to 25. Averages for the player type are given in parentheses.

Table A. 4:
By Type: Comparisons of average absolute [and average net] contributions between treatments (p-values of two-sided U tests)

Type 10	NoMin	FixMin	RelMin	ProgMin
NoMin	-	.1211 [.5453]	.5453 [.4963]	.7624 [.4057]
FixMin	-	-	.3445 [1.000]	**.0257** [.8205]
RelMin	-	-	-	.2725 [.9097]
ProgMin	-	-	-	-

Type 15	NoMin	FixMin	RelMin	ProgMin
NoMin	-	.1617 [.1988	.1508 [.2265]	**.0232** [.8798]
FixMin	-	-	.8798 [.8798]	.1304 [.1306]
RelMin	-	-	-	.1123 [.1124]
ProgMin	-	-	-	-

Type 20	NoMin	FixMin	RelMin	ProgMin
NoMin	-	.2265 [**.0191**]	.9698 [**.0696**]	**.0639** [.5706]
FixMin	-	-	.1509 [.4057]	**.0082** [**.0963**]
RelMin	-	-	-	**.0696** [.1988]
ProgMin	-	-	-	-

Note: Average contributions over rounds 1 to 20 in NoMin, FixMin, RelMin, ProgMin: Type10: $\bar{y}_i$: 6.53, 8.21, 7.32, 6.26; $\bar{y}_i^{Net}$: .6525, .5513, .5533, .5325. Type 15: $\bar{y}_i$: 8.51, 9.84, 9.97, 11.35; $\bar{y}_i^{Net}$: .5675, .4267, .4408, .5947. Type 20: $\bar{y}_i$: 12.80, 10.82, 12.99, 15.78; $\bar{y}_i^{Net}$: .6400, .3443, .4154, .5780.

Table A. 5:
Comparisons of contributions by cooperative and uncooperative players within treatments

		NoMin	FixMin	RelMin	ProgMin
Type 10	U	4.4	7.4	6.0	4.6
	C	8.6	9.0	8.7	7.9
Type 15	U	5.6	7.7	8.1	9.5
	C	11.4	12.0	11.8	13.2
Type 20	U	10.0	7.7	10.3	13.5
	C	15.6	13.9	15.6	18.1

Notes: Average contribution figures involve rounds 1 to 20. U = Uncooperative players, C = Cooperative players. For Type 10 and 20 there are per definition respectively 5 U and 5 C players per treatment and for Type 15 respectively 10 U and 10 C players per treatment.

Table A. 6:
Relative frequency of individual decisions at the lower bound or full contribution to the public investment

	Lower-bound contributions (in percent)	Full contributions (in percent)
NoMin – Type 10	15.0 [39.5; 25.0; 17.5]	41.5
NoMin – Type 15	14.3 [38.3; 38.3; 38.3]	32.3
NoMin – Type 20	10.0 [19.0; 23.0; 27.0]	32.0
FixMin – Type 10	32.0	44.0
FixMin – Type 15	33.3	24.8
FixMin – Type 20	28.0	17.5
RelMin – Type 10	20.5	37.0
RelMin – Type 15	28.8	18.8
RelMin – Type 20	18.0	17.5
ProgMin – Type 10	25.5	36.5
ProgMin – Type 15	19.8	40.0
ProgMin – Type 20	25.0	43.5

Notes: All figures involve rounds 1 to 20. Lower bound contributions are 0 in NoMin for all player types; 6 in FixMin for all player types; 4, 6, and 8 in RelMin; and 2, 6, and 10 in ProgMin for Type 10, Type 15, and Type 20 players, respectively. Figures in [] respectively show the percentage of contributions that were below the minimum contributions in FixMin, RelMin, and ProgMin for the three player types.

Appendix B

Experiment Instructions (ProgMin)

You participate in an economic decision experiment, in which you can earn money. How much each of you will earn depends on your personal decisions and those of other participants in the experiment. Each participant makes his decisions at a computer, isolated from the others. We ask you not to talk to other participants.

The experiment consists of 25 rounds. In the beginning of the experiment you will be randomly matched with three other persons to build a group of four. You will remain in this group during the entire experiment. You will not know the identity of your group members at any time, though.

Each group member is endowed in each round with a certain amount of tokens. Player 1 is endowed with 10 tokens per round. Players 2 and 3 are endowed with an amount of 15 tokens each. Player 4 is endowed with 20 tokens per round. The individual player numbers (and thus the individual endowments) will be randomly assigned and announced at the beginning of the experiment.

Decisions

In each of the 25 rounds, all group members each group member has to decide on how to allocate her/his tokens between two alternatives, called X and Y. The return of a token, in experimental currency units (ECU), is different for the two alternatives. The return of the allocation decision is determined as follows:

Each token that you contribute to X yields a return of 2 ECU. If you contribute nothing to X, your return from X is zero.

Each token that you contribute to Y, yields to you and to each of the other group members a return of 1 ECU. You may thus have a positive return from Y even if you yourself don't contribute anything to Y.

During the allocation of your tokens, you must note that you are required to contribute a minimum contribution to Y. This minimum contribution is 2 tokens for Player 1, 6 tokens for Players 2 and 3 each, and 10 tokens for Player 4.

Group Member	Endowment (tokens)	Mandatory Contribution to Y
Player 1	10	2
Player 2	15	6
Player 3	15	6
Player 4	20	10

You may allocate your tokens, above the minimum contribution to Y, to X or to Y only, but you may also allocate them among both alternatives. However, only entire tokens may be contributed. In the decision box on your screen you need to enter, for each alternative, the number of tokens that you want to allocate. If you do not want to contribute anything to X or Y, you need to type in a zero. The sum of the tokens contributed to X and Y must be always equal to your endowment. This means that the entire token endowment has to be allocated among X and Y. With the <Tab> key you can switch among the entry fields. The entries have to be confirmed by clicking on <OK>.

Your individual return per round is the sum of your returns from X and Y and is calculated as follows:

Return = 2 × (your contribution to X) + (sum of tokens contributed to Y in your group).

PAYMENT

At the end of the experiment, you will be paid based on your individual total profit over all 25 rounds. Your individual total profit in ECU will be converted into € (1 ECU = 0.01 €) and paid to you in cash. You are paid at the end of the experiment. The payment is carried out individually and anonymously.

AVAILABLE INFORMATION

In each round, you will see an overview table on your screen which provides you with the results of all previous rounds that you have played. The results include the following information for each round:

Your endowment, your mandatory minimum contribution to Y, your contribution to X, your contribution to Y, the individual contributions to Y of each of the other group members, your return from X, your return from Y, your round profit, and your total profit.

If you want to see the results of earlier rounds, which are no longer visible in the table, please use the scroll function on the right side of the table.

We ask you now to go to the computer with your participation number. There you have to click on <Continue>. You then will be given on your screen a number of questions regarding these instructions. If you have any questions please address yourself to the experimenter. Only when all participants have correctly answered all questions, the experiment starts.