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Rebate rules in reward-based crowdfunding: Introducing the bid-cap rule

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Abstract

We study the efficacy of rebate rules in reward-based crowdfunding, where a project is only realized when a funding goal is met, and only those who pledge at least a reservation price receive a reward from the project. We propose and experimentally test two rebate rules against the customary all-or-nothing model. Firstly, we adapt the proportional rebate rule from threshold public good games to our reward-based setting. Secondly, we develop the novel bid-cap rule. Here, pledges must only be paid up to a cap, which is determined ex-post such that the provision point is exactly met. Theoretically, the bid-cap rule induces weakly less variance in payments compared with the proportional rebate rule. In our experiment, we find that both rebate rules induce higher pledges and increase the project realization rate in comparison to the all-or-nothing model. Further, we can confirm that the variance of payments is lower under the bid-cap rule compared with the proportional rebate rule.

Keywords: Crowdfunding, laboratory experiment, provision point mechanism, rebates

JEL Codes: C72, C92, H41

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1 Introduction

Crowdfunding is the practice of raising capital from many people through an online platform and is quickly expanding worldwide (Agrawal et al., 2014). There exist several reasons for project creators and contributors, commonly referred to as (project) backers, to use crowdfunding. Project creators that have traditionally relied on other sources like banks or venture capitalists can raise funds directly from a large base of backers to realize projects. Crowdfunding also provides project creators that have limited access to traditional financing sources with a new channel to raise money and pursue their projects. Furthermore, crowdfunding can increase the popularity of a project and can stimulate long-term customer acquisition (Gerber and Hui, 2013). On the demand side, backers can be part of a community, support similarly interested people, or get compensation (Deb et al., 2019).

In this paper, we focus on reward-based crowdfunding, where backers receive direct non-monetary rewards for their pledge to a project if their pledge exceeds a pre-set entry fee.[1] By virtue of this funding scheme, project backers are not only customers but also the investors of the project creator, i.e., reward-based crowdfunding allows project creators to contract the purchasing decision before investments into productions are made and thus sunk. The rapid expansion of crowdfunding in many countries has given rise to multiple large-scale crowdfunding platforms such as Kickstarter, GoFundMe, and Indiegogo. As a result, the global reward-based crowdfunding market achieved a $13.64 billion market value in 2021, forecast to double by 2028 with an annual expected growth rate of 11% (Statista, 2021).

Crowdfunding platforms match supply, funding, and demand via a mechanism where the all-or-nothing and keep-it-all models are most commonly used. Under the all-or-nothing model, project creators get all pledges if the funding goal is reached, while all pledges are paid back otherwise. In contrast, under the keep-it-all model, the project creators receive all pledges accumulated during the funding time, independent of whether the funding goal is reached. Comparing these two models, it is commonly understood that the all-or-nothing model is superior to the keep-it-all model by attracting higher pledges and yielding more project successes (see Coats et al., 2009; Cumming

[1] Such rewards can take on various forms such as early access to a product, a limited version of a product or some forms of individualization, like signed or otherwise customized products. The pre-set entry fee corresponds to minimum amounts that have to be pledged to receive the goods or perks.

et al., 2020; Wash and Solomon, 2014). The all-or-nothing model is particularly popular in reward-based crowdfunding, as it is a screening device that helps to reduce demand uncertainty (Strausz, 2017; Chemla and Tinn, 2020; Xu and Ni, 2022).

Similar to conventional financial markets, not all demand for funding can be satisfied on crowdfunding platforms. Around 60% of projects on Kickstarter failed to reach the self-set funding goal as of March 2023.[2] While many failed projects are far from reaching the funding goal, some projects are just shy of the funding goal when the funding period ends. For these projects, a small increase in pledges could mean project success. This issue is particularly critical under the all-or-nothing model, common in reward-based crowdfunding, where project creators only obtain the pledges when the funding goal is reached. Hence, project creators (and crowdfunding platforms) want to find ways to either reach new backers or increase the pledges of existing backers if the opportunities for attracting additional backers are exhausted.

Several studies focus on ways to increase the number of backers and improve the coordination between backers, e.g., by encouraging early pledges (Ansink et al., 2017; Solomon et al., 2015), disseminating positive opinions (Comeig et al., 2020), highlighting specific projects (Corazzini et al., 2015), giving greater project involvement to customers (Cornelius and Gokpinar, 2020; Regner and Crosetto, 2021), and the timing of promotions (Regner and Crosetto, 2018; Li and Wang, 2019). However, exploring ways to induce a given number of backers to increase their pledges has received little attention in the crowdfunding literature. In this case, raising funds to reach the funding goal can be viewed as a residual threshold public good game among all investing backers. One solution to overcome the residual public good problem is refund bonuses. Refund bonuses are granted to backers in addition to their pledge when the funding goal is not met, i.e., when projects are unsuccessful. Cason and Zubrickas (2017, 2019) find that contributors respond to incentives induced by refund bonuses in line with predictions and that refund bonuses can increase project realization rates substantially. Cason et al. (2021) scrutinize the dynamics of funding by focusing on refund bonuses that are only rewarded to early contributors in case of fundraising failure. They find that offering refund bonuses only to early contributors works just as well as offering a refund bonus to every contributor. However, as refund bonuses are granted upon project failure, it remains to be clarified who would pay for them since neither project creators nor crowdfunding platforms

[2] See https://www.kickstarter.com/help/stats?ref=global-footer for more information.

may have the necessary funds.

The threshold public goods literature identifies rebating excess contributions back to contributors when the total contributions exceed the provision point as another way to increase contributions and project success rates. Smith (1980) originally proposed a proportional rebate rule in public good auctions. Marks and Croson (1998) and Rondeau et al. (1999) introduced this rebate rule in provision point mechanisms by rebating excess contributions proportionally back to contributors when the provision point is exceeded. Marks and Croson (1998) compare contributions in the presence and absence of proportional rebates and a utilization rule. They find that under rebate rules, similar contributions are obtained as without rebates, and contributions were highest when excess contributions were utilized via a secondary standard public good. Rondeau et al. (1999) show that a provision point mechanism with proportional rebates can be empirically demand-revealing. Besides the proportional rebate rule, Spencer et al. (2009) consider five alternative rebate rules, including variations of lottery-like winner-take-all rules and random rebate rules. They find that for all rules, total contributions equal total benefits or exceed them.

Our main contribution to the crowdfunding literature is the development of a new rebate scheme which we call the bid-cap rule. The bid-cap rule sets an ex-post limit on pledges such that the funding goal is exactly reached. Pledges above this limit are reduced to the cap making it less risky to pledge greater amounts. We additionally adapt the proportional rebate rule to a reward-based crowdfunding framework. Under this rule, backers are not rebated proportionally to their pledge but proportionally to the part of their pledge that exceeds the pre-set entry fee. We then experimentally test both rebate rules against the all-or-nothing model and each other regarding backer's pledges and project success rates. By design of the rebate rules, all backers receive a rebate under the proportional rebate rule, while under the bid-cap rule, only those who pledge the most, i.e., those who pledge more than the cap, receive a rebate. Theoretically, the bid-cap rule induces weakly less variance in payments upon project realization and rewards those who pledge the most compared with the proportional rebate rule. However, how this affects pledging behavior is ambiguous as it could also induce higher pledges due to decreased perceived risk and reinforce free-riding behavior. With our experiment, we show that both rebate rules substantially increase backer pledges and the project realization rate compared with the all-or-nothing model, while we can confirm that the variance of payments is lower under the bid-cap rule compared with the proportional rebate rule.

2 The Game

Consider a static game with N individuals, respectively backers, where each backer $i \in \{1, \ldots, N\}$ has an endowment of E_i. Each backer can decide on a pledge $b_i \in [0, E_i]$ that is used for the realization of a project. The project is realized if the total pledges $\sum b_i$ weakly exceed an exogenously given provision point PP.[3] If the total pledges are short of PP each backer gets back their pledge b_i and pays 0. To capture the nature of reward-based crowdfunding, a backer receives their private valuation v_i from the realized project if and only if they pledge more than a pre-set reservation price of r. Hence, if the project is realized but backer i has pledged $b_i < r$, they will not receive their valuation from the project, while all backers with $b_i \geq r$ will receive their valuation v_i from the project. Pledges below r are collected and are considered donations toward the realization of the project.[4] In the following, $n \leq N$ is the number of backers pledging at least r, and $N - n$ is the number of backers with pledges $b_i \in [0, r)$.

We assume that $\sum v_i > PP$ such that the realization of the project is socially desirable as its total benefits exceed the costs of provision. Further, we will focus on the cases where $PP > N \cdot r$, i.e., pledging has a public good character in addition to the inherent purchasing decision, as these are the cases in which the all-or-nothing model is prone to fail.

When the total pledges exceed the provision point, the excess pledges may be reallocated back to the backers who pledged at least r or may be kept in the project yielding no additional benefit to backers. The latter corresponds to the all-or-nothing model. We further consider the case where the excess pledges are rebated to backers proportional to the amount their pledges exceed the reservation price. Additionally, we develop the new bid-cap rebate rule, where an ex-post limit on payments is determined such that either the provision point is met exactly or backers pay the reservation price at most. Details for these rebate rules and the individual payoff function according to these rules are explained below.

[3] Throughout $\sum$ always represents $\sum_{i=1}^{N}$ if not stated otherwise.

[4] Reservation prices are commonly observed on crowdfunding platforms such as Kickstarter, Indiegogo, and StartNext, where project creators post a minimal price which backers have to pledge to receive the good but are allowed to pledge more or less than the reservation price.

All-or-nothing model

Under the all-or-nothing model, excess pledges above PP are not rebated to backers. The individual payoff π_i is given by

$$\pi_i = \begin{cases} E_i - b_i + v_i & \text{if} \quad \sum b_i \geq PP \text{ and } b_i \geq r \\ E_i - b_i & \text{if} \quad \sum b_i \geq PP \text{ and } b_i < r \\ E_i & \text{if} \quad \sum b_i < PP \end{cases} \cdot \tag{1}$$

The marginal penalty associated with over-pledging is

$$\frac{\partial \pi_i}{\partial b_i} = -1, \tag{2}$$

meaning that while the provision point is met, an increase of backer i's pledge by one reduces backer i's payoff by the same amount.[5]

Proportional rebate rule

In our adaption of the proportional rebate rule to the reward-based crowdfunding case, excess pledges are rebated proportional to the difference between pledge and reservation price $e_i := \max\{0, b_i - r\}$ to those backers who pledged at least r.[6] The reservation price is often set at marginal cost, whereby a company would make a loss if backers paid less than r. The individual payoff π_i is

$$\pi_i = \begin{cases} E_i - b_i + v_i + \frac{e_i}{\sum e_i}\left(\sum b_i - PP\right) & \text{if} \quad \sum b_i \geq PP \text{ and } b_i \geq r \\ E_i - b_i & \text{if} \quad \sum b_i \geq PP \text{ and } b_i < r \\ E_i & \text{if} \quad \sum b_i < PP \end{cases} \cdot \tag{3}$$

[5]Following the literature we define over-pledging similar to over-contribution as a marginal increase of b_i while $\sum b_i \geq PP$.

[6]This is in contrast to Rondeau et al. (1999) and Marks and Croson (1998) who rebate proportional to the full contribution in a standard threshold public good game.

The marginal penalty associated with over-pledging is

$$\frac{\partial \pi_i}{\partial b_i} = \begin{cases} -1 + \frac{\left(\sum b_i - PP\right)\left(\sum e_i - e_i\right) + \left(e_i \sum e_i\right)}{\left(\sum e_i\right)^2} & \text{if} \quad b_i \geq r \\ -1 & \text{if} \quad b_i < r \end{cases}. \tag{4}$$

Note that the absolute value of the marginal penalty of over-pledging under the proportional rebate rule is weakly smaller than under the all-or-nothing model. This is the case since, given that the project is realized, $\sum b_i - PP \geq 0$, $\sum e_i - e_i \geq 0$, and $e_i \sum e_i > 0$ so that the second term in the first case must be positive or zero. In Appendix A.1, we further show that the second term in the first case is smaller than one such that the penalty of marginally increasing the pledge is strictly negative.

Bid-cap rule

For the bid-cap rule, consider any sequence of pledges by all backers $(b_1, \ldots, b_N)$. Without loss of generality, we assume $b_1 \leq b_2 \leq \ldots \leq b_N$. When total pledges exceed the provision point, we find a bid-cap $\bar{b} > r$ such that $\sum_{i=1}^{k} b_i + (N-k)\bar{b} = PP$, where $\bar{b} \in [b_k, b_{k+1})$ is the cap, i.e., the highest payment any backer has to make. The bid-cap $\bar{b}$ is determined via a recursive algorithm that gradually increases $\bar{b}$, while backers either pay the bid-cap $\bar{b}$ if $b_i \geq \bar{b}$ or their individual pledge b_i if $b_i < \bar{b}$. The algorithm stops increasing $\bar{b}$ when the sum of (capped) pledges is equal to the provision point PP.[7] Hence, k backers pay their full pledge and $N-k$ backers pay the bid-cap $\bar{b}$.[8] The individual payoff π_i is given as

$$\pi_i = \begin{cases} E_i - b_i + v_i + (b_i - \bar{b}) & \text{if} \quad \sum b_i \geq PP \text{ and } b_i \geq \bar{b} \\ E_i - b_i + v_i & \text{if} \quad \sum b_i \geq PP \text{ and } b_i \in [r, \bar{b}) \\ E_i - b_i & \text{if} \quad \sum b_i \geq PP \text{ and } b_i < r \\ E_i & \text{if} \quad \sum b_i < PP \end{cases}. \tag{5}$$

[7] An explicit example of the procedure is given in the translated instructions, see Page A-17 in the Appendix.

[8] Note, that the condition $\bar{b} > r$ must be necessarily fulfilled since we only consider cases where $PP > N \cdot r$. For the special case of $k = 0$ we have $r \leq \bar{b} < b_1 \leq \ldots \leq b_N$ where everything that follows holds as well.

The marginal penalty associated with over-pledging is

$$\frac{\partial \pi_i}{\partial b_i} = \begin{cases} 0 & \text{if} \quad b_i \geq \bar{b} \\ -1 & \text{if} \quad b_i < \bar{b} \end{cases}. \tag{6}$$

In Appendix A.2, we show that under the bid-cap rule a solution $(k, \bar{b})$ must always exist. In Appendix A.3, we further show that $(k, \bar{b})$ is uniquely determined for any sequence of pledges.

Note that, similar to the proportional rebate rule, the absolute value of the marginal penalty of over-pledging under the bid-cap rule is weakly smaller than under the all-or-nothing model. Further, the absolute value of the marginal penalty of over-pledging under the bid-cap rule is weakly smaller than under the proportional rebate rule if $b_i \geq \bar{b}$ and strictly greater if $r \leq b_i < \bar{b}$.

Comparison of rebate rules

To have a sensible comparison between the rebate rules, we assume the same sequence of pledges for both rules and compare the outcomes that different rebate rules induce. Consider a fixed sequence of ordered pledges $(b_1, \ldots, b_N)$ with $\sum b_i > PP$. Under the proportional rebate rule, every backer who pledges more than the reservation price r receives a rebate. In contrast, under the bid-cap rule only backers $i \in \{k+1, \ldots, N\}$, i.e., backers who pledged more than $\bar{b}$, receive a rebate. Since the total amount of rebates cannot change, it follows that backers with high (low) pledges must be better (worse) off under the bid-cap rule compared with the proportional rebate rule. In fact, we find that the relation of payments is as shown in Figure 1.

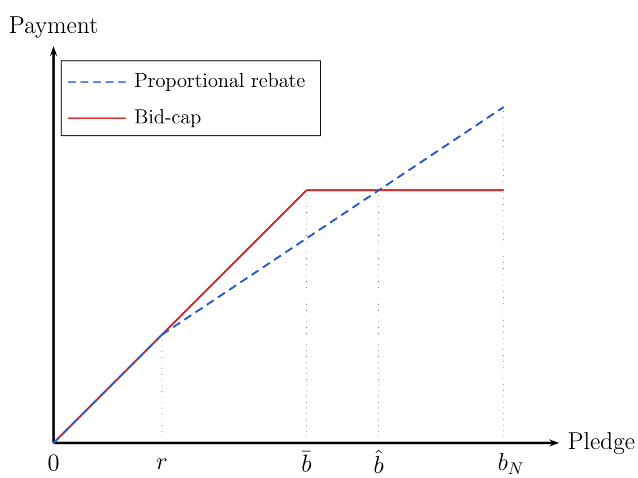

Figure 1: An example of payments by pledge under rebate rules.

All backers below an intersection $\hat{b} \in (\bar{b}, b_N)$ are better off under the proportional rebate rule, and all backers with pledges above the intersection are better off under the bid-cap rule. Backers pledging close to (or equal to) $\bar{b}$ are worst off under the bid-cap rule compared with the proportional rebate rule. In Appendix A.4, we show that these properties hold for any discrete sequence of pledges. A direct consequence of these findings is that the variance of payments is lower under the bid-cap rule compared with the proportional rebate rule for any given sequence of pledges that, in sum, exceed the provision point.

3 The Experiment

3.1 Experimental Design and Procedures

We implemented the game described in Section 2 as an experiment with participants acting as project creators or backers. Our experiment consisted of three experimental treatments, following the three cases of our game: all-or-nothing, proportional rebate, and bid-cap. We chose the parameters in the experiment such that the number of players, aggregate benefits to costs ratio, and share of aggregate endowment necessary for project realization are in line with past work on threshold public goods (Croson and Marks, 2000). Each treatment consisted of two parts and was structured as follows. Participants were randomly assigned to a computer upon entering the laboratory. Participants then read the instructions for the first part and could ask questions to ensure comprehension. The instructions for the first part stated that the participants play the game once. Further, it was mentioned that the experiment includes a second part but not what the task was in the second part. The task in the second part, comprising ten repetitions of the same game with randomly determined valuations, was revealed in separate instructions provided after the first part had elapsed. Since participants did not know that they were playing the same game in the second part again, we interpret the first round as behavior in a one-shot game. Comprehension of the instructions of Part 1 was checked with on-screen control questions, which had to be answered correctly before the first part started.

Similar to Spencer et al. (2009), we presented our game as an investment game by referring to pledges as "investments" and the provision point as "investment costs" in the instructions. The participants were assigned to groups comprising eleven participants that remained the same throughout the experiment. At the beginning of the experiment, it was randomly determined whether a participant was active or passive, with each group consisting of $N = 10$ active players and one passive player. The active players represent project backers, while the passive player corresponds to a project creator who benefits from the project realization but cannot actively contribute to the project. In addition, the passive player was paid the excess pledges in the all-or-nothing treatment if the project was realized. This mimics actual crowdfunding platforms where excess pledges go to the project owner upon realization.[9] Moreover, without a passive player, excess pledges would be kept by the experimenter in the all-or-nothing treatment while they are redistributed among participants in both rebate treatments, potentially causing experimenter demand effects. Each participant was endowed with $E_i = 65$ experimental currency units (ECU) and each active participant could pledge any amount out of this endowment toward the realization of a project. The project was only realized if the provision point of $PP = 300$ ECU was reached. In contrast to Spencer et al. (2009), we informed participants about the provision point ex-ante since in crowdfunding the provision goal is most commonly featured in the project descriptions. If an active player pledged at least the ex-ante known reservation price of $r = 15$ ECU, this participant could obtain a payout upon project realization. Pledges below 15 ECU did not entitle an active player to the payout. If the total pledges were below the provision point of 300 ECU, then each participant was refunded their pledge. If the project was successfully funded, each active player who pledged at least 15 ECU received their valuation of $v_i = 45$ ECU. This means each active player had the same project valuation. The passive player received 65 ECU independent of project realization and received an extra 45 ECU if the project was realized. If the total pledges exceeded the provision point of 300 ECU, the excess amount was rebated to the active players in the proportional rebate and bid-cap treatments according to the respective applied rebate rule, while the passive player received the excess amount in the all-or-nothing treatment.

After the first part had ended, each participant received additional instructions for Part 2, i.e., the repeated version of the game. Importantly, participants did not receive any feedback about the outcome of the first part after it had elapsed. The second part was almost identical to the first, with two major changes. The game was repeated for ten rounds, and the value active players ascribed to the project was heterogeneous. The valuation was a whole number drawn each round

[9] All theoretical results from section 2 hold with the passive player.

from a uniform distribution with support [30, 60]. Thereby, the minimum aggregate project value for the active players was 300 ECU, which covered the costs of project realization. The actual realized minimum aggregate project value of the active players was 350 ECU with an average of 442.41 ECU. Participants received no feedback between the rounds, eliminating any feedback effects. Again, the comprehension of these instructions was checked via on-screen control questions. The payoff for the second part equaled the payoff obtained in a randomly drawn round, where each round is equally likely to be chosen. Each participant's final payoff was the sum of their first and second part payoffs.

The experiment was conducted at Technische Universität Berlin in November 2022. The experiment was programmed with the experiment software z-Tree (Fischbacher, 2007). In total, 132 Participants were recruited using ORSEE (Greiner, 2015). We conducted six sessions, two sessions per treatment, with 22 participants each. The (translated) experimental instructions can be found in the Appendix. Sessions lasted around 30 minutes. Participants earned 10.89 EUR on average, including a show-up fee of 6 EUR.

3.2 Hypotheses

The all-or-nothing model and both rebate rules underlying the experimental treatments share the same inefficient and efficient Nash equilibria. In inefficient Nash equilibria, the project is not realized and no backer can increase their pledge to achieve realization. Efficient Nash equilibria are any combinations of individually rational pledges ($b_i \leq v_i$) that exactly sum up to the provision point.[10] Nonetheless, the proportional rebate rule and the bid-cap rule better the outcome of some (or all) backers in the off-path cases, where the sum of pledges strictly exceeds the provision point. Due to this, higher pledges come with lower risk under the rebate rules, as also indicated by the lower marginal penalty for all pledges above the reservation price ($b_i > r$) under the proportional rebate rule, as shown in equation (4) and for all pledges above the bid-cap ($b_i > \bar{b}$) under the bid-cap rule as shown in equation (6). This leads to our first hypothesis.

Hypothesis 1: *The pledges will be higher under the rebate rules compared with the all-or-nothing model.*

[10] When there is over-pledging ($\sum b_i > PP$), every backer individually has the incentive to lower their pledge under all cases.

As a consequence of Hypothesis 1, we expect that the pledges are sufficiently increased under the rebate rules compared with the all-or-nothing model to positively affect the probability of a project realization, yielding our second hypothesis.

Hypothesis 2: *The project realization rates will be higher under the rebate rules compared with the all-or-nothing model.*

Conditional on project realization, the mean payments of active players are $PP/N = 30$ by design under both rebate rules. Hence, we can only expect differences in the distributions of payments. Given that the bid-cap rule only reduces high pledges ($b_i > \bar{b}$) but does not impact low pledges ($b_i \leq \bar{b}$), while the proportional rebate rule reduces all pledges above the reservation price ($b_i > r$), we arrive at our third hypothesis.

Hypothesis 3: *The variance of payments will be smaller under the bid-cap rule than under the proportional rebate rule.*

This Hypothesis requires that pledging behavior is not too different between the two rebate rules. A possible behavioral conjecture would be that the bid-cap rule induces higher pledges among those who try to guarantee the realization of the project and lower pledges among free-riders, i.e., those who try to maximize their own payoff with little regard for the realization of the project. In this case, dependent on the pledging behavior, this could either cause a lower, similar, or even higher variance of payments under the bid-cap rule compared with the proportional rebate rule. Yet, there is no theoretical reason or empirical evidence indicating that pledging behavior is different between the bid-cap and proportional rebate rules.

4 Results

In Table 1, we show summary statistics by experimental treatment, divided by Part 1 and Part 2. On average, the pledges are greater than the efficient equilibrium prediction of 30 under both rebate rules and below 30 under all-or-nothing. Demand revelation is below 1 in all treatments. By design, the mean payments are exactly 30 under both rebate rules. Under all-or-nothing, around 1/3 of the projects were funded, while more than 3/4 of the projects were funded under either rebate rule. Overall, results are very similar between both parts of the experiment.

	All-or-nothing	Proportional rebate	Bid-cap
Part 1:			
Mean pledge b_i	28	33.75^a	33.08
	(13.91)	(14.00)	(13.48)
Demand revelation b_i/v_i	0.62^b	0.75^b	0.74^b
	(0.27)	(0.31)	(0.30)
Payment when project funded	31.2	30	30
	(10.69)	(10.07)	(6.54)
Proportion of projects funded	0.25	0.75	0.75
Part 2:			
Mean pledge b_i	27.84	35.77^a	33.63^a
	(14.07)	(17.12)	(14.41)
Demand revelation b_i/v_i	0.63^b	0.82^b	0.77^b
	(0.30)	(0.40)	(0.35)
Payment when project funded	32.56	30	30
	(13.28)	(12.23)	(9.28)
Proportion of projects funded	0.35	0.88	0.85

[a]Significantly different from equilibrium prediction of 30, see Table A.1 in the Appendix.
[b]Pledges are significantly different from valuation, see Table A.2 in the Appendix.

Table 1: Summary statistics with standard deviations in brackets.

We provide an overview of general pledging tendencies in Figure 2 where we classify by pledges below the reservation price, pledges above the reservation price and below the mean equilibrium pledge of 30, which we consider free riding, pledges within the mean equilibrium pledge of 30 and the valuation, which we consider contributions, and pledges strictly above the valuation.[11] Notably, under the all-or-nothing treatment we find the most instances of pledges below the reservation price.[12] Under the bid-cap rule, we find the least instances of free riding and the most contributions. Lastly, under the proportional rebate rule, we find considerably more pledges above the valuation and the smallest share of contributions.

In Figure 3, we show a mapping from pledges to payments for both rebate rule treatments. We also add fitted predictions based on our observations. To fit the proportional rebate treatment, we

[11]See Figure A.1 for the cumulative distribution and kernel density estimation of pledges.
[12]In all treatments pledges of $b_i = 0$ account for around 3/4 of pledges $b_i < 15$.

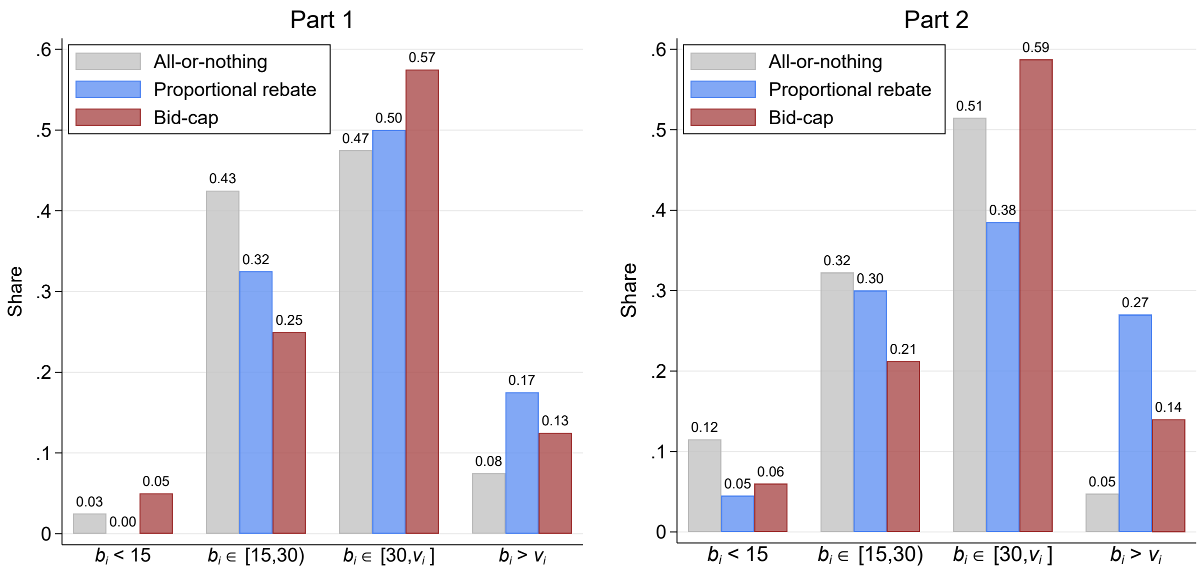

Figure 2: Distribution of pledges (classified).

ran a regression of payments on pledges for pledges $b_i \in [15, 65]$ with suppressed constant term to determine the slope, while payments are equal to the pledges for $b_i < 15$ by design of the rebate rules. To fit the bid-cap treatment, we calculated the mean bid-cap $\bar{b}$ for funded projects. This constant is the payment for every pledge $b_i \geq \bar{b}$, while payments are equal to the pledges for $b_i < \bar{b}$ by design of the rule.

Based on Spearman's rank correlation coefficients, we find that pledges are correlated with the drawn valuations in all experimental treatments; all-or-nothing: Spearman's rho $= 0.42$, $p < 0.001$; proportional rebate: Spearman's rho $= 0.34$, $p < 0.001$; bid-cap: Spearman's rho $= 0.29$, $p < 0.001$. As indicated by demand revelations below one and despite these correlations, we find that participants pledge significantly below their valuation in all experimental treatments and both parts of the experiment, as seen in Table A.2 in the Appendix. There we run the same regressions as before, albeit normalizing the pledges at the individual valuation instead of the mean equilibrium pledges. This result contrasts the findings of Rondeau et al. (1999) and Spencer et al. (2009), who find demand revelation close to one, i.e., that pledges were equal to valuations, in threshold public good settings. A potential reason for this difference is that Rondeau et al. (1999) and Spencer et al. (2009) did not provide information on the exact provision point but only on the distribution it is drawn from. In Table A.1 in the Appendix, we normalize the pledges to the equilibrium prediction

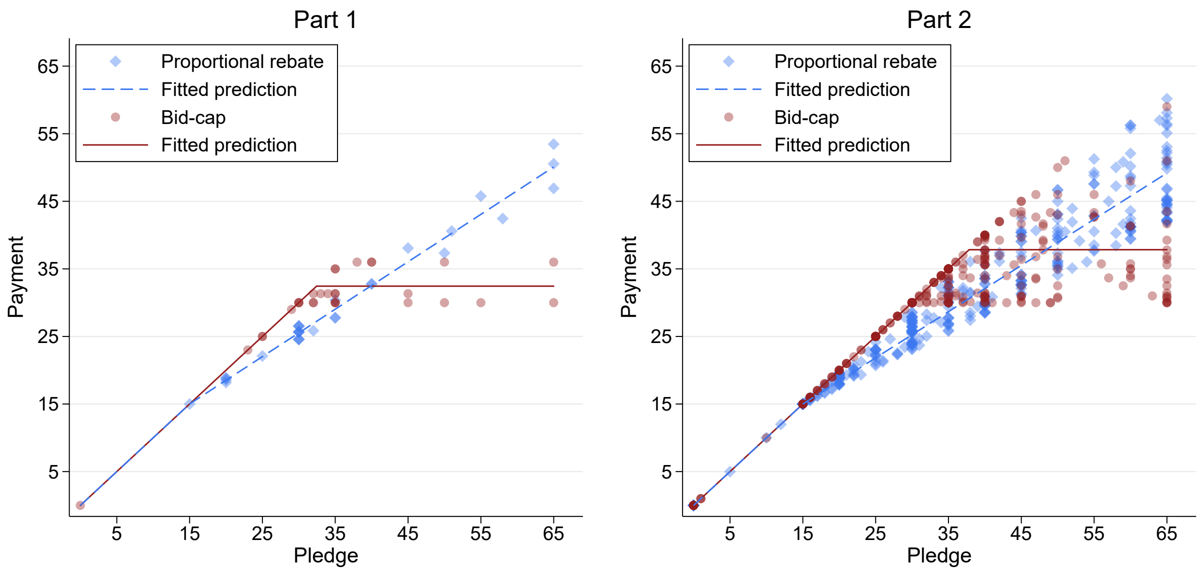

Figure 3: Pledge to payment mapping of funded projects in rebate rule treatments.

by subtracting 30 from each pledge and run regressions on the constant remainder. We find that participants pledge on average less than in equilibrium under the all-or-nothing treatment in both parts of our experiment, yet this difference does not reach statistical significance at conventional levels. In contrast, under both rebate rules, participants pledge more on average than in equilibrium in both parts of the experiment. This is highly significant for Part 2 under the proportional rebate rule.

Next, we test for treatment effects on pledges. We show the results in the first two columns of Table 2. For Part 1, we run an OLS regression with robust standard errors, and for Part 2, we run random-effects regressions with standard errors clustered on the subject level. For both parts of our experiment, we find that pledges are significantly greater under both rebate rules compared with the all-or-nothing model, while there is no significant difference between the two rebate rules.[13] Given these results, we can confirm our first Hypothesis.

Result 1: *Pledges are larger under any rebate rule treatment compared with the all-or-nothing treatment.*

[13]The results hold when pooling Part 1 and Part 2 (see Table A.4 in the Appendix).

	Part 1 (One round)	Part 2 (Ten rounds)	
	$b_i \in [0, 65]$	$b_i \in [0, 65]$	Funded $\in \{0, 1\}$
Proportional	5.88*	7.89***	0.53**
	(3.019)	(2.593)	(0.207)
Bid-cap	4.99*	5.67**	0.50**
	(2.994)	(2.593)	(0.217)
Constant	19.24**	15.53**	0.35*
	(8.548)	(7.428)	(0.188)
Level of observations	Subject	Subject	Group
Number of observations	120	1200	120
Postestimation Wald tests to compare proportional rebate and bid-cap treatments:			
H_0: Proportional rebate = bid-cap	$p = 0.78$	$p = 0.44$	$p = 0.86$

Standard errors in parentheses. Estimation by OLS regression with robust standard errors for Part 1 and estimation by random-effects regression with clustering on level of observations for Part 2. The baseline category is all-or-nothing in all specifications. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

Table 2: Analysis of treatment effects on pledges and the successful realization of projects.

Similarly, in the third column of Table 2, we show the result of a random-effects regression with standard errors clustered on the group level on project realization rates with the inclusion of treatment dummies. We find that projects were significantly more likely to be funded under either rebate rule, while there is no significant difference between rebate rule treatments in the project realization rate.[14] This confirms our second Hypothesis.

Result 2: *Project realization rates are larger under any rebate rule treatment compared with the all-or-nothing treatment.*

These findings contrast Marks and Croson (1998), who found no difference in contributions and project realization rates between no rebates and proportional rebates in a threshold public good setting. The most notable difference between their experiment and ours is that they provided feedback between rounds, introducing reputation effects and punishment opportunities. Moreover, we find consistency in our results as we introduce another rebate rule next to the proportional rebate in the form of the bid-cap.

Lastly, we compare the pledging patterns and payments for funded projects between the two

[14] In Part 1, one out of four projects was funded under the all-or-nothing treatment, while three out of four projects were funded under each rebate rule, respectively. Pooling Part 1 & Part 2 in the estimations does not change the results (see Table A.4 in the Appendix).

rebate rule treatments. In Figure A.2 in the Appendix, we show the cumulative distribution of pledges and payments for funded projects.[15] We begin by considering Part 1. Using Kolmogorov-Smirnov tests, we find that there is no significant difference in distributions of pledges of funded projects between rebate rule treatments, $D(60) = 0.267$, $p = 0.236$, but a significant difference in distributions of payments of funded projects between rebate rule treatments, $D(60) = 0.500$, $p < 0.001$. In contrast, when considering Part 2, we find that between rebate rules, there is a significant difference in distributions of pledges of funded projects, $D(690) = 0.162$, $p < 0.001$, and a significant difference in distributions of payments of funded projects, $D(690) = 0.282$, $p < 0.001$.

Similarly, using variance-comparison tests between rebate rules for Part 1, we find that there is no significant difference in the standard deviation of pledges of funded projects, $F(29, 29) = 1.286$, $p = 0.503$ (two-sided F-Test), while the standard deviation of payments of funded projects is significantly lower under the bid-cap rule compared with the proportional rebate rule, $F(29, 29) = 2.372$, $p = 0.023$ (two-sided F-test). Again, when considering Part 2, we find both a significant difference in the standard deviation of pledges of funded projects, $F(349, 339) = 1.495$, $p < 0.001$ (two-sided F-Test), and a significant difference in the standard deviation of payments of funded projects, $F(349, 339) = 1.736$, $p < 0.001$ (two-sided F-Test).

Albeit the caveat that pledging patterns are different between the rebate rule treatments in Part 2 of our experiment, we find a lower variance of payments under the bid-cap rule compared with the proportional rebate rule in Part 1 and Part 2. Therefore, we can confirm our third Hypothesis.

Result 3: *The variance of payments is smaller under the bid-cap treatment compared with the proportional rebate treatment.*

5 Conclusion

In this study, we derive two rebate rules for reward-based crowdfunding, namely the bid-cap rule and proportional rebate rule, and compare their theoretical properties to each other and the widely applied all-or-nothing model. Both rebate rules benefit backers whenever the sum of pledges strictly exceeds the provision point, which has to be met for project realization, compared with the all-or-

[15] In Figure A.3 in the Appendix, we show according kernel density estimations of pledges and payments for funded projects.

nothing model.

Applying all three rules in a laboratory experiment, we find that under both rebate rules, pledges and the project realization rate are greater than under the all-or-nothing. In line with its theoretical properties, we observe that the bid-cap rule induces less variance of payments compared with the proportional rebate rule. Compared with the proportional rebate rule, those who pledge the most pay less under the bid-cap rule, while in contrast to the proportional rebate rule, those who pledge the least do not receive a rebate under the bid-cap rule.

Since projects are realized more often if the excess pledges are rebated, it seems advisable for crowdfunding platforms to offer some variation of a rebate rule. However, we cannot give definite guidance on which rebate rule to implement. We observed more pledges above the valuation under the proportional rebate rule. A potential reason might be that participants misinterpreted the proportional rebate rule and erroneously tried to wager on high rebates, even though this could not increase gains and might, in fact, even lead to losses.[16] Hence, the proportional rebate rule might be preferred by project creators but not by the crowdfunding platform and project backers since it might induce over-pledging. On the other hand, the bid-cap rule might be preferred by project backers concerned about fairness in terms of payments since payments exhibit less variance under the bid-cap rule. In direct comparison, our results slightly favor the bid-cap rule over the proportional rebate rule.

A caveat to our findings is that on crowdfunding platforms, project creators can endogenously determine the provision point and reservation price. The creators might increase the provision point when they offer rebate rules as they cannot keep the excess pledges. Whether the positive effects of rebate rules still prevail when the provision point, reservation price, or both are chosen endogenously is an interesting question for future research.

Furthermore, we focus on cases where the provision point cannot be met when all individuals pledge the reservation price, yielding a residual public good game. For future research, one could extend the present study by introducing uncertainty in the number of individuals who participate in the crowdfunding game, such that it is unclear whether a residual public good game arise. Uncertainty in the number of backers is equivalent to an uncertain provision point, as in Rondeau

[16]Even though we checked comprehension of the instructions via control questions and asked if people had any further questions, we cannot rule out that participants still misinterpreted the rebate rules and their resulting payoffs.

et al. (1999) and Spencer et al. (2009). It would be interesting to test whether the bid-cap rule extends to this situation similar to the proportional rebate rule in that demand revelation increases. Also, in line with most crowdfunding applications, the rules could be extended to allow for different tiers of rewards. Lastly, the efficacy of rebate rules could be tested in field experiments using actual crowdfunding services.

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A Appendix

A.1 Proof of negative marginal penalty of over-contribution

For the marginal penalty to be negative, it remains to be shown that the denominator is greater than the numerator since then the second term in the first case will be strictly smaller than one, i.e.,

$$\big(\sum e_i\big)^2 > \big(\sum b_i - PP\big)\big(\sum e_i - e_i\big) + e_i\big(\sum e_i\big). \tag{7}$$

Rearranging yields:

$$\sum e_i > \sum b_i - PP. \tag{8}$$

To see this inequality holds under the assumptions when the project is funded consider that there are $n \in (0, N]$ backers who pledge at least r and $N - n$ who pledge strictly less than r[17]. In the following, we refer to the set of backers who pledge at least r as $I = \{\text{all } i \text{ such that } b_i \geq r\}$ and use this to express $\sum e_i$ in terms of pledges b_i:

$$\sum e_i = \sum_{i \in I}(b_i - r). \tag{9}$$

Plugging this into (8) and rearranging yields

$$PP > \sum_{i \notin I} b_i + n \cdot r. \tag{10}$$

The RHS is bounded from above by $N \cdot r$. Since we consider the case where $N \cdot r < PP$, the inequality is satisfied.[18]

[17] Note, that due to the assumption $N \cdot r < PP$ there needs to be at least one backer who pledges more than r if the project is realized.

[18] If $N \cdot r > PP$, this result must not necessarily hold. When $\sum_{i \in I} r + \sum_{i \notin I} b_i > PP$, the marginal penalty will be positive and individuals would choose infinitely large pledges.

A.2 Proof that a solution for the bid-cap rule must exist

The bid-cap rule determines a solution of the form $(k, \bar{b})$ for the following equation:

$$PP = \sum_{i=1}^{k} b_i + (N-k)\bar{b}, \tag{11}$$

where $b_k \leq \bar{b} < b_{k+1}$ and $k \in \{0, \ldots, N-1\}$. We arrive there by starting with $\sum b_i > PP$ and introducing the slack variable $S > 0$ to turn the inequality into an equality:

$$\sum b_i - S = PP. \tag{12}$$

We can set (12) equal to (11):

$$\sum b_i - S = \sum_{i=1}^{k} b_i + (N-k)\bar{b}. \tag{13}$$

We substitute $S = \sum_{i=k+1}^{N} s_i$:

$$\sum_{i=k+1}^{N} b_i - \sum_{i=k+1}^{N} s_i = (N-k)\bar{b} \iff \sum_{i=k+1}^{N} (b_i - s_i) = (N-k)\bar{b}. \tag{14}$$

We can represent (14) with the definitions of S and $\bar{b}$ as a system of equations:

$$\begin{aligned} \sum_{i=k+1}^{N} s_i &= S \\ b_{k+1} - s_{k+1} &= \bar{b} \\ &\cdots \\ b_N - s_N &= \bar{b} \\ b_{k+1} &> \bar{b} \\ b_k &\leq \bar{b} \end{aligned} \tag{15}$$

We continue to show that a solution to this system of equations must exist. Note that we only consider cases where $\sum b_i > PP$. Consider the upper interval limit $k = N - 1$. The system of equations reduces to $b_N - S = \bar{b}$ and $\bar{b} \geq b_{N-1}$. The highest contributor gets the full rebate S.

In the upper interval limit, the pledge of individual N is required to realize the project. Hence, $0 < S \leq b_N - b_{N-1}$, which implies that the inequalities above are satisfied. Now consider the lower interval limit $k = 0$. Everyone gets a positive rebate and pays exactly $\bar{b}$. This is a solution as $r \leq \bar{b} < b_1$ and $S > \sum(b_i - b_1)$. We generalize this observation to note that for any $S > 0$, we can find a k to solve the system of equations:

$$\exists k \text{ such that } \sum_{i=k+1}^{N} (b_i - b_{k+1}) < S \leq \sum_{i=k+1}^{N} (b_i - b_k) \text{ and } b_k \leq \bar{b} < b_{k+1}. \tag{16}$$

This requires $\sum_{i=k+1}^{N}(b_i - b_k) > \sum_{i=k+1}^{N}(b_i - b_{k+1})\ \forall k$, which holds as $\sum_{i=k+1}^{N}(b_i - b_k) = \sum_{i=k+1}^{N} b_i - (N-k) \cdot b_k > \sum_{i=k+1}^{N} b_i - (N-k)b_{k+1} = \sum_{i=k+1}^{N}(b_i - b_{k+1})$ since $0 \leq k \leq N-1$ and $b_{k+1} > b_k$ by definition. Now we express S in terms of $\bar{b}$, which is

$$S = \sum_{i=k+1}^{N} (b_i - \bar{b}) \tag{17}$$

and notice that this does not violate (16), as $b_k \leq \bar{b} < b_{k+1}$. As plugging (17) back into (12) yields (11), a solution of the proposed form always exists as long as we have $\sum b_i > PP$.

A.3 Proof that the solution in A.2 is unique

We conduct our proof by contradiction. Consider a solution to (11) that we call $(k, \bar{b})$ following A.2.

First suppose $(k', \bar{b}')$ with $k' < k$ and $b_{k'} \leq \bar{b}' < b_k$ is also a solution to (11). The last inequality follows as we consider a situation in which decision maker k does not cap out her pledge in contrast to $(k, \bar{b})$. However, $(k', \bar{b}')$ cannot be a solution to (11) as $\sum_{i=1}^{k'} b_i + (N-k')\bar{b}' < \sum_{i=1}^{k} b_i + (N-k)\bar{b}' < \sum_{i=1}^{k} b_i + (N-k)b_k \leq \sum_{i=1}^{k} b_i + (N-k)\bar{b}$.

Now assume $(k', \bar{b}')$ with $k' > k$ and $\bar{b} < b_{k+1} \leq \bar{b}'$ is a solution to (11). The inequalities follow since as $k' > k$, we must have at least $k' \geq k+1$, while $\bar{b} \leq b_k < b_{k+1}$ when under $(k, \bar{b})$ only consumers up to k cap out their pledges. Again, $(k', \bar{b}')$ does not solve (11) since $\sum_{i=1}^{k'} b_i + (N-k')\bar{b}' > \sum_{i=1}^{k} b_i + (N-k)\bar{b}' \geq \sum_{i=1}^{k} b_i + (N-k)b_{k+1} > \sum_{i=1}^{k} b_i + (N-k)\bar{b}$.

A.4 Proof of payment relation of bid-cap and proportional rebate for a discrete sequence of pledges

Consider a sequence of ordered pledges $(b_1, \ldots, b_N)$ with

$$\sum b_i > PP, \tag{18}$$

where we, w.l.o.g., assume that $b_1 > r$. The sequence of final payments for all N individuals under proportional rebate is given by:

$$\left(b_1 - \frac{e_1 \cdot (\sum b_i - PP)}{\sum e_i}, \ldots, b_N - \frac{e_N \cdot (\sum b_i - PP)}{\sum e_i}\right), \tag{19}$$

where $e_i \cdot (\sum b_i - PP)/\sum e_i$ are the individual rebates, which are weakly increasing, just like the payments. Similarly, we denote the rebates and payments for all N individuals in the bid-cap rule:

$$\begin{array}{lccccccc} \text{Rebate:} & (0, & \ldots, & 0, & b_{k+1} - \bar{b}, & \ldots, & b_N - \bar{b}), \\ \text{Payment:} & (b_1, & \ldots, & b_k, & \bar{b} \quad , & \ldots, & \bar{b} \quad). \end{array} \tag{20}$$

All individuals from 1 to k would be increasingly better off under the proportional rebate rule since they receive no rebate under the bid-cap rule, while rebates under proportional rebate increase proportionally with pledges. The difference in rebates is maximized when $b_k = \bar{b}$. Since under both rules, the sum of payments is equal to PP, the individuals from $k+1$ to N would receive the same total rebates under the bid-cap rule as all individuals from 1 to N would receive under the proportional rebate rule. Moreover, these $N - k$ individuals each pay the bid-cap $\bar{b}$. Hence, the sum of payments by individuals from $k+1$ to N must be greater under the proportional rebate rule compared with the bid-cap rule.

We continue to show that we can construct a hypothetical intersection pledge $\hat{b}$ with the property that people pledging more (less) than $\hat{b}$ pay more (less) under the bid-cap rule compared with the proportional rebate rule. To this end, consider the introduction of an additional backer who pledges $\hat{b}$, which induces the same payment under both rebate rules, i.e.,

$$\hat{b} - \frac{(\hat{b} - r) \cdot (\sum b_i + \hat{b} - PP - \bar{b})}{\sum e_i + (\hat{b} - r)} = \bar{b}. \tag{21}$$

Note that the introduction of $\hat{b}$ must leave the payment and rebate of all other individuals unaffected. In order to have unaffected payments and rebates under the bid-cap rule, the additional pledge $\hat{b}$ needs to correspond to a payment of $\bar{b}$ and the provision point needs to be increased by $\bar{b}$. So that payments under proportional rebate are unaffected we must have

$$\begin{aligned} b_i - \frac{(b_i - r) \cdot (\sum b_i - PP)}{\sum e_i} &= b_i - \frac{(b_i - r) \cdot (\sum b_i + \hat{b} - PP - \bar{b})}{\sum e_i + (\hat{b} - r)} \\ \iff \frac{\sum b_i - PP}{\sum e_i} &= \frac{\hat{b} - \bar{b}}{\hat{b} - r} \end{aligned} . \tag{22}$$

The introduction of this additional pledge and the increase of the provision point will still lead to the provision of the good because by (21) it follows that $\hat{b} > \bar{b} \Rightarrow \sum b_i + \hat{b} > PP + \bar{b}$. By solving (22) for $\hat{b}$ and plugging it into (21), we can confirm that these conditions hold for the proportional rebate rule, while it is immediate for the bid-cap rule, since $\hat{b}$ is strictly greater than $\bar{b}$ due to (21). Further, we observe that any individual $i \in \{k+1, \dots, N\}$ whose pledge is greater (smaller) than $\hat{b}$ pays more (less) under the bid-cap rule compared to the proportional rebate rule, indicating that $\hat{b}$ is a (hypothetical) intersection pledge.

A.5 Additional regressions

	Part 1 (One round)			Part 2 (Ten rounds)		
	$b_i - 30$	$b_i - 30$	$b_i - 30$	$b_i - 30$	$b_i - 30$	$b_i - 30$
Constant	-2.00	3.75*	3.08	-2.16	5.77***	3.63*
	(1.950)	(2.213)	(2.131)	(1.706)	(2.106)	(1.862)
Treatment	All-or-nothing	Proportional rebate	Bid-cap	All-or-nothing	Proportional rebate	Bid-cap
Observations	40	40	40	400	400	400

Standard errors in parentheses. Estimation by OLS regression with robust standard errors for Part 1 and estimation by random-effects regression with clustering on subject level for Part 2. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

Table A.1: Analysis of pledges compared to the equilibrium prediction within experimental treatments.

	Part 1 (One round)			Part 2 (Ten rounds)		
	$b_i - v_i$	$b_i - v_i$	$b_i - v_i$	$b_i - v_i$	$b_i - v_i$	$b_i - v_i$
Constant	-17.00***	-11.25***	-11.93***	-16.18***	-8.25***	-10.83***
	(1.950)	(2.213)	(2.131)	(1.644)	(2.134)	(1.962)
Treatment	All-or-nothing	Proportional rebate	Bid-cap	All-or-nothing	Proportional rebate	Bid-cap
Observations	40	40	40	400	400	400

Standard errors in parentheses. Estimation by OLS regression with robust standard errors for Part 1 and estimation by random-effects regression with clustering on subject level for Part 2. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

Table A.2: Analysis of pledges compared to valuation within experimental treatments.

	Part 1 & Part 2 (Eleven rounds)			Part 1 & Part 2 (Eleven rounds)		
	$b_i - 30$	$b_i - 30$	$b_i - 30$	$b_i - v_i$	$b_i - v_i$	$b_i - v_i$
Constant	-2.14	5.59***	3.58**	-16.25***	-8.52***	-10.93***
	(1.628)	(2.031)	(1.811)	(1.577)	(2.056)	(1.905)
Treatment	All-or-nothing	Proportional rebate	Bid-cap	All-or-nothing	Proportional rebate	Bid-cap
Observations	440	440	440	440	440	440

Standard errors in parentheses. Estimation by OLS regression with robust standard errors for Part 1 and estimation by random-effects regression with clustering on subject level for Part 2. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

Table A.3: Analysis of pledges compared to the equilibrium prediction and the valuation within experimental treatments with Part 1 & Part 2 pooled.

	Part 1 & Part 2 (Eleven rounds)	
	$b_i \in [0, 65]$	Funded $\in \{0, 1\}$
Proportional	7.73***	0.52**
	(2.583)	(0.211)
Bid-cap	5.72**	0.50**
	(2.416)	(0.221)
Constant	27.86***	0.34*
	(1.615)	(0.186)
Level of observations	Subject	Group
Number of observations	1320	132
Postestimation Wald tests to compare rebate treatments:		
H_0: Proportional rebate = bid-cap	$p = 0.46$	$p = 0.88$

Standard errors in parentheses. Estimation by OLS regression with random-effects regression with clustering on level of observations. The baseline category is all-or-nothing in all specifications. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

Table A.4: Analysis of treatment effects on pledges and the realization of projects with Part 1 & Part 2 pooled

A.6 Additional figures

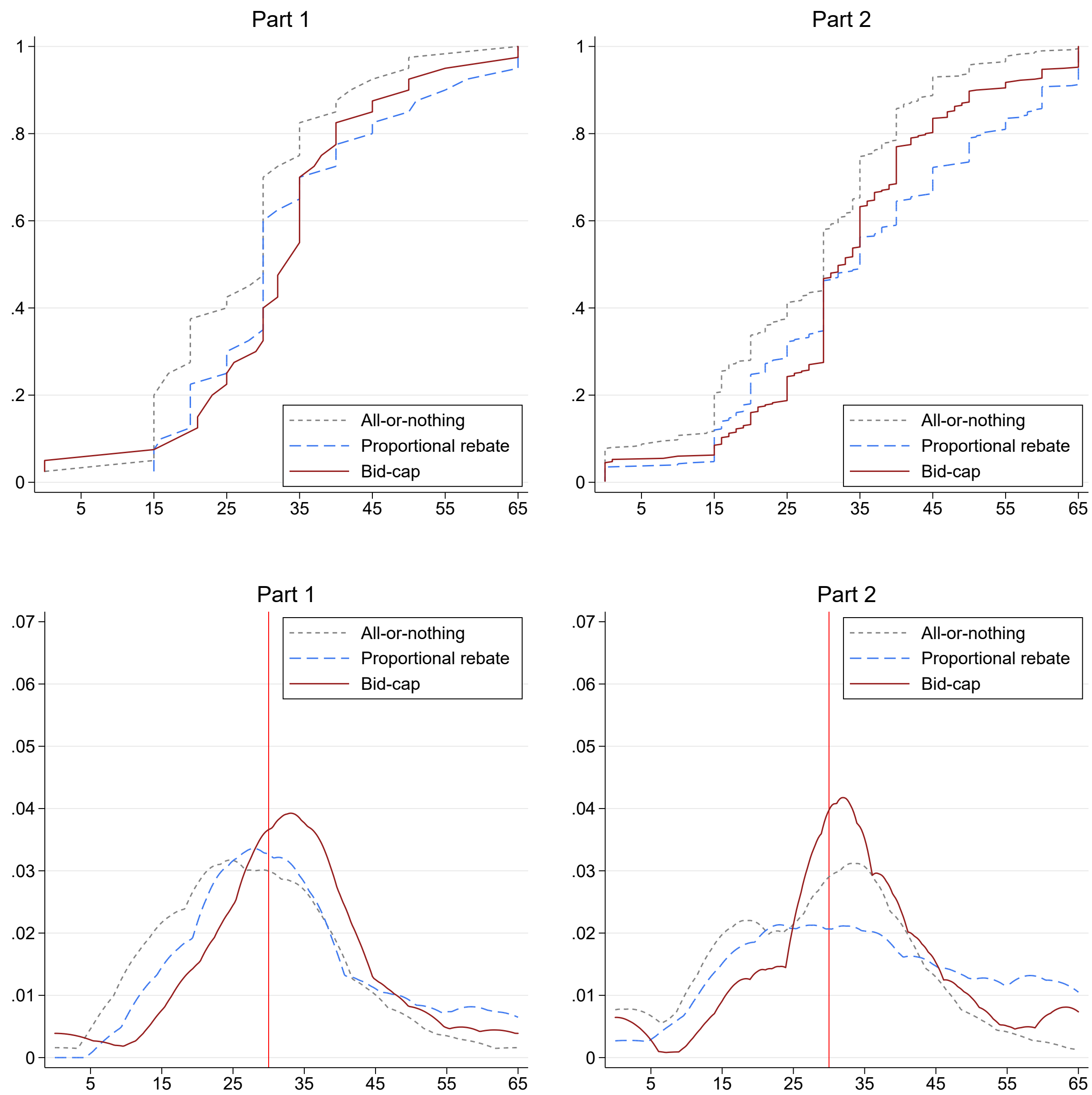

Figure A.1: Cumulative distribution of pledges (top) and kernel density estimation of pledges (bottom) by experimental treatment.

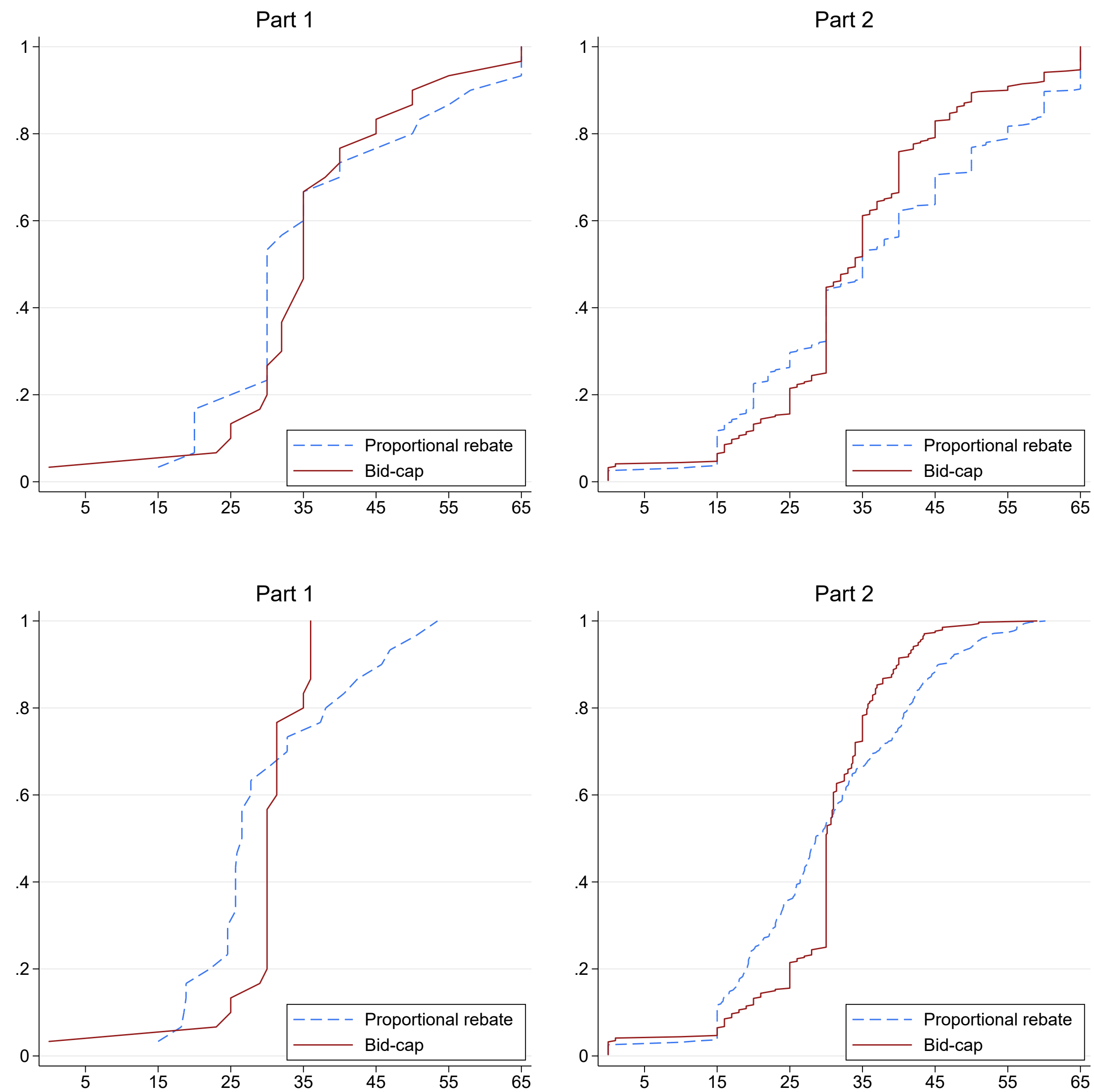

Figure A.2: Cumulative distribution of pledges (top) and payments (bottom) of funded projects by experimental treatment (only rebate rule treatments).

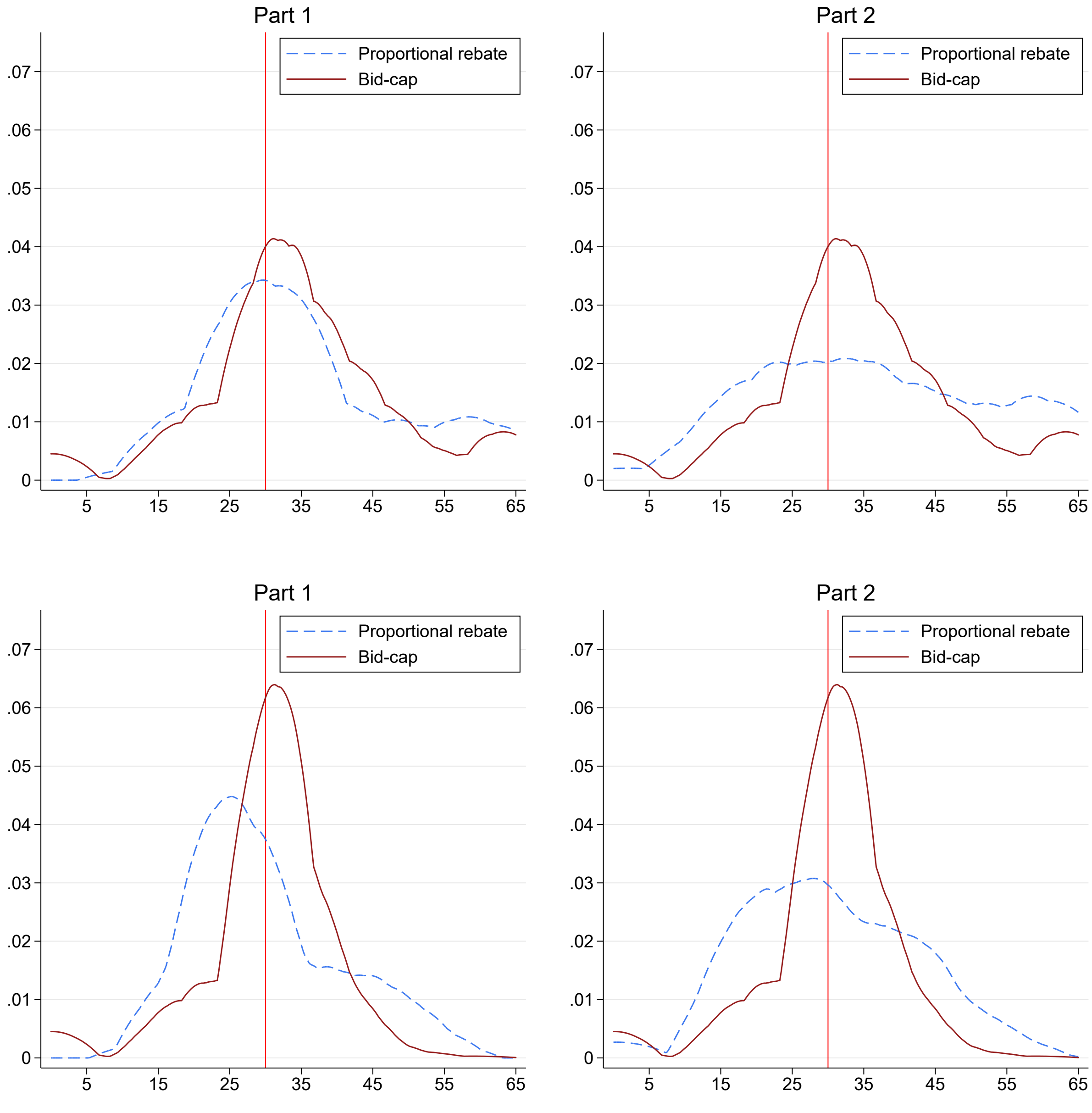

Figure A.3: Kernel density of pledges (top) and payments (bottom) of funded projects by experimental treatment (only rebate rule treatments).

A.7 Translated instructions

[Original instructions were in German. Expressions in square brackets were not visible to participants]

Instructions [All experimental treatments]

Welcome to this experiment and thank you for your participation! This experiment begins now. Please read these instructions carefully. The instructions are identical for all participants present. If you have any questions, please raise your hand and an experimenter will come by to you to answer your questions. If the question that you have asked should be relevant to everybody, then we will repeat the questions for all and provide a response.

Please do not communicate with other participants during the experiment and please turn off your mobile phones now. This is an experiment on decision-making. You can earn money in this experiment which depends on your decisions and the decisions of the other participants. The amount you earn will be paid out to you in cash after the experiment.

In beginning, you will be randomly assigned to a group consisting of you and **ten** other participants. This group remains the same and does not change throughout the experiment. You will make your decisions privately and **not** learn who the other group members are.

This experiment consists of **two** parts. You can find the instructions for the first part below. You will receive instructions for part **two** after the first part is over.

All monetary values in this experiment are denominated in <u>E</u>xperimental <u>C</u>urrency <u>U</u>nits (*ECU*). Your total earnings is the sum of the payoff you earned in part 1 and in part 2 which will be exchanged at a rate of 10 $ECU =$ 0,40 Euro at the end of the experiment. In addition, independent of your earnings, you receive 6 Euros for your participation.

Part 1 [All-or-nothing treatment]

Your task in the first Part:

In the beginning, you and your group members will be assigned one of two roles (active/passive) with there being **ten** active group members and **one** passive group member in each group.

You and your other group members each are given 65 *ECU* to start independently from your role. The **active** group members can invest any amount out of the given **endowment** into a project which will only be realized if the total **investment costs** of 300 *ECU* are reached. The **passive** group member **cannot** invest into the project. Your payoff in the first part depends on whether you are an **active** or **passive** group member and the decisions of the **active** group members.

Every **active** group member can become an **investor** of the project. To be considered an **investor** of the project, an **active** group member needs to make a minimum investment of **at least** 15 *ECU*. Investments below 15 *ECU* are just seen as a **donation** and do not entitle a participant to a payout.

If the total group investments are below the investment costs of 300 *ECU*, the investment put forward by **active** group members is returned and they do no receive a payout from the project, neither does the **passive** member. All **active** and **passive** members receive their endowment.

If your group's total investment is at least 300 *ECU* and meets the investment costs, each **active** group member's investment that is below 15 *ECU* is considered as a donation and these members do not receive a payout from the project. They just receive the remaining amount of their endowment, which they have not invested. Every **investor** receives a **payout** of 45 *ECU*, and their remaining amount of the endowment, which they have not invested. The **passive** group member also receives a **payout** of 45 *ECU* in addition to the initial endowment. If your group's total investment is above 300 *ECU*, the passive group member **additionally** receives the **excess investments**.

Example

Participant	A	B	C	D	E	F	G	H	I	J	K
Role	active										passive
Investments	0	7	14	21	28	35	42	49	56	63	-

Based on these investments D, E, F, G, H, I, and J are investors as they invested above 15 *ECU* whereas A, B and C are not. Consequently, the investments of A, B and C are merely considered donations. After subtracting the donations of A, B and C $0+7+14=21$ *ECU* from the investment costs of 300 *ECU*, only 279 *ECU* are needed in order to realize the project. The remaining investments are enough to cover 279 *ECU*, as $28+35+42+49+56+63=294$. This results in additional excess investments of $294-279=15$ *ECU* which are paid out to the passive participant K.

Summary of potential earnings for active group members

- If the investment cost are not reached, the active group member receives:

  $earnings = endowment$

- If the investment costs are exactly covered but the active group member invested less than the minimum required to become an investor, then the investment is considered a donation:

$earnings = endowment - donation$

- If the investment costs are covered and the active group member invested at least the minimum required to become an investor, the paid amount is determined by:

  $earnings = endowment + payout - investments$

Summary of potential earnings for passive group members

- If the investment cost are not reached, the passive group member receives:

  $earnings = endowment$

- If the investment costs are exactly covered the passive group member receives:

  $earnings = endowment + payout$

- If the overall investments made by the group exceed the investment costs the passive group member receives:

  $earnings = endowment + payout + excess\ investments$

If you have questions with regard to **Part 1**, please raise your hand and an experimenter will come by and answer your question.

Part 1 [Proportional rebate treatment]

Your task in the first Part:

In the beginning, you and your group members will be assigned one of two roles (active/passive) with there being **ten** active group members and **one** passive group member in each group.

You and your other group members each are given 65 *ECU* to start independently from your role. The **active** group members can invest any amount out of the given **endowment** into a project which will only be realized if the total **investment costs** of 300 *ECU* are reached. The **passive** group member **cannot** invest into the project. Your payoff in the first part depends on whether you are an **active** or **passive** group member and the decisions of the **active** group members.

Every **active** group member can become an **investor** of the project. To be considered an **investor** of the project, an **active** group member needs to make a minimum investment of **at least** 15 *ECU*. Investments below 15 *ECU* are just seen as a **donation** and do not entitle a participant to a payout.

If the total group investments are below the investment costs of 300 *ECU*, the investment put forward by **active** group members is returned and they do no receive a payout from the project, neither does the **passive** member. All **active** and **passive** members receive their endowment.

If your group's total investment is at least 300 *ECU* and meets the investment costs, each **active** group member's investment that is below 15 *ECU* is considered as a donation and these members do not receive a payout from the project. They just receive the remaining amount of their endowment, which they have not invested. Every **investor** receives a **payout** of 45 *ECU*, and the remaining amount of their endowment, which they have not invested. The **passive** group member also receives a **payout** of 45 *ECU* in addition to the initial endowment.
If your group invests more than the required investment costs of 300 *EC*, then each investor receives a share of the excess investments. The **rebate** of the excess investments is made according to the following rule:
Firstly, it is determined for each investor how much more than the minimum investment of 15 *ECU* each of them has invested. The difference between the investment and minimum investment is called **contribution**. The share out of the excess investments each investor gets, is directly proportional to each investor's share of the sum of contributions. For instance, if an investor is responsible for a quarter of the total contributions then this investor receives a quarter of the excess investments.

This means investors pay <u>at most</u> their investment and potentially less if the entirety of their investment is not needed in order to cover the investment costs. This also means that investors with higher investments potentially receive higher rebates. Investors only pay their entire investment if needed to realize the project. We refer to the part of the investment actually used to realize the project – i.e. what an investor ultimately pays for the realization of the project – as the **paid amount**.
The following example illustrates this rule in more detail.

Example

Participant	A	B	C	D	E	F	G	H	I	J	K
Role	active										passive
Investments	0	7	14	21	28	35	42	49	56	63	-

Based on these investments D, E, F, G, H, I, and J are Investors whereas A, B and C are <u>not</u>. Consequently, the investments of A, B and C are merely considered donations. After subtracting the donations of A, B and C $0 + 7 + 14 = 21$ *ECU* from the investment costs, only 279 *ECU* are needed in order to realize the project. The remaining investments are enough to cover 279 *ECU*, as $28 + 35 + 42 + 49 + 56 + 63 = 294$. So $294 - 279 = 15$ *ECU* will be contributed as excess investments, which will be returned proportionally to the **investor contributions**. Below you will find the calculation of the contributions and rebates of all investors:

The minimum investment in order to become an investor is 15 *ECU* and D invests 21 *ECU*. D's contribution is then $21 - 15 = 6$ *ECU*. E's contribution is 28-15=13 *ECU*, F's contribution is 35-15=20 *ECU*, G's contribution is 42-15=27 *ECU*, H's contribution is 49-15=34 *ECU*,I's is 56-15=41 *ECU* und J's is 63-15=48 *ECU*. The sum of all contributions is then 6+13+20+27+34+41+48=189 *ECU*.

D's contribution is 6 ECU and the sum of all contributions is 189 ECU. So D's share of the contributions is $6/189$. This portion of the contributions is multiplied by the excess investment of 15 ECU to determine the rebate.

Consequently, D receives a rebate of $6/189 \cdot 15 = 0.48$ *ECU*. Equivalently, E receives a rebate of $13/189 \cdot 15 = 1.13$ *ECU*, F a rebate of $20/189 \cdot 15 = 1.59$ *ECU*, G a rebate of $27/189 \cdot 15 = 3.14$ *ECU*, H a rebate of $34/189 \cdot 15 = 2.7$ *ECU*, I a rebate of $41/189 \cdot 15 = 3.25$ *ECU* and J a rebate of $48/189 \cdot 15 = 3.81$ *ECU*.

In the table below you can see the investments and the paid amounts made by all investors.

Participant	A	B	C	D	E	F	G	H	I	J	K
Role	active										passive
Investment	0	7	14	21	28	35	42	49	56	63	-
Paid Amount	**0**	**7**	**14**	**20.52**	**26.97**	**33.41**	**39.86**	**46.30**	**52.75**	**59.19**	**-**

Summary of potential earnings for active group members

- If the investment cost are not reached, the active group member receives:

  $earnings = endowment$

- If the investment costs are exactly covered but the active group member invested less than the minimum required to become an investor, then the investment is considered a donation:

  $earnings = endowment - donation$

- If the investment costs are covered and the active group member invested at least the minimum required to become an investor, the paid amount is determined by:

  $earnings = endowment + payout - paid\ amount$

Summary of potential earnings for passive group members

- If the investment cost are not reached, the passive group member receives:

  $earnings = endowment$

- If the investment costs are exactly covered the passive group member receives:

$earnings = endowment + payout$

- If the overall investments made by the group exceed the investment costs the passive group member receives:

  $earnings = endowment + payout$

If you have questions with regard to **Part 1**, please raise your hand and an experimenter will come by and answer your question.

Part 1 [Bid-cap treatment]

Your task in the first Part:

In the beginning, you and your group members will be assigned one of two roles (active/passive) with there being **ten** active group members and **one** passive group member in each group.

You and your other group members each are given 65 *ECU* to start independently from your role. The **active** group members can invest any amount out of the given **endowment** into a project which will only be realized if the total **investment costs** of 300 *ECU* are reached. The **passive** group member **cannot** invest into the project. Your payoff in the first part depends on whether you are an **active** or **passive** group member and the decisions of the **active** group members.

Every **active** group member can become an **investor** of the project. To be considered an **investor** of the project, an **active** group member needs to make a minimum investment of **at least** 15 *ECU*. Investments below 15 *ECU* are just seen as a **donation** and do not entitle a participant to a payout.

If the total group investments are below the investment costs of 300 *ECU*, the investment put forward by **active** group members is returned and they do no receive a payout from the project, neither does the **passive** member. All **active** and **passive** members receive their endowment. If your group's total investment is at least 300 *ECU*, each **active** group member's investment that is below 15 *ECU* is considered as a donation and these members do not receive a payout from the project. They just receive the remaining amount of their endowment, which they have not invested. Every **investor** receives a **payout** of 45 *ECU*, and the remaining amount of their endowment, which they have not invested. The **passive** group member also receives a **payout** of 45 *ECU* in addition to the initial endowment.

If your group invests more than the required investment costs, then each investor receives a share of the excess investments. The **rebate** of the excess investments is made according to the following rule:

Firstly, the donations of **active** group members that invested less than 15 *ECU* are subtracted from the investment costs. Then it is checked whether the investment costs minus the donations would be reached if each investor contributes the lowest investment that has been made. If this is the case, then each investor pays the lowest investment and the excess investments are distributed equally between all investors.

If this is not the case, then the investor(s) who made the lowest investment, pay the lowest investment and it is checked again whether the investment cost minus the donations is reached if all other investors pay the second-highest investment. If this is the case, then the investor(s) with the lowest investment contribute the lowest investment and all other investors contribute the second-lowest investment. The excess investments are distributed equally between investors that paid the second-lowest investment.
This process continues until the lowest possible investment is found for which the investment costs minus the donations are reached.

The investors pay at most their investment and potentially less if the entirety of their investment is not needed in order to cover the investment costs. This also means that investors with higher investments potentially receive higher rebates. Overall, the investors only pay their entire investment only if needed. We refer to the part of the investment actually used to realize the project – i.e. what an investor ultimately pays for the realization of the project – as the **paid amount**. The following example illustrates this rule in more detail. The following example illustrates this rule in more detail:

Example

Investor	A	B	C	D	E	F	G	H	I	J
Investment	0	7	14	21	28	35	42	49	56	63

Based on these investments D, E, F, G, H, I, J are Investors whereas A, B and C are not. Consequently, the investments of A, B and C are merely considered as donations. After subtracting the donations of A, B and C $0+7+14 = 21$ *ECU* from the investment costs, only 279 *ECU* are needed in order to realized the project.

Now it is checked whether 279 *ECU* can be covered if all investors make the lowest investment of 21 *ECU*. As $21 \cdot 7 = 147 < 279$, this does not cover the costs. D pays 21 *ECU* and it is checked whether 279 *ECU* can be covered if all other investors E ,F ,G ,H, I, J each make the second-lowest investment of 28 *ECU*. As $6 \cdot 28+21 = 189 < 279$ the costs are not covered. In the next iteration, D pays 21 *ECU* und E pays 28 *ECU* and it is checked whether 279 *ECU* can be covered if all other investors each make the third-lowest investment of 35 *ECU* which results in $21+28+5 \cdot 35 = 224 < 279$.

This process continues until Investor **I** is reached. In this case, all investors pay their invested amounts and I and J pay 56 ECU each. This results in total investments of $21 + 28 + 35 + 42 + 49 + 2 \cdot 56 = 287$ ECU which covers the investment cost minus the donations. Therefore, J receives a rebate of $63 - 56 = 7$ ECU, as J's investment is reduced to I's investment.

In addition, these investments lead to excess investments of $287 - 279 = 8$ ECU. These 8 ECU are now distributed equally among investors I and J, so that I and J each receive a rebate of 4 ECU.

In the end, all investors pay their investments except for I and J, who pay less than their investments as their entire investment is not needed to cover the investment costs. I's paid amount is $56 - 4 = 52$ ECU, since I receives a rebate out of the excess investments. J's paid amount is $63 - 7 - 4 = 52$ ECU, since J's investment is reduced to I's investment and J receives a rebate out of the excess investments.

The following table summarizes the investments and the paid amounts for all investors.

Participant	A	B	C	D	E	F	G	H	I	J	K
Role	active										passive
Investment	0	7	14	21	28	35	42	49	56	63	-
Paid Amount	**0**	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**52**	**52**	-

Summary of potential earnings for active group members

- If the investment cost are not reached, the active group member receives:

  $earnings = endowment$

- If the investment costs are exactly covered but the active group member invested less than the minimum required to become an investor, then the investment is considered a donation:

  $earnings = endowment - donation$

- If the investment costs are covered and the active group member invested at least the minimum required to become an investor, the paid amount is determined by:

  $earnings = endowment + payout - paid\ amount$

Summary of potential earnings for passive group members

- If the investment cost are not reached, the passive group member receives:

  $earnings = endowment$

- If the investment costs are exactly covered the passive group member receives:

$earnings = endowment + payout$

- If the overall investments made by the group exceed the investment costs the passive group member receives:

  $earnings = endowment + payout$

If you have questions with regard to **Part 1**, please raise your hand and an experimenter will come by and answer your question.

Part 2 [All experimental treatments]

The second part of the experiment begins now. In this part, you will be repeating the task from **Part 1** **ten** times. Your role is identical to the first part. In each round, you will receive a **starting capital** of 65 *ECU*. The **payout** each **active** group member can get (in *ECU*) will be determined independently for each **active** group member at the beginning of every round through a random draw from the interval [30, 60]. Each number in the interval is equally likely to be drawn and each **active** group member will receive their individual number independently of other **active** player numbers. The potential payout for the **passive** group member in every round is 45 *ECU* as in the first part. You will neither get feedback about the investments that other **active** group members made in previous rounds nor whether the investment costs were reached.

In this part overall, group members and roles, the investment costs, starting capital, the minimum investment in order to become an investor and the rule concerning excess investments are the same. At the beginning of each round, **active** group members will learn their randomly drawn payout as an investor and decide how much to invest into the project.

The potential earnings in each round are determined the exact same way as in the first part of the experiment. **Active** group members receive their investment back in case the project is not successfully realized. **Passive** group members also receive their investment back in case the project is not successfully realized. The earnings equal the start capital minus the investment if the project is realized but the **active** group member invested less than 15 *ECU*. If the investment costs are covered and an **active** group member invested at least 15 *ECU*, then they receive their randomly drawn payout in addition to the starting capital, minus the paid amount, which is determined following the same rule as in part 1.

[Proportional rebate treatment/Bid-cap treatment]

If the project is realized in a round, a **passive** group member receives the endowment and their payout from the project.

[**All-or-nothing treatment**]

If the project is realized in a round, a **passive** group member receives the endowment, their payout from the project and any excess investment.

[**All experimental treatments**]

The overall payoff from **Part 2** equals the payoff you have received in a randomly drawn round. Hereby, each round is equally likely to be drawn. Your earnings in this part will be exchanged at a rate of 10 ECU = 0,40 Euro.

Since you do not know which round is relevant for your payment of the second part, it is optimal for you to decide as if each round determines your payment.

In case you have any questions with regard to **Part 2** please raise your hand and an experimenter will come by to you to answer your questions. If the question that you have asked should be relevant to everybody, then we will repeat the questions for all and provide a response.