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Abstract

For reward-based crowdfunding, we introduce the strategy-proof Generalized Moulin-Shenker mechanism (GMS) and compare its performance to the prevailing All-Or-Nothing mechanism (AON). Theoretically, GMS outperforms AON in equilibrium profit and funding success. We test these predictions experimentally, distinguishing between a sealed-bid and a dynamic version of GMS. We find that the dynamic GMS outperforms the sealed-bid GMS. It performs better than AON when the producer aims at maximizing funding success. For crowdfunding in practice, this suggests that the current standard of financing projects may be improved upon by implementing a crowdfunding mechanism that is similar to the dynamic GMS.

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1 Introduction

Crowdfunding has firmly established itself as a major source of finance. Over the past decade-and-a-half it has become widely accepted to raise capital by collecting contributions from individual investors, customers, friends, and family. The Cambridge Center for Alternative Finance (2021) estimates the global market for crowdfunding to exceed $100 billion per year.[1] This figure surpasses the GDP of approximately two-thirds of the countries worldwide. Crowdfunded capital is used for a large variety of purposes, ranging from donations for an individual medical treatment or charities to 'pre-sales' to fund the recording of music albums or the development of a new product like a smartwatch. The latter examples involve crowdfunding used to raise finances for startups or existing businesses that have traditionally relied on other sources like venture capitalists or banks. The widespread use of the internet and social media has made it possible to tap into a large pool of potential funders. Various large-scale crowdfunding platforms like Kickstarter, Indiegogo, and GoFundMe have appeared, where demand and supply for funding are matched using a mechanism chosen by the platform.

When contributing to a business, funders may be rewarded with equity shares (the funder obtains a stake in the business) or a reward. Our focus is on the latter.[2] Reward-based crowdfunding denotes the practice to raise monetary contributions for a project from a large number of people who, in exchange, obtain a non-financial reward.[3] Examples include a pre-release streaming of an album, a personalized version of a product, or even a public "thank you" by a celebrity. Reward-based fundraising offers producers a low-cost opportunity to advertise and finance their projects (Belleflamme et al., 2010; Gerber and Hui, 2013), and enables them to gain information about market demand prior to production (Da Cruz, 2018; Ellman and Hurkens, 2019b; Chang, 2020; Chemla and Tinn, 2020).

[1] More than 80% involves credit- (a.k.a. loan-) based crowdfunding, which has been around for centuries (Everett, 2019).

[2] Lee and Parlour (2022) compare reward-based crowdfunding to equity-based crowdfunding in an equilibrium analysis.

[3] Statista (2023) estimates the global reward-based crowdfunding market in 2023 at $1.1 billion and expects an annual growth rate of about 2.5%.

In spite of its growing importance, reward-based crowdfunding has so far received little attention in the economics and finance literatures (notable exceptions are discussed below).[4] As a consequence, little is known about the characteristics of the mechanisms used by crowdfunding platforms, such as the popular All-or-Nothing mechanism (AON). In this study we address this gap in the literature. We investigate the performance of AON and ask whether other mechanisms exist that score better. For this purpose, we introduce an alternative crowdfunding mechanism, the Generalized Moulin-Shenker mechanism (GMS).

AON and GMS differ in how consumers' bids are mapped into outcomes. In AON, all consumers bid a price to fund the good. If the sum of all bids exceeds the fundraising threshold, the good is produced, all consumers pay their stated price, and all consumers whose bids are greater than the reservation price gain access to the good. In GMS, all consumers state the maximal price they are willing to pay. The good is produced at the lowest price greater than the reservation price, for which the price times the number of consumers whose bid is greater than this price exceeds the fundraising threshold. If such a price exists, all consumers with a bid greater than this price pay the price and gain access to the good. Under both mechanisms, consumers pay nothing if the good is not produced.

GMS generalizes Moulin and Shenker's (1992) serial cost sharing mechanism, while retaining its desirable properties (in particular, strategy proofness, individual rationality, anonymity, and budget balancedness). Because of these favorable properties, we choose this alternative for the comparison to AON. While AON is the prevailing reward-based crowdfunding mechanism in practice, GMS provides a simple and theoretically promis-

[4]In contrast, the management literature has paid ample attention to crowdfunding (see Moritz and Block (2016), Shneor and Vik (2020), Alegre and Moleskis (2021) and Deng et al. (2022) for reviews of this literature). A large part of this literature has focused on the relationship between funding success and specific characteristics of the producer and product. A producer's track record, the size of her social network and her local proximity to potential consumers are positively related to the likelihood of funding success (see e.g. Agrawal et al., 2015; Zvilichovsky et al., 2015; Lin and Viswanathan, 2016; Buttice et al., 2017; Giudici et al., 2018; Cai et al., 2021). Further, projects that have a non-profit focus, feature a product video and have low fundraising thresholds and time-limited rewards are more likely to get funded (Belleflamme et al., 2013; Mollick, 2014; Pitschner and Pitschner-Finn, 2014; Lin et al., 2016; Kunz et al., 2017).

ing alternative. We distinguish between a sealed-bid and a dynamic version of GMS. The latter generalizes Deb and Razzolini's (1999) 'English Auction-Like Mechanism' for allocating an indivisible and excludable public good. The dynamic GMS is obviously strategy-proof in the sense of Li (2017), while the sealed-bid GMS is not. Together, this makes the dynamic GMS a promising alternative to the AON.

In our theoretical analysis, we compare these crowdfunding mechanisms using a model in which a producer can develop a non-rivalrous but excludable good at fixed costs. A producer may do so either for direct profit, or – perhaps more importantly – aim to develop the good per se. Reasons for developing the good may include a wish to establish a reputation in the market; a need to finance the infrastructure needed to sell the good on future spot markets; or an intrinsic utility for the producer, derived from bringing the crowdfunded good into existence. To accommodate these distinct motives that producers may have when crowdfunding, we consider two separate producer objectives: maximization of profit and maximization of the fundraising success probability. As is standard in crowdfunding practice, the producer decides on a threshold for the amount to be raised and a reservation price. Given this choice, consumers decide on how much to offer for the good. Consumer values for the good are drawn independently from a continuous distribution function.[5] For this environment, we show that for a sufficiently large crowd of consumers, both versions of GMS outperform AON in expected producer profits and success probability. Moreover, aggregate surplus is larger under GMS when the producer's goal is to maximize the likelihood of success.[6]

We test our theoretical predictions in a laboratory experiment. While GMS is predicted to outperform AON when consumers follow the intuitive and weakly dominant

[5]Our analysis focuses on crowdfunding with private values. This is arguably an obvious starting point for reward-based crowdfunding, where idiosyncratic bidder preferences for the reward seem to outweigh a possible common market value. In future research, it would, however, be interesting to consider a setting with interdependent values. This would also allow one to capture, e.g., distinct (but correlated) consumer perceptions about expected product quality.

[6]Though we do consider the efficiency of the mechanisms, this is usually not seen as a main goal of crowdfunding activities. We will see in the following section that for the environment we are interested in, no efficient, incentive-compatible and individually rational mechanism exists where the producer's expected revenue in equilibrium is non-negative.

strategy to bid their own value, GMS is plagued by a multitude of equilibria. AON may outperform GMS if consumers play according to some of these equilibria. Our experiment allows us to identify which equilibrium is empirically most plausible. Further, our choice to use the laboratory as the environment for our empirical analysis is motivated by its superior level of control. Testing the theoretical properties of the mechanisms we are interested in requires that we create an environment where the basic assumptions of the theory are met (Schram, 2005; List, 2020). Laboratory control allows us to meet this requirement.[7] If the theoretical dominance of GMS over AON is not supported in the controlled setting of the laboratory, there is little reason to expect that GMS will do better in the field. If the laboratory does support the theoretical predictions, then this is a good reason to move forward with trials in the field.[8]

In our experiment, we systematically vary the mechanism, producer objective, and cost level. This allows us to draw conclusions for a wide range of possible crowdfunding scenarios. To capture the 'crowd' in crowdfunding, we use comparatively large consumer groups of 15 subjects each. Simulation results show that even a crowd of 'only' 15 consumers is sufficient for GMS to outperform AON in terms of expected producer profits and success probability. Our laboratory results show that the dynamic GMS performs consistently better than the sealed-bid GMS and outperforms AON when the producer's objective is to maximize funding frequency. While subjects play close to the theoretical predictions in both the dynamic GMS and AON, there is severe underbidding in the sealed-bid GMS. In the concluding section, we discuss the implications of our results for crowdfunding in practice.

The remainder of the paper is organized as follows. The next section discusses the literature on which we build and the contributions we aim to make. Section 3 theoretically

[7]For this reason, laboratory experiments have become an established research tool in the finance literature (e.g. Gneezy, Kapteyn, and Potters, 2003; Haruvy and Noussair, 2006; Bossaerts, Plott, and Zame, 2007; Bossaerts et al., 2010; Sutter, Huber, and Kirchler, 2012; Haruvy et al., 2014; and Weber et al., 2018).

[8]Note the similarity to the role of laboratory experiments in the FCC spectrum auctions. Paul Milgrom and Robert Wilson, based on their seminal theoretical contributions, advised the FCC to use the simultaneous multiple round auction. The FCC commissioned experiments to further test this auction format before applying it for the first time in the field in 1994 (McMillan, 1994).

analyzes the mechanisms, while Section 4 describes the experimental design and states the hypotheses. Section 5 presents the results and Section 6 concludes.

2 State of the Art

Our study is related to several strands of the literature. To start, reward-based crowdfunding resembles a public good in the sense that all consumers could potentially benefit from the project being completed. Think, for example, of crowdfunding aimed at producing a smartwatch. Pebble Time used the platform Kickstarter to raise funds to set up production facilities for its watch, and raised over $20 million (Brown et al., 2017). Once the production capacity was set, other consumers could benefit from it by buying the watches it produced. The problem they faced is that Pebble Time would not have raised enough money beforehand if all consumers had waited for the production to be set up. Indeed, for public goods both theory and experiments show that free riding causes severe underprovision, resulting in an inefficient outcome (see Batina and Ihori, 2005 for a review).

In recent decades, several ingenious mechanisms have been developed that mitigate free riding and achieve (almost) efficient provision of the public good in settings with private information, such as ours (e.g. Arrow, 1979; d'Aspremont and Gérard-Varet, 1979; d'Aspremont and Gerard-Varet, 1979; Walker, 1981; Falkinger, 1996). The most famous of these mechanisms is perhaps the Vickrey-Clarke-Groves mechanism (VCG) (Vickrey, 1961; Clarke, 1971; Groves, 1973; Groves and Loeb, 1975). VCG achieves an efficient outcome by charging or compensating the agents for the externalities that they exert on or are caused by others. VCG, however, is unsuitable for application to crowdfunding because it is generally not weakly budget balanced in that setting, i.e., in expectation, the consumers' equilibrium contributions fall short of the project costs.

This negative result for VCG has important consequences for crowdfunding mechanisms. In particular, there exists no efficient, incentive-compatible and individually rational mechanism that balances the budget in an environment where VCG results in an expected deficit (Krishna and Perry, 1998). Therefore, no efficient crowdfunding mechanism exists where the producer obtains a non-negative expected revenue in equilibrium. Instead of searching for an efficient mechanism, we therefore resort to finding mechanisms with favorable other properties and comparing them in a setting where consumers can be excluded from consuming the good when produced. Our study contributes by introducing GMS, a strategy-proof, individually rational, anonymous, and (weakly) budget-balanced mechanism, that can be easily implemented in practice and by comparing it to AON, the dominant mechanism used in practice.

A different strand of the non-excludable public-goods literature focuses on revenue rather than efficiency. For some organizations (like charities), revenue is an important objective. Such organizations are therefore interested in the extent to which a fundraising mechanism elicits contributions. A public good provider can, for example, increase contributions by bundling the public good with a private good (e.g. Morgan, 2000; Goeree et al., 2005; Lange et al., 2007). By selling the private good in a lottery or auction, the free-rider problem inherent in public-good provision is alleviated by the negative externalities consumers exert on each other when buying lottery tickets or bidding in an auction (Morgan, 2000). Laboratory experiments predominantly confirm the theoretical predictions (e.g. Morgan and Sefton, 2000; Lange et al., 2007; Schram and Onderstal, 2009), while the results of field experiments are mixed (Landry et al., 2006; Onderstal et al., 2013). By the very nature of crowdfunding, revenue also plays an important role in our study. We add to this literature in that we theoretically and experimentally analyze fundraising mechanisms in a setting with an excludable good.

There is also a small but growing literature studying the theoretical properties of reward-based crowdfunding (see Miglo (2022) for a review). Compared to traditional financing, crowdfunding introduces efficiency gains because it enables producers to adapt production to demand and execute projects that would otherwise not have been executed (Ellman and Hurkens, 2019b; Kumar et al., 2020). Crowdfunding also caters to donors who just want the campaign to succeed (Deb et al., 2023). Moreover, crowdfunding allows firms to explore their market at an early stage to inform possible future investments.

This real option value of learning helps to overcome moral-hazard issues (Chemla and Tinn, 2020), though payments need to be deferred to prevent entrepreneurs from running away with consumers' contributions (Strausz, 2017; Belavina et al., 2020). In crowdfunding settings characterized by a common-value element, donors should anticipate information cascades (Cong and Xiao, 2023) as well as the loser's blessing and the winner's curse (Brown and Davis, 2020).

In practice, crowdfunding mechanisms tolerate some fraud to increase profits and welfare (Ellman and Hurkens, 2019a).[9] In the field, crowdfunding indeed acts as a mechanism to reveal demand. Producers that were unsuccessful with their crowdfunding campaign tend to nevertheless release the product if contributions suggest sufficient market demand (Da Cruz, 2018). GMS is particularly informative in this respect due to its strategy proofness, which ensures that consumers have an incentive to reveal their true demand even when there is a secondary market for the good. To focus on a between-mechanism performance comparison, however, our study abstracts from moral-hazard and screening issues. We will show that GMS has favorable properties in comparison to AON even without these issues.

Aside from studies on general crowdfunding characteristics, there is also a small literature that introduces or tests the performance of alternative crowdfunding mechanisms. In line with the theoretical prediction in Chang (2020), Cumming et al. (2020) observe empirically that AON outperforms the Keep-it-All mechanism in which the producer may keep the money raised regardless of reaching the threshold. In a setting similar to ours, the profit-maximizing crowdfunding mechanism (Cornelli, 1996) is impractical as it conditions funding success on individual bids in a complicated manner. Nevertheless, practical mechanisms could exist that outperform AON. Though AON constitutes the optimal crowdfunding mechanism when consumers' values are binary, it falls short for three or more possible values (Ellman and Hurkens, 2019b). Existing mechanisms like AON can also be modified. For example, producers can increase the success rate

[9] The term 'fraud' refers to an entrepreneur pocketing the money raised in crowdfunding without delivering the project or rewards.

of their crowdfunding campaigns by rebating excess contributions proportionally or via bid-caps (Li et al., 2016; Gerstmeier et al., 2023) and offering refund bonuses (Cason and Zubrickas, 2019; Cason et al., 2021) and profit by introducing type-specific tokens (Ellman and Hurkens, 2019b). We depart from such modifications to AON and add to the literature by introducing a promising and easily implementable new crowdfunding mechanism, GMS, and test its performance relative to AON.

GMS is a generalization of the serial cost sharing mechanism by Moulin and Shenker (1992).[10] Amongst budget-balanced and strategy-proof mechanisms, the worst possible welfare loss is minimized by this serial cost sharing mechanism (Moulin and Shenker, 2001). It also maximizes welfare among a restricted set of strategy-proof mechanisms (Deb and Razzolini, 1999). These results are particularly relevant for our study; we will show that for a producer aiming to maximize funding success probability, the optimal funding threshold and reservation price imply that GMS coincides with the serial cost sharing mechanism.

There are a few papers that have tested the serial cost sharing mechanism in laboratory experiments. In groups of three consumers, subjects predominantly bid their value in this mechanism (Gailmard and Palfrey, 2005). In groups of four, subjects deviate from playing the dominant strategy at the beginning of the experiment but converge to it over time (Chen et al., 2007; Razzolini et al., 2007). Such convergence diminishes as the number of players grows (Friedman et al., 2004). Our experiment uses comparatively large groups of consumers. In line with these previous studies, we observe that a substantial number of subjects does not converge to playing the dominant strategy in the sealed-bid GMS. Moreover, to the best of our knowledge, we are the first to study a *dynamic* serial cost sharing mechanism in the laboratory. In contrast to the sealed-bid GMS, we find that behavior in the dynamic GMS rapidly converges to bidding one's value. Finally, while our experiment provides an additional test of the serial cost sharing mechanism for larger groups, we are also the first to test a cost-sharing mechanism when the producer aims to

[10] Moulin and Shenker's (1992) serial cost sharing mechanism was developed for indivisible and excludable public goods. GMS is a generalization in the sense that it endogenizes the threshold amount and minimum price.

maximize her profits.

3 Theory

3.1 Model

A risk-neutral producer can develop a non-rivalrous and excludable good at fixed costs $C > 0$. Once the good has been developed, the producer produces the good at constant marginal costs that are normalized to zero. $N \geq 2$ risk-neutral consumers, labelled $i = 1, \ldots, N$, are interested in obtaining a unit of the good. Let v_i denote consumer i's value for the good. We assume that the values are drawn independently from the interval $[0, \overline{v}]$ with distribution function F that is differentiable and strictly increasing over $[0, \overline{v}]$. We assume that $0 < \overline{v} < C$ and $N\overline{v} > C$. This ensures that production requires at least two consumers buying the good and that efficient production is sometimes feasible.

Consumers have quasi-linear utilities. Consumer i's utility is given by

$$u_i = \begin{cases} -p_{i,} & \text{if she does not obtain a unit} \\ v_i - p_i, & \text{if she obtains a unit} \end{cases}$$

where p_i is the amount paid by consumer i.

The good is allocated either via AON or GMS. Both are characterized by a threshold T and a reservation price r set by the producer and observed by consumers. The AON and sealed-bid GMS are simultaneous-move games in which each consumer i reports a bid. In the dynamic GMS, consumers implicitly report bids, as explained below. All three crowdfunding mechanisms then map bids, threshold and reservation price into an outcome specifying whether the good is produced, and if so, which consumers obtain the good and how much each consumer pays to the producer.

More formally the mechanisms are described as follows.

All-or-Nothing (AON). Each consumer i simultaneously and independently reports a bid $b_i \geq 0$. The good is produced if and only if $\sum_{i=1}^{N} b_i \geq T$. If the good is produced, consumer i pays her own bid b_i to the producer. She obtains a unit if and only if $b_i \geq r$. If the good is not produced, all consumers pay zero.

Sealed-bid Generalized Moulin-Shenker (sGMS). Each consumer i simultaneously and independently reports a bid $b_i \geq 0$. sGMS then proceeds according to the following algorithm:

1. Arrange in ascending order all bids b_i that satisfy $b_i \geq r$.

2. If there are no bids on the list, the good is not produced, all consumers pay zero, and the algorithm ends. Otherwise, calculate the producer's revenue R assuming that all consumers whose bids are on the list pay the lowest bid on the list.

3. If $R \geq T$, proceed to step 4. Otherwise, remove the lowest bid from the list and go back to step 2.

4. The good is produced. All M consumers whose bids are on the current list obtain a unit of the good and pay $\max\left\{r, \frac{T}{M}\right\}$. The remaining consumers do not obtain a unit of the good and pay zero.

Dynamic Generalized Moulin-Shenker (dGMS): In dGMS, the price is raised successively, starting at the reservation price r. At any price, consumers can drop out. This decision is irrevocable. Let $M(p)$ be the number of consumers remaining at price p. The resulting revenue at price p is $M(p)\,p$. The ascending clock stops when it reaches price p, for which either (1) all consumers have dropped out, in which case the good is not produced and all consumers pay zero or (2) $M(p)\,p \geq T$, in which case the good is produced and all remaining consumers obtain a unit and pay p. Note that this procedure is sequential, but is strategically equivalent to an environment where consumers bid by specifying a priori at which price they wish to drop out. In what follows, we refer to such a drop-out price as a 'bid' in dGMS.

3.2 Equilibrium Properties

This is a game of incomplete information involving producers and consumers interacting in two stages. In the first stage, producers choose a threshold T and a reservation price r. In the second stage, each consumer is informed about T and r as well as her value v_i, and then chooses her bid b_i. The mechanism in place subsequently determines whether the good is produced, which consumers receive it, and how much they pay. To find perfect Bayesian equilibria (PBE) of the game, we start by considering the subgames that can occur between consumers after T and r have been set. For these subgames, we derive Bayesian Nash equilibria (BNE). First, however, we make one assumption regarding the choice of T. This is that no producer will choose a threshold that allows for the possibility of making a loss. That is, we assume that $T \geq C$. We will see below that this condition is fulfilled in the equilibria we are interested in.

3.2.1 Bayesian-Nash Equilibria for Consumers

To derive BNE, we start by noting that any consumer strategy in any mechanism is a function mapping values to bids. We label an equilibrium '*truthful*' if all consumers having a value weakly greater than r submit a bid equal to value, that is $b_i = v_i \; \forall \; i : v_i \geq r$. We refer to an equilibrium as '*semi-pooling*' if all consumers having a value weakly greater than r submit a bid equal to r and the remaining consumers bid zero, i.e., $b_i = r \; \forall \; i : v_i \geq r$ and $b_i = 0 \; \forall \; i : v_i < r$.

We start the BNE analysis with AON. In Appendix B, we implicitly derive a general form for a symmetric BNE in AON. That analysis suggests pooling at r for values greater than, but close to, r. The following theorem establishes that for sufficiently large N, AON has a unique semi-pooling equilibrium.

Theorem 1 *Suppose $\bar{v} > r > 0$. Then, for sufficiently large N, AON has a BNE in* *undominated strategies, which is given by:*

$$B(v) = \begin{cases} 0 \text{ if } v < r \\ r \text{ if } v \geq r \end{cases}.$$

Proof See Appendix A

The semi-pooling equilibrium in Theorem 1 has an intuitive appeal. Recall that if the threshold is reached, all consumers pay their bid in AON, irrespective of whether they receive the good (which they only do if they bid at least r). For consumers whose value lies below the reservation price, it is then best to bid zero. For consumers with a value above r, the intuition is that if N is large enough, it is unlikely for a consumer's bid to be pivotal for reaching the threshold. This induces her to bid the reservation price, i.e. the lowest possible amount that guarantees her a unit of the good if it is produced. It turns out that in many instances the number of consumers (N) needed to obtain a semi-pooling equilibrium is not very high. For example, Section 4.2 shows that for some of our experimental parameters, semi-pooling is already an equilibrium for $N = 15$.

We now turn to GMS. dGMS is strategically equivalent to sGMS. In fact, dGMS is an ascending-price implementation of GMS in the same way as the Japanese auction is an ascending-price implementation of the second-price sealed-bid auction (Milgrom and Weber, 1982). Because the equilibrium properties of dGMS carry over to sGMS, we frame all theoretical results in terms of the more general representation of GMS only, unless indicated otherwise. In GMS, the amount a consumer pays when obtaining the good only depends on the bids of the other consumers, not on her own bid. Moreover, a consumer pays at most her own bid. Theorem 2 presents the main equilibrium result for GMS.

Theorem 2 *In GMS, $\beta(v_i) = v_i$, $i = 1, \ldots, N$, constitutes a BNE in weakly dominant strategies.*

Proof See Appendix A

Theorem 2 establishes that GMS has a truthful equilibrium in weakly dominant strategies. Moreover, following Moulin and Shenker (2001), it can be shown that consumer behavior in GMS is 'group strategy-proof', i.e. no group of consumers has an incentive to lie about their values. Given that bidding one's value is also an intuitive strategy, we expect the truthful equilibrium to be a natural focal point for consumers. However, the truthful equilibrium is not unique; in Appendix B, we show that GMS has a multiplicity of equilibria. Some equilibria involve bidders bidding 'in the neighborhood' of their value. Such equilibria are outcome equivalent to the truthful equilibrium. This is a useful property of the GMS in that small mistakes in consumers' bidding strategies have no effect on the outcome. Other equilibria involve underbidding relative to the truthful equilibrium, including a semi-pooling equilibrium, resulting in lower producer profit and success probability than in the truthful equilibrium. Our laboratory data will allow us to investigate which equilibrium is empirically most plausible.

Although sGMS and dGMS yield the same BNE for any subgame following a producer's choice of T and r, we can still theoretically distinguish between the two mechanisms. For the extensive-form representation of a mechanism, Li (2017) introduces the notion of 'obvious strategy-proofness'. This is defined as follows. Strategy s is *obviously dominant* if, for any other strategy s', at the earliest information set where s and s' differ, the worst possible outcome from s is at least as good as the best possible outcome from s'. A mechanism that has an equilibrium in obviously dominant strategies is *obviously strategy-proof*. This yields the following difference between sGMS and dGMS.

Theorem 3 *sGMS is not obviously strategy-proof. dGMS is obviously strategy-proof.*

Proof See Appendix A

Li (2017) argues that obviously strategy-proofness has the intuitive behavioral interpretation that a cognitively limited agent can recognize a strategy as weakly dominant if and only if it is obviously dominant. In other words, Theorem 3 suggests that for cognitively limited consumers it is easier to recognize that bidding value is a weakly dominant strategy in dGMS than in sGMS.

3.2.2 Producers' Best Response

To complete the PBE, we derive the optimal choice of T and r by the producers. We consider two possible producer objectives. The first concerns the maximization of the likelihood of the project's success. The project is marked a success if and only if (1) the project is initiated, i.e. $\sum_{i=1}^{N} p_i \geq T$, and (2) the project's revenues exceed its costs, i.e., $\sum_{i=1}^{N} p_i \geq C$. The second producer objective is the maximization of the project's profit. To derive producer behavior in the PBE, we assume that consumers play the semi-pooling equilibrium in AON (Theorem 1) and the truthful equilibrium in GMS (Theorem 2). We let T_o^m and r_o^m denote the optimal threshold and reservation price respectively for mechanism $m = \{AON, GMS\}$ and objective $o = \{s, \pi\}$, where s (π) stands for the success (profit) objective.

We first consider the AON when the producer's goal is to maximize the project's success probability. We have

Theorem 4 *Suppose that in AON consumers play according to the semi-pooling equilibrium. The producer maximizes the project's success probability by setting* $T_s^{AON} = C$ *and* $r_s^{AON} \in \arg\max_r I_{(1-F(r))}\left(\frac{C}{r}, \frac{(N+1)r-C}{r}\right)$ *s.t.* $r \in \left\{\frac{C}{N}, \ldots, \frac{C}{2}\right\}$ *&* $r \leq \overline{v}$*, where* $I_x(\cdot)$ *denotes the regularized incomplete beta function. The solution involves* $\lim_{N\to\infty} r_s^{AON} = 0$*.*

Proof See Appendix A

While the theorem does not provide a closed-form solution for the optimal producer choices in AON under a success objective, it restricts the number of potentially optimal threshold/reservation price combinations to $N-1$. The producer optimally sets $T_s^{AON} = C$ because consumers who play according to a semi-pooling equilibrium do not make bids that depend on the threshold. Setting $T < C$ puts the producer at risk of a loss, while setting $T > C$ puts the producer at risk of unnecessary project failure. Similarly, the producer chooses a reservation price from the discrete set of prices that potentially fund the project without excess aggregate payments.

When producers in AON aim to maximize profits, we show in Lemma A4 in Appendix A that the producer optimally sets $T_\pi^{AON} = C$. For the optimal reservation price, we find no analytical solution but show in Theorem B2 of Appendix B that for sufficiently large N, r_π^{AON} is equal to the price that a monopolist would charge in this market if the production costs were sunk. Appendix D shows how the optimal r_π^{AON} can be derived numerically.

Turning to GMS, we again start with the success probability objective. Theorem 5 displays the optimal parameters.

Theorem 5 *Suppose that in GMS, consumers play according to the truthful equilibrium. Then the producer maximizes the project's success probability by setting* $T_s^{GMS} = C$ *and* $r_s^{GMS} = 0$.

Proof See Appendix A

Thus, the PBE for GMS when producers aim to maximize the likelihood of success is intuitive for both producer and consumers. It involves producers choosing a threshold equal to the project costs and reservation price zero, while consumers bid their value. By choosing $T = C$ and $r = 0$, a producer optimally uses the serial cost sharing mechanism by Moulin and Shenker (1992). The intuition is straightforward. The project should not be produced if the costs are not covered. So, $T_s^{GMS} \geq C$. Then, conditional on the costs being covered, the producer maximizes the likelihood that the project is completed by pushing T and r as low as possible so that $T_s^{GMS} = C$ and $r_s^{GMS} = 0$.

Comparing Theorems 4 and 5 shows that when the producer aims at maximizing the likelihood of success, $T_s^{AON} = T_s^{GMS} = C$. The optimal reservation price is larger in AON but converges to that in GMS ($r_s^{GMS} = 0$) with increasing N.

For the case of profit maximization under GMS, we have found no generally applicable analytical solutions. We show in Appendix D that these can be easily derived numerically for any specific environment. The numerical solutions all involve $T_\pi^{GMS} \geq C$, because they would otherwise involve including outcomes that yield a loss.

Finally, note that the PBE for both mechanisms and both objectives involve setting the threshold weakly above the costs. This justifies the assumption that $T \geq C$ made above.

3.3 Comparing Mechanisms

Our main objective in this theoretical analysis is to compare the equilibrium properties of AON and GMS. Although we have not analytically derived the complete PBE for all cases, the comparison turns out to be straightforward if consumers bid according to the equilibria derived in Theorems 1 and 2. Our first proposition then shows that GMS outperforms AON in terms of expected producer profit and success probability.

Proposition 1 *Consider the PBE for AON and GMS where consumers play according to the semi-pooling equilibrium in AON and the truthful equilibrium in GMS.*

(i) If the producer aims to maximize expected profit, GMS yields weakly higher expected profit than AON. GMS yields strictly higher expected profit than AON if $C < (\lceil \frac{C}{r_\pi^{AON}} \rceil - 1)\bar{v}$.[11]

(ii) If the producers aims to maximize success probability, GMS yields weakly higher success probability than AON. GMS yields strictly higher success probability than AON if and only if $C < (N-1)\bar{v}$.

Proof See Appendix A

In the semi-pooling equilibrium of AON, consumers with a value below the reservation price bid 0 and all others bid the reservation price r. The underlying intuition for Proposition 1 is that a producer in GMS can always set the threshold and reservation price that are optimal under AON – and will never do worse and sometimes outperform AON for these choices (because consumers with a value above r have a higher equilibrium bid in GMS than in AON) – but may even do better for other parameter choices.

We also compare the two mechanisms in terms of the aggregate surplus that they generate in their PBE. Recall that no efficient, incentive-compatible and individually rational mechanism exists where the producer's expected revenue in equilibrium is positive. Nevertheless, Proposition 2 establishes that GMS is weakly more efficient – not just in expectation, but also ex post – than AON in equilibrium under a success objective.

[11] $\lceil \cdot \rceil$ denotes a ceiling function that rounds up its argument to the nearest integer.

Proposition 2 *Assume that producers' objective is to maximize the project's success probability. In the BNE described in Theorems 4 and 5, aggregate surplus is weakly higher in GMS than in AON. Expected aggregate surplus is strictly higher in GMS than in AON if and only if* $C < (N - 1)\overline{v}$.

Proof See Appendix A

Together, Propositions 1 and 2 establish that GMS outperforms AON both from the producer's perspective (irrespective of their objective) and from the perspective of aggregate welfare (under a success objective). Of course, whether this theoretical dominance is realized depends very much on how consumers bid. To study this behavior, we designed the experiment described in the following section.

4 Experimental Design and Hypotheses

4.1 Experimental Procedures and Design

The experiment consisted of 18 sessions that were conducted at the CREED laboratory of the University of Amsterdam. For each session we recruited 16 subjects from the CREED subject pool. Subjects were on average about 22 years old. Our sample was almost gender-balanced (54% females) and consisted primarily (68%) of Economics or Business students. 71% of the subjects had no prior experience with crowdfunding. Throughout the experiment, payoffs are denoted by 'francs'. Accumulated earnings are paid out at an exchange rate of 1 Euro for 8 francs. Sessions lasted about 80 minutes and subjects earned 14.14 Euros on average, including a show-up fee of 7.00 Euros.

The experiment is structured as follows. First, subjects read the instructions on their monitor. We then ask subjects to answer questions that test whether they have understood the crowdfunding game. Appendix E presents a transcript of the instructions and comprehension questions. Subjects are allowed to move forward only after they have correctly answered all comprehension questions. Thereafter, subjects are asked some crowdfunding intuition questions concerning theoretically optimal producer and consumer behavior. One of the subjects that has correctly answered the most producer intuition questions is assigned the role of (passive) producer.[12] Once all subjects have answered all test and intuition questions, subjects assigned the role of consumers play the crowdfunding game for 45 rounds, while the subject assigned the role of passive producer plays a non-incentivized allocation game. Subsequently, all subjects are required to fill out a short survey and are then privately paid out their earnings.

The experiment features a 3x2x3-design. It varies the mechanism (AON, sGMS, dGMS) between subjects, and the producer objective (profit, success) and project costs (low, medium, high) within subjects. As we focus on consumer behavior, we computerize producer decisions. This is common knowledge. In each session, 15 subjects are assigned the role of consumers, while the subject who is assigned the role of a passive producer cannot influence the producer decisions, which are set by the computer.[13]

To provide subjects with sufficient opportunity to learn to play the crowdfunding game, they interact in it for 45 rounds. In 27 of these rounds, the producer has a profit objective. The computerized producer chooses the threshold and reservation price to maximize expected profit as predicted by theory (details are presented below). In the other 18 rounds, the producer has a success objective, setting the threshold and reservation price that maximize funding success probability. Note that the consumers are not informed about the objective, but simply face a given threshold and reservation price in each round. For each producer objective, project costs in any given round are low, medium, or high. In rounds with a profit objective, costs are $C = 50$, $C = 70$, and $C = 90$ respectively. In rounds with a success objective, costs are $C = 60$, $C = 80$, and $C = 100$ respectively. The 45 rounds are split in three blocks of 15, nine with a profit objective and six with a success objective. Project costs are randomly drawn in such a way that in each block, $C = 50$, $C = 70$ and $C = 90$ occur three times each, while $C = 60$, $C = 80$ and

[12]This procedure intends to reflect that producers tend to be more knowledgeable about using crowdfunding as a fundraising practice than consumers.

[13]We assign a subject to be a passive producer in order to allow for potential pro-social behavior of consumers towards the producer. In a companion paper, we study producer behavior in crowdfunding (Woerner et al., 2023). That study motivates our selection procedure for producers, described above. Even though producers are passive in the experiment reported here, we use the same procedure in order to maintain consistency across studies.

$C = 100$ occur twice each. The different cost levels allow us to analyze subject behavior in situations when funding success is supposed to be very likely, somewhat likely and unlikely according to the theoretical predictions presented in Section 4.2.

At the start of each round, the consumers are informed about the fundraising threshold T and reservation price r, which depend on the round's producer objective and project costs (details are presented below). Consumers are not informed about the producer's objective and project costs. The consumers are privately informed about their values, which are drawn independently from a discrete uniform distribution over the set $\{0, 1, \ldots, 19, 20\}$. Then, the consumers interact in the crowdfunding mechanism resulting in integer bids between 0 and 30.[14] To reduce noise, the order of the cost levels and the draws of the values are kept constant across mechanisms.[15]

At the end of each round, all subjects are informed about their payoffs, whether the good was produced, the other consumers' decisions (listed anonymously in ascending order), and which price was implemented if the good is produced (in GMS).[16] A consumer's payoff when obtaining the good equals her value minus the payment she made to the producer. If she does not obtain the good, her payoff is equal to zero minus her payment. The earnings of the passive producer are determined by the producer's payoff. Under the profit objective, the producer's payoff in francs is 20% of the profits, that is, 20% of the aggregate consumers' payments minus the project costs, if the product was produced and zero otherwise. Under the success objective, the payoff is 3 francs if the producer managed to successfully fund the project and zero otherwise. At the end of the experiment, each subject's payoffs in francs across all 45 rounds are paid out.

[14] Decision screens in AON, sGMS and dGMS are depicted in Figures E1, E3 and E5 in Appendix E. Note that subjects in dGMS were not informed during the bidding phase about the number of consumers remaining in the market at a given price.

[15] To illustrate, the second session in AON has the same cost order and value draws as the second session in sGMS; it has a different cost order and different value draws than the third session in AON.

[16] Feedback screens in AON, sGMS and dGMS are depicted in Figures E2, E4 and E6 in Appendix E.

4.2 Hypotheses

We apply the theoretical predictions to the parameters of our experiment to derive hypotheses that we will test with the laboratory data. We are interested in the mechanisms' performance in terms of producer objectives and welfare. For this reason, we derive hypotheses both about the producers' profit and probability of success and about overall efficiency.

We first derive the optimal choice of parameters r and T for both mechanisms under each of the two producer objectives. We start with AON. Recall from the theory section that consumers face a trade-off between increasing the likelihood of production and paying as little as possible to obtain the good. If N is large enough, consumers' behavior is characterized by the semi-pooling equilibrium (cf. Theorem 1). For a moderately large crowd of 15 consumers (as used in this experiment), it is already quite unlikely that a consumer's individual contribution is pivotal. In that case, even consumers with a high value are unwilling to pay a price that is substantially higher than the reservation price, r. Nevertheless, it is a priori unclear whether $N = 15$ is sufficient to make semi-pooling the BNE for consumers for all r and T. It is clear, however, that an unwillingness to pay substantially more than r implies that the producer must set high reservation prices to mitigate consumers' scope to free ride.

Aside from the reservation price, the producer has a second instrument, the fundraising threshold T. This allows the producer to only produce the good if the consumers are willing to pay enough for it in aggregate. If the producer sets $T \geq C$, she can ensure to never make a loss.

We use numerical analyses to simultaneously determine the BNE for consumers and the optimal r and T for producers for our experimental parameters (Appendix D describes the algorithm used). For the producers, we find equilibrium behavior in AON as depicted in the top panel of Table 1. It appears that the equilibrium threshold not only depends on the project costs but also on the producer's objective. Under the success objective, the producer sets the fundraising threshold equal to the costs (cf. Lemma A4 in the appendix). Under the profit objective, it can be worthwhile to choose a threshold that is strictly higher than the costs. A threshold that equals a multiple of the reservation price plus one unit, for example, induces consumers with a high value to deviate from semi-pooling and bid one monetary unit above the reservation price.

Table 1: Equilibrium Thresholds and Reservation Prices

		Success Objective			Profit Objective		
	Costs	60	80	100	50	70	90
AON	Threshold	60	80	100	50	78	97
	Reservation Price	10	10	11	11	11	12
GMS	Threshold	60	80	100	56	78	97
	Reservation Price	0	0	0	11	11	11

Notes: The table presents equilibrium thresholds and reservation prices in AON and GMS for all cost levels used in the experiment.

Next, consider GMS. We derive the optimal r and T assuming that consumers play according to the truthful equilibrium, which is an equilibrium in weakly dominant strategies (Theorem 2). Therefore, unlike in AON, consumers do not adjust their bids with respect to the threshold and reservation price; this somewhat simplifies the analysis. As in AON, the equilibrium producer behavior depends on the producer's objective. Recall that producer behavior if the producer wants to maximize her success probability coincides with the serial cost sharing mechanism by Moulin and Shenker, i.e. $T_s^{GMS} = C$ and $r_s^{GMS} = 0$ (Theorem 5). The intuition is that as consumers bid their own value irrespective of the fundraising threshold and reservation price, setting $T > C$ and $r > 0$ only make it more difficult to reach aggregate payments equal to or higher than the costs. This is confirmed in the lower panel of Table 1.

If the producer's objective is to maximize expected profit, she should set a relatively high reservation price. By doing so, she can ensure that payments, and therefore profits, are large in case she faces many high-valued consumers. The producer sets a threshold above the costs to still ensure a strictly positive payoff if only few consumers contribute. Using numerical analysis (see Appendix D for the algorithm used), we find equilibrium producer behavior in GMS as depicted in Table 1.

Table 2 shows the expected performance of AON and GMS in terms of average profit, average surplus, and success frequency. Surplus is defined as the sum of the consumer values for the consumers who obtain the good minus the costs conditional on the good being produced. The sealed-bid and dynamic GMS are predicted to perform equally well, outperforming AON in all four outcome measures (cf. Propositions 1 and 2). However, the difference in expected performance between GMS and AON is considerably larger for the success objective than for the profit objective.

Table 2: Theoretical Predictions

	Success Objective		Profit Objective	
	Success	Surplus	Profit	Surplus
AON	0.559	33.84	15.79	35.77
GMS	0.651	46.73	16.29	37.62

Notes: For the experimental parameters, the table presents theoretical predictions for expected success frequency and surplus under a success objective and expected profit and surplus under a profit objective in AON and GMS.

The superior theoretical performance of GMS compared to AON (cf. Propositions 1 and 2, and Table 2 yields the following two hypotheses that we test in the experiment.

Hypothesis 1 *Relative to AON, sGMS yields*

(a) higher average profits under a profit objective

(b) higher average surplus under a profit objective

(c) higher success frequency under a success objective

(d) higher average surplus under a success objective.

Hypothesis 2 *Relative to AON, dGMS yields*

(a) higher average profits under a profit objective

(b) higher average surplus under a profit objective

(c) higher success frequency under a success objective

(d) higher average surplus under a success objective.

Theory predicts that sGMS and dGMS should perform equally well on all outcome measures as both mechanisms have a truthful equilibrium in weakly dominant strategies (see Theorem 2). However, there is reason to believe that more consumers will recognize that bidding one's own value is weakly dominant in dGMS than in sGMS (cf. Li, 2017; Breitmoser and Schweighofer-Kodritsch, 2021). Consumers that deviate from bidding truthfully might bid according to one of the equilibria as described in Appendix B. As said, these equilibria have some consumers bid below their value. Put together, we expect lower bids in sGMS than in dGMS. Underbidding decreases expected profits, success probability and – as it exacerbates underprovision of the good – expected surplus, leading to the following hypothesis.

Hypothesis 3 *Relative to sGMS, dGMS yields*

(a) higher average profits under a profit objective

(b) higher average surplus under a profit objective

(c) higher success frequency under a success objective

(d) higher average surplus under a success objective.

As we state directional hypotheses, we will use one-tailed hypothesis testing.

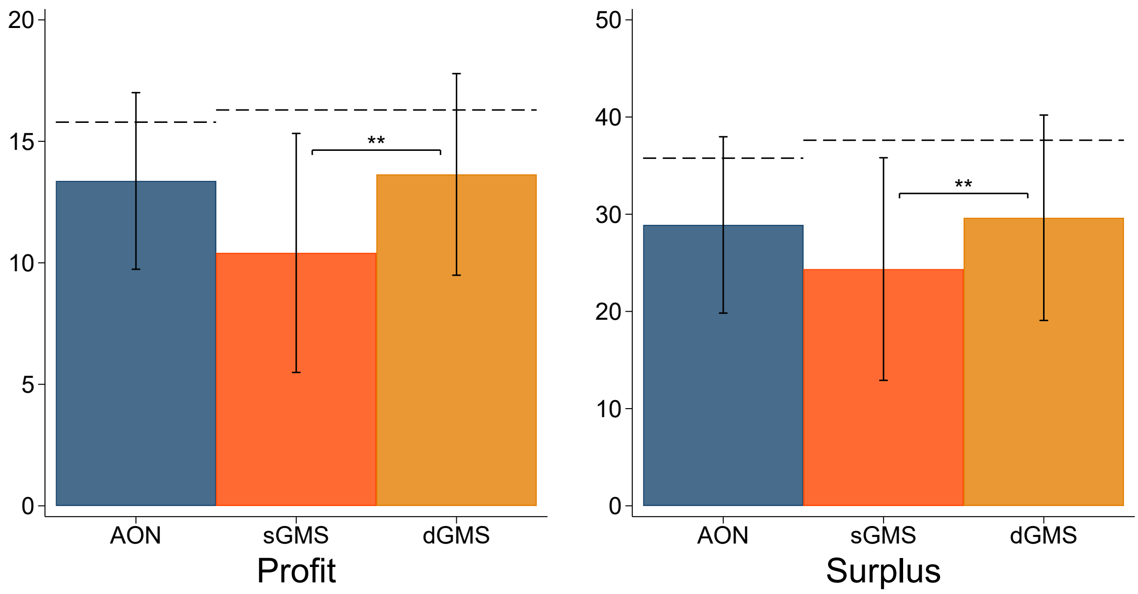
5 Results

This section presents the experimental results. We use paired Fisher-Pitman permutation tests to compare the mechanisms' performance. To allow for learning, we base our analysis on rounds 16 to 45. Section 5.1 presents results for when the producer aims to maximize profits. Section 5.2 shows results for when the producer aims to maximize success probability.[17] Section 5.3 compares the mechanisms' performance when pooling the data for the two objectives. Section 5.4 analyzes consumer behavior in more detail.

5.1 Profit Objective

Figure 1 shows average producer profit (left panel) and average surplus (right panel) in AON, sGMS and dGMS under the profit objective.

Figure 1: Producer Profit and Overall Surplus – Profit Objective



Notes: The figure shows average producer profit (left graph) and average overall surplus (right graph) in AON, sGMS and dGMS for a profit objective. Error bars indicate ninety-five percent confidence intervals. The dashed lines denote the theoretical predictions. ** $p < 0.05$ in a one-tailed paired Fisher-Pitman permutation test.

The figure reveals that dGMS yields a slightly and insignificantly higher producer

[17] Our main analysis shows the mechanisms' performance separately under the profit and success objective, even though differences to the theoretical predictions are solely driven by the behavior of consumers, who are unaware of a given round's objective. We nevertheless do so as actual consumer behavior might influence a mechanism's performance differently under the two objectives. In particular, this could be the case in sGMS and dGMS due to the large difference in reservation prices between rounds with a profit and success objective (cf. Table 1). To check for robustness, we also show pooled results in Section 5.3.

profit than AON (13.64 vs. 13.37; $p = 0.344$). However, dGMS yields a significantly higher producer profit than sGMS (10.41; $p = 0.047$). Clearly, sGMS does not yield a higher profit than AON ($p = 0.984$). An almost identical pattern is observed for average surplus. dGMS yields an insignificantly higher surplus than AON (29.64 vs. 28.90; $p = 0.344$) but a significantly higher surplus than sGMS (24.36; $p = 0.047$). sGMS does not yield a higher surplus than AON ($p = 0.984$).

These results are in contrast with Hypotheses 1a and 1b that predict that sGMS outperforms AON on both measures. For Hypotheses 2a and 2b, we cannot reject the null of a weakly higher profit and surplus in AON than dGMS. The superior performance of dGMS compared to sGMS confirms Hypotheses 3a and 3b. We further observe that all mechanisms yield lower profit and surplus than theoretically predicted. For sGMS this is significantly so; both realized profit and surplus lie outside the 95% confidence interval.

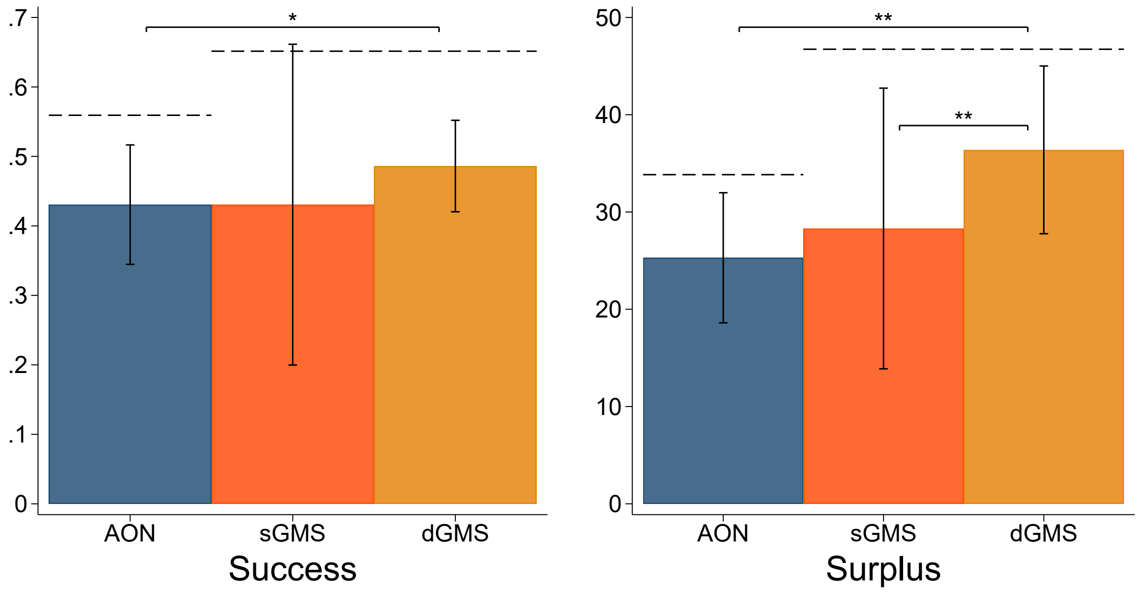
5.2 Success Objective

Figure 2 shows the success frequency (left panel) and average surplus (right panel) in AON, sGMS and dGMS under the success objective.

We observe that dGMS yields a higher success frequency than AON and sGMS (0.49 vs. 0.43 resp. 0.43). The difference between dGMS and AON is marginally significant ($p = 0.063$), while the difference between dGMS and sGMS is statistically insignificant ($p = 0.250$). In terms of welfare, dGMS yields a significantly higher surplus than AON and sGMS (36.39 vs. 25.29 resp. 28.31; $p = 0.016$ resp. $p = 0.031$). The difference in average surplus between AON and sGMS is not significant ($p = 0.250$).

The data thus do not confirm the predicted superior performance in success probability and surplus of sGMS compared to AON (Hypotheses 1c and 1d). Comparing dGMS and AON, our results are in line with Hypothesis 2c and confirm the predicted higher surplus in dGMS than in AON (Hypothesis 2d). While, for Hypothesis 3c, we cannot reject the null of a weakly higher success probability in sGMS than dGMS, the significantly higher surplus in dGMS compared to sGMS confirms Hypothesis 3d. Finally, as also observed for the profit objective, the mechanisms all perform worse than theoretically predicted.

Figure 2: Producer Success and Overall Surplus – Success Objective



Notes: The figure shows the average success frequency (left graph) and the average overall surplus (right graph) in AON, sGMS and dGMS for a success objective. Error bars indicate ninety-five percent confidence intervals. The dashed lines denote the theoretical predictions. ** $p < 0.05$, * $p < 0.1$ in a one-tailed paired Fisher-Pitman permutation test.

In this case, the prediction falls outside of the estimated 95% interval in five out of six cases.

Taking both producer's objectives into account, we find that, as predicted by theory, dGMS weakly outperforms AON. dGMS scores better than AON in all four comparisons and significantly so in one. dGMS also weakly outperforms sGMS. In contrast to theory, the ranking between AON and sGMS is ambiguous.

5.3 Pooled Objectives

Though the two objectives that we distinguish between lead to distinct choices of T and r and are evaluated at different cost levels C, note that consumers do not know the objective *per se*. From this perspective, we can therefore pool the data from the two objectives and correct for the threshold and reservation price that the consumers face. The overall superior performance of dGMS is supported further when pooling the data in this way.

More specifically, we run tobit regressions of profit and surplus and probit regressions of success on treatment group. We control for mean values, threshold and reservation price and cluster at the producer level. Results are presented in Table C1 in the online appendix. We find that employing dGMS rather than AON significantly increases profit ($p = 0.039$) and marginally significantly increases overall welfare ($p = 0.074$). While positive, there is no significant effect of using dGMS rather than AON on success frequency ($p = 0.159$) with pooled data. Switching from sGMS to dGMS significantly increases success frequency ($p = 0.030$) and welfare ($p = 0.023$) and marginally significantly increases profit ($p = 0.082$). The analysis with pooled data thus confirms that dGMS weakly outperforms AON and sGMS on all outcome measures. In contrast, switching from AON to sGMS does not increase profit ($p = 0.560$), success frequency ($p = 0.851$) nor surplus ($p = 0.816$), confirming our earlier results.

5.4 Consumer Behavior

In order to better understand the differences in the mechanisms' performance, we analyze consumers' bidding behavior. We start with AON.

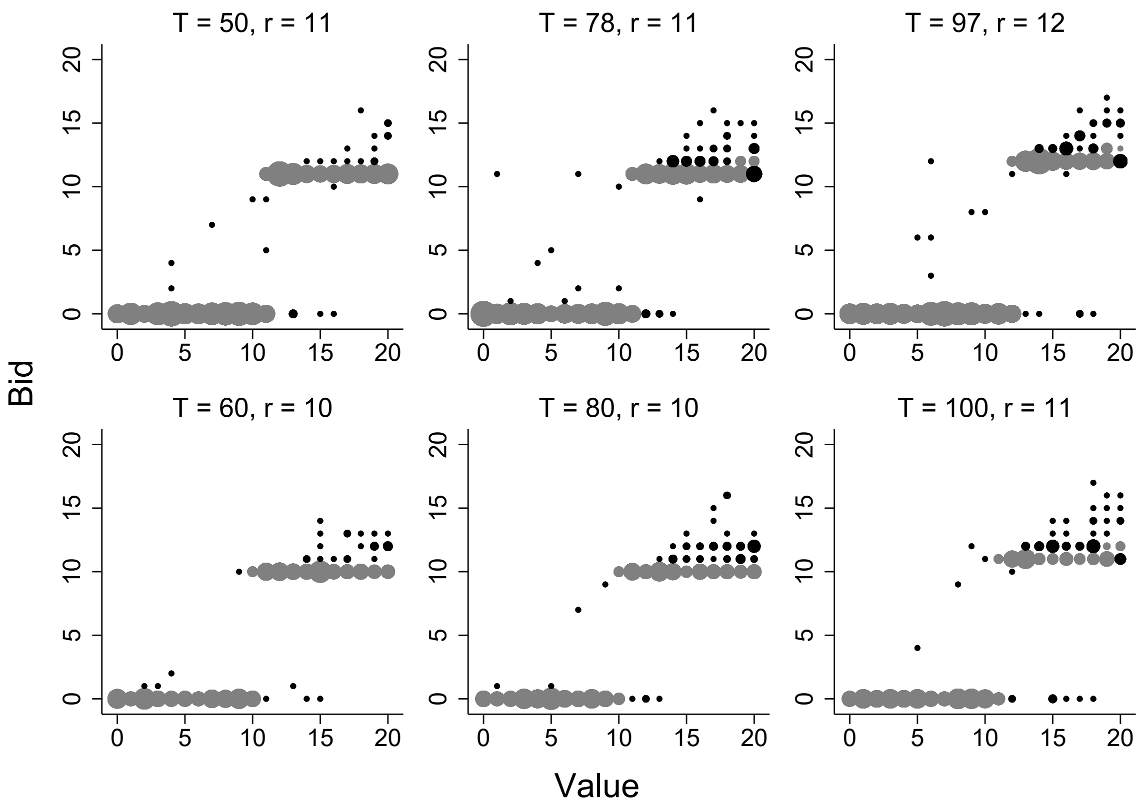
5.4.1 AON

Figure 3 depicts the frequency of bid-value combinations in AON for each combination of the threshold T and reservation price r. The larger the dot, the more frequent a bid-value combination occurred. Gray dots denote observations corresponding to the symmetric equilibrium bidding functions derived in Section 3.2.[18] Black dots denote bids that deviate from these predictions.

We observe that subjects' behavior is close to the theoretical prediction. In total, 88% of the bids correspond to the theoretical equilibrium bidding functions. Subjects with

[18]In fact, not all gray dots correspond precisely to the proposed equilibrium. The exception is a bidder with a value equal to the reserve price bidding zero, where the equilibrium involves bidding the reserve price. We note, however, that bidding zero in this case is also a best response. This is why we say that these bids 'correspond' to the equilibrium. Further, notice that for three parameter sets ($T = 50$, $r = 11$; $T = 60$, $r = 10$; $T = 80$, $r = 10$) AON has a semi-pooling equilibrium, i.e. the equilibrium bid is r for any value weakly above r. By Propositions 1 and 2, GMS is then predicted to outperform AON.

Figure 3: Bidding Behavior in AON



Notes: The figure depicts the frequency of bid-value combinations in AON for each T, r combination. The larger the dot, the more frequent a bid-value combination occurred. Gray dots denote observations that correspond to the theoretical symmetric equilibrium bidding functions. Black dots denote bids that deviate from the theoretical predictions.

values below the reservation price almost always (98%) bid zero, and subjects with values strictly above the reservation price almost always (97%) bid at least the reservation price. Both observations are consistent with equilibrium behavior (see Lemmas A1 and A2 in Appendix A). Interestingly, about two thirds of the subjects with values equal to the reservation price bid zero rather than the reservation price. While either yields a payoff of zero for oneself, bidding zero harms other subjects as it decreases the likelihood that the good is produced.[19] In line with Lemma B1 in Appendix B, we observe that bids tend to weakly increase in subjects' values. A regression of bids on values v, reservation price r

[19]Spiteful preferences provide a potential motive for this behavior. Note that spite has also been proposed as a possible explanations for overbidding in second-price auctions (Morgan et al., 2003).

and threshold T for subjects with $v > r$ clustering standard errors at the individual level yields that subjects increase bids by 0.19 units per value unit, which is strongly significant ($p < 0.001$). Bids do not significantly increase in the threshold ($p = 0.390$). Taking into account the frequent choice of bidding zero when the value equals the reservation price, still 85% of the bids are in line with the theoretical equilibrium bidding functions. There is, however, more overbidding (9%) than underbidding (3%).[20]

5.4.2 sGMS

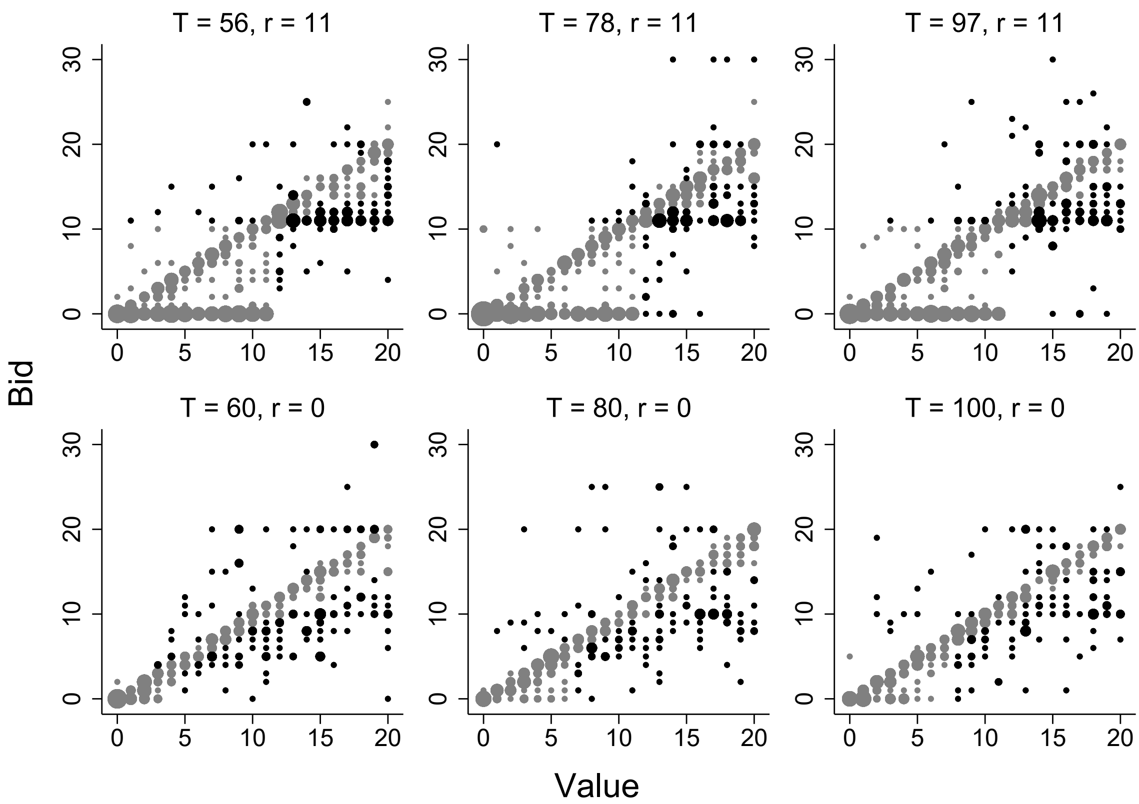
We now turn to GMS. Figure 4 depicts the frequency of bid-value combinations in sGMS in the same way that Figure 3 does for AON. Note that bidding one's value is not the unique weakly dominant strategy as the set of candidate prices is discrete (cf. Theorem B4 in Appendix B). Recall that in GMS the realized price is given by the uniform price $p^* = \max\{\lceil \frac{T}{M} \rceil, r\}$, while anyone bidding less than p^* pays zero and does not obtain the good. Therefore, any bidding strategy that satisfies both $b \geq p^*$ if $v > p^*$ and $b < p^*$ if $v < p^*$ for all $M \in \{1, 2, \ldots, 15\}$ is weakly dominant. The case for higher values follows from the uniform price, while bidding anything positive but below the realized price results in paying zero.

In total, 73% of the bids are weakly dominant.[21] We observe in Figure 4 that the majority of black dots lies below the identity line. Subjects thus tend to underbid (20% of the bids) rather than overbid (7% of the bids). This asymmetry in deviations from weakly dominant play is the reason why sGMS does not outperform AON as predicted by theory. The bidding behavior suggests that a noteworthy share of subjects falsely expects that bidding below value increases one's payoff conditional on the good being produced. Ceteris paribus, an underbidding subject forewent on average 21% of the round's payoff

[20]Figure C1 in the online appendix shows that subjects' behavior approaches the theoretical prediction over time. In particular, we observe that subjects learn to refrain from weakly dominated play. The share of weakly dominated bids drops from 10% (rounds 1-15) to 4% (rounds 16-30) to a mere 2% (rounds 31-45).

[21]There is large heterogeneity in the share of weakly dominant bids within consumers. For instance, consumers at the 20th resp. 80th percentile of the distribution of the fraction of weekly dominant bids choose weakly dominant bids in 50% resp. 97% of the rounds.

Figure 4: Bidding Behavior in sGMS



Notes: The figure depicts the frequency of bid-value combinations in sGMS for each T, r combination. The larger the dot, the more frequent a bid-value combination occurred. Gray dots denote weakly dominant bids. Black dots denote weakly dominated bids.

that she would have earned by bidding value. The type of underbidding differs, however, between the two producer objectives. This is because the two objectives give rise to distinct reservation prices. In rounds with a profit objective (top row), underbidding subjects often (46%) bid the reservation price of 11. In rounds with a success objective (bottom row) the reservation price is zero and most (83%) underbidding subjects bid a few units below their value. A possible explanation for this difference is that the reservation price of 11 acts as a focal point in rounds with a profit objective, but the reservation price of 0 in rounds with a success objective is ill-suited to do so as a bid of zero renders a positive payoff impossible.

Given that the foregone payoff from underbidding is substantial and that subjects play the crowdfunding game for 45 rounds, the question arises why many subjects do not learn over time to play a weakly dominant strategy.[22] One reason might be that useful feedback on one's behavior is rare in this environment. In most cases of underbidding (88%), this had no impact on a subject's payoffs compared to if she had placed a bid equal to her value, because either bid would have resulted in the same production outcome and price.

In addition, even when underbidding negatively affected subjects' payoffs, this might be difficult to spot. It is arguably cognitively challenging to recognize that in a case where a product was not produced it would have been produced if one had bid higher. The only 'clear' mistakes occur when a product is produced and underbidding subjects obtain zero payoff but could have obtained a positive payoff by bidding higher. However, this occurs in only 7% of the cases involving underbidding, which might explain why learning by underbidding subjects is rare in sGMS. This issue is particularly pronounced under a profit objective, where a noteworthy minority of subjects bids the reservation price. It then becomes unlikely that a price above the reservation price is implemented. This, in turn, decreases the likelihood that underbidding subjects realize their mistakes.

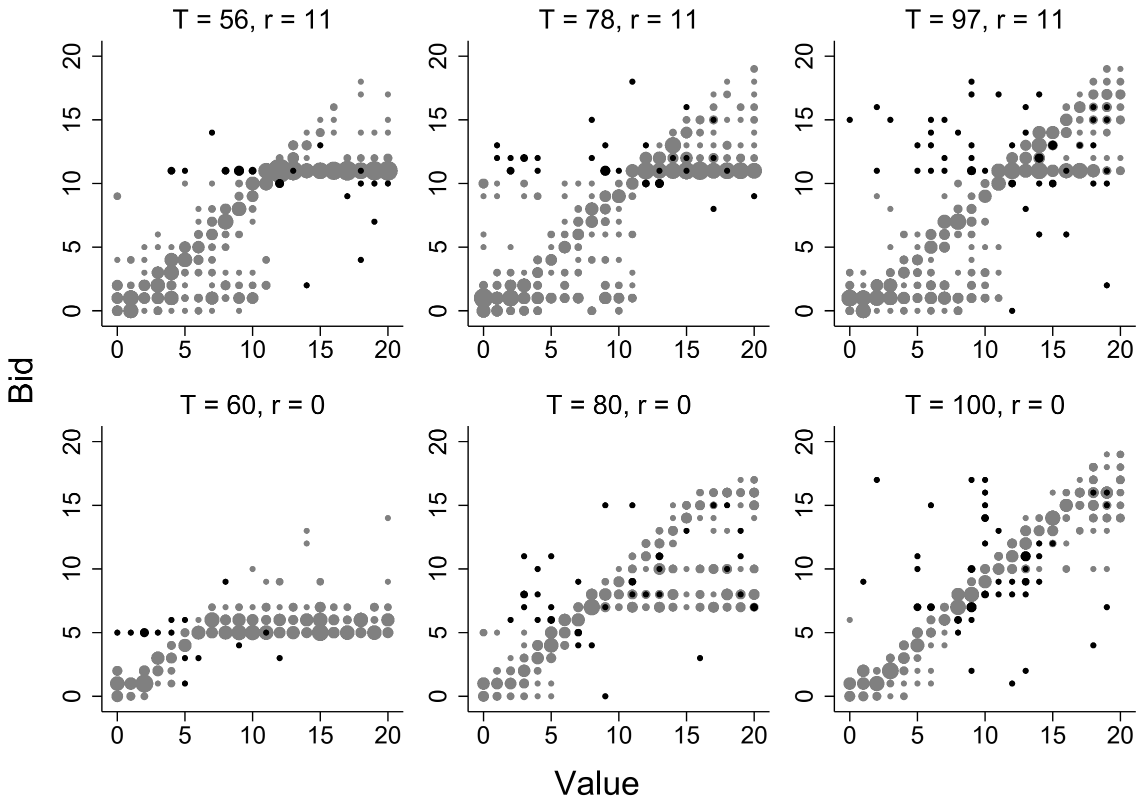
5.4.3 dGMS

Analyzing subjects' bidding behavior in dGMS is less straightforward than in AON or sGMS. This is because one cannot observe what subjects would have bid in cases where they had not yet dropped out when the ascending clock stopped. We can, however, denote a bid as the last price that a subject implicitly agreed upon before she either dropped out or the ascending clock stopped. Doing so, we obtain Figure 5. Note that we can only identify weakly dominated bids, however, if a subject has dropped out before the

[22] The overall frequency of underbidding decreases from 30% in the first 15 rounds to 21% in the second 15 rounds. However, we observe little aggregate learning after that as subjects still underbid 18% of the time in the third 15 rounds, as depicted in Table C2 in the online appendix. Figure C2 shows that the type of underbidding also stays similar over time. At the individual level, Figure C4 shows that underbidding is relatively stable over time. Consumers who underbid in the beginning of the crowdfunding game tend to also regularly underbid in the remaining rounds. In contrast, consumers who rarely underbid at the beginning typically do not start underbidding later on (the Pearson correlation coefficient between underbidding in the first 15 and last 30 rounds is 0.69).

ascending clock stops or has not dropped out at a price higher than her value. If a bid is not weakly dominated, we assign it a gray dot.

Figure 5: Bidding Behavior in dGMS



Notes: The figure depicts the frequency of bid-value combinations in dGMS for each T, r combination. The larger the dot, the more frequent a bid-value combination occurred. Gray dots denote possibly weakly dominant bids. Black dots denote surely weakly dominated bids. The reason why gray dots are only 'possibly' weakly dominant is explained in the main text.

We observe that the panels are pre-dominantly gray, and, in fact, 92% of the bids are in line with a (possibly) weakly dominant strategy.[23] The black dots are distributed evenly above (47% of weakly dominated bids) and below (53% of weakly dominated bids) the identity line.

In order to obtain a fair comparison between subjects' bidding in dGMS and sGMS,

[23]Table C2 and Figure C3 in the online appendix show that the frequency of possibly weakly dominant bids increases from 81% (rounds 1-15) to 90% (rounds 16-30) to 93% (rounds 31-45), predominantly due to a decrease in underbidding from 14% to 6% to 3%.

we construct counterfactual bids that reflect how subjects in sGMS would have bid in dGMS. To do so, we assume that subjects' bids in sGMS determine the highest price at which a subject would be willing to stay in the market. Doing so shows that 84% of these counterfactual bids in sGMS are in line with a possibly weakly dominant strategy (recall that 73% of the actual bids are in line with a weakly dominant strategy). This means that at least 16% are part of a weakly dominated strategy. 74% of these (surely) weakly dominated counterfactual bids constitute underbidding, the remaining 26% reflect overbidding. Recall that only 8% of the bids in dGMS are in line with a surely weakly dominated strategy, and that deviations are distributed evenly above and below the identity line. This suggests that subjects deviate from optimal play twice as often in sGMS than in dGMS, and they do so by more excessive underbidding. The differences in optimal play and underbidding are statistically significant (both $p = 0.031$) and are the reasons for why dGMS (weakly) outperforms sGMS along all dimensions.[24]

6 Conclusion

This paper introduces a new reward-based crowdfunding mechanism, the Generalized Moulin-Shenker mechanism (GMS). We theoretically analyze both a sealed-bid version (sGMS) and a dynamic version (dGSM) of GMS and show that they are promising alternatives to the prevailing All-or-Nothing mechanism (AON). Unlike AON, both versions of GMS are strategy-proof. In contrast to sGMS, dGMS – that builds on Deb and Razzolini (1999) – is obviously strategy-proof in the sense of Li (2017). For a sufficiently large crowd of consumers we find that both versions of GMS outperform AON, both for the producer and in terms of efficiency.

We test our theoretical predictions in a laboratory experiment. We compare the performance of both versions of GMS with AON, allowing for two producer objectives: profit maximization and success probability maximization. In line with our predictions,

[24]Figure C5 in the online appendix further shows that the shares of possibly weakly dominant bids by consumer in dGMS first order stochastically dominates the shares in the 'dynamized' sGMS.

we find that dGMS weakly outperforms AON and sGMS. Contrary to the theoretical predictions, however, the performance ranking between sGMS and AON is ambiguous. While subject behavior in dGMS and AON comes close to our predictions, many subjects tend to underbid in sGMS relative to the truthful equilibrium. Their bidding strategies suggest that subjects perceive a (non-existent) trade-off between on the one hand payoffs conditional on obtaining the good and on the other the likelihood of obtaining the good. The obviously strategy-proofness of dGMS removes this perceived trade-off and thereby reduces subjects' inclination to bid suboptimally low.[25]

We believe our results to be informative about reward-based crowdfunding in practice. Our results provide some justification for the prevalent use of AON. Even though deriving equilibrium bidding functions in AON is computationally involved, subjects' bidding is close to the theoretical predictions, suggesting that AON is both intuitive and easy to understand. AON's low entry requirements might also help crowdfunding platforms to more easily convince new consumers to participate. In contrast, our experiment showed that participants had more difficulty in understanding the rules of sGMS and dGMS. Our results suggest that switching to sGMS may also not be justified in terms of producer profits, project success probability, or efficiency. The prevalent underbidding in sGMS that underlies this also mitigates its potential as a demand elicitation tool. Our results, however, are in line with our theoretical predictions that crowdfunding campaigns could become more efficient (and possibly more likely to succeed) by using dGMS instead of AON, in particular if producers aim to maximize funding success. This implies that dGMS might be a promising alternative to AON especially either when a) the crowdfunded good requires a large initial investment but might generate high demand on future spot

[25] Underbidding in sGMS is the mirror image of overbidding in a second-price sealed-bid auction (e.g. Kagel et al., 1987; Cooper and Fang, 2008; Georganas et al., 2017). One explanation for the latter is that many bidders overbid as it is easy to recognize that a bid above value increases the likelihood of winning but less evident that it only does so in cases in which a bidder would not want to win in the first place. In contrast, in sGMS, many subjects underbid as it seems intuitive that a bid below value decreases the expected price conditional on obtaining the good but less so that a higher price would only be implemented if the project is not already funded at a lower price. Both in experimental auctions and in our crowdfunding experiment, moving to an ascending dynamic mechanism, i.e. to the English auction resp. dGMS, mitigates such deviations from dominated play (Kagel and Levin, 1993; Li, 2017).

markets (e.g. technology-based products) if the crowdfunding campaign is successful; or b) a producer derives intrinsic utility from bringing the crowdfunded good into existence as might be the case, for example, with personal rather than business projects.

A challenge, though, is how dGMS can be implemented in practice. It seems unpractical to require all consumers to be available for bidding at the same time or during specified intervals. A good alternative may be to approximate dGMS via proxy agents, where sealed bids act as automatic drop-out prices. This would allow consumers to bid at any time they like but might still prevent underbidding. This practical solution is supported by Breitmoser and Schweighofer-Kodritsch (2021), who compare intermediate auction formats between a second-price sealed-bid auction and an ascending-clock auction. They show that personally responding as the clock increases the price is unnecessary to induce truthful bidding.

For our empirical analysis, we opted for a laboratory experiment. This choice is grounded in the theory-testing nature of our research question. Having introduced a new crowdfunding mechanism and having shown its desirable theoretical properties, the natural first choice is to test these properties under laboratory control (Schram, 2005; List, 2020). This is particularly the case when the theory's predictions involve comparative statics (List, 2020), as is the case with our mechanisms. Laboratory control allows us to optimize internal validity by ensuring that the theory's assumptions are met as closely as possible.

From here, two follow-up steps naturally arise. First, because this study has focused on one side of the crowdfunding market, the consumers, it is natural to study the extent to which the supply side (producer behavior) confirms the theoretical predictions. Once again, the laboratory seems an obvious place to start. This extension is the topic of our companion study (Woerner et al., 2023). The second obvious extension involves testing the theory in an environment to which it is ultimately intended to apply (List, 2020). For these crowdfunding mechanisms, this would imply, for example, comparing the results of AON and dGMS on platforms in the field.

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A Proofs

We first establish three lemmas regarding equilibrium bidding behavior in AON that are needed for the proofs of the theorems and propositions in the main text.

Lemma A1 *In AON, it is a weakly dominant strategy for consumer i to bid $B(v_i) = 0$ if $v_i < r$, $i = 1, ..., N$.*

Proof of Lemma A1 Consider consumer i with $v_i < r$. First, assume that i bids $0 < b_i < r$. Her utility is $u_i = -b_i < 0$ if $\sum_{i=1}^{N} b_i \geq T$, and $u_i = 0$ otherwise. Now, assume that i bids $b_i \geq r$. Her utility is $u_i = v_i - b_i \leq v_i - r < 0$ if $\sum_{i=1}^{N} b_i \geq T$, and

$u_i = 0$ otherwise. By bidding $B(v_i) = 0$, i always obtains $u_i = 0$. It is therefore a weakly dominant strategy for consumer i to bid $B(v_i) = 0$ for $v_i < r$. ■

Lemma A2 *In AON, bids $b < r$ are weakly dominated by bidding $B(v_i) = r$ for $v_i > r$.*

Proof of Lemma A2 Consider consumer i with $v_i > r$. First, assume $\sum_{j \neq i} b_j + r < T$. The good is not produced, neither for $b_i = r$, nor for $b_i < r$. In both cases, $u_i = 0$. Now, assume $\sum_{j \neq i} b_j + b_i < T \leq \sum_{j \neq i} b_j + r$. By bidding $b_i = r$, consumer i obtains $u_i = v_i - r > 0$. This is higher than $u_i = 0$, which she obtains by bidding $b_i < r$. Lastly, assume $\sum_{j \neq i} b_j + b_i \geq T$. By bidding $b_i = r$, consumer i obtains $u_i = v_i - r > 0$. This is higher than $u_i = -b_i \leq 0$, which she obtains by bidding $b_i < r$. Bidding $b_i < r$ is therefore weakly dominated by bidding $B(v_i) = r$ for $v_i > r$. ■

Lemma A3 *In AON, bids $b \geq v_i$ are weakly dominated by bidding $B(v_i) = r$ for $v_i > r$.*

Proof of Lemma A3 Consider consumer i with $v_i > r$. First, assume $\sum_{j \neq i} b_j + b_i < T$. The good is not produced, neither for $b_i = r$, nor for $b_i \geq v_i$. In both cases, $u_i = 0$. Now, assume $\sum_{j \neq i} b_j + r < T \leq \sum_{j \neq i} b_j + b_i$. By bidding $b_i = r$, consumer i obtains $u_i = 0$. This is weakly higher than $u_i = v_i - b_i \leq 0$, which she obtains by bidding $b_i \geq v_i$. Lastly, assume $\sum_{j \neq i} b_j + r \geq T$. By bidding $b_i = r$, consumer i obtains $u_i = v_i - r > 0$. This is higher than $u_i = v_i - b_i \leq 0$, which she obtains by bidding $b_i \geq v_i$. Bidding $b_i \geq v_i$ is therefore weakly dominated by bidding $B(v_i) = r$ for $v_i > r$. ■

Proof of Theorem 1 $\leftarrow$ According to Lemmas A1 – A3, any BNE $\beta \equiv (\beta_1, \beta_2, \ldots, \beta_N)$ in undominated strategies of AON satisfies $\beta_i(v_i) = 0$ for $v_i < r$ and $v_i > \beta_i(v_i) \geq r$ for $v_i > r$. Without loss of generality, assume that $\beta_i(v_i) = r$ – rather than $\beta_i(v_i) = 0$ – for $v_i = r$. Consider consumer j having value $v_j > r$. Suppose each consumer $i \neq j$ bids according to $\beta_i(v_i) = B(v_i)$. Bidder j's best response must be contained in the set $B \equiv \{r, 2r + T - \lceil T/r \rceil r, 3r + T - \lceil T/r \rceil r, \ldots, \bar{k}r + T - \lceil T/r \rceil r\}$, where $\bar{k}$ is the greatest k for which $kr + T - \lceil T/r \rceil r < v_i$. Then bidding r is the unique best response for consumer j if and only if

$$P\left\{\sum_{i\neq j}\beta_i(v_i)+r\geq T\right\}(v_j-r)>P\left\{\sum_{i\neq j}\beta_i(v_i)+b_j\geq T\right\}(v_j-b_j)$$

for all $b_j \in B\setminus\{r\}$. The probability on the left-hand [right-hand] side is the probability that the good is produced conditional on consumer j bidding r [b_j] and all other consumers bid according to β. The inequality can be rewritten as follows:

$$P\left\{\sum_{i\neq j}\beta_i(v_i)+b_j\geq T\right\}(b_j-r)>P\left\{b_j\geq T-\sum_{i\neq j}\beta_i(v_i)\geq r\right\}(v_j-r)$$

Now, for arbitrarily large N, the probability on the left-hand side of the second inequality approaches 1 while the probability on the right-hand side converges to zero. Therefore, bidding r is the unique best response for consumer j for sufficiently large N. As a result, for sufficiently large N, strategy B constitutes a BNE in undominated strategies of AON.

■

Proof of Theorem 2 ← We show that it is a weakly dominant strategy for consumer i to bid her own value $\beta(v_i)=v_i$ in GMS, following Moulin and Shenker (1992). The reasoning closely parallels the arguments for truthful bidding in second-price auctions. First, note that how much a consumer needs to pay to obtain the good does not depend on her own but only on her fellow consumers' bids. Now assume consumer i deviates from $\beta(v_i)=v_i$ and bids $b_i>v_i$. Denote the candidate price by $p=\max\{\frac{T}{k},r\}$. If $p>b_i>v_i$, the deviation makes no difference; consumer i does not obtain the good and thus pays nothing anyways. If $b_i>v_i\geq p$, the deviation again makes no difference; consumer i obtains the good in both cases and pays p. But if $b_i\geq p>v_i$, the deviation leads to a loss. Consumer i obtains the good and pays p so that $v_i-p<0$. Bidding above one's value is thus weakly dominated by bidding exactly one's value. Now assume that consumer i bids $b_i<v_i$. If $p>v_i>b_i$, the deviation makes no difference as consumer i does not obtain the good and pays nothing with or without deviation. If $v_i>b_i\geq p$, the deviation again does not change her payoff. Consumer i obtains the good and pays p. But if $v_i\geq p>b_i$, consumer i gets a payoff of $u_i(b_i < v_i) = 0$, whereas she would have received a positive payoff if she had bid her value, namely $v_i - p \geq 0$. Thus, bidding below one's value is also weakly dominated by bidding one's own value. ■

Proof of Theorem 3 ← Li (2017) shows that a strategy is only obviously dominant if it is weakly dominant. For both sGMS and dGMS, any weakly dominant strategy has a consumer bid value if her value exceeds the reservation price. Consider consumer i having value $v_i > \max\{\frac{T}{|N|}, r\}$ who considers the strategies 'bidding v_i' and 'bidding $b_i > v_i$'. For sGMS, the earliest information set where these strategies differ is the point where the consumer submits her bid. Then, the worst possible outcome when bidding v_i is that the good is not developed, resulting in a payoff of zero. The best possible outcome when bidding $b_i > v_i$ is that the good is developed and consumer i obtaining the good for which she pays $\max\{\frac{T}{N}, r\}$. The resulting utility equals $v_i - \max\left\{\frac{T}{N}, r\right\} > 0$. Ergo, sGMS does not have an obviously dominant strategy. Therefore, it is not obviously strategy-proof. In dGMS, the earliest information set where quitting at $b_i > v_i$ diverges from quitting at v_i is when the ascending clock reaches price v_i. When that information set is reached, the best possible outcome from quitting at b_i is not better than the worst possible outcome from quitting at v_i. So, bidding value is an obviously dominant strategy and, consequently, dGMS is obviously strategy proof. ■

Lemma A4 *Setting $T_\pi^{AON} = T_s^{AON} = C$ is weakly dominant when consumers play according to a semi-pooling equilibrium in AON.*

Proof of Lemma A4 Denote the indicator function by $\mathcal{I}\{\cdot\}$. Producer profit equals

$$\pi^{AON}(r, T) = \mathbb{E}\left\{\left[\sum_{i=1}^{N} B(v_i) - C\right] \mathcal{I}\left\{\sum_{i=1}^{N} B(v_i) \geq T\right\}\right\}.$$

Similarly, the success probability equals

$$Pr^{AON}(r, T) = \mathbb{E}\left\{\mathcal{I}\left\{\sum_{i=1}^{N} B(v_i) \geq T \;\middle|\; \sum_{i=1}^{N} B(v_i) \geq C\right\}\right\}.$$

Note that under a semi-pooling equilibrium, $B(v_i)$ only depends on v_i and r but not on T. Now assume that the producer deviates and sets $T > C$. If $\sum_{i=1}^{N} B(v_i) \geq T$, then the project is successful and profit equals $\sum_{i=1}^{N} B(v_i) - C$ either way. If $\sum_{i=1}^{N} B(v_i) < C$, the good is not successful and profit equals 0 either way. If $T > \sum_{i=1}^{N} B(v_i) \geq C$, then the project is not successful and profit equals 0 under the deviation but the project would have been successful and yielded a profit equal to $\sum_{i=1}^{N} B(v_i) - C \geq 0$ for $T = C$. Now assume that the producer deviates and sets $T < C$. If $\sum_{i=1}^{N} B(v_i) \geq C$, then the project is successful and profit equals $\sum_{i=1}^{N} B(v_i) - C$ either way. If $\sum_{i=1}^{N} B(v_i) < T$, the project is not successful and profit is zero either way. If $C > \sum_{i=1}^{N} B(v_i) \geq T$, then the project is not a success either way. Under the deviation, profit equals $\sum_{i=1}^{N} B(v_i) - C < 0$ but would have been 0 for $T = C$. Thus, setting $T_{\pi}^{AON} = T_{s}^{AON} = C$ is therefore weakly dominant under a semi-pooling equilibrium in AON. ■

Proof of Theorem 4 ← To maximize the probability of success, it is a dominant strategy to choose $T_{s}^{AON} = C$ (Lemma A4). For any $r \leq \bar{v}$, the probability that a randomly drawn consumer has $v_i < r$ and will therefore bid 0, is $F(r)$. All other consumers bid r. In a population of N consumers, the number of consumers bidding 0, denoted by n_0, is binomially distributed with $p = F(r)$. The project is successful if $N - n_0 \geq \frac{C}{r}$, or $r \geq \frac{C}{N-n_0}$. Success is therefore only possible if $r \geq \frac{C}{N}$. Also, success is only possible if $r \leq \bar{v} < C$ as $C > \bar{v}$ by assumption. Further, the optimal r_{s}^{AON} must satisfy $r_{s}^{AON} \in \left\{\frac{C}{N}, \ldots, \frac{C}{2}\right\}$ as any $\frac{C}{k} < r' < \frac{C}{k-1}, k \in 2, \ldots, N$ is weakly dominated by $r = \frac{C}{k}$ as both r and r' require k consumers to bid r resp. r' but $p = F(r) < F(r')$. The probability of success is then given by $I_{(1-F(r))}\left(N - \frac{rN-C}{r}, \frac{rN-C}{r} + 1\right) = I_{(1-F(r))}\left(\frac{C}{r}, \frac{(N+1)r-C}{r}\right)$, where $I_x(\cdot)$ denotes the regularized incomplete beta function (Askey and Roy, 2010).

The producer's optimization problem is therefore

$$\max_{r} I_{(1-F(r))}\left(\frac{C}{r}, \frac{(N+1)r-C}{r}\right), \ s.t. \ r \in \left\{\frac{C}{N}, \ldots, \frac{C}{2}\right\} \ \& \ r \leq \bar{v}$$

For given values of $\bar{v}$, N and C, the optimal reservation price can be determined numerically.

As $N \to \infty$, $\frac{C}{N}$ (the lower bound on r) converges to zero. Because $\max_x I_x(a,b) = 1$ and is reached for all (a,b), when $x = 1$, the maximum involves $1 - F(r) \to 1$, therefore $r \to 0$. ■

Proof of Theorem 5 ← Recall that in GMS, all consumers who obtain a unit of the good pay the same price. Because consumers bid truthfully in GMS, projects are successful if and only if a price p^* exists for which both $p^* = \min\{p \geq r : p \sum_{i=1}^{N} \mathcal{I}\{v_i \geq p\} \geq T\}$ and $p^* \sum_{i=1}^{N} \mathcal{I}\{v_i \geq p^*\} \geq C$. Therefore, the project's success probability is maximized at $T_s^{GMS} = C$ and $r_s^{GMS} = 0$. ■

Proof of Proposition 1 ←

(i) Under a profit objective, the producer in AON optimally sets $T_\pi^{AON} = C$ when consumers play according to the semi-pooling equilibrium (Lemma A4). The good is then produced if and only if $Mr_\pi^{AON} \geq C$, where M is the number of consumers having a value of r_π^{AON} or greater. Define by k the minimum number of consumers bidding r_π^{AON} that is required to fund the project, thus $k = \lceil \frac{C}{r_\pi^{AON}} \rceil$. Now, consider GMS with (possibly suboptimal) $r^{GMS} = r_\pi^{AON}$ and $T^{GMS} = C + \epsilon < kr_\pi^{AON}$ if $kr_\pi^{AON} > C$ and $T^{GMS} = C + \epsilon < (k+1)r_\pi^{AON}$ if $kr_\pi^{AON} = C$, with consumers playing the truthful equilibrium. If $Mr_\pi^{AON} \geq C$, AON and GMS yield the same profit. GMS yields strictly higher profit if $Mr_\pi^{AON} < C$ and a subset S exists for which $v_i \geq \max\left\{r_\pi^{AON}, \frac{T^{GMS}}{|S|}\right\}$ for all $i \in S$. GMS thus yields weakly higher profit than AON. GMS yields strictly higher expected profit than AON if the subset S exists with strictly positive likelihood. As in GMS every equilibrium price $p < \overline{v}$ is implemented with strictly positive likelihood, there need to be at least two equilibrium prices strictly below $\overline{v}$. This is the case if $C < (k-1)\overline{v}$. As $k = \lceil \frac{C}{r_\pi^{AON}} \rceil$, we obtain that GMS yields strictly higher expected profit than AON if $C < (\lceil \frac{C}{r_\pi^{AON}} \rceil - 1)\overline{v}$. ■

(ii) Under a success objective, the producer in AON also optimally sets $T_s^{AON} = C$ (Lemma A4) and chooses $r_s^{AON} \in \left\{\frac{C}{N}, \ldots, \frac{C}{2}\right\}$ s.t. $r \leq \overline{v}$ (Theorem 4). In GMS, the producer optimally sets $T_s^{GMS} = C$ and $r_s^{GMS} = 0$ (Theorem 5). Therefore, equilibrium prices in GMS are in the set $\{\frac{C}{N}, \ldots, C\}$. Thus, producers optimally set the same threshold in AON and GMS, and the set of potentially optimal reservation prices in AON coincides with the set of equilibrium prices in GMS. Therefore, whenever the good is produced in AON, it is also produced in GMS. Now assume that the good is not produced in AON. In this case, the good is produced in GMS if $\exists p : p \sum_{i=1}^{N} \mathcal{I}\{v_i \geq p\} \geq C$. GMS thus yields weakly higher success than AON. GMS yields strictly higher success probability if there are at least two equilibrium prices that are strictly below $\overline{v}$ as every equilibrium price $p < \overline{v}$ is implemented with strictly positive likelihood. Clearly, this is the case if and only if $C < (N-1)\overline{v}$. ■

Proof of Proposition 2 ← Producers optimally set the same threshold in AON and GMS, and the set of potentially optimal reservation prices in AON coincides with the set of equilibrium prices in GMS (cf. Proof of Proposition 1). Now, fix the value vector v. Consider the case that the good is produced in AON at the optimal threshold/reservation price pair C, r_s^{AON}.

Then, it must be the case that $\min\left\{p \geq 0 : p \sum_{i=1}^{N} \mathcal{I}\{v_i \geq p\} \geq C\right\} \leq r_s^{AON}$ because otherwise the good would not have been produced in AON. AON and GMS yield the same total surplus if $\min\left\{p \geq 0 : p \sum_{i=1}^{N} \mathcal{I}\{v_i \geq p\} \geq C\right\} = r_s^{AON}$, as in this case the same consumers obtain the good paying r_s^{AON} each. If $\exists p < r_s^{AON} : p \sum_{i=1}^{N} \mathcal{I}\{v_i \geq p\} \geq C$, then GMS yields strictly higher surplus. If the good is not produced in AON, then GMS yields strictly higher surplus if $\exists p > r_s^{AON} : p \sum_{i=1}^{N} \mathcal{I}\{v_i \geq p\} \geq C$ & $\exists v_i > p$. Together, this implies that GMS yields weakly higher aggregate surplus than AON. Now, note that all candidate reservation prices in AON are reached with strictly positive likelihood in GMS. Thererefore, GMS yields weakly higher expected aggregate surplus than AON if there are at least two candidate reservation prices that are strictly below $\overline{v}$. Clearly, this is the case if and only if $C < (N-1)\overline{v}$. ■

Internet Appendix

B Additional Theoretical Results

AON. Together, Lemmas A1, A2 and A3 show that, unlike in GMS, consumers have an incentive to bid below their value in AON whenever $v_i \neq r$.

We now turn to the properties of a symmetric Bayesian Nash equilibrium bid function $B : [0, \bar{v}] \to [0, \bar{v}]$, if one exists. Let $\rho(b) \equiv P\{\sum_{i=1}^{N-1} B(v_i) \geq T - b\}$ for $b \in [r, \bar{v}]$. $\rho(b)$ denotes the probability that – conditional on the other $N-1$ bidders using the equilibrium strategy – a bid b is sufficient to make the threshold. We call $\rho(b)$ the 'threshold probability function'. Note that this can be written as $1 - G(T - b)$, where G is the cumulative distribution function of $[\sum B(v_i)]$, which is fully determined by F and the functional form of B. Also, $\rho(b) \geq 0$ and $\rho'(b) \geq 0$. A consumer's expected payoff in a symmetric Bayesian Nash equilibrium then equals $\rho(b)(v - b)$. Let $\alpha(b, v) \equiv \rho'(b)(v - b) - \rho(b)$ be the derivative of the expected payoff with respect to bid b. The sign of $\alpha(b, v)$ indicates whether a consumer can increase her expected payoff by infinitesimally increasing her bid.

Before we derive an equilibrium strategy, Lemma B1 first establishes a property of all equilibria in AON.

Lemma B1 *Suppose $(N-1)r > T$. If $B(v_i)$ constitutes a Bayesian Nash equilibrium in undominated strategies of AON, then $B(v_i)$ is weakly increasing.*

Proof Lemma A1 establishes that, $B(v) = 0$ for $v < r$. For $v \geq r$, the proof is by contradiction. Suppose values $v \geq r$ and $w > v$ exist for which $B(v) > B(w)$. Note that the probability that $N-1$ value draws are all larger than or equal to r is positive; together with Lemma A2 and the assumption that $(N-1)r > T$, this implies that $\rho(b) > 0$ for all $b \in [r, \bar{v}]$. A consumer for whom $\rho(B(v)) \leq \rho(B(w))$, strictly prefers bidding $B(w)$ over $B(v)$, which contradicts the assumption that she bids $B(v)$ when her value is v. Now, assume $\rho(B(v)) > \rho(B(w))$. In equilibrium, it must be the case that $\rho(B(v))(v - B(v)) \geq$

$\rho(B(w))(v - B(w))$ and

$$\rho\left(B\left(w\right)\right)\left(w - B\left(w\right)\right) \geq \rho(B(v))(w - B(v)).$$

Because $B(v)$ and $B(w)$ are best responses for v and w, respectively, adding up the two inequalities gives

$$\left(\rho\left(B\left(w\right)\right) - \rho\left(B\left(v\right)\right)\right)\left(w - v\right) \geq 0.$$

This implies $\rho\left(B\left(w\right)\right) \geq \rho(B(v))$, which contradicts $\rho(B(v)) > \rho(B(w))$. ■

The intuition is as follows. Consumers with a value below the reservation price r optimally bid zero (Lemma A1). Consumers with a value above the reservation price face a trade-off: bidding the reservation price maximizes one's payoff if the good is produced while bidding higher increases the likelihood that the good is produced. The latter becomes relatively more important the higher is a consumer's value; this results in a weakly monotonic bidding function.

We can now derive a general form for a symmetric equilibrium bidding strategy under mild assumptions.

Theorem B1 *Suppose $\rho(b)$ is differentiable on the domain $[r, \overline{v}]$ and $\alpha(b, v)$ is decreasing in b for all $b \in [r, v]$ and $v \in [r, \overline{v}]$. Let $\hat{v} \equiv \max\{v : \rho'(r)(v - r) - \rho(r) \leq 0\}$. Consider the bid function B for which $B(v) = 0 \ \forall \ v \in [0, r)$, $B(v) = r \ \forall \ v \in [r, \hat{v})$ and implicitly by $B(v) = v - \frac{\rho(B(v))}{\rho'(B(v))}$ for $v \in [\hat{v}, \overline{v}]$. Then, B constitutes a symmetric BNE of AON.*

Proof Consider consumer i. Suppose all other consumers bid according to B. If $v_i < r$, bidding $B\left(v_i\right) = 0$ is indeed a best response. By Lemmas A3 and B1, for $v_i \geq r$, the optimal bid B^* is in the interval $[r, v_i]$. So, B^* follows from

$$B^* \in \arg\max_{r \leq b \leq v_i} \rho(b)\left(v_i - b\right) \quad .$$

The first order condition is given by

$$\rho'(b)(v_i - b) - \rho(b) = \alpha(b, v_i) \leq 0$$

where equality must hold for any $b > r$ to be a best response. As $\alpha(b)$ is decreasing in b for $b \in [r, v]$ by assumption, the second order condition for a maximum is fulfilled. Therefore, B constitutes a Bayesian Nash equilibrium. ■

Note that B describes a semi-pooling equilibrium when $\hat{v} \geq \overline{v}$. We now present one additional result for optimal producer behavior under a profit objective when consumers play according to such a semi-pooling equilibrium.

Theorem B2 *Suppose that in AON consumers play according to the semi-pooling equilibrium and that F is log-concave. Then for sufficiently large N, the producer maximizes expected profit by setting $r_\pi^{AON} = \frac{1-F(r_\pi^{AON})}{f(r_\pi^{AON})}$.*

Proof For any finite C, and $r = \epsilon$, with ϵ small, there is an N, such that $rN > C$. For this reason, as $\epsilon \rightarrow 0$, almost every r suffices to cover the costs. To optimize, producers must then choose an r that maximizes the expected revenue. Note that $r = 0$ yields zero revenue and no success. Therefore, consider $r > 0$. Expected revenue is then $N(1 - F(r))r$. The first order condition for maximization of the expected revenue is $-f(r)r + 1 - F(r) = 0 \Leftrightarrow r_\pi^{AON} = \frac{1-F(r_\pi^{AON})}{f(r_\pi^{AON})}$ if F is log-concave. ■

Note that Theorem B2 establishes that for large enough N, the reservation price of a profit-maximizing producer will approach the monopoly price. This is intuitive; when N is sufficiently large, the producer does not need to fear falling short of the threshold and can charge any price she feels fit. Also note that this can be achieved for any finite threshold T.

GMS. We now derive additional theoretical results for GMS. We assume that $T \geq C$ and $r < \overline{v}$. Later, we will show that this is fulfilled in any PBE of the two-stage game between producer and consumers.

Let $B_i(v_i)$ denote the bid submitted by consumer i having value $v_i \in [0, \overline{v}]$ and let $p_k \equiv \max\left\{r, \frac{T}{k}\right\}, \; k = 1, \ldots, N$ be the price each successful consumer will pay if k consumers are successful in obtaining the good. Note that p_k is non-increasing in k. The set $\wp = \{p_k, \; k = 1, \ldots, N\}$ then gives all possible prices in GMS. Let $\overline{b} \in [r, T]$ denote a commonly recognized highest equilibrium bid. In other words, all consumers believe that no other consumer will bid higher than $\overline{b}$.

Definition B1 *For $v_i \in [0, \overline{v}]$ and $\overline{b} \in [r, T]$, define the following price levels:*

(i) $p^-(v_i) \equiv \max p_k \in \wp : v_i > p_k$ *if such a p_k exists, and 0 otherwise. $p^-(v_i)$ is the highest price in $\wp$ that gives a consumer with value v_i strictly positive earnings if she obtains the good.*

(ii) $p^{\#}\left(\overline{b}\right) \equiv \max p_k \in \wp : \overline{b} \geq p_k$. *$p^{\#}\left(\overline{b}\right)$ is the highest price in $\wp$ that is smaller than the maximum bid $\overline{b}$. Note that by its definition, $p_k \geq r, \; \forall k$. Because $\overline{b} \geq r$, we have $p^{\#}\left(\overline{b}\right) \geq r$.*

(iii) $p^+(v_i) \equiv \min p_k \in \wp : v_i < p_k$, *$p^+(v)$ is the lowest price in $\wp$ that gives a consumer with value v_i negative earnings when obtaining the good for that price.*[26] *Note that by assumption $\overline{v} < C \leq T$. Therefore, $p_1 = T > \overline{v} \geq v_i$, so $p^+(v_i)$ always exists for $v_i \in [0, \overline{v}]$. Also note that $p^+(v_i) > p^-(v_i)$.*

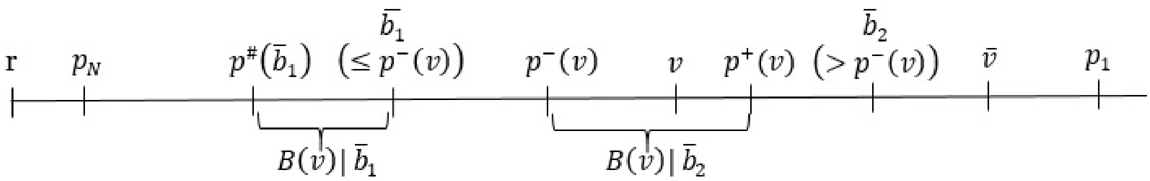
Figure B1 denotes the relative positions of the price levels in Definition B1.

Theorem B3 *Fix $\overline{b} \in [r, T]$. Let, for consumer $i = 1, \ldots, N$, B_i be given by $B_i(v_i) \in [0, r)$ if $v_i < r$, and*

$$B_i(v_i) \in \begin{cases} \left[r, \overline{b}\right] & \text{if } p^{\#}\left(\overline{b}\right) \leq r \\ \left[p^{\#}\left(\overline{b}\right), \overline{b}\right] & \text{if } p^{\#}\left(\overline{b}\right) > r \text{ and } \overline{b} < p^-(v_i) \\ \left[p^-(v_i), \overline{b}\right] & \text{if } p^{\#}\left(\overline{b}\right) > r \text{ and } p^-(v_i) \leq \overline{b} < p^+(v_i) \\ \left[p^-(v_i), p^+(v_i)\right) & \text{if } p^{\#}\left(\overline{b}\right) > r \text{ and } \overline{b} \geq p^+(v_i) \end{cases}$$

[26] To illustrate, for $N = 15$, $T = 5$, and $r = 1$, $\wp = \{5, 2.5, 1.67, 1.25, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1\}$. Assume that $v_i = 1.3$. If $\overline{b} = 2 > v_i$, then $p^-(1.3) = p_4 = 1.25$. If $\overline{b} = r = 1 < v_i$, then $p^{\#}(1) = 1$. Moreover, i has negative earnings for any of the $p_k = 1.67, 2.5, 5$, so $p^+(1.3) = 1.67$.

Figure B1: Illustration of Price Levels



Notes: Variables are defined in the main text and Definition B1. In this example, $p_N > r$, but $p_N = r$ is also possible. $B(v)|\bar{b}$ denotes an equilibrium bid given value v under maximum equilibrium bids $\bar{b} = \bar{b}_1, \bar{b}_2$ (see Theorem B3).

otherwise. Then B_i*,* $i = 1, \ldots, N$*, constitutes a Bayesian-Nash equilibrium of GMS.*

Proof First note that no bids larger than $\bar{b}$ can be sustained in equilibrium, because this would violate the rationality of beliefs. In equilibrium it must therefore hold that $b_i \leq \bar{b}$, $\forall i$. Also note that for consumers with $v < r$, bidding more than r is never profitable, because if the good is produced, they would pay more than its value. Bidding any amount strictly below r results in paying 0 and not obtaining the good and is therefore a weakly best response when $v < r$. In what follows, we consider consumers with $v \geq r$.

Now, first assume that $\bar{b} < p_N = max\left\{r, \frac{T}{N}\right\}$. Because $\bar{b} \geq r$, it holds that $p_N > r$, giving $T > Nr$. That is, at price r, the good is not produced and all consumers earn zero. Because $p_N \leq p_{N-1} \leq \cdots \leq p_1$, $\bar{b} < p^-(v)$, $\forall v \geq p_N$. The theorem then stipulates that $B(v) = \left[r, \bar{b}\right]$ for all consumers with $v \geq r$. This gives a price equal to r, ergo, the good is not produced in equilibrium. Bidding more than r does not change the price, nor the chance of success and is therefore not a profitable deviation. Because no equilibrium exists with bids exceeding $\bar{b}$, this is the only equilibrium when $\bar{b} < p_N$.

For $\bar{b} \geq p_N$, we distinguish between four cases.

1. If $p^{\#}\left(\bar{b}\right) \leq r$, $B(v) = \left[r, \bar{b}\right]$, $\forall v \geq r$. If $T \leq Nr$, there is a positive probability that the good will be produced at price r, giving the consumer with $v > r$ positive expected earnings. Bidding less than r reduces expected earnings to zero irrespective of others' bids. Thus, $B(v) = \left[r, \bar{b}\right]$ is the unique symmetric equilibrium set when $p^{\#}\left(\bar{b}\right) \leq r$.

2. If $p^{\#}\left(\overline{b}\right) > r$, then for $v : \overline{b} < p^{-}(v)$, $B(v) = \left[p^{\#}\left(\overline{b}\right), \overline{b}\right]$. The good is produced with positive probability at a price between r and $p^{\#}\left(\overline{b}\right)$. Bidding $\beta \in \left[r, p^{\#}\left(\overline{b}\right)\right)$ does not affect the consumer's prospects in those realized value distributions where biding $p^{\#}\left(\overline{b}\right)$ yields a price in $[r, \beta]$. If doing so yields a price in $\left(\beta, p^{\#}\left(\overline{b}\right)\right]$, these earnings opportunities are lost by bidding β. This is therefore not a profitable deviation. Similarly, bidding $\beta \in \left[r, p^{\#}\left(\overline{b}\right)\right)$ cannot be part of a symmetric BNE because deviating to the range $\left[p^{\#}\left(\overline{b}\right), \overline{b}\right]$ is profitable.

3. If $p^{\#}\left(\overline{b}\right) > r$, then for $v : p^{-}(v) \leq \overline{b} < p^{+}(v)$, $B(v) = \left[p^{-}(v), \overline{b}\right]$. Bidding $\beta \in [r, p^{-}(v))$ does not affect the consumer's prospects in those realized value distributions where biding $p^{-}\left(\overline{b}\right)$ yields a price in $[r, \beta]$. If doing the latter yields a price in $(\beta, p^{-}(v)]$, these opportunities are lost by bidding β. This is therefore not a profitable deviation. Once again, bidding below $p^{-}(v)$ cannot be part of a symmetric BNE because a deviation to $B(v) = \left[p^{-}(v), \overline{b}\right]$ is profitable.

4. If $p^{\#}\left(\overline{b}\right) > r$, then for $v : \overline{b} \geq p^{+}(v)$, $B(v) = [p^{-}(v), p^{+}(v))$. For the same reason as in (iii), bidding less than $p^{-}(v)$ is not a profitable deviation. Moreover, bidding $p^{+}(v)$ or more only adds realizations of value distributions where the consumer obtains the good, but makes a loss. There is therefore no profitable deviation. On the other hand, bidding more than or equal to $p^{+}(v)$ is not part of a BNE because a profitable deviation to $B(v) = [p^{-}(v), p^{+}(v))$ exists. ■

This equilibrium involves the following bidding. If a consumer believes that the other consumers will bid 'high', then the consumer bids in some range around her value. This range is determined by the two prices in $\wp$ that are just below and just above one's v. This ensures that the consumer will be successful in acquiring the good for all realizations of $p_k \in \wp$ where she has positive earnings and that she will not acquire the good for any $p_k \in \wp$ where her earnings are negative. Notice that the 'truthful' equilibrium is included.

Another type of equilibria occurs when bidding close to one's value would imply bidding higher than the maximum possible bid expected from any other consumer. In this case, the consumer will bid anywhere between the highest price in $\wp$ that is below this maximum and the maximum itself. Note that this makes the maximum a self-fulfilling prophecy. We call this the set of 'conformism' equilibria, because it involves consumers conforming to what they expect others to do. If everyone expects all bids to always be below a certain number, then nobody will bid above that number in equilibrium. Observe that conformism equilibria involve common beliefs that may be unlikely to be observed behaviorally. One exception is that consumers might believe that nobody will ever bid more than the reservation price, which can serve as a focal point. In this case, bidding the reservation price whenever $v \geq r$ constitutes a BNE for consumers under GMS, which yields a semi-pooling equilibrium if consumers with $v < r$ bid $b = 0$.[27]

The equilibrium set displayed in Theorem B3 is large. At the same time, many equilibria are 'implausible' in that they involve weakly dominated strategies. To obtain a sharper equilibrium prediction, we first present results regarding weakly dominant bidding.

Lemma B2 *In GMS, for consumer i having value* $v_i < max\left\{r, \frac{T}{N}\right\}$*, bidding* $b \geq max\left\{r, \frac{T}{N}\right\}$ *is weakly dominated by bidding* 0*.*

Proof Suppose consumer i has value $v_i < max\left\{r, \frac{T}{N}\right\}$. Then, her expected utility when bidding 0 equals zero. When bidding $b \geq max\left\{r, \frac{T}{N}\right\}$, her expected utility equals 0 if she does not obtain the good and is strictly negative if does obtain the good (because the price she pays is at least $max\left\{r, \frac{T}{N}\right\}$, which is greater than v_i). The latter case occurs if all other consumers bid b. ■

Lemma B3 *In GMS, for consumer i having value* $v_i > max\left\{r, \frac{T}{N}\right\}$*, bidding* $b < p^-(v_i)$ *is weakly dominated by bidding* $B_i(v_i) = v_i$*.*

Proof Suppose consumer i has value $v_i > max\left\{r, \frac{T}{N}\right\}$. As $B_i(v_i) = v_i$ is a weakly dominant strategy (Theorem 2), consumer i's expected utility from bidding $B_i(v_i) = v_i$ is at least as

[27] Conformism equilibria arise because our assumptions that $C > \bar{v}$ and $T \geq C$ make it impossible for any consumer to fund the good alone. It is then never profitable to bid more than the maximum expected from others because this could only change the price and production decision to a level where only the lone consumer would remain.

great as when bidding $b < p^-(v_i)$ for any strategy profile chosen by the other consumers. To construct a strategy profile by the other consumers for which consumer i obtains strictly higher expected utility by bidding $B_i(v_i) = v_i$ than by bidding b, take $k \in \{1, \ldots, N\}$ for which $p_k = p^-(v_i)$. Suppose $k - 1$ consumers other than consumer i always bid p_k regardless of their value and the remaining $N - k$ consumers bid 0 regardless of their value. Notice that $b < p^- (v_i) = p_k = max \left\{r, \frac{T}{k}\right\}$ implies that no price $p \geq r$ exists for which $p \leq b$ and $kp \geq T$. As a result, consumer i obtains zero utility when bidding b because the good will not be produced. In contrast, when bidding $B_i(v_i) = v_i$, consumer i obtains the good for price $p_k = p^- (v_i) < v_i$ and realizes utility $v_i - p_k > 0$. ■

Lemma B4 *In GMS, for consumer* i *having value* $v_i > max \left\{r, \frac{T}{N}\right\}$, *bidding* $b \geq p^+(v_i)$ *is weakly dominated by bidding* $B_i(v_i) = v_i$.

Proof Suppose consumer i has value $v_i > max \left\{r, \frac{T}{N}\right\}$. As $B_i(v_i) = v_i$ is a weakly dominant strategy (Theorem 2), consumer i's expected utility from bidding $B_i(v_i) = v_i$ is at least as great as when bidding $b \geq p^+(v_i)$ for any strategy profile chosen by the other consumers. To construct a strategy profile by the other consumers for which consumer i obtains strictly higher expected utility by bidding $B_i(v_i) = v_i$ than by bidding b, take $k \in \{1, \ldots, N\}$ for which $p_k = p^+(v_i)$. Observe that (1) $p^+ (v_i) > v_i$ by definition and (2) $v_i > max \left\{r, \frac{T}{N}\right\} \geq r$ by assumption. Therefore, $p_k = p^+ (v_i) > v_i > r$ so that, in turn, $p_k \equiv max \left\{r, \frac{T}{k}\right\} = \frac{T}{k}$. Suppose $k - 1$ consumers other than consumer i always bid p_k regardless of their value and the remaining $N - k$ consumers bid 0 regardless of their value. Notice that $v_i < p^+(v_i) = p_k = \frac{T}{k}$ implies that no price $p \geq r$ exists for which $p \leq B_i(v_i) = v_i$ and $kp \geq T$. As a result, consumer i obtains zero utility when bidding $B_i(v_i) = v_i$ because the good will not be produced. In contrast, when bidding b, consumer i obtains the good for price $p_k = p^+ (v_i) > v_i$ and realizes utility $v_i - p_k < 0$. ■

Lemmas B2, B3 and B4 imply that a large range of equilibria displayed in Theorem B3 is weeded out if the equilibrium set is limited to equilibria in undominated strategies. The following result presents the resulting equilibria in undominated strategies.

Theorem B4 *Bidding strategies* B_i, $i = 1, \ldots, N$, *constitute a Bayesian-Nash equilibrium in undominated strategies of GMS if and only if* $B_i(v_i) \in [p^-(v_i), p^+(v_i))$.

Proof First, note that every bid $p^-(v_i) \leq b_i < p^+(v_i)$ always yields the same payoff as $b_i = v_i$ as in both cases, consumer i obtains the good if the good is produced and a price $p \leq p^-(v_i)$ is implemented. As bidding one's own value is weakly dominant (Theorem 2), bidding $p^-(v_i) \leq b_i < p^+(v_i)$ is thus also weakly dominant. For $v_i > \max\left\{r, \frac{T}{N}\right\}$ all other bids are weakly dominated (Lemmas B3 and B4). For $v_i < \max\left\{r, \frac{T}{N}\right\}$, bidding $p^-(v_i) \leq b_i < p^+(v_i)$ translates to bidding $0 \leq b_i < v_i < \max\left\{r, \frac{T}{N}\right\}$. Such a bid always yields the same payoff as bidding zero as in both cases consumer i never obtains the good and thus obtains a payoff of zero. Other bids are weakly dominated (Lemma B2). For $v_i = \max\left\{r, \frac{T}{N}\right\}$ bidding $p^-(v_i) \leq b_i < p^+(v_i)$ translates to bidding $0 \leq b_i < \min p_k \in \wp : v_i < p_k$. For all these bids, consumer i always obtains a payoff of zero. In contrast, bidding $b_i \geq \min p_k \in \wp : v_i < p_k$ yields a loss if the consumer obtains the good and is thus weakly dominated. Put together, bidding strategies B_i, $i = 1, \ldots, N$, constitute a Bayesian-Nash equilibrium in undominated strategies of GMS if and only if $B_i(v_i) \in [p^-(v_i), p^+(v_i))$. ■

To weed out Bayesian-Nash equilibria in undominated strategies, an extension of (trembling-hand) perfect equilibrium to continuous games with incomplete information can be used (see e.g. Bajoori et al., 2016). More in particular, let $\underline{m} \equiv \min\{k = 1, \ldots, N : p_k > r\}$. Then, weakly dominated strategies are not in the set of best responses of any perturbed game that puts a strictly positive probability mass on bids in each of the intervals $\left[r, p_{\underline{m}}\right), \left[p_{\underline{m}}, p_{\underline{m}-1}\right), \ldots, [p_3, p_2), [p_2, p_1 = T]$.

While the equilibrium set established in Theorem B4 is still large, the equilibria are essentially equivalent – with the exception of zero-mass events where $v_i = p_k$ for some i, k. They are equivalent in that given a set of values drawn, the equilibria are outcome identical, i.e. they yield the same allocation (whether or not the good is produced and if so, which of the consumers obtains it) and the same price, if the good is produced. We make this claim more precise in the following analysis.

Definition B2 *Let* $v \equiv (v_1, v_2, \ldots, v_N)$ *be the vector of values and* $M(p,v) \equiv \{\#i, 1 \leq i \leq N : v_i \geq p\}$ *the number of consumers whose value is at least* $p \geq r$. *Define the following price level, if it exists:*

$$p^s(v) \equiv \min\{p \in \wp : pM(p,v) \geq T\}$$

Theorem B5

(i) In any non-zero mass trembling-hand perfect equilibrium of GMS, the good is produced if and only if $p^s(v)$ *exists.*

(ii) If $p^s(v)$ *exists, the good is allocated to all consumers* i *for whom* $v_i \geq p^s(v)$. *Those consumers pay* $p^s(v)$.

Proof Theorem B4 presents the full set of equilibria in undominated strategies of GMS. Take such an equilibrium and let $B(v) \equiv (B_1(v_1), \ldots, B_N(v_N))$ be the vector of bids submitted given value realizations $v_1, v_2, \ldots, v_N$. Part (i) follows directly from the definitions of the GMS mechanism and $p^s(v)$. To prove part (ii), note that $B_i(v_i) \in [p^-(v_i), p^+(v_i))$ implies that for all $p \in \wp$, $v_i \geq p \Leftrightarrow B_i(v_i) \geq p$. As a result, $M(p, B(v)) = M(p,v)$. Therefore, the equilibrium price $p^*(B(v))$, if it exists, is given by $p^*(B(v)) = \min\{p \in \wp : pM(p, B(v)) \geq T\} = \min\{p \in \wp : pM(p,v) \geq T\} = p^s(v)$. Moreover, consumer i obtains the good if and only if $B_i(v_i) \geq p^*(B(v))$ or, equivalently, if and only if $v_i \geq p^s(v)$. ■

C Additional Tables and Figures

Table C1: Pooled Objectives

	Profit (1)		Success (2)		Surplus (3)	
Mean of AON	11.228		0.467		27.456	
sGMS	-0.450		-.052		-6.490	
	(2.959)	*	(0.049)	**	(7.200)	**
dGMS	3.983**		0.040		7.175*	
	(2.256)		(0.040)		(4.950)	
Threshold	-0.851***		-0.013***		-2.009***	
	(0.061)		(.000)		(0.146)	
Reservation Price	2.060***		-0.002		-1.168***	
	(0.274)		(.004)		(0.398)	
Mean value	11.651***		0.151***		27.845***	
	(0.772)		(.009)		(1.352)	
Observations	540		540		540	
(Pseudo-) R^2	0.21		0.56		0.19	

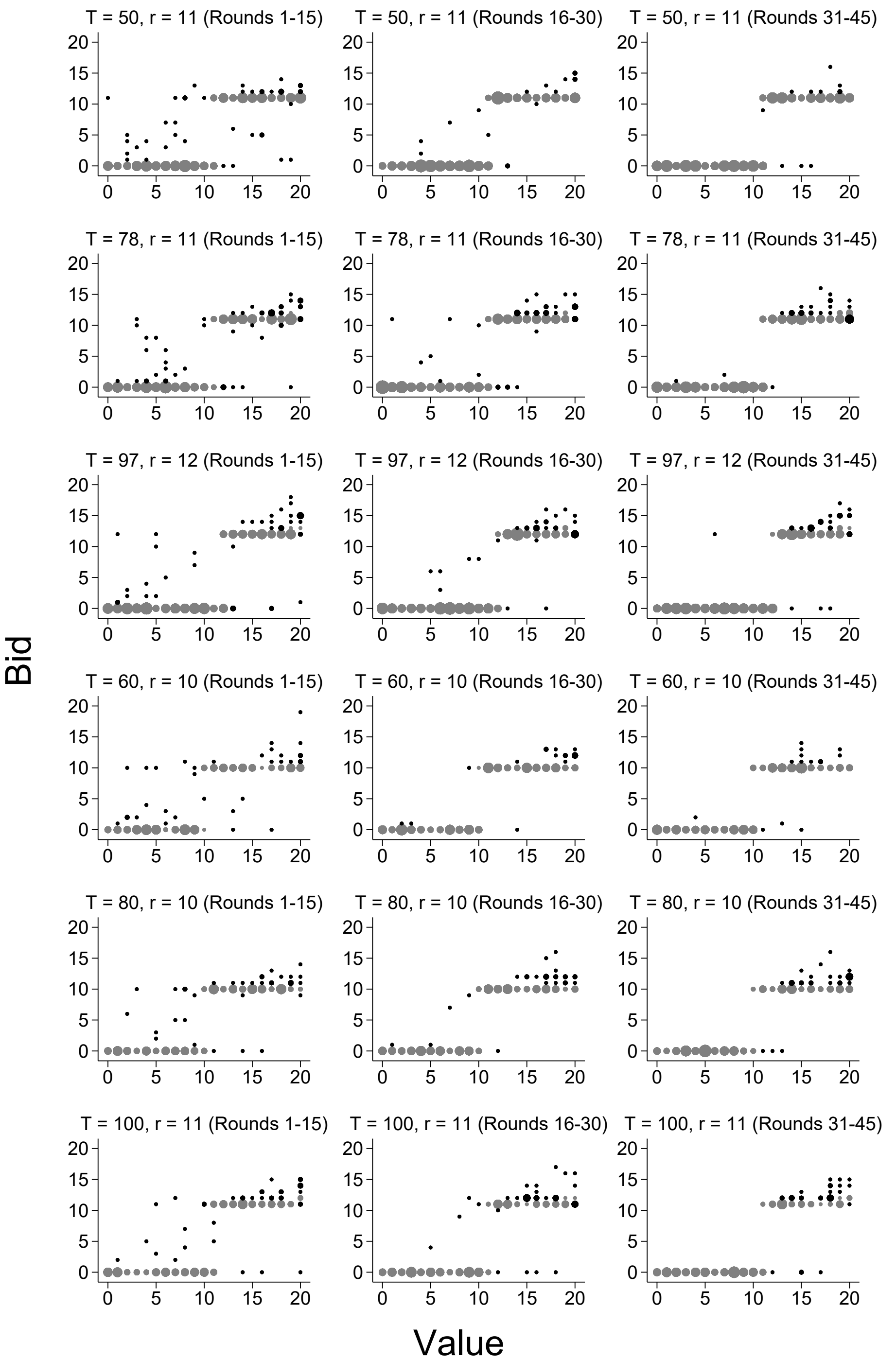
Notes: The table shows estimates of tobit regressions for profit and surplus in columns 1 and 3, and marginal effects of probit regressions for success in column 2. Robust standard errors clustered on the producer level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ in one-tailed hypothesis testing with the hypotheses that dGMS > AON, sGMS > AON and dGMS > AON in each of the three outcome measures.

Table C2: Bidding Behavior over Time

		Rounds		
		1 – 15	16 – 30	31 – 45
AON	Overbidding	0.14	0.10	0.08
	Best response	0.82	0.87	0.89
	Underbidding	0.04	0.03	0.02
sGMS	Overbidding	0.07	0.07	0.07
	Weakly Dominant Bids	0.63	0.72	0.75
	Underbidding	0.30	0.21	0.18
dGMS	Overbidding	0.05	0.04	0.03
	Possibly Weakly Dominant Bids	0.81	0.90	0.93
	Underbidding	0.14	0.06	0.03

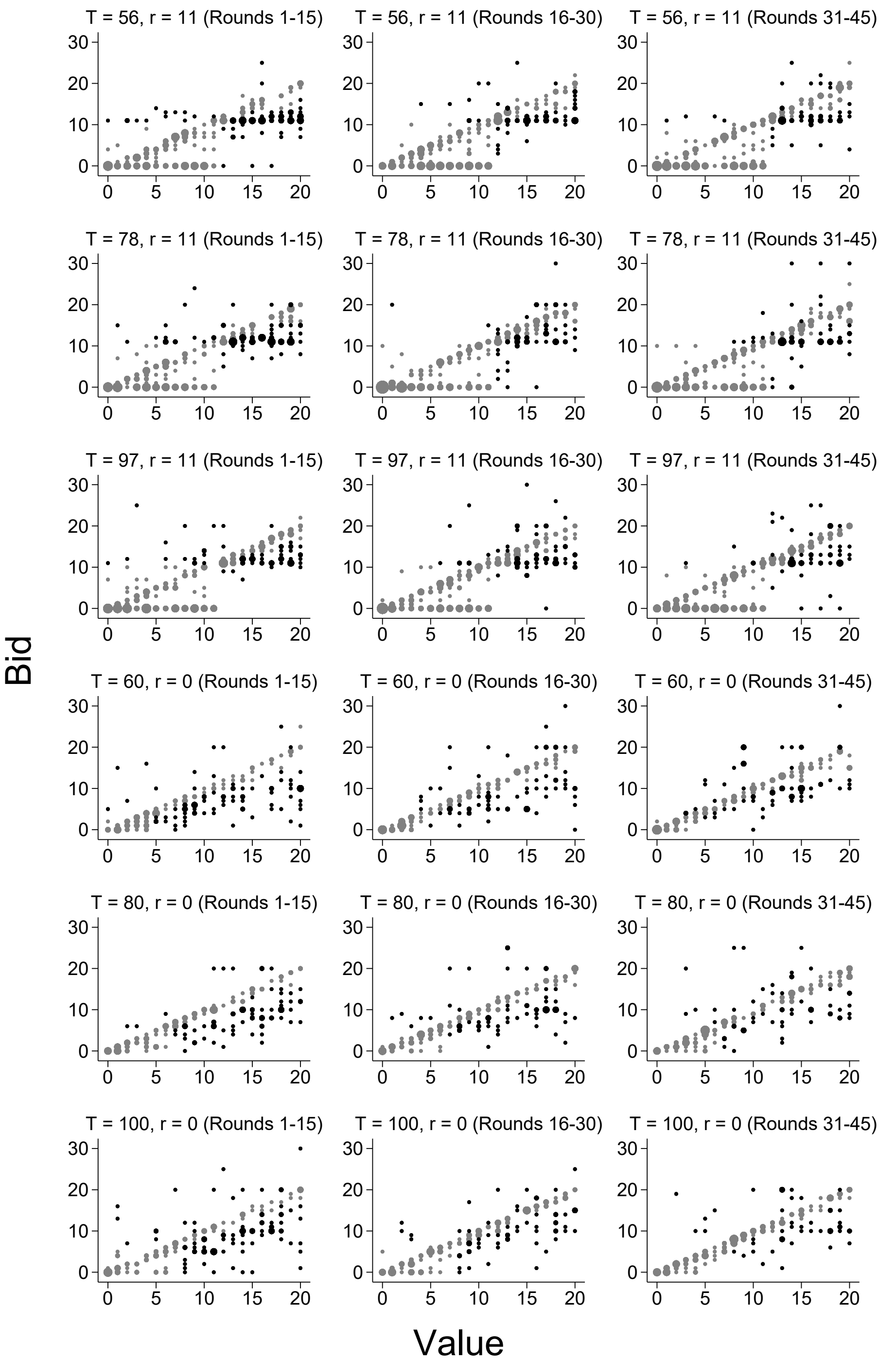
Notes: The table depicts the frequency of overbidding, underbidding and bids in line with the theoretical Bayesian-Nash equilibrium (AON) resp. weakly dominant bids (sGMS and dGMS) over rounds 1 to 15, 16 to 30 and 31 to 45.

Figure C1: Bidding Behavior in AON over Time



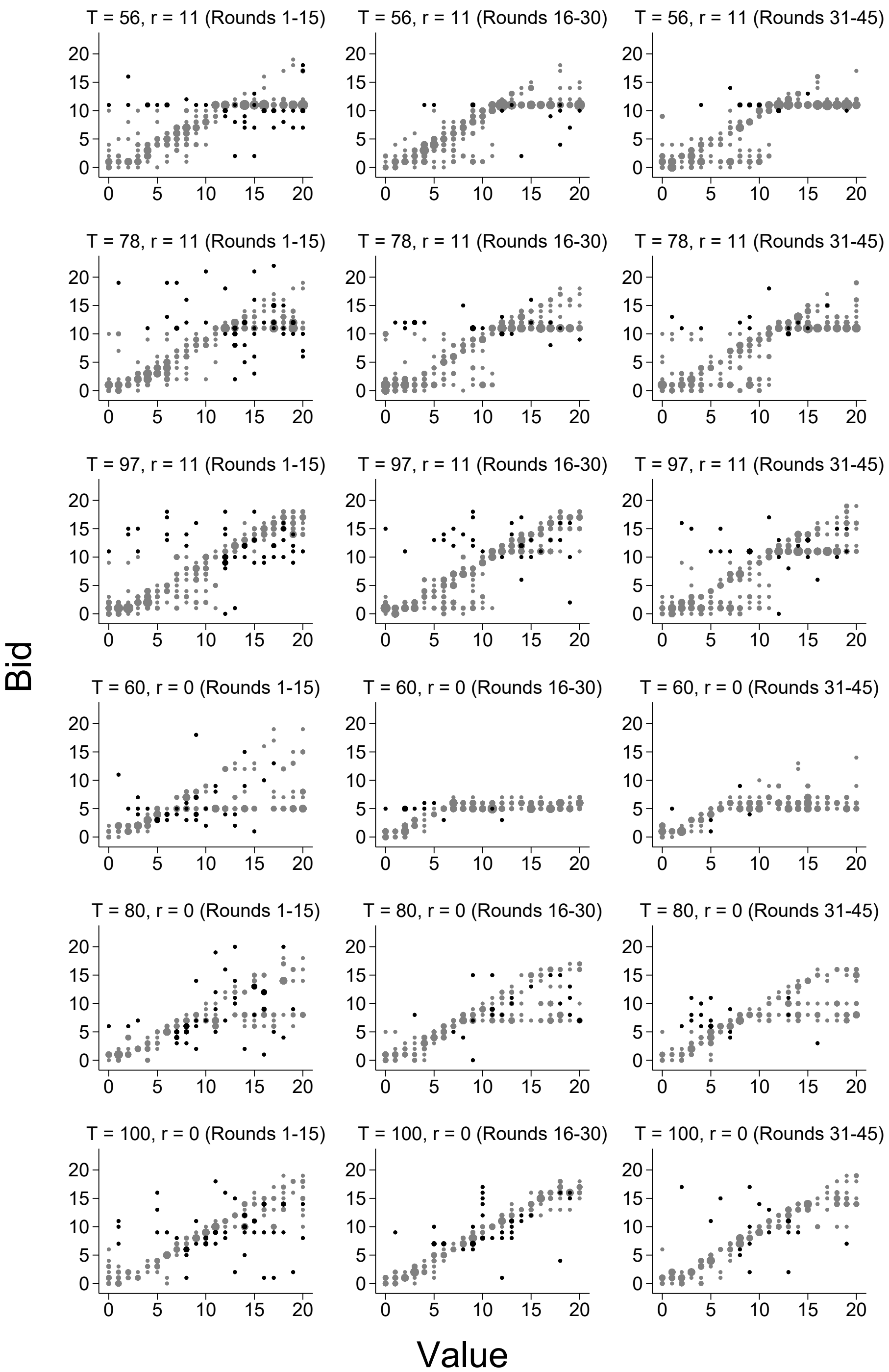
Notes: The figure depicts the frequency of bid-value combinations in AON for each T, r combination, split by rounds. The larger the dot, the more frequent a bid-value combination occurred. Gray dots denote observed best responses to the symmetric theoretical equilibrium bidding functions. Black dots denote bids that deviate from the best responses.

Figure C2: Bidding Behavior in sGMS over Time



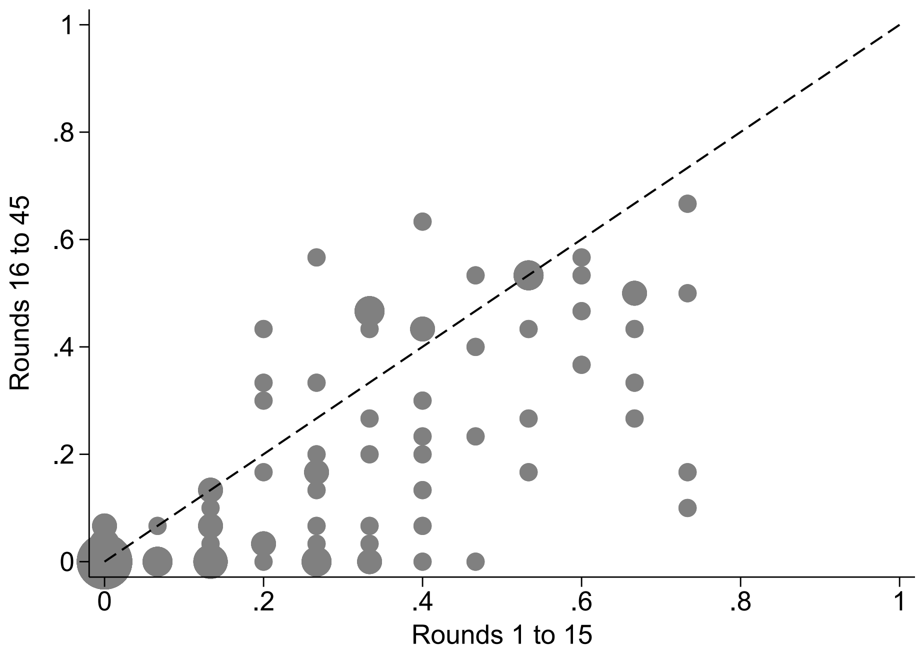
Notes: The figure depicts the frequency of bid-value combinations in sGMS for each T, r combination, split by rounds. The larger the dot, the more frequent a bid-value combination occurred. Gray dots denote weakly dominant bids. Black dots denote weakly dominated bids.

Figure C3: Bidding Behavior in dGMS over Time



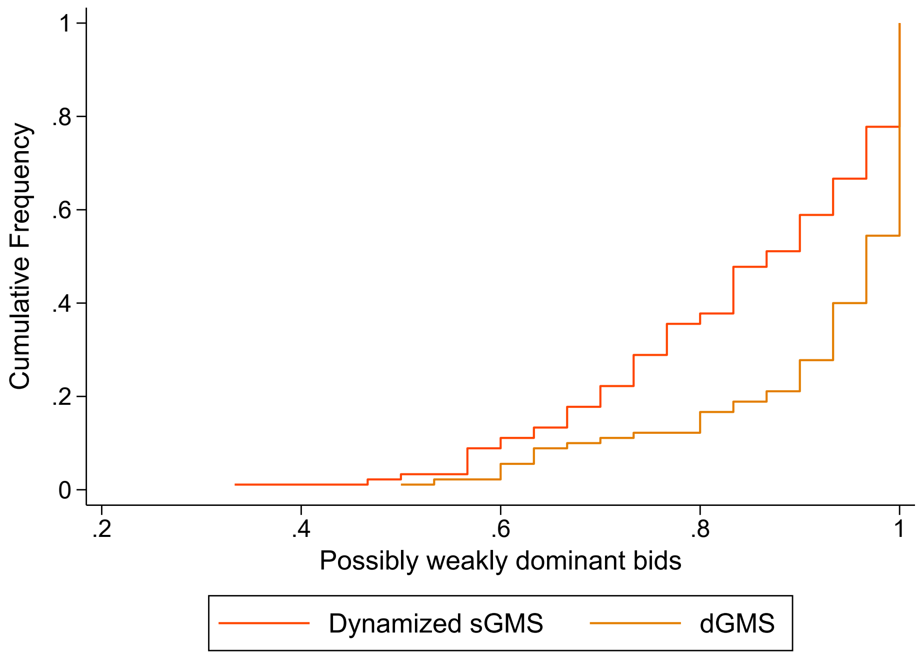
Notes: The figure depicts the frequency of bid-value combinations in dGMS for each T, r combination, split by rounds. The larger the dot, the more frequent a bid-value combination occurred. Gray dots denote possibly weakly dominant bids. Black dots denote surely weakly dominated bids.

Figure C4: Share of Underbidding over Time in sGMS



Notes: The figure depicts the share of underbidding in sGMS in rounds 1 to 15 (horizontal axis) and 16 to 45 (vertical axis) for every consumer. The larger the dot, the more frequent a combination occurred.

Figure C5: Distribution of Possibly Weakly Dominant Bids



Notes: The figure depicts the distribution of consumers' shares of possibly weakly dominant bids in dGMS and in the dynamized sGMS.

D Simulations

This section describes the algorithms that we used in our simulations to obtain theoretical predictions for AON and GMS for the experimental parameters.

AON: We use simulations to determine equilibrium producer's behavior in AON using the following simulation algorithm.

1. Specify the number of consumers $N = 15$, project costs $C \in \{50, 60, \ldots, 100\}$, and number of simulations S. Set simulation $s = 1$. Set threshold $T = 0$, and minimum price $r = 0$. Set the candidate price $p = r$. Draw a matrix of $N \times S$ with i.i.d. values from a discrete uniform distribution $\{0, 1, \ldots, 19, 20\}$. Denote this matrix by v. Create a matrix *Payoff* of 21×21 with each element $\mathit{Payoff}_{ij} = i - j$. Create a matrix *Bid* of $S \times 21$ with elements $\mathit{Bid}_{ij} = j - 1$. Create matrices *SumB* and *Suc* each of $S \times 21$ with elements of zero. Set $\mathit{count} = 1$. Set $\mathit{rounds} = 1000$.

2. Create a weighing matrix of 21×21 with elements of one. Denote this matrix by *Weight*.

3. If $s \leq S$, randomly draw (with replacement) $N - 1$ elements of *Weight*, add them together, and use this result to update elements SumB_{sj} $\forall\ j \in \{1, 2 \ldots, 20, 21\}$. Add *SumB* and *Bid* together and compare each element to T. If the result is weakly positive, set $\mathit{Suc}_{sj} = 1$, otherwise set $\mathit{Suc}_{sj} = 0$, set $s = s + 1$, and repeat step 3. If $s > S$, set $s = 1$, and proceed to step 4.

4. Create a matrix *Meansuc* of 21×21 by taking the mean of *Suc* and replicating the resulting row 20 times. Create a matrix *Utility* of 21×21 by elementwise multiplying *Meansuc* with *Payoff*.

5. Determine the vector J of 21×1 that specifies the column of the element that maximizes *Utility* in a given row. Update $\mathit{Weight}_{ij} = \mathit{Weight}_{ij} + \mathit{count}\ \forall\ \mathit{Weight}_{ij} : j = J_i$. Set $\mathit{count} = \mathit{count} + 1$. If $\mathit{count} \leq \mathit{rounds}$, proceed with step 3. If $\mathit{count} > \mathit{rounds}$, set $\mathit{count} = 1$, and proceed with step 6.

6. Create a matrix *Contributions* of $N \times S$ such that $Contributions_{ij} = k$ where k is chosen randomly between $\{1, 2, \ldots, 20, 21\}$ with likelihood $\frac{Weight_{v_{ij}k}}{\sum_{l \in \{1,2,\ldots,20,21\}} Weight_{v_{ij}l}}$. Then create a vector X of $1 \times S$ that column-wise sums up $\boldsymbol{Contributions}$. Create a vector Y of $1 \times S$ that column-wise sums up all elements in v that are weakly above r.

7. Under a profit objective, if $s \leq S$ & $X_s \geq T$, set $Profit_s = X_s - C$ and $Surplus_s = Y_s - C$. Set $s = s + 1$, and repeat step 7. If $s \leq S$ & $X_s < T$, set $Profit_s = 0$ and $Surplus_s = 0$, set $s = s + 1$, and repeat step 7. If $s > S$, set $s = 1$, and skip to step 8. Under a success objective, if $s \leq S$ & $X_s \geq T$ & $X_s \geq C$, set $Success_s = 1$ and $Surplus_s = Y_s - C$. Set $s = s + 1$, and repeat step 7. If $s \leq S$ & $(X_s < T \mid X_s < C)$, set $Profit_s = 0$ and $Surplus_s = 0$, set $s = s + 1$, and repeat step 7. If $s > S$, set $s = 1$, and skip to step 8.

8. Update elements $Meanprofit_{rT}$, $Meansuccess_{rT}$ and $Meansurplus_{rT}$ by taking the mean of *Profit*, *Success* and *Surplus* respectively. If $T < 300$ & $r < 20$, set $T = T + 1$ and proceed with step 2. If $T \geq 300$ & $r < 20$, set $T = 0$ and $r = r + 1$, and proceed with step 2. If $r \geq 20$, proceed with step 9.

9. Under a profit objective, determine the maximal element of *Meanprofit* and the corresponding r^* and T^*. Under a success objective, determine the maximal element of *Meansuccess* and the corresponding r^* and T^*. In either case, determine the corresponding $Meansurplus_{r^* T^*}$.

GMS: We use the analytic results from Theorem 2 that consumers bid their own value, and from Theorem 5 that the producer maximizes the project's success probability by setting $T = C$ and $r = 0$. We use simulations to determine optimal producer's behavior under a profit objective using the following simulation algorithm.

1. Specify the number of consumers $N = 15$, project costs $C \in \{50, 60, \ldots, 100\}$, and number of simulations S. Set threshold $T = 0$, and minimum price $r = 0$. Set the candidate price $p = r$. Set simulation $s = 1$. Draw a matrix of $N \times S$ with i.i.d. values from a discrete uniform distribution $\{0, 1, \ldots, 19, 20\}$. Denote this matrix by v.

2. If $s > S$, set $s = 1$ and skip to step 3. If $s \leq S$, create a scalar X by multiplying p with the sum of elements of column s in v that are weakly above p. Compare X with T. If $X < T$ & $p \leq 20$, set $p = p + 1$ and repeat step 2. If $X < T$ & $p > 20$, set elements $Profit_s = 0$ and $Surplus_s = 0$. Then set $p = r$ and $s = s + 1$, and repeat step 2. If $X \geq T$, create a scalar Y that sums up all elements of column s in v that are weakly above p. Set elements $Profit_s = X - C$ and $Surplus_s = Y - C$. Then set $p = r$ and $s = s + 1$, and repeat step 2.

3. Update elements $Meanprofit_{rT}$ and $Meansurplus_{rT}$ by taking the mean of *Profit* and *Surplus* respectively. If $T < 300$ & $r < 20$, set $T = T + 1$ and proceed with step 2. If $T \geq 300$ & $r < 20$, set $T = 0$ and $r = r + 1$, and proceed with step 2. If $r \geq 20$, proceed with step 4.

4. Determine the maximal element of *Meanprofit* and the corresponding r^* and T^*. Then determine the corresponding $Meansurplus_{r^* T^*}$.

E Instructions

E.1 AON

Instructions:

A summary of these instructions on paper will be distributed before the experiment starts. Welcome to this experiment on decision making. The instructions for this experiment are simple, and if you follow them carefully, you can earn a considerable amount of money. What you earn depends on the decisions you make and on the decisions of the others. You will be privately paid at the end of the experiment. We ask that you do not communicate with other people during the experiment. Please refrain from verbally reacting to events that occur during the experiment. This is very important. Raise your hand when you have a question and one of the experimenters will come to your table.

These instructions consist of eight pages like this. You may page back and forth by using your mouse to click on "previous page" or "next page" at the bottom of your screen. On the last instruction page you will see the button "ready" at the bottom of your screen. Click this button if you have completely finished with all pages of the instructions.

Producer and Consumers: In this experiment you will be assigned the role of either the producer of a good or a consumer. The payoffs that you obtain during the experiment determine the money that you will receive at the end. Earnings in the experiment will be denoted by "francs". At the end of the experiment, francs will be exchanged for euros. The exchange rate is 1 euro for every 8 francs. We will give you a number of francs to start with. This starting capital equals 56 francs (or 7 euros).

Rounds: Today's experiment consists of 45 rounds. In each round, a producer decides whether or not to produce a fictitious good and sell it to consumers. In the experiment, you will either be producer or consumer. One participant plays the role of producer. The producer can produce a fictitious good that is valuable for the consumers. The 15 other participants play the role of consumer. The producer can only produce the good if she raises sufficient funds to cover her production costs. The producer's production costs are fixed: They do not depend on the number of goods sold. Moreover, only the producer is informed about her costs. The consumers do not know the producer's costs. The producer's costs may vary from one round to the next. The consumers interact in a market. In this market, it is determined whether the producer actually produces the good. Moreover, if the good is produced, the market determines which consumers buy the good and for what price.

The Value of the Good: The value of the fictitious good will typically differ from one consumer to the next. To be more precise, in every round, the computer will draw a new value for every consumer. Values are randomly drawn from the set 0,1,2,. . . ,19,20. Note the following about the value for the good:

1. The value for a consumer is determined independently of the values for the other consumers;
2. Any value in the set {0,1,2,. . . ,19,20} is equally likely;
3. Each consumer only learns her own value, not the value of the other consumers;
4. The producer is not informed about the values of any of the consumers.

The Market: At the start of a round, the producer is informed about her or his costs and all consumers are told their value. The producer then decides on a target amount and a minimum price. In each period, all consumers offer a price to the producer. The prices that consumers offer may differ from one consumer to another. Consumers can only obtain the good if they offer a price equal to or higher than the minimum price. After all offers have been received, the computer determines whether the producer will actually produce the good. More in particular, the computer adds up all offers. The producer will produce the good if the sum of these offers is equal to or higher than the target amount. If the good is produced, all consumers pay the price they offered. All consumers who offered at least the minimum price obtain the good. Consumers who offered less, do not obtain the good but still pay the price they offered. If the sum of offers is lower than the target amount, the good is not produced. Consumers do not obtain the good and make no payments.

Example: To illustrate the market, suppose the target amount equals 85 and the minimum price is 7. The consumers' offers are

$$0 - 0 - 0 - 1 - 2 - 7 - 7 - 7 - 8 - 8 - 9 - 9 - 10 - 11 - 12$$

The sum of the offers equals 91. Because the target amount is reached, the good will be produced. All 15 consumers pay the price they offered and the 10 consumers who offered at least 7 also obtain the good. The consumers who offered 1 and 2 do not obtain the good but still pay the price they offered.

Producer Payoffs: The way the producer's payoffs are determined varies from one round to the next. In some rounds, the producer's payoffs are determined by her profits (Objective: Profit). The producer then obtains one fifth, i.e. 20%, of the realized profits. The profits are determined as the difference between the sum of consumers' payments and the production costs of the given round. If the good is produced, the producer's payoffs thus are:

$$(\textit{Producer payoffs}) = 20\% * [(\textit{Sum of the consumer payments}) - (\textit{Production costs})]$$

If the good is not produced, the producer obtains zero payoffs. In the other rounds, the producer's payoffs are determined by whether the producer was successful in raising sufficient funds to cover her production costs (Objective: Success). The producer obtains 3 francs if the good is produced and the sum of the consumer payments is equal to or higher than the costs of producing the good. Otherwise the producer obtains zero payoffs. The producer is informed about her objective in the given round. The consumers are not informed about the producer's objective. If you happen to be assigned the role of producer, make sure to pay attention to how the producer's payoffs are determined for the round you are currently playing!

Consumer Payoffs: In every round, the payoffs for the consumers are as follows. If the good is produced and a consumer obtains the good in a given round, her payoffs in that round are:

$$(\textit{Consumer payoffs}) = (\textit{Own value for the good}) - (\textit{Own offer})$$

If the good is produced but the consumer does not obtain the good in a given round, her earnings for that round are:

$$(\textit{Consumer payoffs}) = -(\textit{Own offer})$$

If the good is not produced in a given round, a consumer's earnings for that round are zero.

Comprehension Questions:

You will now be asked several example questions. Their purpose is to check for your understanding of the game. Note that the parameters used in the following example questions are not representative!

- If the good is produced, do all consumers who obtain the good pay the same price? (yes; no)
- If the good is produced, is it possible that any of the consumers pay more than their offer? (yes; no)
- [Target Amount: 65, Minimum Price: 8, Own value: 13, Own offer: 9, Sum of offers of other consumers: 60] Assume that you are a consumer. There are 14 other consumers. Given the information in the table above, how many francs would you earn?
- [Target Amount: 75, Minimum Price: 14, Own value: 19, Own offer: 17, Sum of offers of other consumers: 55] Assume that you are a consumer. There are 14 other

consumers. Given the information in the table above, how many francs would you earn?

- [Target Amount: 45, Minimum Price: 5, Own value: 7, Own offer: 2, Sum of offers of other consumers: 48] Assume that you are a consumer. There are 14 other consumers. Given the information in the table above, how many francs would you earn?

- [Target Amount: 55, Minimum Price: 10, Own value: 9, Own offer: 8, Sum of offers of other consumers: 42] Assume that you are a consumer. There are 14 other consumers. Given the information in the table above, how many francs would you earn?

- [Costs: 74, Objective: Success, Target Amount: 80, Minimum Price: 9, Sum of all offers: 80] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

- [Costs: 72, Objective: Success, Target Amount: 62, Minimum Price: 13, Sum of all offers: 70] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

- [Costs: 45, Objective: Profit, Target Amount: 54, Minimum Price: 8, Sum of all offers: 55] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

- [Costs: 67, Objective: Profit, Target Amount: 60, Minimum Price: 5, Sum of all offers: 62] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

Intuition Questions:

You will now be asked some more example questions. Their purpose is to let you develop an intuition for how to play the game before we start with the real rounds. Note that the parameters used in the following example questions are not representative.

- [Target Amount: 45, Minimum Price: 7, Own value: X[28]] Assume that you are a consumer. There are 14 other consumers with values drawn from the set {0,1,2,...,19,20}. What price would you offer?

- [Target Amount: 65, Minimum Price: 4, Own value: X] Assume that you are a consumer. There are 14 other consumers with values drawn from the set {0,1,2,...,19,20}. What price would you offer?

- [Target Amount: 85, Minimum Price: 12, Own value: X] Assume that you are a consumer. There are 14 other consumers with values drawn from the set {0,1,2,...,19,20}. What price would you offer?

- [Target Amount: 105, Minimum Price: 9, Own value: X] Assume that you are a consumer. There are 14 other consumers with values drawn from the set {0,1,2,...,19,20}. What price would you offer?

- [Costs: 55, Objective: Profit] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 21, Minimum Price = 5; Target Amount = 50, Minimum Price = 5; Target Amount = 56, Minimum Price = 1; *Target Amount = 60, Minimum Price = 10*)[29]

- [Costs: 75, Objective: Profit] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 70, Minimum Price = 7; *Target Amount = 78, Minimum Price = 12*; Target Amount = 81, Minimum Price = 3; Target Amount = 98, Minimum Price = 16)

- [Costs: 65, Objective: Success] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 0, Minimum Price = 4; *Target*

[28] X indicates a random value drawn from the discrete uniform distribution {0,1,2,...,19,20}.

[29] Italic answers indicate 'correct' answers.

Amount = 65, Minimum Price = 8; Target Amount = 66, Minimum Price = 0; Target Amount = 75, Minimum Price = 2)

- [Costs: 85, Objective: Success] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 75, Minimum Price = 6; Target Amount = 90, Minimum Price = 4; *Target Amount = 91, Minimum Price = 11*; Target Amount = 91, Minimum Price = 17)

We will continue when everybody has finished reading the instructions and has answered all example questions.

You will now be assigned the role of the producer or of a consumer.

You are assigned the role of [the producer / a consumer].

<u>Important Information:</u> The participant assigned the role of the producer will not set the target amount and minimum price herself. Instead, the computer will set the target amount and minimum price. The way the producer's payoffs is determined does not change. The earnings of the person assigned the role of the producer still exclusively depend on the producer's payoff (which is still computed as is explained in the instruction summary).

Figure E1: Consumers' Decision Screen in AON

Your decision for period 1

Target Amount	Minimum Price	Own value
50	11	13*

You are a consumer. Recall that there are 14 other consumers with values drawn from the set {0,1,2,...,19,20}.
Please offer a price.

Your offer:

Confirm

Notes: Subjects could state an integer bid between 0 and 30. The asterisk indicates that values were drawn randomly; the asterisk was not shown to subjects.

Figure E2: Consumers' Feedback Screen in AON

The result of period 1

Period	Target Amount	Minimum Price	Own value	Own offer	Offers of other consumers	Sum of all offers	Is good produced?	Own earning
1	50	11	13	11	0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 2 - 11 - 11 - 11 - 12 - 14	72	yes	2

To the next period

Questionnaire:

Please fill in this short questionnaire.

- Age: (positive integers)
- Gender: (Male, Female)
- I study at (UvA – Economics and Business; UvA – Social Sciences, Psychology; UvA – Social Sciences, not Psychology; UvA – Science; UvA – IIS, beta gamma bachelor; UvA – Law School; UvA – Humanities; UvA – Medical School; UvA – Dentistry; Another university; A professional school; Otherwise)
- How often have you participated in a crowdfunding campaign? (Never; One time; Two times; Three or more times)

- What strategy did you play?
- What is your feeling towards the other players?
- How fair do you rate the crowdfunding mechanism? (very unfair (1), (2), (3), (4), very fair (5)))
- Do you have any other comments?

E.2 sGMS

Instructions:

A summary of these instructions on paper will be distributed before the experiment starts. Welcome to this experiment on decision making. The instructions for this experiment are simple, and if you follow them carefully, you can earn a considerable amount of money. What you earn depends on the decisions you make and on the decisions of the others. You will be privately paid at the end of the experiment. We ask that you do not communicate with other people during the experiment. Please refrain from verbally reacting to events that occur during the experiment. This is very important. Raise your hand when you have a question and one of the experimenters will come to your table.

These instructions consist of eight pages like this. You may page back and forth by using your mouse to click on "previous page" or "next page" at the bottom of your screen. On the last instruction page you will see the button "ready" at the bottom of your screen. Click this button if you have completely finished with all pages of the instructions.

Producer and Consumers: In this experiment you will be assigned the role of either the producer of a good or a consumer. The payoffs that you obtain during the experiment determine the money that you will receive at the end. Earnings in the experiment will be denoted by "francs". At the end of the experiment, francs will be exchanged for euros. The exchange rate is 1 euro for every 8 francs. We will give you a number of francs to start with. This starting capital equals 56 francs (or 7 euros).

Rounds: Today's experiment consists of 45 rounds. In each round, a producer decides whether or not to produce a fictitious good and sell it to consumers. In the experiment, you will either be producer or consumer. One participant plays the role of producer. The producer can produce a fictitious good that is valuable for the consumers. The 15 other participants play the role of consumer. The producer can only produce the good if she raises sufficient funds to cover her production costs. The producer's production costs are fixed: They do not depend on the number of goods sold. Moreover, only the producer is informed about her costs. The consumers do not know the producer's costs. The producer's costs may vary from one round to the next. The consumers interact in a market. In this market, it is determined whether the producer actually produces the good. Moreover, if the good is produced, the market determines which consumers buy the good and for what price.

The Value of the Good: The value of the fictitious good will typically differ from one consumer to the next. To be more precise, in every round, the computer will draw a new value for every consumer. Values are randomly drawn from the set 0,1,2,...,19,20. Note the following about the value for the good:

1. The value for a consumer is determined independently of the values for the other consumers;
2. Any value in the set $\{0,1,2,\ldots,19,20\}$ is equally likely;
3. Each consumer only learns her own value, not the value of the other consumers;
4. The producer is not informed about the values of any of the consumers.

The Market: At the start of a round, the producer is informed about her or his costs and all consumers are told their value. The producer then decides on a target amount and a minimum price. In each round, all consumers are asked to state their highest acceptable price. We call this the 'maximum offer' because any consumer may end up receiving the good at a lower price than her or his highest acceptable price. The maximum offers may differ from one consumer to another. Consumers can only obtain the good if their maximum offer is equal to or higher than the minimum price. After all maximum offers have been received, the computer determines whether the producer will actually produce the good and if so, at what price it will be sold. If the good is produced, all consumers who obtain the good pay the same price. More precisely, the computer raises the price step by step, starting from the minimum price, up to the point that the price is sufficiently high to meet the target amount. This is determined as follows.

STEP 0: Start with a 'candidate price' that is equal to this round's minimum price.

STEP 1: Compute the producer's revenue at the candidate price: Determine how many consumers' maximum offers are equal to or higher than the candidate price. Calculate how much revenue this candidate price would raise by multiplying the candidate price with the number of consumers whose maximum offers are equal to or higher than the candidate price.

STEP 2: Compare the producer's revenue calculated in STEP 1 with the target amount.

- If the producer's revenue is equal to or higher than the target amount, proceed to STEP 3.
- If the producer's revenue is lower than the target amount, increase the candidate price by one. If the new candidate price is higher than the highest maximum offer, the good is not produced. Otherwise, go back to STEP 1.

STEP 3: The good is produced. All consumers whose maximum offers are equal to or higher than the current price obtain the good and pay this price to the producer. All other consumers do not obtain the good and pay zero.

Note that no consumer will ever pay more than her or his maximum offer, but will often pay less.

Example: To illustrate the market, suppose the target amount equals 85 and the minimum price is 7. The consumers' offers are:

$$0 - 2 - 2 - 4 - 5 - 6 - 7 - 8 - 14 - 14 - 17 - 18 - 18 - 19 - 20$$

The first candidate price is 7, the minimum price. Multiplying the candidate price (7) by the number of offers that are equal to 7 or higher (9) yields 63. This result is lower than the target amount of 85, so that the candidate price is increased by one. Multiplying the new candidate price (8) by the number of offers that are equal to 8 or higher (8) yields 64. This result is again lower than the target amount of 85 so that again the candidate price is increased by one. Sequentially checking for candidate prices of 9, 10, 11 and 12 also yields results that are lower than the target amount of 85. However, multiplying a candidate price of 13 by the number of offers that are equal to 13 or higher (7) yields 91. As this result is higher than the target amount of 85, the good is produced. The 7 consumers whose offers are equal to 13 or higher obtain the good and all pay a price of 13. The other consumers do not obtain the good and pay zero. The sum of consumer payments is thus 91.

Producer Payoffs: The way the producer's payoffs are determined varies from one round to the next. In some rounds, the producer's payoffs are determined by her profits (Objective: Profit). The producer then obtains one fifth, i.e. 20%, of the realized profits. The profits are determined as the difference between the sum of consumers' payments and the production costs of the given round. If the good is produced, the producer's payoffs thus are:

$$(\textit{Producer payoffs}) = 20\% * [(\textit{Sum of the consumer payments}) - (\textit{Production costs})]$$

If the good is not produced, the producer obtains zero payoffs. In the other rounds, the producer's payoffs are determined by whether the producer was successful in raising sufficient funds to cover her production costs (Objective: Success). The producer obtains

3 francs if the good is produced and the sum of the consumer payments is equal to or higher than the costs of producing the good. Otherwise the producer obtains zero payoffs. The producer is informed about her objective in the given round. The consumers are not informed about the producer's objective. If you happen to be assigned the role of producer, make sure to pay attention to how the producer's payoffs are determined for the round you are currently playing!

Consumer Payoffs: In every round, the payoffs for the consumers are as follows. If a consumer obtains the good in a round, her payoffs in that round are:

$$(\textit{Consumer payoffs}) = (\textit{Own value for the good}) - (\textit{Price paid})$$

If a consumer does not obtain the good in a round, her earnings for that round are zero.

Comprehension Questions:

You will now be asked several example questions. Their purpose is to check for your understanding of the game. Note that the parameters used in the following example questions are not representative!

- If the good is produced, do all consumers who obtain the good pay the same price? (yes; no)
- If the good is produced, is it possible that any of the consumers pay more than their offer? (yes; no)
- [Target Amount: 40, Minimum Price: 2, Own value: 12, Offers of all consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 10 – 10 – 10 – 10 – 10] Assume that you are one of the consumers who made an offer of 4. There are 14 other consumers. Given the information in the table above, how many francs would you earn?
- [Target Amount: 40, Minimum Price: 6, Own value: 12, Offers of all consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 10 – 10 – 10 – 10 – 10] Assume that you are one

of the consumers who made an offer of 4. There are 14 other consumers. Given the information in the table above, how many francs would you earn?

- [Target Amount: 40, Minimum Price: 2, Own value: 12, Offers of all consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 10 – 10 – 10 – 10 – 10] Assume that you are one of the consumers who made an offer of 10. There are 14 other consumers. Given the information in the table above, how many francs would you earn?

- [Target Amount: 40, Minimum Price: 6, Own value: 12, Offers of all consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 10 – 10 – 10 – 10 – 10] Assume that you are one of the consumers who made an offer of 10. There are 14 other consumers. Given the information in the table above, how many francs would you earn?

- [Costs: 30, Objective: Success, Target Amount: 40, Minimum Price: 2, Offers of consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 10 – 10 – 10 – 10 – 10] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

- [Costs: 45, Objective: Success, Target Amount: 40, Minimum Price: 2, Offers of consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 10 – 10 – 10 – 10 – 10] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

- [Costs: 30, Objective: Profit, Target Amount: 40, Minimum Price: 2, Offers of consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 10 – 10 – 10 – 10 – 10] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

- [Costs: 45, Objective: Profit, Target Amount: 40, Minimum Price: 2, Offers of consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 10 – 10 – 10 – 10 – 10] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

Intuition Questions:

You will now be asked some more example questions. Their purpose is to let you develop an intuition for how to play the game before we start with the real rounds. Note that the parameters used in the following example questions are not representative.

- [Target Amount: 45, Minimum Price: 7, Own value: X] Assume that you are a consumer. There are 14 other consumers with values drawn from the set $\{0,1,2,\ldots,19,20\}$. What price would you offer?

- [Target Amount: 65, Minimum Price: 4, Own value: X] Assume that you are a consumer. There are 14 other consumers with values drawn from the set $\{0,1,2,\ldots,19,20\}$. What price would you offer?

- [Target Amount: 85, Minimum Price: 12, Own value: X] Assume that you are a consumer. There are 14 other consumers with values drawn from the set $\{0,1,2,\ldots,19,20\}$. What price would you offer?

- [Target Amount: 105, Minimum Price: 9, Own value: X] Assume that you are a consumer. There are 14 other consumers with values drawn from the set $\{0,1,2,\ldots,19,20\}$. What price would you offer?

- [Costs: 55, Objective: Profit] Assume that you the producer. There are 15 consumers with values drawn from the set $\{0,1,2,\ldots,19,20\}$. Which of the following four options would you choose? (Target Amount = 50, Minimum Price = 5; Target Amount = 55, Minimum Price = 3; *Target Amount = 71, Minimum Price = 10*; Target Amount = 90, Minimum Price = 16)

- [Costs: 75, Objective: Profit] Assume that you the producer. There are 15 consumers with values drawn from the set $\{0,1,2,\ldots,19,20\}$. Which of the following four options would you choose? (Target Amount = 38, Minimum Price = 13; Target Amount = 70, Minimum Price = 7; Target Amount = 72, Minimum Price = 2; *Target Amount = 84, Minimum Price = 12*)

- [Costs: 65, Objective: Success] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 30, Minimum Price = 5; Target Amount = 60, Minimum Price = 4; *Target Amount = 67, Minimum Price = 8*; Target Amount = 111, Minimum Price = 1)

- [Costs: 85, Objective: Success] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 78, Minimum Price = 0; Target Amount = 86, Minimum Price = 17; *Target Amount = 89, Minimum Price = 6*; Target Amount = 103, Minimum Price = 14)

We will continue when everybody has finished reading the instructions and has answered all example questions.

You will now be assigned the role of the producer or of a consumer.

You are assigned the role of [the producer / a consumer].

Important Information: The participant assigned the role of the producer will not set the target amount and minimum price herself. Instead, the computer will set the target amount and minimum price. The way the producer's payoffs is determined does not change. The earnings of the person assigned the role of the producer still exclusively depend on the producer's payoff (which is still computed as is explained in the instruction summary).

Figure E3: Consumers' Decision Screen in sGMS

Your decision for period 1

Target Amount	Minimum Price	Own value
56	11	13*

You are a consumer. Recall that there are 14 other consumers with values drawn from the set $\{0,1,2,\ldots,19,20\}$. Please enter your highest acceptable price.

Your maximum offer:

Confirm

Notes: Subjects could state an integer bid between 0 and 30. The asterisk indicates that values were drawn randomly; the asterisk was not shown to subjects.

Figure E4: Consumers' Feedback Screen in sGMS

The result of period 1

Period	Target Amount	Minimum Price	Own value	Own offer	Offers of other consumers	Is good produced?	Price	Sum of payments	Own earning
1	56	11	13	13	0 - 0 - 2 - 5 - 7 - 7 - 8 - 9 - 11 - 11 - 12 - 14 - 16 - 19	yes	11	77	2

To the next period

Questionnaire:

Please fill in this short questionnaire.

- Age: (positive integers)
- Gender: (Male, Female)
- I study at (UvA – Economics and Business; UvA – Social Sciences, Psychology; UvA – Social Sciences, not Psychology; UvA – Science; UvA – IIS, beta gamma bachelor; UvA – Law School; UvA – Humanities; UvA – Medical School; UvA – Dentistry; Another university; A professional school; Otherwise)
- How often have you participated in a crowdfunding campaign? (Never; One time; Two times; Three or more times)

- What strategy did you play?
- What is your feeling towards the other players?
- How fair do you rate the crowdfunding mechanism? (very unfair (1), (2), (3), (4), very fair (5)))
- Do you have any other comments?

E.3 dGMS

Instructions:

A summary of these instructions on paper will be distributed before the experiment starts. Welcome to this experiment on decision making. The instructions for this experiment are simple, and if you follow them carefully, you can earn a considerable amount of money. What you earn depends on the decisions you make and on the decisions of the others. You will be privately paid at the end of the experiment. We ask that you do not communicate with other people during the experiment. Please refrain from verbally reacting to events that occur during the experiment. This is very important. Raise your hand when you have a question and one of the experimenters will come to your table.

These instructions consist of eight pages like this. You may page back and forth by using your mouse to click on "previous page" or "next page" at the bottom of your screen. On the last instruction page you will see the button "ready" at the bottom of your screen. Click this button if you have completely finished with all pages of the instructions.

<u>Producer and Consumers:</u> In this experiment you will be assigned the role of either the producer of a good or a consumer. The payoffs that you obtain during the experiment determine the money that you will receive at the end. Earnings in the experiment will be denoted by "francs". At the end of the experiment, francs will be exchanged for euros. The exchange rate is 1 euro for every 8 francs. We will give you a number of francs to start with. This starting capital equals 56 francs (or 7 euros).

Rounds: Today's experiment consists of 45 rounds. In each round, a producer decides whether or not to produce a fictitious good and sell it to consumers. In the experiment, you will either be producer or consumer. One participant plays the role of producer. The producer can produce a fictitious good that is valuable for the consumers. The 15 other participants play the role of consumer. The producer can only produce the good if she raises sufficient funds to cover her production costs. The producer's production costs are fixed: They do not depend on the number of goods sold. Moreover, only the producer is informed about her costs. The consumers do not know the producer's costs. The producer's costs may vary from one round to the next. The consumers interact in a market. In this market, it is determined whether the producer actually produces the good. Moreover, if the good is produced, the market determines which consumers buy the good and for what price.

The Value of the Good: The value of the fictitious good will typically differ from one consumer to the next. To be more precise, in every round, the computer will draw a new value for every consumer. Values are randomly drawn from the set 0,1,2,...,19,20. Note the following about the value for the good:

1. The value for a consumer is determined independently of the values for the other consumers;
2. Any value in the set {0,1,2,...,19,20} is equally likely;
3. Each consumer only learns her own value, not the value of the other consumers;
4. The producer is not informed about the values of any of the consumers.

The Market: At the start of a round, the producer is informed about her or his costs and all consumers are told their value. He or she will then try to raise money to be able to produce the good. To do so, the producer decides on a target amount and a minimum price. The target amount is the sum of money that the producer wants to at least raise from all consumers together. The minimum price is the lowest price that the producer wants to receive from any single consumer. Note that not every consumer may be willing to pay that price. To determine which consumers are willing to pay a price and how much revenue a price will give to the producer, we use the following procedure in each round. The computer will start by proposing a price equal to 1. Any consumer not willing to pay this price can click the button “Drop Out”. Then, every few seconds the computer raises the price by 1. As the price increases, any consumer may drop out of this round’s market at any price by clicking the “Drop Out” button. Consumers who drop out will not buy the good. Once you drop out, you cannot re-enter in the current round. As the price increases and consumers drop out, three things might happen. First, the price might be below the minimum price. In this case, it is increased further. Second, too many consumers might drop out, so that it becomes impossible for the producer to raise her or his target amount. In this case, the good is not produced and the round ends. Third, it can happen that at a price of at least the minimum price, enough consumers are still willing to buy the good so that together they pay at least the target amount. The good is then produced because the target amount and the minimum price are reached. Then, all remaining consumers obtain the good and pay the last displayed price. For these consumers, the payoff they get from buying the good is equal to their value for this round minus the price at which the computer stopped. In summary, the computer determines whether the good is produced and who obtains the good in the following way.

STEP 0: Start with a ‘candidate price’ of 1.

STEP 1: Check whether the candidate price is below the minimum price. If so, increase the candidate price by 1 and repeat STEP 1. If not, continue with STEP 2.

STEP 2: Determine how many consumers remain in the market, i.e. have not yet clicked on “Drop Out”. Check how much money this candidate price would raise by multiplying the candidate price with the number of remaining consumers. This would be the producer’s revenue at the candidate price.

STEP 3: Compare the producer's revenue calculated in STEP 2 with the target amount.

- If the producer's revenue is equal to or higher than the target amount, proceed to STEP 4.
- If the producer's revenue is lower than the target amount, increase the candidate price by 1. If the number of remaining consumers multiplied by the highest possible price (30) is less than the target amount, the good is not produced and the next round starts. Otherwise, go back to STEP 2.

STEP 4: The good is produced. All remaining consumers obtain the good and pay the current price to the producer. All consumers who dropped out do not obtain the good and pay zero.

Example: To illustrate the market, suppose the target amount equals 85 and the minimum price is 7. The first candidate price is 1. As this candidate price is lower than 7, the minimum price, the price increases by 1 every few seconds until a price of 7. Suppose that at the price of 7, 6 consumers have dropped out already. This leaves 9 remaining consumers at the minimum price of 7. Multiplying this price by the number of remaining consumers yields 63. This is lower than the target amount of 85, so that the candidate price is increased to 8. At this price of 8, one consumer drops out. Multiplying the new candidate price by the number of remaining consumers (8) yields 64, which is again lower than the target amount of 85. The candidate price is increased to 9. Again, one consumer drops out. Multiplying the new candidate price (9) by the number of remaining consumers (7) yields 63, which is again lower than the target amount of 85. The candidate price is increased to 10. Now, suppose that all 7 consumers remain at a candidate price of 10. Still, multiplying 10 by 7 yields 70 which is lower than the target amount of 85. The same occurs for candidate prices of 11 (7*11<85) and 12 (7*12<85) respectively. However, if all 7 remaining consumers also remain at a candidate price of 13, the good is produced because 7*13=91 is higher than the target amount of 85. The process stops and the 7 remaining consumers obtain the good and pay a price of 13. The 8 consumers who dropped out do not obtain the good and pay zero. The sum of consumer payments is thus 91.

Producer Payoffs: The way the producer's payoffs are determined varies from one round to the next. In some rounds, the producer's payoffs are determined by her profits (Objective: Profit). The producer then obtains one fifth, i.e. 20%, of the realized profits. The profits are determined as the difference between the sum of consumers' payments and the production costs of the given round. If the good is produced, the producer's payoffs thus are:

$$(\textit{Producer payoffs}) = 20\% * [(\textit{Sum of the consumer payments}) - (\textit{Production costs})]$$

If the good is not produced, the producer obtains zero payoffs. In the other rounds, the producer's payoffs are determined by whether the producer was successful in raising sufficient funds to cover her production costs (Objective: Success). The producer obtains 3 francs if the good is produced and the sum of the consumer payments is equal to or higher than the costs of producing the good. Otherwise the producer obtains zero payoffs. The producer is informed about her objective in the given round. The consumers are not informed about the producer's objective. If you happen to be assigned the role of producer, make sure to pay attention to how the producer's payoffs are determined for the round you are currently playing!

Consumer Payoffs: In every round, the payoffs for the consumers are as follows. If a consumer obtains the good in a round, her payoffs in that round are:

$$(\textit{Consumer payoffs}) = (\textit{Own value for the good}) - (\textit{Price paid})$$

If a consumer does not obtain the good in a round, her earnings for that round are zero.

Comprehension Questions:

You will now be asked several example questions. Their purpose is to check for your understanding of the game. Note that the parameters used in the following example questions are not representative!

- If the good is produced, do all consumers who obtain the good pay the same price? (yes; no)
- If the good is produced, is it possible that any of the consumers pay more than their offer? (yes; no)
- [Target Amount: 40, Minimum Price: 2, Own value: 12, Offers of all consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 4 – 4 – 4 – 4 – 4] Assume that you are one of the consumers who made an offer of 4. There are 14 other consumers. Given the information in the table above, how many francs would you earn?
- [Target Amount: 40, Minimum Price: 6, Own value: 12, Offers of all consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 4 – 4 – 4 – 4 – 4] Assume that you are one of the consumers who made an offer of 4. There are 14 other consumers. Given the information in the table above, how many francs would you earn?
- [Target Amount: 40, Minimum Price: 6, Own value: 12, Offers of all consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 8 – 8 – 8 – 8 – 8] Assume that you are one of the consumers who made an offer of 4. There are 14 other consumers. Given the information in the table above, how many francs would you earn?
- [Target Amount: 40, Minimum Price: 6, Own value: 12, Offers of all consumers: 0 – 0 – 0 – 0 – 0 – 4 – 4 – 4 – 4 – 4 – 8 – 8 – 8 – 8 – 8] Assume that you are one of the consumers who made an offer of 8. There are 14 other consumers. Given the information in the table above, how many francs would you earn?
- [Costs: 30, Objective: Success, Target Amount: 40, Minimum Price: 2, Offers of consumers: 1 – 1 – 1 – 1 – 1 – 4 – 4 – 4 – 4 – 4 – 4 – 4 – 4 – 4 – 4] Assume that you are

the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

- [Costs: 45, Objective: Success, Target Amount: 40, Minimum Price: 2, Offers of consumers: $1-1-1-1-1-4-4-4-4-4-4-4-4-4-4$] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?
- [Costs: 30, Objective: Profit, Target Amount: 40, Minimum Price: 2, Offers of consumers: $1-1-1-1-1-4-4-4-4-4-4-4-4-4-4$] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?
- [Costs: 45, Objective: Profit, Target Amount: 40, Minimum Price: 2, Offers of consumers: $1-1-1-1-1-4-4-4-4-4-4-4-4-4-4$] Assume that you are the producer. There are 15 consumers. Given the information in the table above, how many francs would you earn?

Intuition Questions:

You will now be asked some more example questions. Their purpose is to let you develop an intuition for how to play the game before we start with the real rounds. Note that the parameters used in the following example questions are not representative.

- [Target Amount: 45, Minimum Price: 7, Own value: X, Current Price: Y[30]] Assume that you are a consumer. There are 14 other consumers with values drawn from the set {0,1,2,...,19,20}. What offer would you make?
- [Target Amount: 65, Minimum Price: 4, Own value: X, Current Price: Y] Assume that you are a consumer. There are 14 other consumers with values drawn from the set {0,1,2,...,19,20}. What offer would you make?

[30] Price increases every four seconds by one.

- [Target Amount: 85, Minimum Price: 12, Own value: X, Current Price: Y] Assume that you are a consumer. There are 14 other consumers with values drawn from the set {0,1,2,...,19,20}. What offer would you make?
- [Target Amount: 105, Minimum Price: 9, Own value: X, Current Price: Y] Assume that you are a consumer. There are 14 other consumers with values drawn from the set {0,1,2,...,19,20}. What offer would you make?
- [Costs: 55, Objective: Profit] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 50, Minimum Price = 5; Target Amount = 55, Minimum Price = 3; *Target Amount = 71, Minimum Price = 10*; Target Amount = 90, Minimum Price = 16)
- [Costs: 75, Objective: Profit] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 38, Minimum Price = 13; Target Amount = 70, Minimum Price = 7; Target Amount = 72, Minimum Price = 2; *Target Amount = 84, Minimum Price = 12*)
- [Costs: 65, Objective: Success] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 30, Minimum Price = 5; Target Amount = 60, Minimum Price = 4; *Target Amount = 67, Minimum Price = 8*; Target Amount = 111, Minimum Price = 1)
- [Costs: 85, Objective: Success] Assume that you the producer. There are 15 consumers with values drawn from the set {0,1,2,...,19,20}. Which of the following four options would you choose? (Target Amount = 78, Minimum Price = 0; Target Amount = 86, Minimum Price = 17; *Target Amount = 89, Minimum Price = 6*; Target Amount = 103, Minimum Price = 14)

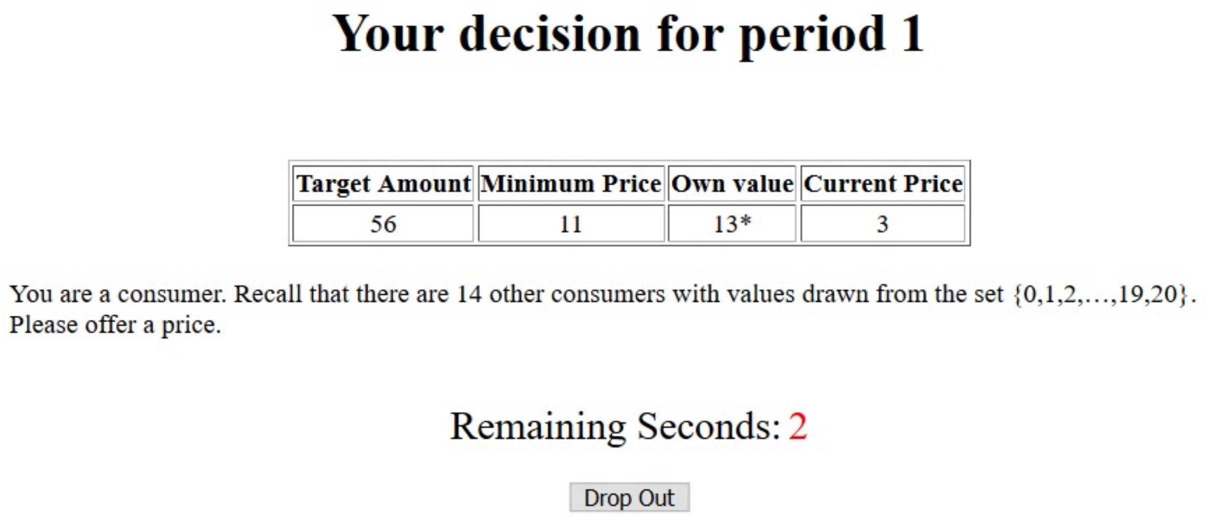
We will continue when everybody has finished reading the instructions and has answered all example questions.

You will now be assigned the role of the producer or of a consumer.

You are assigned the role of [the producer / a consumer].

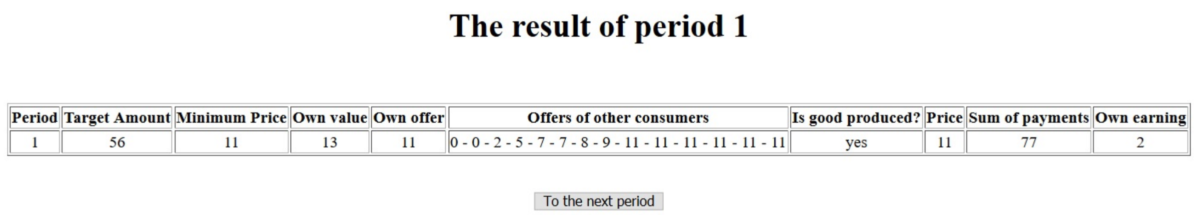
Important Information: The participant assigned the role of the producer will not set the target amount and minimum price herself. Instead, the computer will set the target amount and minimum price. The way the producer's payoffs is determined does not change. The earnings of the person assigned the role of the producer still exclusively depend on the producer's payoff (which is still computed as is explained in the instruction summary).

Figure E5: Consumers' Decision Screen in dGMS



Notes: The price increases every four seconds by one (up to a maximum of 30). The asterisk indicates that values were drawn randomly; the asterisk was not shown to subjects.

Figure E6: Consumers' Feedback Screen in dGMS



The result of period 1

Period	Target Amount	Minimum Price	Own value	Own offer	Offers of other consumers	Is good produced?	Price	Sum of payments	Own earning
1	56	11	13	11	0 - 0 - 2 - 5 - 7 - 7 - 8 - 9 - 11 - 11 - 11 - 11 - 11 - 11	yes	11	77	2

To the next period

Questionnaire:

Please fill in this short questionnaire.

- Age: (positive integers)
- Gender: (Male, Female)
- I study at (UvA – Economics and Business; UvA – Social Sciences, Psychology; UvA – Social Sciences, not Psychology; UvA – Science; UvA – IIS, beta gamma bachelor; UvA – Law School; UvA – Humanities; UvA – Medical School; UvA – Dentistry; Another university; A professional school; Otherwise)
- How often have you participated in a crowdfunding campaign? (Never; One time; Two times; Three or more times)
- What strategy did you play?
- What is your feeling towards the other players?
- How fair do you rate the crowdfunding mechanism? (very unfair (1), (2), (3), (4), very fair (5))
- Do you have any other comments?