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Article

The Loser's Bliss in Auctions with Price Externality

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Abstract: We consider auctions with price externality where all bidders derive utility from the winning price, such as charity auctions. In addition to the benefit to the winning bidder, all bidders obtain a benefit that is increasing in the winning price. Theory makes two predictions in such settings: First, individual bids will be increasing in the multiplier on the winning price. Second, individual bids will not depend on the number of other bidders. Empirically, we find no evidence that increasing the multiplier increases individual bids in a systematic way, but we find that increasing the number of bidders does. An analysis of individual bidding functions reveals that bidders underweight the incentives to win and overweight the incentives to lose.

Keywords: auctions with price externality; bidder aggression; underbidding; experiments

1. Introduction

Auctions play a prominent role in charity fundraising, with billions collected through hundreds of thousands of silent and live auctions in the US alone [1]. Internet auctions with price externality in particular are on the rise, with eBay dedicating a special section for charity auctions. Not only do these auctions play an important role for non-profit organizations, but an increasing number of for-profit firms

are sponsoring charity events to establish themselves as good corporate citizens. In turn, sponsorship of social causes may improve a firm's image or profits [2–4][1].

Individuals bidding in charity auctions are assumed to care about the cause for which they are bidding. Thus, in the literature on auctions with price externality, charitable bidders are typically modeled as maximizing an objective function in which they receive additional utility that is increasing in the final price paid in the auction (*i.e.*, the amount of money going to charity). This is equivalent to an auction where the losing bidder cares about the price paid by the winning bidder [11]. We refer to this class of auctions as *auctions with price externality*.

In the present work, we specify laboratory payoffs corresponding to the functional form of auctions with price externality [12]. That is, bidders in auctions with price externality receive extra utility from the selling price of the auction, expressed as a proportion of that price. We refer to this proportion as the *multiplier* (henceforth also referred to as alpha). We study settings where both winning and losing bidders receive such a proportion of the winning price, and this multiplier varies across conditions.

Theoretical predictions in auctions with price externality [13,14] can be stated in the form of two hypotheses: (1) Revenues will increase in the multiplier, and (2) optimal bids will not change in the number of other bidders. We see that despite having an experimental setup that closely corresponds to the theoretical setting bidders do not in general conform to these predictions. We specifically show that decisions were affected by theoretically irrelevant considerations [15].

First, we document a persistent underbidding pattern in auctions with few bidders. In three-bidder auctions, we see that bid levels decline in response to changes in the multiplier—In a direction opposite to the direction prescribed by theory[2].

Second, we find that in contrast to theoretical predictions, the number of bidders affects the extent of underbidding for a higher multiplier. A larger number of bidders may mitigate and even reverse the above pattern.

Third, in English auctions, the tendency to underbid in response to higher multipliers is not merely driven by a misalignment of bids with valuations. Rather, higher multipliers appear to result in greater reluctance to react to competitors' bids. We therefore highlight a particular source of inconsistency between the theory and the data—an apparent tendency by bidders to bid as if they underweight the incentive to win and overweight the incentive to lose in the charity setting.

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[1]   There is a growing body of research in marketing that has concluded that linking product purchases with donations to charities has a positive impact on perceptions [4–7]. However, these positive effects are not universal, since several researchers have shown that in certain instances it may lead to a reduction in purchase intention [8–10].

[2]   Isaac *et al*. (2010) [12] encountered a hint of this effect in second price sealed bid auctions. They found that charitable preferences of the type investigated here do not significantly increase individual bids or auction revenues, thus identifying a puzzle. In their carefully designed second price sealed bid experiment, four decision makers played 40 auction rounds with multipliers of 0 in a benchmark condition, 0.15 in a low bonus condition or 0.50 in a high bonus condition (different decision makers in each condition). From their plots, bids in the 0.5 multiplier (second price basic charity) condition are on average lower than theoretical predictions, and this gap is quite substantial.

2. Theory

2.1. Setting and Theoretical Properties

An auction with price externality is defined as an auction in which bidders receive a utility that increases in the winning price for the auction. We study two auction formats. The first format is the second price sealed bid (hereafter SPSB). In SPSB, each bidder submits a single bid simultaneously with all other bidders. The bidder who submits the highest bid wins the auction and pays the second highest bid.

The second format we investigate is the English auction, wherein bidders may place ascending bids throughout the auction. It is optimal for bidders to bid up to their valuation in English auctions, and revenues will be identical to a second price sealed-bid auction in the absence of major jump bids [13,14,16].

For both SPSB and English auctions with price externality, the winning bidder receives his valuation for the item and pays the winning price. In addition, each bidder, whether he won or lost, receives a constant portion α of the winning price [12–14].

We derive (see Appendix A) the optimal bid in this environment. Three theoretical properties emerge from this derivation.

> **Property 1.** *The bids in auctions with price externality are increasing in the multiplier (α).*
> **Property 2**. *Auctions with price externality are efficient.*
> **Property 3.** *The bids in auctions with price externality do not depend on the number of bidders (n).*

The first property is straightforward as a higher multiplier results in greater utility, and therefore should result in higher bids. Efficiency, indicated in Property 2, is the property that the bidder with the highest valuation for the item will win the item. The third theoretical property seems to contradict findings from empirical research. Empirical findings often indicate that competitive intensity increases with more bidders [17–19].

In our study, *bidder valuations* are induced and therefore exogenous. *Willingness to pay* (*WTP*) is the maximum amount a bidder is willing to pay in an auction and this is the value we measure in our study. However, WTP will differ from these bidder valuations in auctions with price externality, because there are added incentives to win and to lose, as detailed in Appendix A.

Bids in the English auction format cannot be looked at in the same way as bids in the SPSB format. In the SPSB format, all bids are equally informative about bidder WTP, whether or not the bidder ends up winning or losing the auction. Under SPSB, it is a strictly dominant strategy for each bidder to bid his true WTP. Thus, we can view the observed bid as a proxy for WTP. In contrast, in an English auction, each bidder should bid incrementally as long as his WTP has not been reached. As such, if all bidders bid incrementally, the highest bid of each losing bidder is an indication of WTP. If there are *jump bids*— Bids that are more than an increment above the previous bid—then the last bid by each bidder is a less informative statistic. Therefore, this is at best a noisy indication of WTP. In the English auction analysis, we therefore focus on losers' bids. In particular, we pay attention to a construct we call *loser underbidding*, where bidders bid below their theoretically predicted bid.

2.2. Hypotheses

We now state three important hypotheses arising directly from the established theory. The findings, to be reported shortly, will pertain directly to the hypotheses. As we alluded to in earlier sections, the findings of this work offer evidence to suggest rejection of most of these hypotheses.

2.2.1. Hypothesis 1. Individual Bids and Revenues Increase in the Multiplier

As the extra utility that bidders receive from the selling price of the auction, increases we expect an increase in bids and revenue. The intuition behind this hypothesis is that the multiplier serves as a subsidy to the winning bidder, who gets a portion (equal to the multiplier) of his winning price refunded. As the multiplier increases, the subsidy to the winning price is higher, resulting in an incentive to bid higher. As bids increase, so does the revenue.

It is a generalization that is in line with Equation (4) in Appendix A and is consistent with theoretical results elsewhere [13,14]. Empirically, there is conflicting evidence for this hypothesis. On the one hand [12], which has a design similar to the present one, do not find support for this prediction in SPSB. On the other hand, field experiments by [20,21] report that bidders in English auctions are willing to pay a higher price for higher donation promises. Both papers ran simultaneous pairs of English auctions identical in all respects but the percentage of proceeds donated to charity. While these papers did not directly vary the multiplier, higher donations to charity should result in greater utility to charitable bidders.

We further note that the optimal bid does not vary in the number of bidders, which is a well-known theoretical result, consistent with Equation (4) in Appendix A and with results elsewhere in the literature [14]. We express this as hypothesis 2.

2.2.2. Hypothesis 2. Auctions with Price Externality are Efficient

Consistent with the theory for auctions without price externalities, it is expected that with price externalities the bidder with the highest valuation will win the auction. As winning bidders receive a subsidy proportional to the multiplier, they have an incentive to bid higher with a price externality. Therefore, the bidder with the highest valuation has the greatest incentive to win the auction.

We further note that the optimal bid does not vary in the number of bidders, which is a well-known theoretical result, consistent with Equation (4) in Appendix A and with results elsewhere in the literature [14]. We express this as hypothesis 3.

2.2.3. Hypothesis 3. Bidders' WTP is Unchanging in the Number of Other Bidders

The theoretical prediction of unchanging WTP in response to the number of bidders notwithstanding, empirical studies typically find that the number of bidders in an auction does impact bidder behavior. For example, [19] report that auctions with a higher number of bids resulted in a higher WTP. In contrast, [22] find that bidders in auctions with fewer bidders tend to bid more aggressively. Unlike the competitive settings in these other works, in the present setting of auctions with price externality each bidder's utility increases with higher selling price, even when that bidder is not the one paying the price. The number of other bidders directly affects the probability of not paying the price. Specifically, as the

number of bidders increases, the likelihood of winning decreases. Having more opponents enables a bidder to increase his expected utility by raising the eventual price paid by others, while maintaining a low probability of winning. In summary, when there are more bidders we expect to see more aggressive bidding. This is related to the concept of shill bidding, which is bidding with the intent of raising the price without winning, and we may expect to see more shill bidding in auctions with price externality [21].

3. Experimental Design

In total, 570 undergraduate students at a major North American public university participated in the study. They were recruited for an auction experiment but were not told the purpose of the study. Participants were invited in groups of 12 to 18, and groups were randomly assigned to one of 12 different conditions in a 2 (auctioned format: English *vs.* SPSB) × 2 (number of bidders participating in the auction: 3 *vs.* 6) × 3 (multiplier: 0 *vs.* ¼ *vs.* ¾) between-subjects design. The number of bidders was either three bidders per group or six bidders per group, depending on the condition. The number of participants by condition is summarized in Table 1. Each session tested a single experimental condition, and bidders participated in ten rounds of auctions per session.

Table 1. Different experimental conditions and number of sessions in each condition.

		Multiplier		
Format	**# Bidders**	**0**	**¼**	**¾**
SPSB	**3 bidders**	*"3-bidder m = 0"* 15 sessions	*"3-bidder m = ¼"* 19 sessions	*"3-bidder m = ¾"* 13 sessions
SPSB	**6 bidders**	*"6-bidder m = 0"* 4 sessions	*"6-bidder m = ¼"* 6 sessions	*"6-bidder m = ¾"* 5 sessions
English	**3 bidders**	*"3-bidder m = 0"* 13 sessions	*"3-bidder m = ¼"* 25 sessions	*"3-bidder m = ¾"* 17 sessions
English	**6 bidders**	*"6-bidder m = 0"* 6 sessions	*"6-bidder m = ¼"* 15 sessions	*"6-bidder m = ¾"* Sessions

Participants were seated next to private computer terminals and were given written instructions (included in Appendix B). After decision makers were given an opportunity to review the written instructions, the instructions were read aloud by the experimenter. Decision makers were then allowed to ask questions. This was followed by two practice auctions and another round of questions. Decision makers were not allowed to talk during the study and had to remain seated at the computer terminal until the completion of the study. The experiment was computerized, using the popular experimental platform of zTree [23].

The private valuation for the item, denoted by *v* was uniformly distributed between 50 and 100, and restricted to integers. New values were drawn for each bidder in each of the rounds decision makers participated in. The item was denoted generically as "Item A," and bidders were shown their private value for the item in large letters on the screen. Hence, bidders knew their own valuation, but the only

information they had about other bidders' valuations was that they were randomly drawn from 50 to 100. Bidders received pay in the form of tokens. The exchange rate ranged from 1 to 15 cents per token[3].

The multiplier, denoted by α in Equation (1), took on the value of 0, ¼ or ¾. When the multiplier was 0, each winning bidder received his private valuation minus the winning bid for each round in which he won and the losing bidders received nothing. With a positive multiplier, all bidders, whether they won or lost, received in each round an additional amount equal to the winning bid times the multiplier. Thus, losing bidders received a portion of the winning bid whereas winning bidders can be thought of as receiving a subsidy so that they pay only a fraction of their winning bid. This approach is similar to the method used by [12]. They showed that results of this approach were consistent with those of an actual auction with price externality where proceeds were donated to charity.

In conditions that involved the English auction format, each round lasted for a minimum of two minutes, with a "soft" closing time—A 15 s extension occurred when a last second bid was placed. Thus, for example, if there are 3 s remaining and a bid is placed, the timer will reset and there will be 15 s remaining from that point on. The purpose of that feature was to avoid sniping—Or last second bids.

4. Experimental Results

Table 2 provides a comprehensive overview of our results in terms of efficiency, revenue and predicted bids, while Table 3 presents the significance tests of these results, comparing outcomes for different conditions (multipliers and number of bidders). Table 4 provides a summary with the findings from our hypotheses tests.

4.1. The Effect of the Multiplier on Individual Bids and Revenues

We first consider hypothesis 1 which predicts that individual bids and revenues increase in the multiplier. We look at the predictions for individual bids, and compare bids to theoretical predictions as well as the impact of the multiplier on auction revenue.

We begin with the analysis of the SPSB format, because in that format, we observe the uncensored bids by all bidders, which is essential for the first part of hypothesis 1 pertaining to comparisons of individual bids.

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3   The intent was to calibrate earnings to be roughly the same for different sessions—in the $15 range per subject including a show up fee. We varied the exchange rate within treatments to test for exchange rate effect. No exchange rate effect was found.

Table 2. Comparison of SPSB and English auctions for different conditions (multipliers and number of bidders) (Standard errors in parentheses).

Condition	Results SPSB Auctions				Results English Auctions			
	1. Predicted Bid Minus Bid [a]	2. Valuation Minus Bid [a]	3. Revenue	4. Efficiency [b]	5. Predicted Bid Minus Bid [a]	6. Valuation Minus Bid [a]	7. Revenue	8. Efficiency [b]
3-bidder, $m = 0$	$−2.90 (1.43)	$−2.90 (1.43)	$93.44 (1.35)	63.80 (5.10)	$13.24 (2.11)	$13.24 (2.11)	$75.13 (0.82)	84.28 (4.68)
3-bidder, $m = ¼$	8.45 (3.32)	3.49 (3.32)	95.77 (3.68)	56.93 (4.51)	22.60 (1.99)	16.58 (2.02)	71.49 (1.33)	64.57 (3.73)
3-bidder, $m = ¾$	14.66 (3.35)	3.65 (3.29)	90.61 (3.38)	65.95 (4.99)	27.75 (2.17)	14.66 (2.16)	78.33 (0.71)	69.50 (4.06)
6-bidder, $m = 0$	0.70 (5.30)	0.70 (5.30)	101.65 (3.79)	55.00 (11.90)	23.92 (1.36)	23.92 (1.36)	86.17 (1.52)	68.33 (7.17)
6-bidder, $m = ¼$	5.53 (4.79)	0.572 (4.83)	110.37 (7.54)	36.67 (6.15)	24.48 (1.29)	19.34 (1.28)	96.35 (0.88)	49.33 (4.09)
6-bidder, $m = ¾$	−8.01 (5.09)	−18.56 (5.03)	151.50 (14.96)	30.00 (4.47)	8.83 (8.90)	−2.72 (8.97)	128.44 (20.03)	38.75 (8.95)

[a] In English auctions, this statistic pertains only to losers' bids; [b] % of time highest value bidder won.

Table 3. T-tests for significance of different outcome from Table 2, for different conditions (multipliers and number of bidders). (T-statistics and *p*-values reported).

Test	Results SPSB Auctions				Results English Auctions			
	1. Predicted Minus Bid [a]	2. Valuation Minus Bid [a]	3. Revenue	4. Efficiency [b]	1. Predicted Bid Minus Bid [a]	2. Valuation Minus Bid [a]	3. Revenue	4. Efficiency [b]
T-test for: 3 bidders 0 *vs.* ¼	T = 2.87 / *p* = 0.005	T = 1.62 / *p* = 0.109	T = 0.54 / *p* = 0.590	T = 1.01 / *p* = 0.315	T = 2.54 / *p* = 0.010	T = 0.79 / *p* = 0.180	T = 1.70 / *p* = 0.090	T = 3.18 / *p* = 0.002
T-test for: 3 bidders ¼ *vs.* ¾	T = 1.27 / *p* = 0.207	T = 0.03 / *p* = 0.974	T = 0.98 / *p* = 0.328	T = 1.32 / *p* = 0.190	T = 1.90 / *p* = 0.060	T = 0.46 / *p* = 0.650	T = 4.08 / *p* < 0.001	T = 1.12 / *p* = 0.270
T-test for: 3 bidders 0 *vs.* ¾	T = 5.06 / *p* < 0.001	T = 1.91 / *p* = 0.059	T = 0.82 / *p* = 0.416	T = 0.30 / *p* = 0.766	T = 4.32 / *p* < 0.001	T = 0.42 / *p* = 0.673	T = 2.80 / *p* = 0.007	T = 2.28 / *p* = 0.025
T-test for: 6 bidders 0 *vs.* ¼	T = −0.66 / *p* = 0.527	T = 0.02 / *p* = 0.987	T = 0.88 / *p* = 0.404	T = 1.51 / *p* = .170	T = 0.11 / *p* = 0.913	T = 0.90 / *p* = 0.377	T = 3.74 / *p* = 0.001	T = 3.14 / *p* = 0.005
T-test for: 6 bidders ¼ *vs.* ¾	T = 1.93 / *p* = 0.086	T = 2.73 / *p* = 0.023	T = −2.59 / *p* = 0.029	T = 0.84 / *p* = 0.421	T = 2.05 / *p* = 0.053	T = 2.88 / *p* = 0.009	T = 2.21 / *p* = 0.038	T = 1.31 / *p* = 0.205
T-test for: 6 bidders 0 *vs.* ¾	T = 1.17 / *p* = 0.279	T = 2.61 / *p* = 0.035	T = −2.88 / *p* = 0.024	T = 2.15 / *p* = 0.068	T = 1.43 / *p* = 0.179	T = 2.51 / *p* = 0.028	T = 1.81 / *p* = 0.096	T = 2.75 / *p* = 0.018

[a] In English auctions, this statistic pertains only to losers' bids; [b] % of time highest value bidder won.

The left-hand side of Figure 1 shows the bids prescribed by the theory for each possible bidder valuation under the SPSB conditions. The theory-predicted bids are linear in valuation for each of the conditions. The theory unambiguously prescribes that the bid-valuation relationship, for all but the top of the support, would shift upwards as the multiplier increases. That means that for a given valuation, a higher multiplier would imply a higher bid for most of the range of valuations. The lines intersect at the top of the valuation support. The right-hand side of Figure 1 shows the estimated linear bid functions that are based on the actual bids, which seem to indicate less of an impact due the multiplier than suggested by theory.
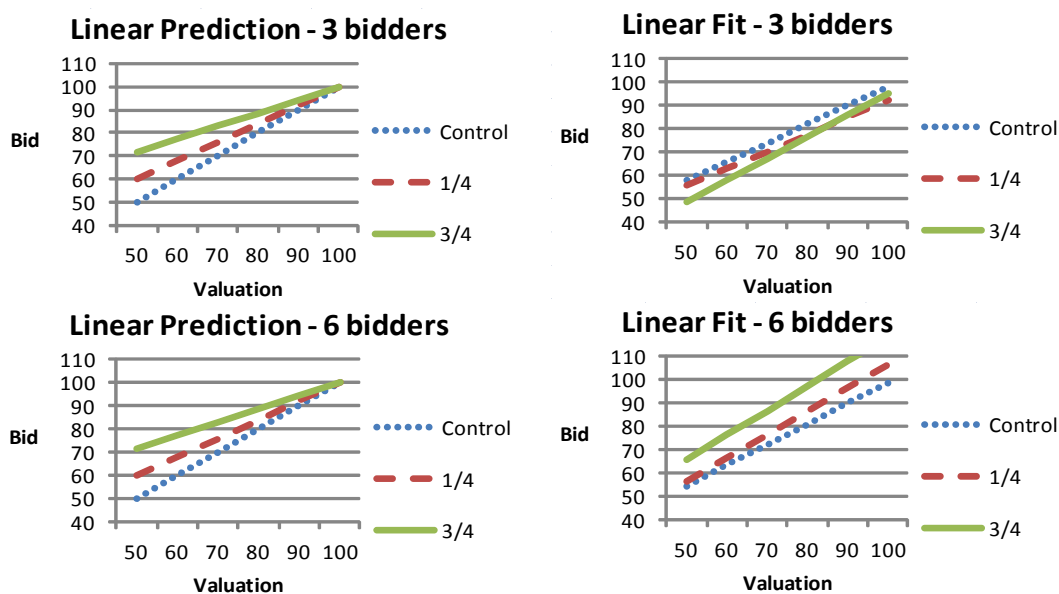

Figure 1. SPSB conditions. Theory and linear fit of the bid data on valuation.

WTPs obtained from the auctions for 3-bidder SPSB are different from the theoretical predictions. The p-values are 0.01, 0.33, <0.01, for the 3-bidder $m = 0$ (control) condition, $m = \frac{1}{4}$ condition and $m = \frac{3}{4}$ condition, respectively. Results for 6-bidder SPSB do not differ from theoretical predictions (*p*-values are 0.62, 0.46, 0.10, for 6-bidders $m = 0$ condition, $m = \frac{1}{4}$ condition, and $m = \frac{3}{4}$ condition respectively). Unlike the clearly separated predictions for the different multipliers, the estimated linear bid functions are remarkably close to one another for the range of values used in the study. The intercepts for the $\frac{1}{4}$ and $\frac{3}{4}$ multiplier are not significantly different from the intercept for the $m = 0$ condition ($p = 0.80$ for condition $\frac{1}{4}$ and $p = 0.12$ for condition $\frac{3}{4}$). The slopes for the $\frac{1}{4}$ and $\frac{3}{4}$ multiplier are not significantly different from the slope for $m = 0$ ($p = 0.46$ for condition $\frac{1}{4}$ and $p = 0.35$ for condition $\frac{3}{4}$). Thus, the data ranking of the condition manipulations is inconsistent with the theoretical prediction for the three-bidder conditions, although it appears in line with theoretical predictions for six player conditions.

Next, we examine how (under) bidding patterns correspond to bidder valuations in the English auction format. Unlike the SPSB format, in the English auction format we can only gauge underbidding for losing bidders. We find that underbidding in English auctions with $n = 3$ significantly increases ($p = 0.01$) between 0 and $\frac{1}{4}$ and marginally increases ($p = 0.06$) between $\frac{1}{4}$ and $\frac{3}{4}$. For $n = 6$ English

auctions, we see no evidence of increased underbidding with higher multiplier[4]. In contrast, for $n = 6$, the magnitude of underbidding decreases in the multiplier between $m = ¼$ and $m = ¾$, and this is significant ($p = 0.05$).

One important finding is that there is substantial loser underbidding (even in the control condition with zero multiplier)[5]. Such underbidding has been documented before [24] and explained with the observation that bidders are reactive and inexperienced [24–26].

Figure 2 shows the extent of underbidding over time—across the auctions in which decision makers participated—separately for three bidders and six bidders. Especially in the SPSB formats—less so in the English formats—we observe a decrease in the extent of underbidding over time. This greater movement overtime in SPSB auctions than in English auctions is likely due the fact that in English auctions bidders are able to adapt to what the competition does in the course of the auctions (within-round learning), whereas in SPSB auctions learning can only take place between rounds.
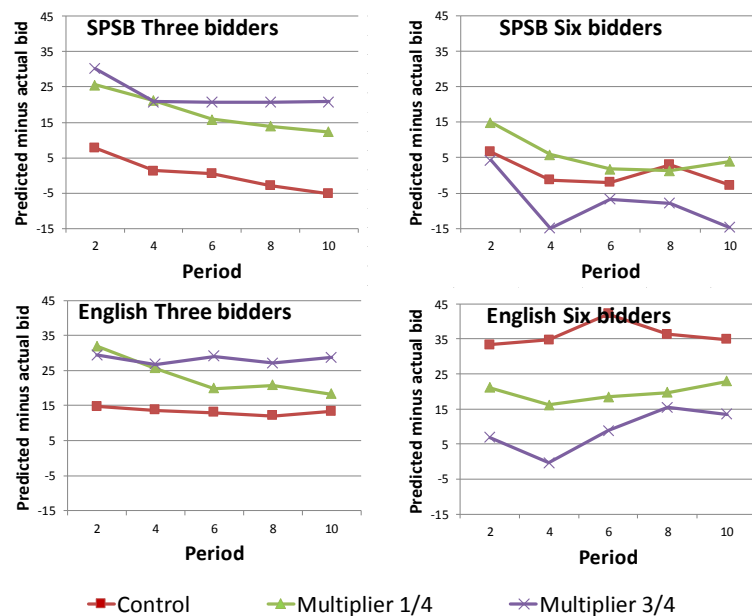

Figure 2. Extent of Underbidding over time in SPSB and English Auctions.

In English auctions with three bidders, decreased underbidding over time is only evident for the 3-bidder $m = ¼$ condition. For the 3-bidder $m = ¾$ condition, losing bidders gain more and there is less incentive to adapt bidding behavior and so we see flatter curves in the $m = ¾$ condition. This persistence

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[4]   Note that revenue (equal to the winning price) in condition $m = ¾$ with 6 bidders is significantly above the maximum bidder valuation of 100, which is nevertheless below the theoretical prediction for this condition.

[5]   Some underbidding in the control treatment is expected. The predicted bid for a losing bidder is at one's valuation. Any bid above one's valuation in the zero-multiplier condition results in a loss conditional on winning regardless of bidding strategy or beliefs. So any bidder deviation from prediction should be below the predicted bid. Deviations could be due to any number of reasons including bidders bidding intermittently, jump bidding, or simply truncated errors.

of underbidding is reminiscent of results in the auction and winner's curse literature regarding the persistence of overbidding over time in common value auctions [27] as well as takeover bids [28][6].

In 6-bidder English auctions with $m = 0$ we see a small increase and then decrease in underbidding over time. For both $m = ¼$ and $m = ¾$ conditions we initially see a decline in underbidding followed by an increase. In 6-bidder SPSB auctions, underbidding is less pronounced in the $m = 0$ and $m = ¼$ conditions. In the 6-bidder $m = ¾$ condition, we first see movement towards less underbidding, and eventually towards overbidding.

We construct a linear regression of underbidding on bidder valuation, such that the dependent variable is underbidding (either loser valuation minus bid; or theoretically predicted best bid minus bid) and the explanatory variable is bidder valuation, plus a constant. The resulting fitted lines are exhibited in Figure 3.

The figures point to the same relative rankings. In the 3-bidder English auction conditions, the 3-bidder $m = ¾$ English auction condition exhibits the greatest underbidding, followed by $m = ¼$ English auction condition and then the 3-bidder $m = 0$ English auction condition. However, in the $m = 0$ condition and the 3-bidder $m = ¾$ condition bidders exhibit a negative slope of underbidding to valuation as shown in Figure 3: Underbidding drops as bidders' valuations increase. This is intuitive—as bidders have a higher chance of winning, their incentives to compete increase.

The 3-bidder $m = ¾$ condition's high intercept in Figure 3 could mean that likely losers (low valuation bidders) in the ¾ condition are more discouraged relative to the other conditions. Note however, that we do not observe this pattern for the 6-bidder conditions where we expect that bidders should be even more discouraged, due to reduced likelihood of winning.
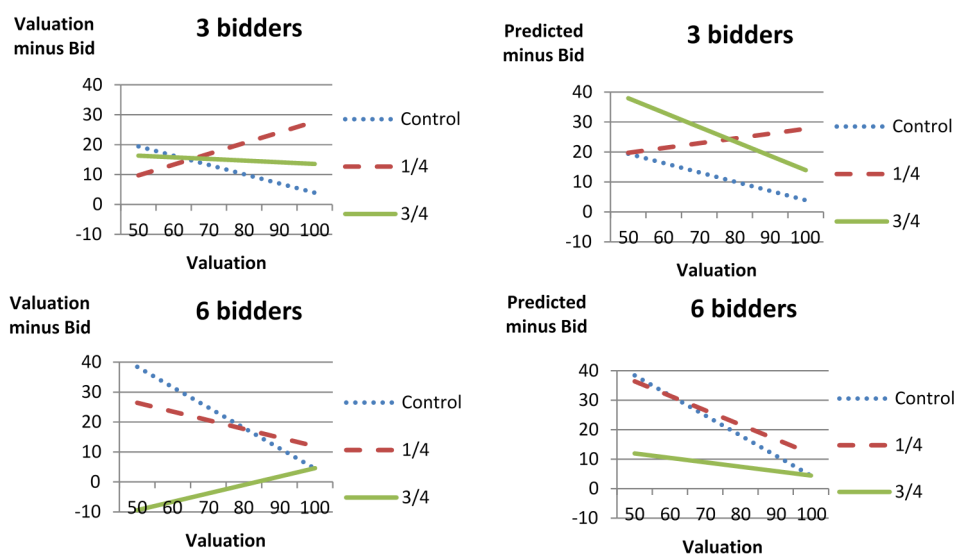

Figure 3. English auctions. Relationship between loser underbidding and valuation.

The 3-bidder $m = ¼$ condition has a highly significant ($p < 0.001$) positive slope of underbidding in valuation. That is, as valuations increase, bidders are more likely to underbid. This suggests some

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[6] Foreman and Murnighan (1996) [27] investigated whether feedback and relevant experience over four weeks could help alleviate overbidding in common value auctions (known as the winner's curse). They found that while some learning occurred, the overbidding was remarkably persistent over time.

reluctance to win in that condition because as one's likelihood to win increases, his underbidding is more pronounced.

In the 6-bidder English auction conditions, the $m = ¼$ condition was shown to have more underbidding than the 6-bidder $m = ¾$ condition (see bottom panel of Figure 3). Figure 3 confirms that ranking. Recall that we speculated early on that there might be less underbidding in the 6-bidder conditions because the probability of winning is lower. The 6-bidder $m = ¾$ condition shows a small positive slope in the theoretical underbidding (but a small negative slope in the underbidding relative to valuation). Neither slope in the 6-bidder $m = ¾$ condition is significant ($p > 0.10$).

In summary, we observe that underbidding increases as the multiplier increases, which is a rejection of hypothesis 1. In particular, English auctions with three bidders display a clear rejection of hypothesis 1 in that revenues fall and the magnitude of underbidding increases in the multiplier. These patterns parallel the patterns in SPSB, offering a consistent set of evidence.

4.2. The Effect of the Multiplier on Auction Revenues

The second part of hypothesis 1, pertaining to revenue comparisons, is assessed in column 4 of Table 2. Revenues in the three-bidder SPSB are 93.44 (1.35), 95.77 (3.68), and 90.61 (3.38) for condition $m = 0$, condition ¼ and condition ¾ respectively. The t-tests reported in Table 3 show no significant differences in revenues between the different multipliers in the three-bidder SPSB conditions. Thus, our tests indicate that the multiplier does not significantly affect revenues in the three-bidder SPSB conditions. As we will see in subsequent analysis, this is due to the disproportional impact of the multiplier on bidders' reactions to the incentive to lose.

In the six-bidder SPSB conditions, the revenues are clearly increasing and are 101.65 (1.37), 110.37 (3.79) and 151.50 (14.96) for condition $m = 0$, condition ¼ and condition ¾ respectively. Thus, Table 3 indicates that the multiplier significantly affects revenues in the six-bidder SPSB conditions and in the direction predicted by the theory. Table 3 provides pairwise tests between the conditions.

For English auctions revenue comparisons show that for $n = 3$, a higher multiplier does not monotonically result in higher prices as theory predicts. In comparing the $m = 0$ condition to the ¼ multiplier condition for $n = 3$, we see, in contrast to hypothesis 1, a marginally significantly *lower* revenue with the multiplier increase ($p = 0.09$) (see Table 3 for significance tests). However, for $n = 6$, revenues increase as the multiplier increases from 0 to ¼, in accordance with the theory ($p = 0.001$). Moreover, we find that as the multiplier increases from ¼ to ¾, revenues significantly increase for both $n = 3$ ($p < 0.001$) and for $n = 6$ ($p = 0.038$), in support of hypothesis 1. We also see for $n = 3$ a significant ($p = 0.007$) difference in revenues between the 0 multiplier and the ¾ multiplier in the direction predicted by hypothesis 1. This difference is only marginally significant for $n = 6$ ($p = 0.096$).

The main finding with respect to hypothesis 1, that revenue increases in the multiplier, is that we find support for this in the English auction, but only partial support in the SPSB auction (only for the six-bidder condition). Thus, the theory regarding the multiplier does not seem to hold all the way for smaller groups of bidders.

4.3. Efficiency in Auctions with Price Externalities

Hypothesis 2 proposed that auctions with price externality are efficient. Recall from property 2 that efficiency implies that the highest valuation bidder wins the auction. In Table 2, efficiency is computed as the percentage of time that the highest valuation bidder won. Ideally, according to Property 2, efficiency should be at 100%. Table 2 shows that the loss of efficiency (see columns 4 and 8) resulting from underbidding is pretty substantial for both SPSB and English auctions. In addition, as expected, efficiency decreases as the number of competing bidders increases from three to six, and efficiency is greater for English than for SPSB auctions.

In general, efficiency is higher in auctions without externalities (a multiplier) than for auctions with a multiplier. For English auctions this is the case for both positive multipliers and for both 3 and 6 bidder-auctions (see Table 3), while for SPSB auctions efficiency is only significantly lower, relative to $m = 0$, for the ¾ condition with 6 bidders.

Overall, auctions with externalities are not efficient as in less than half of the instances the highest bidder actually wins in a SPSB auction and only a little above half of the instances in English auctions. While in general English auctions were more efficient, as bidders can update their bids, efficiency is more influenced by the multiplier (a reduction in efficiency) in the English auctions than in the SPSB auction.

4.4. The Effect of the Number of Bidders on WTP

Hypothesis 3, predicted that bidders' WTP is unchanging in the number of other bidders. For SPSB auctions we find that increasing the group size from three to six bidders yields a significant increase in individual bids, which is counter to what theory prescribes (see Column 1 of Table 2). Thus, we reject hypothesis 3 for the SPSB format and conclude that increasing the number of bidders appears to result in higher individual bids.

In the English auction we find significant underbidding for losing bidders (see Column 1 of Table 2). We see that the losing bidders typically underbid relative to their theoretically prescribed bids but that the deviation is significantly smaller for 6 bidders with a multiplier of ¾ relative to 3 bidders with a multiplier of ¾. This goes against the theoretical result as expressed in hypothesis 3. We can thus reject hypothesis 3 for the ¾ multiplier, but not for the ¼ multiplier.

Overall we found limited support for the hypotheses, derived from theory. In particular, we observe significant underbidding in both English and SPSB auctions, which is contrary to theoretical predictions. We also find, contrary to theoretical predictions, that auctions with price externality (both English and SPSB) are not efficient. Finally, in contrast to theoretical predictions, we find that bidders' WTP tends to vary with the number of bidders. The results of these hypotheses are summarized in Table 4.

Table 4. Summary of Hypotheses tests for different conditions.

	H1. Individual Bids Increase in the Multiplier	H1. Revenues Increase in the Multiplier.	H2. Auctions with Price Externality are Efficient.	H3. Bidders' WTP is Unchanging in Number of Other Bidders.
SPSB–3 bidders	Not Supported	Not Supported	Not Supported (same as $m = 0$)	Not Supported
SPSB–6 bidders	Supported (only for $m = ¾$)	Supported (only for $m = ¾$)	Not Supported (same as $m = 0$)	
English–3 bidders	Not Supported	Supported (only for $m = ¾$)	Not Supported (less efficient then $m = 0$)	Supported (for ¼ multiplier) Not Supported (for ¾ multiplier)
English–6 bidders	Supported (only for $m = ¾$)	Supported	Not Supported (less efficient then $m = 0$)	

4.5. Analysis of Heterogeneous Population Models

Up to this point we have assumed that bidders are homogeneous in their bidding behavior. However, it is to be expected that bidders vary in their behavior. In particular, we expect that some bidders will be less aggressive and others overaggressive in their winning propensity (independent of the experimental conditions). Note that if no bidder is overaggressive or under-aggressive, we should expect to see in the three bidder auctions, 3.33 wins per bidder out of the ten auctions that bidders participate in. This is in sharp contrast to the actual proportions observed in the data, which indicate a significant amount of both overbidding and underbidding. We do not observe a specific trend in the data, suggesting that this is due to individual differences rather than due to the different conditions in our study (*i.e.*, the multiplier or the number of bidders).

The existence of both overbidding and underbidding, suggests that we ought to be using a utility-based econometric estimation that permits bidder heterogeneity. The utility function we employ is linear in its terms (for a more formal presentation, see Appendix A). The first term in the utility is the direct payoff—the difference between the private value for the item and the bid—multiplied by the probability of winning with that bid. The next two terms are additional payoffs winning and losing bidders receive from the money raised. Both winners and losers receive an additional payoff α_i from each dollar of revenue. Following [12,13], we allow each bidder to possess two parameters α and β. [12] describe the parameters α and β as denoting the utility a bidder gains for each additional unit of revenue the auctioneer raises when the bidder loses the auction and when the bidder wins the auction, respectively[7]. We refer to parameter α as the *incentive to losers* and to parameter β as the *incentive to winners.*

We use the mixture model approach for estimation. The mixture model approach posits discrete segments of bidders, where bidders within a segment all possess the same underlying behavioral parameters. The point of this mixture model is to group bidders into "types". This type of model is often very useful in making predictions or characterization in a setting such as auctions with price externality.

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[7] Bidders who gain greater utility from seller revenue when they are the winning bidder could be interpreted as wanting to be seen as a generous person. Salmon and Isaac (2006) [13] and Isaac *et al.* (2010) [12] refer informally to such preferences as preferences to see-and-be-seen.

In Table 5 we report estimates of the three-segment bidding functions for the SPSB and English conditions, using the structural functional form of Equation (4′). For the purpose of estimation, all bidders are used for the SPSB bidding functions (winners and losers) as opposed to only losing bidders for the English auction estimates. This is because in SPSB, all bidders have symmetric information and symmetric strategies.

Several things are worth noting in Table 5. First, we see that the number of segments differs across conditions. The number of segments to include is based on likelihood ratio tests, incrementally increasing the number of segments till there is no further improvement in fit. For identification, when there are three segments, one of the three segments' alpha and beta parameters are fixed at zero. This parameterization cannot be rejected in terms of likelihood and fixing the parameters gets us cleaner inference on the remaining parameters.

We see that for segment 1 in the one-fourth condition, the coefficients for alpha and beta are not individually significantly different from 0. However, these two parameters are jointly significantly different from zero at $p < 0.05$, and the difference between them is different from zero at $p < 0.05$.

Other than the three-segment characterization, a key take-away is that in the $m = 0$ condition as well as the one-fourth condition, there are both a losing-prone segment (segment 1) and a winning-prone segment (segment 2). This is especially notable for the $m = 0$ condition, because in that condition, the multiplier is zero so there should not be an externality to either losers or winners so for rational bidders, alpha and beta should be 0.

The alpha and beta parameters in all conditions are significantly different from one another, suggesting that the incentive to losers (alpha) and incentive to winners (beta) are not perceived as being of the same magnitude, which is in contrast to the actual underlying incentives. It is interesting that the underlying parameters are generally decoupled from the incentive structure. That is, the monetary incentives influence the underlying propensity to win or lose but we cannot detect any clear and meaningful pattern of that relationship. This seems to suggest that bidder aggressiveness (both over-aggressiveness and under-aggressiveness) is bidder-specific and not necessarily related to the incentive structure. The three-fourth SPSB three-bidder condition, where underbidding was most evident, is characterized by fairly mild perceived bonus incentives to lose but no perceived bonus incentives to win. Thus, even though the effects appear to be lower in the three-fourth condition, they are consistently tilted in the direction towards losing, which appears to make the difference. In the English auctions three-bidder condition, segment 1 is the losing prone segment and segment 2 is a more indifferent segments.

Table 5. Mixture model estimates of the bidding functions.

Three Bidders SPSB			
Parameter	**Control**	**One-Fourth**	**Three-Fourth**
Segment 1–Alpha	0.40 **	0.52 $^{\pm}$	0.14 **
Segment 1–Beta	0.36 **	0.34 $^{\pm}$	0.00
Segment 2–Alpha	0	0.22 **	0.06 **
Segment 2–Beta	0.07 **	0.30 **	0.00
Segment 3–Alpha	0	0	0
Segment 3–Beta	0	0	0
Proportion Segment 1	0.74	0.63	0.23
Proportion Segment 2	0.14	0.21	0.28
Proportion Segment 3	0.12	0.16	0.49
Log-Likelihood	−1739	−2535	−1648
Six Bidders SPSB			
Parameter	**Control**	**One-Fourth**	**Three-Fourth**
Segment 1–Alpha	0.582 **	0	0
Segment 1–Beta	0	0.227 **	0.383 **
Segment 2–Alpha	0.166 **	0.132 **	0
Segment 2–Beta	0.192 **	0	0
Proportion Segment 1	0.874 **	0.673 **	0.652 **
Log-Likelihood	−1441	−1599	−1756
Three Bidders English–Only Pivotal Bids (Second Price) Used			
Parameter	**Control**	**One-Fourth**	**Three-Fourth**
Segment 1–Alpha	0.24 **	1.16 **	0.91 **
Segment 1–Beta	0.07	0.81 **	0.70 **
Segment 2–Alpha	−0.01	0	−0.02
Segment 2–Beta	−0.02	0	0
Proportion Segment 1	0.62 **	0.71 **	0.70 **
Log-Likelihood	−372	−1021	−583
Six Bidders English–Only Pivotal Bids (Second Price) Used			
Parameter	**Control**	**One-Fourth**	**Three-Fourth**
Segment 1–Alpha	0.087 **	0	0
Segment 1–Beta	0	0.158 **	0.623 **
Segment 2–Alpha	0.012 **	0.954 **	0
Segment 2–Beta	0	0.949 **	0.151 **
Proportion Segment 1	0.75 **	0.87 **	0.82 **
Log-Likelihood	−117	−521	−681

** Parameter significant at $p < 0.05$; $^{\pm}$ Alpha and beta are individually not significant at $p < 0.05$ but jointly significantly different from 0 ($p < 0.05$).

5. Conclusions

In this work, we study bidding behavior in auctions with price externality. Such auctions are understood in the literature to be the closest theoretical abstraction to charity auctions—auctions where the levels of proceeds presumably affect the utility of the bidder. Not all charity giving falls under this classification. For example, a bidder might donate to charity auctions for warm glow [29,30]—utility

from the act of giving that is decoupled from the amount raised. Therefore, in applying the insights from this work to charity auctions, one should take care to find auctions where the benefit to the bidder is relatively direct. Examples include school or church auctions, where the proceeds go towards enhancing services to members who are also the bidders in the auctions.

One of the variables that the investigation focused on is the *multiplier*. This multiplier serves as an abstraction for the degree that the proceeds directly affect the bidder. This has a direct parallel to the multiplier in the public good literature [31] and the implied marginal per capita return [32].

We find that while the multiplier—the direct benefit from the proceeds—can encourage bidders to increase bids, it can also result in ambivalence towards winning which might lower bid levels. Consistent with the latter, we observe significant underbidding in our controlled laboratory experiments. Bidders bid significantly below their valuations in most conditions and well below the theoretical optimal bid.

The empirical findings in the laboratory stand in sharp contrast to theoretical predictions, which suggest that bidders should bid more than their valuations and these bids should increase in the multiplier.

The pattern of underbidding includes observed bidders' reluctance to place bids in auctions with higher multipliers. That is, the patterns suggest that bidders facing a moderate to high multiplier do not bid aggressively. We propose that the observed pattern can be explained by bidders perceiving higher benefit to losing than to winning, as expressed by a higher alpha relative to beta in the theoretical model. The current results, including the estimation of the mixture model, suggest that the observed pattern is driven largely by a higher perceived benefit from losing than from winning.

The mixture model estimates rely on a particular utility specification. Clearly, there are alternative specifications for utility that might better fit the observed patterns. The most obvious modification would be to add concavity. This is not possible in the present heterogeneous estimation as it is not reliably separately identifiable by subpopulation from the other parameters. Estimating and correctly identifying more complex yet heterogeneous utility functions that will explain the observed patterns will require a different experimental design (e.g., varying the multiplier within subjects rather than between subjects). That said, the fact that subjects consistently bid below their valuations in the $n = 3$ conditions is pretty convincing evidence of loser incentives looming larger. This is because for any utility curvature, a bidder will not bid under their valuation in any of the conditions unless that incentive to lose is overweighted relative to the incentive to win. The pattern we uncovered is not invariant to incentives and competition. As the number of competing bidders increases from three to six, it changes both the total welfare stake and the competitive intensity.

In terms of social welfare, if we think of the auction with price externality as a social dilemma game and look at the extent of social inefficiency from underbidding [33], we can see that the 6-bidder settings have a greater extent of social inefficiency from low bids and this social incentive could be playing a role in reducing underbidding. In terms of competitive intensity, 6-bidder conditions are more likely to involve a bidding war that will bring bids up. Therefore, the 6-bidder auctions are characterized by far less underbidding.

This set of empirical results adds to a larger empirical literature indicating an unresolved puzzle regarding motivations in auctions with price externality. While empirical studies such as [20,21,34] report significant and respectable charity premiums, other studies such as [12] do not find a charity premium for more controlled settings.

The present set of results attempted to shed light on one possible explanation for this inconsistency—namely the asymmetric perceptions of the benefits from winning and losing. This asymmetry will presumably be particularly critical in settings that do not have endogenous participation like the setting here as well as the settings in [12] and less problematic in settings with bidder self-selection like the auctions in [20,21,34] where bidders choose to bid in auctions with price externality[8].

Moreover, we found that despite a substantial level of underbidding, as the multiplier increases winning prices significantly increase. This is an encouraging finding relative to [12], who find no significant revenue increase in sealed bid settings. It suggests that revenues can be increased, relative to no-externality settings, by conducting auctions with price externality with charitable bidders. Both the present work and [12]'s work suggest that the increase in revenues will be substantially less than the theoretical predictions, but our demonstrated increase in revenues is more optimistic than past findings.

In our auctions with price externality we see decreased competitive intensity as manifested by fewer bids. We attribute this behavior to the perceptions about benefits from winning and losing.

There are of course other variables that may influence competitive bidding behavior in charity auctions. For example, [21] observe reduced bidder entry in auctions with price externality relative to non-charity auctions. Other variables that may differentially influence competitive behavior in charity auctions include altruistic preferences [37] and "see and be seen" preferences [12]. That is, some individuals behave in a seemingly more altruistic manner when they think they are observed by others [38,39] and when they observe others behaving altruistically [40][9]. These issues merit further investigation.

Acknowledgments

Author Contributions

Both authors contributed equally to this article.

Conflicts of Interest

The authors declare no conflict of interest.

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8 Elsewhere in this literature, theoretical predictions do not seem to hold very well. For example, [35] report the results of four sealed bid auctions with price externality for four different preschools, comparing revenues of a first price, second price and all-pay auctions. In contrast to the theoretical work [35,36], they find that first price auctions revenues are highest followed by second price and finally all-pay auctions. They attribute this discrepancy to endogenous bidder participation.

9 This observation could imply predictions in either direction—depending on whether individuals are altruistic towards the charities or towards other bidders. It is reasonable to assume that when bidding in auctions with price externality auctions with price externality, the bidder's altruism towards the charity dominates.

Appendix A. Derivation and Proofs

Let *v* denote one's valuation, *b* denotes his bid, B_S denotes the second highest price in the auction, and α denotes the portion of the winning bid that every bidder gets. From here on, the parameter α is referred to as the *multiplier*. The payoff function is specified as:

$$\pi(v,b) = (v-b)[if \ win] + \alpha B_S \qquad (1)$$

We show the solution for a second price auction, which is arguably equivalent to an English clock auction, as argued by [13] and proved in [14]. This bid function could also be interpreted to deliver the highest price a bidder would be willing to stay in for in a non-clock English auction, although this may not be the case with non-incremental bids [41].

The payoff maximization problem for a bidder with valuation v_i in the second-price auction is specified below [13,14].

$$\max_b \pi(v_i, b) =$$

$$\int_{\underline{v}}^{b} \left[v_i - (1-\alpha_i) B_S(x) \right] dF(x)^{n-1} dx$$

$$+ \alpha_i B_S(b)(n-1)F(b)^{n-2}(1-F(b)) \qquad (2)$$

$$+ \int_b^{\bar{v}} \alpha_i B_S(x)[(n-2)(n-1)F(x)^{n-3}(1-F(x))f(x)]dx$$

The first term represents the utility that the bidder gets in the event that he wins the auction. It is equal to his valuation minus the price he pays, discounted by (1 − α) because every bidder gets the multiplier, α, multiplied by the winning price. The price paid is equal to the second highest bid, denoted B_S[10]. We integrate that over the possible prices that the winner might pay. Since the payment price is the second highest bid by an opponent, we integrate this term over the opponent's valuation.

The second term defines the utility that the bidder receives from placing the second highest bid as he will set the price and will thus get his share of that price. This is multiplied by the probability that his bid is the second highest bid and thus the pivotal bid. Note that this is the only instance of B_S in this equation that has one's own bid, denoted here by *b*, as a term. That is, one's own bid b only affects the price when it is the second highest, and thus the pivotal, bid.

The final term represents the utility from coming in lower than second. Bidders whose bids are lower than second will get α times the second highest bid. Note that the second highest bidder and lower price bidders are similar in that they all receive α times the second highest bid. The fact that utilities for the second highest bidders and lower price bidders are expressed by different terms is not due to different utility considerations[11]. Rather, the difference comes from the second highest bid determining the price, whereas lower bidders do not. This means that the second highest bidder directly impacts his own utility with his bid, where lower price bidders do not impact their own utilities with their bids.

Maximizing the objective function of Equation (2) for the case of bidders adopting symmetric bid functions results in a general solution [14].

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[10] There might also be an added small bid increment which is conveniently ignored here.

[11] In other words, there is no additional utility per se from being the price setter.

$$B_S(v_i) = v_i + \int_{v_i}^{\bar{v}} \left(\frac{(1-F(x))}{1-F(v_i)} \right)^{\frac{1}{\alpha_i}} dx \qquad (3)$$

Applying this to the case of the uniform distribution on the range [50,100], used in this research, the bid function can be expressed as shown below.

$$B_S(v_i) = v_i + \frac{(100-v_i)\alpha_i}{1+\alpha_i} \qquad (4)$$

A critical element of this solution is that the bid function for a second-price auction with price externality is independent of the number of bidders, *n*. Also notice that when α is zero the solution simplifies to *v*, the bidding rule for a second-price independent private value non-auction with price externality. Based on these result, we state critical properties. Using these properties, we then form the bases for our experimental tests.

An important feature of the present environment is that winning and losing bidders receive the same additional payoff, α_i, from each dollar of revenue to the charity. However, decision makers in the laboratory may or may not perceive the incentive to winners and the incentive to losers as being of the same magnitude. Following [12,13], we allow each bidder to possess two parameters α and β. [12] describe the parameters α and β as denoting the utility a bidder gains for each additional unit of revenue the auctioneer raises when the bidder loses the auction and when the bidder wins the auction[12], respectively. We refer to parameter α as the *incentive to losers* and to parameter β as the *incentive to winners*. The objective function is now changed to equation (2′):

$$\max_b \pi(v_i, b) =$$

$$\int_{\underline{v}}^{b} [v_i - (1-\beta_i)B_S(x)] dF(x)^{n-1} dx$$

$$+\alpha_i B_S(b)(n-1)F(b)^{n-2}(1-F(b)) \qquad (2')$$

$$+\alpha_i \int_{b}^{\bar{v}} B_S(x)[(n-2)(n-1)F(x)^{n-3}(1-F(x))f(x)] dx$$

The optimal bid function gets restated in equation (4′):

$$B_S(v_i) = \begin{cases} \dfrac{v_i(1-\beta_i+\alpha_i)+100\alpha_i}{(1-\beta_i+2\alpha_i)(1-\beta_i+\alpha_i)} & if\ \alpha_i > 0 \\ \dfrac{v_i}{(1-\beta_i)} & if\ \alpha\ =0 \end{cases} \qquad (4')$$

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[12] Bidders who gain greater utility from seller revenue when they are the winning bidder could be interpreted as wanting to be seen as a generous person. Salmon and Isaac (2006) [13] and Isaac *et al.* (2010) [12] refer informally to such preferences as preferences to see-and-be-seen.

Appendix B. Experiment Instructions

Experimenter: Welcome. This is a study in decision making. You will participate in several auctions, and if you pay careful attention and make wise decisions you will earn a considerable amount of cash which will be paid to you in private and in cash at the end of this study. Please carefully read the instructions. After this, we first run two practice auctions. Then you have an opportunity to ask questions before we start with the study. Please do not touch the computer until I instruct you to do so.

Instructions for Research Study

Welcome. This is a study in decision making. You will participate in several auctions, and if you pay careful attention and make wise decisions you will earn a considerable amount of cash which will be paid to you in private and in cash at the end of this study.

What to do in this study? The study will involve 10 separate rounds of auctions. In each round, you will place *bids* in tokens (Exchange rate 1 token = 2 cents) for a virtual item. These are "English" auctions where you keep on bidding, and prices keep going up, till only the winner remains.

How do I win? You *win* an auction if your *bid* is the highest for an item from among all bids submitted for this item. For example, if the highest bids submitted for an auction by bidders 1, 2, and 3 are 54, 48, and 87, respectively, then the number 87 is the highest and bidder 3 wins.

How can I tell if I am winning? The winning bid and bidder for each item will always be at the bottom of the list of bids for that item.

What do I win? When you win, you get your value for the item (shown in the top left corner of the screen), [minus 75% (three-fourth) of your winning bid]. To help you determine how much you will win, the CALCULATE button will compute the buyer net for any bid you enter and the computed amount will be displayed underneath the CALCULATE button as shown in the screen below.

What do I get when I lose? (When you lose, you get 25% (one fourth)) of the winning bid for the auction.

How to place a bid? To place a bid, you enter your bid in the box under "Enter a bid". Then press CALCULATE. Next, highlight the row underneath the CALCULATE button and press the Submit Bid button. The computer will then ask you to confirm one more time and you are done.

Can I place more than one bid? Yes, but not consecutively. You will need to wait for at least one bid by another bidder before you can enter a follow-up bid.

How much time do I have to place bids? You have **two minutes** to place bids. If anyone places a bid anytime in the last 15 s, the time will be **extended by 15 s**. So for example, if there are 3 s remaining and you place a bid, the timer will reset and there will be 15 s remaining from that point on.

What do I know about other bidders? (There are two other bidders competing with you.) Their bids will be shown on the screen under the Submit Bid button. You will not know their values. However, all values are randomly drawn from **50 to 100**. Each round a new set of numbers is independently generated for each participant.

We first start with 2 practice rounds after which you can ask questions.

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