Bidding to Give:

An Experimental Comparison of Auctions for Charity

Arthur J.H.C. Schram and Sander Onderstal[1]

University of Amsterdam, The Netherlands

January 18, 2008

ABSTRACT:

We experimentally compare three mechanisms used to raise money for charities: first-price winner-pay auctions, first-price all-pay auctions, and lotteries. We stay close to the characteristics of most charity auctions by using an environment with incomplete information and independent private values. Our results support theoretical predictions by showing that the all-pay format raises substantially higher revenue than the other mechanisms.

KEYWORDS: Auctions; Lotteries; Charity; Laboratory Experiments

***JEL* CODES:** C91; D44; H41

[1] We would like to thank Jacob Goeree for substantial contributions at the early stages of this project, and participants at the ESA 2006 conference in Nottingham for useful suggestions. Financial support from the Dutch National Science Foundation (NWO-VICI 453-03-606) is gratefully acknowledged. Please address correspondence to: Arthur Schram, CREED, Amsterdam School of Economics, Roetersstraat 11, 1018 WB Amsterdam, the Netherlands. Email: *Schram@uva.nl*.

1. Introduction

What do Eric Clapton's guitar, Margaret Thatcher's handbag, and Britney Spears' pregnancy test kit have in common? The answer: all were auctioned for the benefit of charity. Indeed, auctions are often used as a means to raise money for charities.[2] They are not the only method, however. Charities also organize lotteries and voluntary contributions to raise money. This co-existence of various mechanisms gives rise to the obvious question of their relative performance. In this paper, we use a laboratory experiment to answer this question.[3]

When the proceeds of an auction are donated to a charity, bidders may care about how much money is raised. Compared to the case where auctions or lotteries are only used as mechanisms to allocate private goods, cases where the proceeds matter to the bidders will affect the way in which they evaluate the outcome and the way they bid. Moreover, if the revenue constitutes a public good, the criteria used to evaluate mechanisms may be different from those used in the standard case. Whereas efficiency is a prime concern of a vast majority of the auction literature, mechanisms where the proceeds are dedicated to a charity are typically evaluated based on the revenue they generate.[4]

We consider the case where a single unit of a good is allocated by way of auction or lottery. The proceeds (revenue) are donated to a charity. Our focus is on the case where all participants care about the charity. *Ceteris paribus*, they attribute higher utility to higher revenue. Moreover, each individual attributes value to the good being offered. In this respect, note a second characteristic that the three collector's items mentioned above have in common: the value

[2] Charity auctions are not only used for selling expensive collector's items like the ones above. eBay, for instance, offers daily thousands of less valuable items for sale of which the revenue is partly or entirely donated to charity.
[3] Alternatively, one could study this question in field experiments. As argued by Levitt and List (2006), however, the laboratory is the preferred environment to start investigations on this type of mechanism selection. We will return to this point in the conclusions.
[4] Cramton *et al.* (1987) study the efficiency effects of dividing an auction revenue (not necessarily equally) among bidders. They show that an efficient allocation is usually not possible with unequal division.

attributed to them may vary significantly across individuals. This is typically the case for charity auctions. In our analysis, we therefore assume that individuals attribute independent private values to the good.

Many theoretical results have been obtained for both private and common value settings where bidders positively value the proceeds. First of all, auctions and lotteries dominate voluntary contribution mechanisms (Morgan, 2000; Lange *et al.*, 2007; Orzen; 2005). The reason lies in the negative externality that occurs when a person bids [buys lottery tickets]: this decreases the chances of others winning the auction [lottery]. This negative externality mitigates the free-riding incentive compared to voluntary contributions.

Second, the equilibrium bidding strategies for first-price and second-price winner-pay auctions unbalance the traditional revenue equivalence result (Vickrey, 1961; Myerson, 1981), with higher prices expected in the second-price auction (Goeree *et al*., 2005; henceforth GMOT); Engelbrecht-Wiggans, 1994; Engers and McManus, 2007; Maasland and Onderstal, 2007).

Third, the first-price all-pay auction dominates the first-price winner-pay auction (Engers and McManus, 2007; GMOT) and the lottery (GMOT; Orzen, 2005; Faravelli, 2007), as well as the second-price winner-pay auction if the number of bidders is sufficiently large (Engers and McManus, 2007; GMOT). The underlying intuition why the all-pay auction performs better than the winner-pay auctions is based on the opportunity costs of raising one's bid in the latter: topping another bid implies elimination of the benefit from its contribution to the revenue, in contrast to the all-pay auction. Moreover, a lottery's inefficiency (the participant with the highest value may not win the object) will lead to less aggressive bidding and lower revenues than in an efficient mechanism (GMOT). A priori, auctions may provide a more efficient allocation and may therefore be expected to raise more money.[5] Indeed, this turns out to be the case for the first-price all-pay auction. The optimal fundraising mechanism also has an 'all-pay' element: it is the lowest-price all-pay auction with entry fee and reserve price (GMOT). If an entry fee is not possible and sellers are committed to sell, the lowest-price all-pay auction is revenue maximizing (GMOT; Orzen, 2005).

Several experimental and field studies have been undertaken to test these theories. Most of these empirical studies focus on situations in which the value of the prize is the same for all bidders, *i.e.*, the common value scenario. In line with the theory, these studies find that voluntary contributions generate less money than lotteries and auctions (Morgan and Sefton, 2000, Lange *et al.*, 2007, and Orzen, 2005 provide evidence from the laboratory, Landry *et al.*, 2007 use field data),[6] and that the lowest-price all-pay auction raises more money than lotteries and the first-price all-pay auction (Orzen, 2005). However, the lottery (weakly) dominates the first-price all-pay auction in laboratory studies, in contrast to what the theory predicts (Orzen, 2005, and Corazzini *et al.*, 2007).

Fundraising mechanisms with private values have hardly been examined empirically. Two notable exceptions are Davis *et al.* (2006) and Carpenter *et al.* (2008).[7] Davis *et al.* observe in a laboratory experiment that lotteries raise more money than the English auction. In contrast to our setting, they employ a perfect information environment where each bidder is completely informed about how much other bidders value the object for sale. This is unlikely to hold true for most charity auctions in the field, however. Carpenter *et al.* conducted a field experiment during

[5] Moreover, in some auctions, losing bidders have an incentive and a possibility to drive up the price to be paid by the winner (*e.g.*, Cramton *et al.*, 1987; Graham and Marshall, 1987; McAfee and McMillan, 1992; Singh, 1998; Bulow *et al*., 1999; Maasland and Onderstal, 2007).

[6] There is a vast experimental literature on voluntary contributions to public goods. For surveys, see Ledyard (1995) and Zelmer (2003). The bottom line in this research is that free-riding, though not complete, does cause inefficiency in the provision of the good.

[7] Another is Isaac and Schnier (2005), who mainly focus on bidding behavior in 'silent auctions', jump bidding in particular. They do not compare mechanisms in terms of their revenue generating properties.

fund-raising festivals organized by preschools in Addison County. Their data suggest that the first-price auction dominates both the second-price and all-pay auction. As a potential explanation for why their findings deviate from the theory, the authors argue that bidders were unfamiliar with the rules of the second-price and all-pay auction, so that many were reluctant even to participate in these auctions.[8]

All in all, we believe our study to be the first to empirically compare fund-raising mechanisms in a controlled environment with private values and imperfect information. We think that this environment best describes the situation for most charity auctions, including the three mentioned in our opening sentence.

We begin in Section 2 by describing our experimental design and constructing hypotheses on the basis of our private values model. Our theoretical results closely resemble the findings from the literature in that the all-pay auction dominates both the winner-pay auction and the lottery if bidders positively value the proceeds. Moreover, all mechanisms are predicted to generate more money with than without the charity. In addition, without a charity, the two auctions are revenue equivalent, and raise more revenue than the lottery.

We present our experimental findings in Section 3. These findings confirm the predictions from our theory about the relative performance of mechanisms used to raise money. Of our other predictions, only two are not supported: (1) without charity, the first-price winner-pay auction does not dominate the lottery, and (2) the first-price winner-pay auction and the lottery do not raise more money with than without the charity. One reason for the latter observation is that in all mechanisms, subjects systematically overbid relative to the Nash prediction in the case without charity.

[8] In our experiment, subjects could stay out of the auction by bidding zero. We will show below that this occurred much more often in the all-pay auction than in the other formats.

2. Experimental Design and Hypotheses

2.1. Procedures and Parameters

We ran the experiments at the Center for Experimental Economics and political Decision making (CREED) of the University of Amsterdam in the fall of 2002 and in October 2007. 290 students from the undergraduate population of the University were recruited by public announcement and participated in 12 original sessions and 6 additional sessions. On top of a show-up fee of €5, subjects earned on average €24.46 in the original sessions and €20.20 in the additional sessions. Each session lasted between 60 and 90 minutes. An example of the experimental instructions is given in Appendix A.

In each of 28 rounds of a session, groups of 3 subjects are formed.[9] Members of a group compete in an auction or lottery for a private good. Values and earnings are given in experimental 'francs', with an exchange rate of €1=300 francs. As is common in auction experiments, subjects were given a starting capital (1500 francs in our case). In every round, subject i's value v_i for the good is independently drawn from a uniform distribution on [0,500].[10] We reallocate subjects to groups in every round. Unknown to subjects, we do so within sets of 6 subjects (two groups). These 'matching groups' constitute statistically independent units of observation.

A positively valued charity is introduced by making the revenue a public good for the participants. Each subject is paid a fraction α of the revenue of the auction or lottery she

---

[9] This is where the original experiments differed from the sessions in 2007. Following suggestions by an anonymous reviewer we added sessions where the number of bidders per group was higher. In what follows we will focus on the original sessions. After discussing the results we will describe the additional sessions and their results in section 3.4. At this stage it is important to note that, theoretically, the all-pay auction dominates the winner-pay auction (Engers and McManus, 2007) and the lottery (GMOT), independently of the number of bidders.

[10] In theory, subjects could make a loss. They were told that their earnings would be set to zero and that the computer would take over their decision if this occurred but that they would have to remain seated. Other group members would be informed. This never happened, however: all subjects had positive earnings throughout the experiment.

participates in, irrespective of her bid or value. In all original sessions, α=0.5,[11] i.e., every subject earns €0.50 for every €1 her group contributes to revenue.[12] We benchmark these 'charity' results in a within-subject design by including rounds where the revenue does not affect payoffs (α=0). To do so, we split the 28 rounds in 4 blocks of 7 and alternate between blocks with and without public good. To check for order effects, we sometimes start with a public good and sometimes without.

In order to study the effect of fund-raising mechanisms on revenue, we examine three institutions in a between-subject design. Our selection of mechanisms is inspired by the theoretical results in GMOT. They distinguish three qualitatively different mechanisms: winner-pay auctions, lotteries, and all-pay auctions. Within the auction institutions, one can distinguish between first-price, second-price, etc. Because we wish to focus on the main effects, we restrict our attention to the first-price versions of the two auction types. Lower-price auctions can be studied in future research.

Hence, we distinguish three allocation mechanisms:

1) *First-price winner-pay auction* (WP). Each of the three subjects submits a bid, b_i. The highest bidder wins the object and pays her bid. The winning bidder w earns v_w-b_w from the private good. Other bidders' payoff from the private good is 0. The auction revenue is b_w. In rounds with public good, each bidder additionally receives αb_w.
2) *First-price all-pay auction* (AP). Each of the three subjects submits a bid, b_i. The highest bidder wins the object and each bidder pays her bid. Revenue is $b=b_1+b_2+b_3$. The winning

[11] As will be explained below, we chose α=0.3 for the additional sessions.

[12] Note the resemblance to a linear public good game with a marginal per capita return equal to 0.5 (Isaac *et al.*, 1984). An important difference is the private value that a player can obtain by winning the auction. There are, of course, other ways to model the fact that the auction revenue matters to the bidders. We chose this 'public good scenario' for two main reasons: (1) it mirrors the setup of the theories we are testing; (2) it allows us to capture the 'public good' characteristic of charity donations in a way that has a long tradition in experimental economics.

bidder w earns v_w-b_w from the private good. Private good payoff for i≠w is $-b_i$. In rounds with public good, each bidder receives an additional αb.

3) *Lottery* (LOT). Each of the three bidders buys b_i tickets for a raffle. One of the $b=b_1+b_2+b_3$ tickets is randomly drawn and determines the winner, w, who earns v_w-b_w from the private good. Private good payoff for i≠w is $-b_i$. In rounds with public good, each bidder receives an additional αb.

Table 1 summarizes our treatments including the number of observations per cell.

TABLE 1: Summary of the treatments

Mechanism		**Order of rounds***	**# sessions**	**# groups**	**# independent observations**
First-price winner-pay	WP	NC-C-NC-C	2	12	6
		C-NC-C-NC	2	8	4
Lottery	LOT	NC-C-NC-C	2	12	6
		C-NC-C-NC	2	8	4
First-price all-pay	AP	NC-C-NC-C	2	12	6
		C-NC-C-NC	2	8	4

*NC-C-NC-C: rounds 1-7 and 15-21 without charity; rounds 8-14 and 22-28 with charity.
C-NC-C-NC: rounds 1-7 and 15-21 with charity; rounds 8-14 and 22-28 without charity.

2.2 Hypotheses

Let each individual value €1 raised for the charity by €α. Hence, auction revenue R is considered to be a public good, adding αR to each individual's net earnings from the auction. Excluding the cases of a public bad (α<0) and those where individuals care more about the charity than about themselves (α>1), we assume α to lie in the interval [0,1].

The equilibrium bidding strategies for the auctions can be straightforwardly derived from the literature. Appendix B provides the outline for this theoretical derivation. For WP (first price winner-pay), the (risk-neutral) symmetric Nash equilibrium bid is:

$$b_i^{WP} = \frac{2v_i}{3-\alpha} \quad . \tag{1}$$

By substituting α=0, this simplifies to the standard Nash equilibrium bid for the three-bidder case: bidding 2/3 of one's value. For α=0.5, this gives $b_i^{WP} = 0.8v_i$. In equilibrium, the expected revenue of this auction is found by evaluating (1) at the expected value of the highest of the three draws, which gives:

$$R^{WP} = \frac{3}{6-2\alpha} * 500 \tag{2}$$

Thus, $R_{\alpha=0}^{WP}$= 250 without, and $R_{\alpha=0.5}^{WP}$=300 with the public good.

For AP, the symmetric equilibrium bid is:

$$b_i^{AP} = \frac{2}{3(1-\alpha)} * 500 * \left(\frac{v_i}{500}\right)^3 \tag{3}$$

For α=0, this gives $b_i^{AP} = \frac{2v_i^3}{750{,}000}$.[13] For α=0.5, we have $b_i^{AP} = \frac{2v_i^3}{375{,}000}$. Expected revenue in the all-pay auction is given by:

$$R^{AP} = \frac{1}{2} * \frac{1}{1-\alpha} * 500 \quad , \tag{4}$$

[13] See also Krishna and Morgan (1997), theorem 2.

which gives $R^{AP}_{\alpha=0}$ = 250 and $R^{AP}_{\alpha=0.5}$ = 500.

For the lotteries, no closed form solution for the optimal bid can be derived for the case with private values.[14] Numerically, one can derive the Nash bid for any given value, however. We did so for values starting at 0, with increments of 10. We then estimated a 4th-order polynomial for the equilibrium bid function:

$$b_i^{LOT} = \frac{500}{1-\alpha}\left(0.0000353 - 0.0774619\left(\frac{v_i}{500}\right) + 1.125996\left(\frac{v_i}{500}\right)^2 - 1.395296\left(\frac{v_i}{500}\right)^3 + 0.5727756\left(\frac{v_i}{500}\right)^4\right) \quad (5)$$

We will use these estimated Nash bids in our data analysis. Evaluation at the expected values gives $R^{LOT}_{\alpha=0}$ =156.28 and $R^{LOT}_{\alpha=0.5}$ =312.57.

TABLE 2: Expected revenue in equilibrium

	Winner-pay (WP)	All-pay (AP)	Lottery (LOT)
Without charity (α=0)	250	250	156
With charity (α=0.5)	300	500	313

Table 2 summarizes expected equilibrium revenue for our original treatments. Expected revenue without a charity is lowest for LOT while WP and AP are revenue equivalent. With the charity, expected revenue of LOT is approximately equal to that of WP. For both cases, expected revenue is higher in AP than in LOT. Table 2 serves as a basis for the hypotheses that we will test in Section 3.[15] The first concerns our main research question: the relative performance of mechanisms for raising revenues for charity:

[14] In the case where the prize has a common value, v, to all participants, it can be shown that in equilibrium each participant will buy (n-1)v/(n^2(1-α)) tickets, giving revenue of (n-1)v/(n(1-α)) (*e.g.*, Orzen, 2005).
[15] Formally, each hypothesis will serve as an alternative to the null that there is no difference in revenue.

H1: With the charity, revenue is higher in the all-pay auction than in either of the other two mechanisms: (a) $R^{AP}_{\alpha=0.5} > R^{WP}_{\alpha=0.5}$; (b) $R^{AP}_{\alpha=0.5} > R^{LOT}_{\alpha=0.5}$.

In addition, the predictions allow us to formulate the following hypotheses:

H2: Without a charity, revenue is higher in either auction format than in the lottery: (a) $R^{WP}_{\alpha=0} > R^{LOT}_{\alpha=0}$; (b) $R^{AP}_{\alpha=0} > R^{LOT}_{\alpha=0}$;

H3: For each mechanism, revenue is higher with the charity than without: (a) $R^{WP}_{\alpha=0.5} > R^{WP}_{\alpha=0}$; (b) $R^{AP}_{\alpha=0.5} > R^{AP}_{\alpha=0}$; (c) $R^{LOT}_{\alpha=0.5} > R^{LOT}_{\alpha=0}$.

3. Experimental Results

We will start our presentation of the experimental results with a general overview of observed efficiency and revenue in Section 3.1. Section 3.2 gives test results for our hypotheses on treatment effects. In Section 3.3, we analyze bidding behavior in our data and use this to explain the treatments effects we observe. Finally, in section 3.4 we describe and analyze the additional sessions that we organized after seeing the results of the first set of sessions.

3.1. Efficiency and Revenue

The observed relative efficiency[16] and revenue are given in table 3, distinguishing both between mechanisms and order of rounds. Of course, the revenue in the case of equilibrium bidding will vary across rounds and treatments, depending on the actual values drawn. For comparison to observed revenue, table 3 also gives the average revenue per treatment for the equilibrium bids (which we denote by "*ex-post* Nash revenue", i.e., Nash revenue given the values drawn).

[16] To avoid extreme numbers due to low value draws, the efficiency is calculated relative to the lowest of the three draws in a group: relative efficiency = (winner's value – lowest value)/(highest value – lowest value).

TABLE 3: Efficiency and Revenue (all rounds)

			Efficiency	Revenue	*Ex-Post* Nash-Revenue
Winner-pay	**NC-C-NC-C**	**no charity**	0.94	301	256
		charity	0.88	282	301
	C-NC-C-NC	**no charity**	0.90	285	255
		charity	0.89	271	300
All-pay	**NC-C-NC-C**	**no charity**	0.83	373	247
		charity	0.85	373	441
	C-NC-C-NC	**no charity**	0.81	322	228
		charity	0.79	404	502
Lottery	**NC-C-NC-C**	**no charity**	0.70	290	149
		charity	0.69	330	318
	C-NC-C-NC	**no charity**	0.81	343	150
		charity	0.70	346	301

Note: NC-C-NC-C: rounds 1-7 and 15-21 without charity; rounds 8-14 and 22-28 with charity.
C-NC-C-NC: rounds 1-7 and 15-21 with charity; rounds 8-14 and 22-28 without charity.
Ex-post Nash Revenue = revenue predicted by the Nash equilibrium, for the actual values drawn.

From table 3 it appears that *efficiency* is highest in the winner-pay auctions and lowest in the lottery. All pairwise differences are significant at the 5%-level (Mann-Whitney tests, using matching groups as unit of observation). The inefficiency of lotteries is as expected, because any number of tickets gives a positive probability of winning, so even bidders with low values may win the good, in equilibrium. As for the order in which the rounds with and without charity are presented, there is no systematic effect: for each auction type differences are statistically insignificant at the 10%-level (Mann-Whitney tests).[17] We can therefore pool data from sessions that started with and without charity.[18]

In charity auctions, one is typically more interested in *revenue* than in efficiency. First note that the revenues in the case of Nash bids are close to the predictions of table 2, indicating that the realized value draws did not cause severe deviation from these predictions. The only

[17] To avoid flooding the text with pairwise test results, we summarize the Mann-Whitney tests in this way. Detailed test results are available from the authors upon request.
[18] This is confirmed by the regression results below.

exception is for the all-pay auctions starting with no-charity rounds. For the rounds with charity, realized values were relatively low, leading to an equilibrium revenue of 441 instead of 500.[19] Perhaps as a consequence of these low draws, the realized revenue in this case is equal to that without charity. Comparing mechanisms, revenues seem to be highest in the all-pay auctions. A statistical analysis of revenue differences is presented below.[20]

Observed average revenue may be affected by erratic behavior in early rounds. To see if learning takes place over time, figure 1 shows how average revenue and the average (*ex post*) Nash-revenue develop across rounds. We distinguish between rounds with and without charity and aggregate across sessions that start with charity and those that start without (see the note to the table). Figure 1 displays no obvious learning effects in any institution.

A number of other patterns are visible in figure 1. First of all,. the *ex post* Nash revenue fluctuates around the *ex ante* level (*cf*. table 2) as expected. Second, for both auctions, revenue is generally above the equilibrium level in rounds without charity and below equilibrium in rounds with charity (yielding a smaller difference in revenue than predicted by theory). Third, no-charity lotteries tend to elicit high revenues, but the addition of a charity does not increase lottery revenues. Finally, revenues are also not increased if a charity is added to a winner-pay auction.

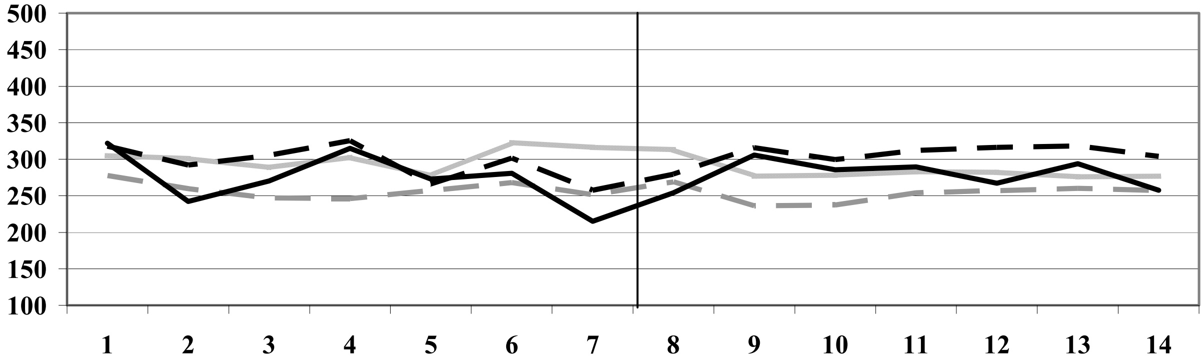
3.2 Testing our Hypotheses

We test the hypotheses on revenue presented in Section 2.2 using regressions explaining observed revenue by treatment variables. Random effects are included at the level of statistically

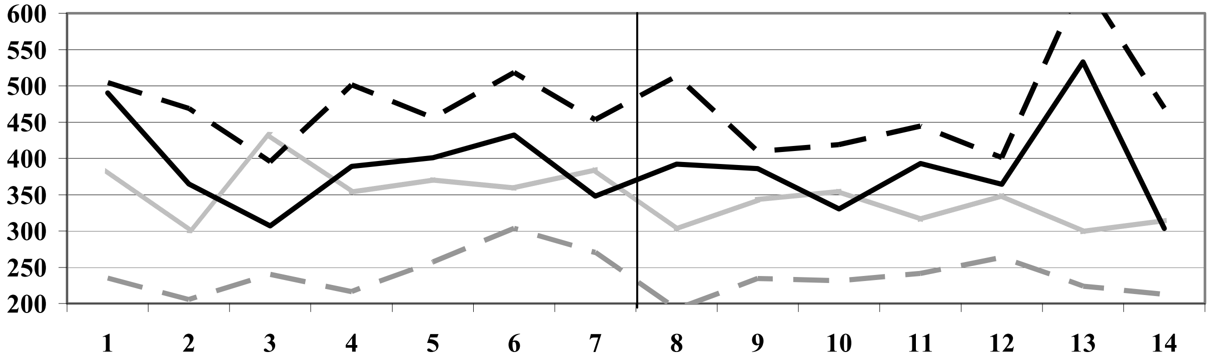
[19] This deviation of 59 units may seem large for the 168 observations we have (14 rounds for 12 groups). It can be shown, however, that the standard deviation of the predicted revenue is approximately 327. Therefore, the standard deviation for the mean of 168 draws from this deviation is just over 25. Note that it is not very surprising to find one of the 12 variables in the last column of table 3 to have a deviation of just over twice the standard deviation.

[20] Pairwise Mann-Whitney tests show a significantly higher revenue for the all-pay auction than for the first-price winner-pay auction ($p<0.01$). Other differences are not significant. We will observe more differences in our more detailed analysis, below.

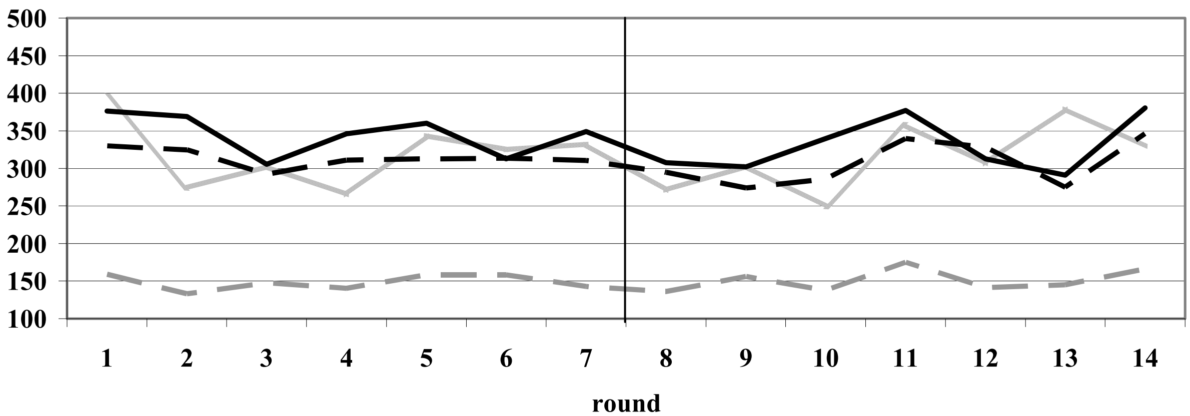
FIGURE 1: Observed and Nash Revenues



a. Winner-pay auctions



b. All-pay auctions



c. Lotteries

no charity Rev **no charity NashRev** **charity Rev** **charity NashRev**

Note: Each figure gives, per round for the treatment concerned (*charity vs. no charity*), the average (*ex post*) Nash revenue (*NashRev*) and observed revenue (*Rev*). We aggregate across sessions that start with charity and those that start without. For example, round 3 in a charity auction is the third round in which any subject was bidding for a charity, irrespective of whether this was actual round 3 or actual round 10. The latter was the case for subjects starting with 7 rounds without charity. Note that the vertical axis in panel b has a different scale. The vertical line denotes a split between blocks (of 7 rounds).

independent matching groups (of 6 individuals).[21] Dummy variables representing the order of rounds and the second half (rounds 15-28) of the session are added to correct for learning effects. The model to be estimated is given by:

$$R_{it}^{k} = \beta_0^k + \beta_1^k D_{1i} + \beta_2^k D_{2i} + \beta_3^k Order_i + \beta_4^k Experience_t + u_j^k + \varepsilon_{it}^k, \qquad (6)$$

k=charity, no-charity; i=1,..,60; j=1,..,30; t=1,..28,

where k distinguishes between rounds with and without charity, i ($\in j$) denotes the group of 3 subjects competing for the object; j represents the group of 6 subjects that interact over time[22]; t gives the round; D_1 and D_2 are dummies representing the mechanism (the third is absorbed in the constant term); *Order*=0 [1] if the session started with a (no) charity round; *Experience*=0 [1] for rounds 1-14 [15-28]; the β's are coefficients to be estimated. The random terms u_j^k and ε_{it}^k are normally distributed. u_i^k captures the panel structure in the data. Table 4 presents the maximum likelihood estimates for the coefficients in (6). These results confirm that the order of rounds does not affect revenue. Contrary to our preliminary observation from figure 1, having experience does have an effect, however: lower revenues are observed in the second block of (seven) non-charity rounds than in the first.[23]

First, consider our main research question, that is, the performance of the various formats for raising revenues for a charity. The theoretical prediction is given by *H1*: (a) $R_{\alpha=0.5}^{AP} > R_{\alpha=0.5}^{WP}$; (b)

[21] Contrary to the non-parametric tests discussed above, these allow us to correct for order effects.
[22] In every round each group j is randomly split in two groups i. Table 1 shows that there are 6 sessions with 18 participants (3 matching groups j) and 6 sessions with 12 participants (2 matching groups j) for a total of 30 independent groups (and 60 auctions per round).
[23] The effect of experience does not depend on the mechanism involved. If we add interaction terms between mechanism and experience to (6), none of these terms obtains a significant coefficient at the 10% levels. Moreover, the qualitative conclusions with respect to other coefficients are unaffected.

TABLE 4: Revenue and Mechanism

	Without Charity	With Charity
Constant	325.17 (15.86)**	379.91 (15.90)**
Winner-pay	-16.85 (0.67)	-107.56 (3.64)**
All-pay	41.19 (1.64)*	--
Lottery	--	-48.95 (1.66)*
Order	-4.27 (0.20)	11.98 (0.49)
Experience	-24.55 (2.07)**	0.91 (0.07)
LR-test for random effects	p<0.001	p<0.001
Test of β_1=β_2	p=0.02	p=0.05

Note: The table gives maximum likelihood estimates of the coefficients in eq. (6) with t-values in parentheses (*,** denote that the coefficient is statistically significantly different than 0 at the 10%-, and 5%-level, respectively). In each equation, one mechanism dummy is dropped and included in the constant term. The dummy dropped is the mechanism for which a different equilibrium revenue is hypothesized than for the other two. A test for equality of the coefficients of the other two mechanisms is presented in the last row. The LR-test for random effects tests σ_u=0, which is strongly rejected in both cases.

$R^{AP}_{\alpha=0.5} > R^{LOT}_{\alpha=0.5}$. Both inequalities are confirmed by the results in the last column of table 4 (H1a at the 5%-level, H1b at the 10%-level). Hence, the all-pay format is the preferred mechanism to raise proceeds for charities.[24] In addition (and contrary to the equilibrium prediction), the last row of table 4 shows that revenue in WP is significantly (5%) lower than in LOT, when there is a charity. Though the equilibrium prediction is more or less equal for these two mechanisms (at 300), figure 1 shows that average bids are roughly at the equilibrium level for the lotteries, while there is underbidding in the winner-pay auctions.

Our additional hypothesis about the case without charity reads *H2*: (a) $R^{WP}_{\alpha=0} > R^{LOT}_{\alpha=0}$; (b) $R^{AP}_{\alpha=0} > R^{LOT}_{\alpha=0}$. The second column shows that equality of revenue in WP and LOT cannot be rejected.[25] H2b is supported at the 10%-level, however.[26] Finally, in equilibrium, we do not expect a difference in revenue between AP and WP. The last row of table 4 rejects equal

[24] Note, however, that the observed differences in revenue between mechanisms (represented by the coefficients in table 4) are smaller than predicted in table 2 (200 for the AP-WP comparison and 187 for the AP-LOT comparison).
[25] As far as we know, we are the first to experimentally compare winner-pay auctions and lotteries in a setting without charity.
[26] Davis and Reilly (1998) and Potters *et al.* (1998) also observe that revenue in an all-pay auction dominates that of a lottery, albeit that these studies use a common value environment in their experiments.

revenues in favor of higher revenue in AP at the 5%-level, however.[27] All in all, when there is no charity, revenue in the winner-pay auction in comparison to the other two formats is lower than expected. From figure 1, we observe that this is caused by revenue in AP and LOT 'overshooting' equilibrium revenue by much more than in WP.

Finally, *H3*: (a) $R^{WP}_{\alpha=0.5} > R^{WP}_{\alpha=0}$; (b) $R^{AP}_{\alpha=0.5} > R^{AP}_{\alpha=0}$; (c) $R^{LOT}_{\alpha=0.5} > R^{LOT}_{\alpha=0}$ predicts that revenues are higher when there is a charity. To test this, we regress revenue on a variable distinguishing between rounds with and without charity. For each of the three mechanisms, we estimate the coefficients of:

$$R^k_{it} = \beta^k_0 + \beta^k_1\, Charity_t + \beta^k_2\, Order_i + u^k_j + \varepsilon^k_{it}\,, \tag{7}$$

k=WP,AP,LOT; i=1,..,60; j=1,..,30; t=1,..28,

where $Charity_t$=1 [0] if a charity was [not] provided in round t. When estimating the coefficients of this equation, we need to take account of the results in table 4. These show that *Experience* has a (significantly) negative effect on revenue for rounds without charity, but no effect for rounds with charity. When estimating (7), this interaction between $Experience_t$ and $Charity_t$ may cause spurious results.[28] For this reason, we only use data from the second half of the experiment

TABLE 5: Revenue and Charity

	WP	AP	LOT
Constant	286.40 (33.30)**	363.31 (12.62)**	278.40 (7.64)**
Charity	-3.21 (0.31)	56.15 (2.04)**	26.30 (1.35)
Order	-6.92 (0.64)	-71.17 (1.78)*	60.51 (1.09)
LR-test	p=0.45	p=0.04	p<0.001

Note: The table gives maximum likelihood estimates of the coefficients in eq. (6) with absolute z-values in parentheses (*,** denote that the coefficient is statistically significantly different than 0 at the 10%-, and 5%-level, respectively). The LR-test for random effects tests σ_u=0, which is rejected for AP and LOT, but not for WP. The difference between AP and LOT is not statistically significant (p=0.12).

[27] Noussair and Silver (2006) find the same in their experiment.

[28] This problem is not solved by adding the variable $Experience_t$ to the right hand side of (6). The second half of each session includes rounds with and without charity and $Experience_t$ affects these differently.

(t | $Experience_t$=1) to estimate the coefficients in (6). Table 5 presents the results.[29] The coefficients for *Charity* support *H3b* (for all-pay auctions), but not H3a (WP; which even has the wrong sign, though not significantly so) or H3c (LOT). Apparently, for WP and LOT, a charity does not boost revenue to the extent predicted.[30] To investigate why this is the case, we take a closer look at bidding behavior.

3.3. Bidding Behavior

To start, we consider participation in the various mechanisms. Recall that bidders can 'withdraw' from the auction by bidding 0. For both auctions with and without charity, we observe highest participation in the winner-pay auction (>99% in both cases) and lowest in the all-pay case (80% without charity and 84.1% with charity). Participation in the lottery is in between these two (92.9% without charity and 90.6% with charity). All pairwise differences are significant at the 5%-level (Mann-Whitney tests at the independent group level). Hence, as in Carpenter *et al.* (2008), the all-pay format suppresses participation. Contrary to their results from the field, however, we nevertheless find the highest revenue for this auction format.[31]

Next, take a closer look at the way bidders bid. For each of the mechanisms, we estimated a 3^{rd}-order polynomial, fitting the bids as a function of the data. We did so separately for the environments with and without charity. To minimize noise due to learning, we decided to use

[29] The results show a (mild) order effect for AP. This disappears if we estimate the coefficients using all rounds, however. Hence, it is not expected to affect the results in table 4 (which are based on all rounds).

[30] This contrasts to recent findings by Elfenbein and McManus (2007) and Popkowski Leszczyc and Rothkopf (2007), who observe (in internet auctions) that bidders bid more in winner-pay auctions if the auction's revenue is (partly) donated to charity. On the other hand, Chua and Berger (2006) observe that bidders bid less in these auctions when the revenue is donated.

[31] It is important to note, however that participation in our auctions was costless, as in the theoretical model of GMOT. Carpenter *et al*. (2007) show that positive participation costs will only reverse the GMOT results if they vary across institutions. This provides an interesting avenue for future research.

only data from experienced subjects (after round 14). More specifically, we estimate the bid functions:

$$b_{it}^{kl} = 500 * \left(\beta_0^{kl} + \beta_1^{kl} * \left(\frac{v_{it}}{500} \right) + \beta_2^{kl} * \left(\frac{v_{it}}{500} \right)^2 + \beta_3^{kl} \left(\frac{v_{it}}{500} \right)^3 \right) + u_i^{kl} + \varepsilon_{it}^{kl}, \tag{8}$$

k=WP,AP,LOT, *l*=charity, no charity, *i*=1,…,30, *t*=15,…,28,

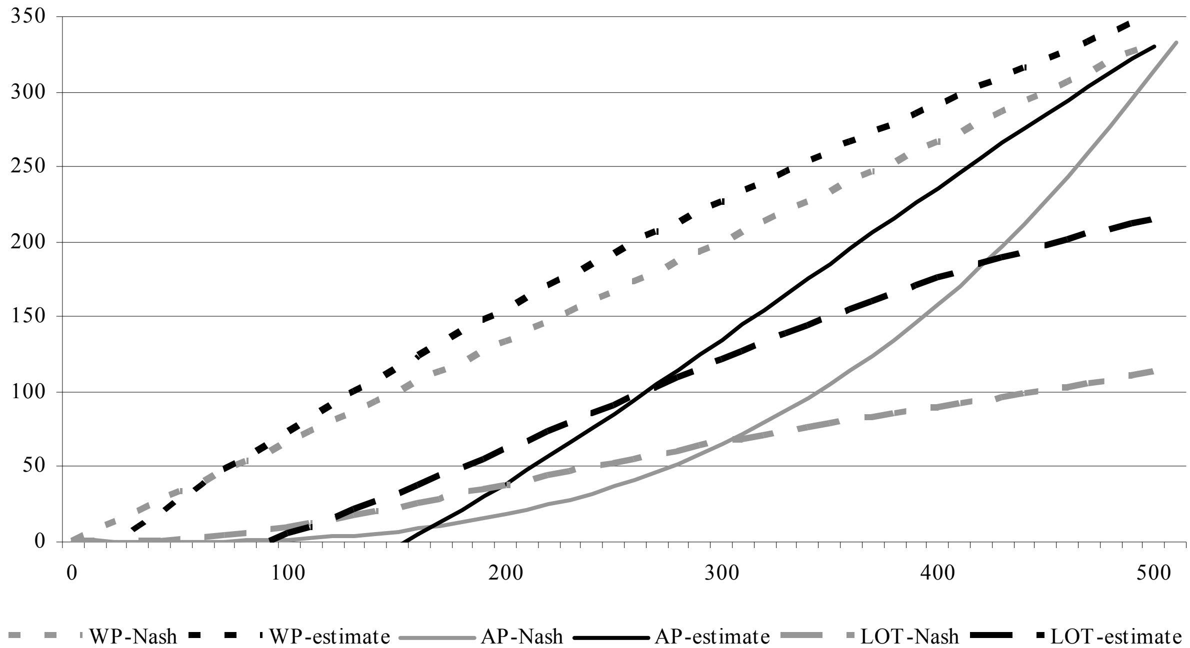
where *k* denotes the mechanism, *l* distinguishes between environments with and without charity, *i* gives the individual and *t* is the round. The bid is given by *b* and the value by *v*. The random terms u_i^{kl} and ε_{it}^{kl} are normally distributed. u_i^k captures the panel structure in the data, where random effects are now included at the level of individuals. Coefficients β are estimated with Maximum Likelihood. To allow for truncation due to the non-negativity of bids, we use tobit regressions to estimate the coefficients of (8). Note that the observed frequency of zero-bids means that this truncation may matter.[32]

Instead of giving the estimates of β (which are difficult to interpret), we present the results by showing graphs of the estimated functions. These are shown in figure 2, distinguishing between the no charity (top panel) and charity (bottom panel) cases. In both graphs, gray lines show the Nash bid functions (*cf*. Section 2.2) and black lines show the estimated functions. Mechanisms are distinguished by the type of line: short-dashed (WP), solid (AP) or long-dashed (LOT).

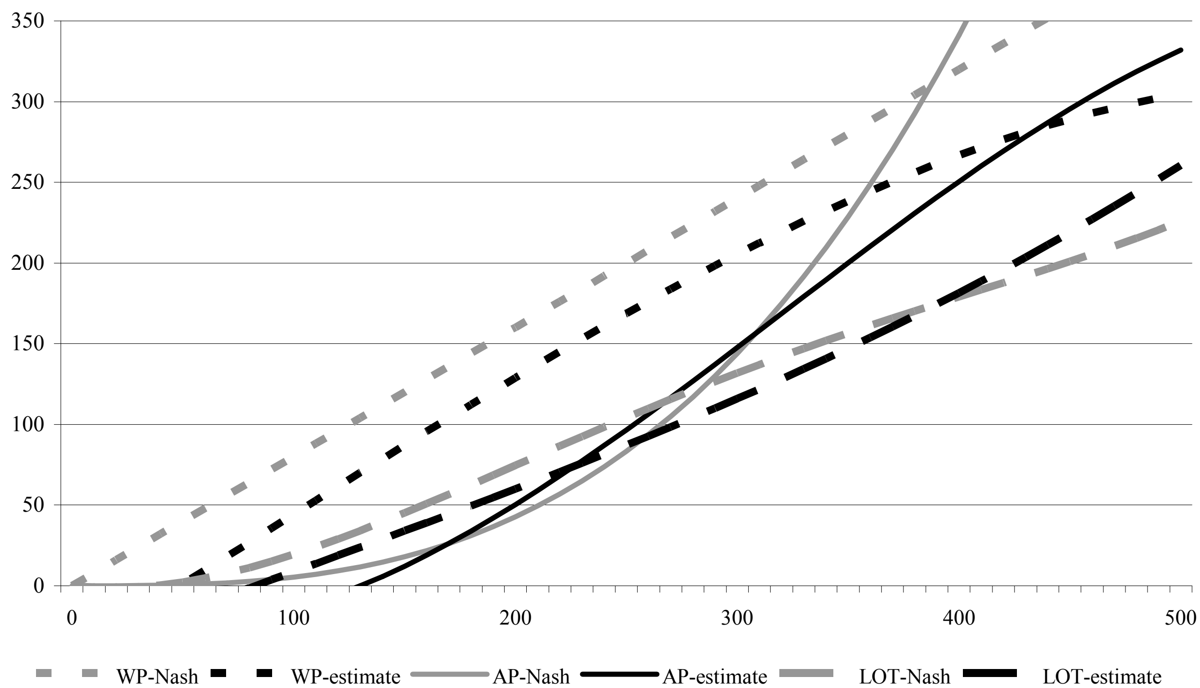
A first thing to note about the figure is that the general shapes of the estimated bid functions correspond to the Nash benchmarks. The WP functions are almost linear, those estimated for AP are more or less convex (though only slightly so for the non-charity case) and the LOT bid

[32] We are grateful to an anonymous referee for pointing this out.

FIGURE 2: Estimated Bid Functions



a. Without Charity



b. With Charity

functions are convex for low values and slightly concave for high values. Note however that for WP and AP with charity (see panel b), there appears to be a slight 'concave bend-off' for very high values (>400).

The deviations from Nash that we observe appear to occur not because of the shape of the bid functions but due to their location. Without charity, the estimated bid function lies at or above the Nash benchmark in almost the entire range for all mechanisms. In other words, there is systematic overbidding in all mechanisms.[33] With charity, the equilibrium bid function lies above the observed bids for WP while for LOT, the theoretical bidding function and the approximated one are very close to each other. The AP bidding function is estimated to lie above [below] the Nash bids for values lower [larger] than approximately 310. Interestingly, for values above approximately 433, Nash predicts that bids will exceed values in AP. The idea of bidding above one's value seems to scare bidders off, however.

Recall that only for AP, our testing of *H3* yields support for the prediction that revenues are higher with charity. The reason appears to lie in the above observation that in all mechanisms, subjects systematically overbid relative to the Nash prediction in the case without charity, while most bidders submit bids at or below Nash with charity in LOT and WP. In AP, we observe systematic overbidding in the case with charity for low and moderate values, but high value bidders underbid. Because all bids add to revenue, and equilibrium bids with charity are twice as high as without charity, the aggregate result still supports *H3* for AP.

Finally, the estimated functions in figure 2 give an indication of the threshold values bidders use for entering the auction. Note that the ranking of thresholds across mechanisms is the same

[33] In the absence of charity, other laboratory studies also observe overbidding in WP (e.g., Cox *et al.*, 1982, Kagel *et al.*, 1987, and Kagel and Levin, 1993), AP (Davis and Reilly, 1998, and Noussair and Silver, 2006), and LOT (Davis and Reilly, 1998, and Potters *et al.*, 1998). However, for AP, Potters *et al.* (1998) do not observe significant divergence from the Nash prediction.

with and without charity. Without charity, the lowest threshold is observed for the WP auction: subjects enter at a value of approximately 18. For the lottery this value is 90 and for AP it is 155. With charity, these thresholds are estimated to be 48, 82, and 130, respectively. Note that this again renders support for the Carpenter *et al*. (2008) observation of lower participation in the all-pay auction.

3.4 Additional Sessions with Larger Groups

The result from the original sessions that stands out is the support for the hypothesized higher revenue in AP than FP, in spite of the lower participation in the former. This result is in contrast to what Carpenter *et al.* (2008) find in their field experiment. An anonymous referee to this journal pointed out this discrepancy may be explained by the relatively high public good return from every token submitted (α=0.5) combined with the small groups (n=3) in our experiment. We therefore ran five additional sessions where we decreased the return to α=0.3 and simultaneously increased the group size to n=5.[34] Table 6 summarizes the new treatments. Note that we did not vary the order of periods with and without charity; all sessions used the sequence C-NC-C-NC. Moreover, we decided to focus on the comparison between AP and WP and did not run any lottery sessions. Finally the matching groups now consisted of 10 subjects each.

TABLE 6: Summary of the Additional Treatments

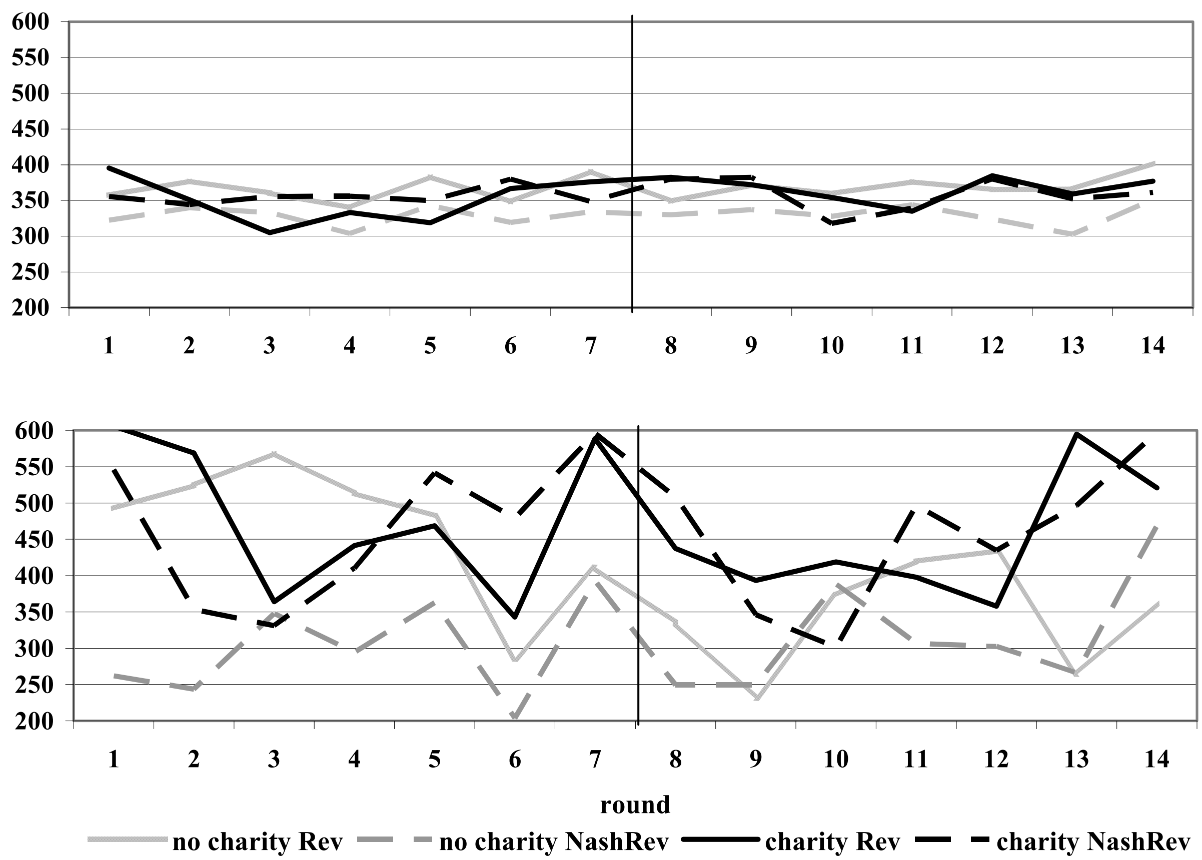
Mechanism		**# sessions**	**# groups**	**# independent observations**
First-price winner-pay	WP	2	8	4
First-price all-pay	AP	3	10	5

[34] By simultaneously changing two parameters we run the risk that if we observe differences, we cannot attribute them to one or the other change. As it turns out, the results support the previous results.

The hypotheses derived for the original sessions straightforwardly carry over to these new treatments. In the absence of a charity, it can easily be derived that for n=5, $R^{WP}_{\alpha=0} = R^{AP}_{\alpha=0} = 333$. Our data show average revenues of 368 and 407, for WP and AP, respectively. When there is a charity, the equilibrium revenues are $R^{WP}_{\alpha=0.3} = 355$ and $R^{AP}_{\alpha=0.3} = 475$; and our observed revenues are 358 and 464, respectively. Once again, only for AP does the contribution to a charity substantially raise revenues.

Parallel to figure 1, figure 3 shows the dynamics of average revenue and average (*ex post*) Nash revenue across rounds.

FIGURE 3: Observed and Nash Revenues for Large Groups



Note: See the note to figure 1. The top panel refers to WP, the lower to AP

The figure closely resembles the corresponding panels in figure 1. Notably, for these larger groups we replicate the lack of learning effects and the fluctuation of the *ex post* Nash revenue around the *ex ante* level. Moreover, revenue is once again above the equilibrium level in rounds without charity and below equilibrium in rounds with charity and revenues are not increased if a charity is added to a winner-pay auction but a all-pay auction with charity does appear to elicit higher revenues than an all-pay auction without charity.

The equilibrium revenues imply that the hypotheses for the smaller groups carry over to the present case:

H1': $R^{AP}_{\alpha=0.3,n=5} > R^{WP}_{\alpha=0.3,n=5}$.

H3': (a) $R^{WP}_{\alpha=0.3,n=5} > R^{WP}_{\alpha=0,n=5}$; (b) $R^{AP}_{\alpha=0.3,n=5} > R^{AP}_{\alpha=0,n=5}$.

Note that the signs of the differences in observed revenues support H1' and H3'b. The lack of support for H3'a mirrors the results we observed for the original sessions. To statistically test H1'a we replicate the regression in eq. (6). Table 7 presents the results.

TABLE 7: Revenue and Mechanism: Large Groups

	Without Charity	With Charity
Constant	439.84**	470.87**
Winner-pay	-39.31	-106.47*
Experience	-65.94**	-13.05
LR-test for random effects	p=0.02	p=0.18

Note: The table gives maximum likelihood estimates of the coefficients in eq. (6) with t-values in parentheses (*,** denote that the coefficient is statistically significantly different than 0 at the 10%-, and 5%-level, respectively). The LR-test for random effects tests σ_u=0, which is rejected for the case without charity.

Note the remarkable similarity of the results to those reported in table 4. Qualitatively, all results are the same. Most notable is again the support for our main hypothesis (H1'): all-pay charity auctions generate higher revenues than winner-pay auctions. Quantitatively, the main difference is an overall increase in revenues (measured by the constant term) caused by the increased competition.

Finally, in order to test H3'a and H3'b we re-estimated eq. (7) for FP and AP (without the order dummy). Table 8 presents the results. Once again, these support the conclusions for smaller groups. Only in the all-pay auction does the charity significantly increase revenue.

TABLE 8: Revenue and Charity: Large Groups

	WP	AP
Constant	367.55**	406.86
Charity	-9.67	57.49*
LR-test	p=0.30	p=0.11

Note: The table gives maximum likelihood estimates of the coefficients in eq. (7) with absolute z-values in parentheses (*,** denote that the coefficient is statistically significantly different than 0 at the 10%-, and 5%-level, respectively). The LR-test for random effects tests σ_u=0, which is not rejected in either case.

All in all, the additional sessions show that the observed higher revenues for all-pay auctions cannot simply be attributed to the small group size and high return that we used in the original experiments. Though we support the lower participation in all-pay auction observed by Carpenter *et al.* (2008), this does not cause revenues to decrease below the levels observed in WP.

4. Conclusions

Charities often organize raffles or auctions to raise money. Staggering amounts are involved (reported estimates are that over $240 billion was raised by charities in the U.S. in 2003; see Isaac and Schnier, 2005).[35] There has recently been considerable interest in studying the performance of various mechanisms used. Yet, this is the first experimental investigation for the arguably most realistic case where the prize to be won is characterized by independent private

[35] Of course, a large proportion of this was not raised by way of lotteries or auctions. Still, Morgan and Sefton (2000) report that in the U.S. in 1992, at least $6 billion was raised by lotteries. We have not been able to find numbers for auctions, but a google search with the terms "charity auction" and "charity auctions" gives about 2 million hits.

values and where there is incomplete information about others' values. Our study compares winner-pay (first-price) auctions, lotteries and all-pay (first-price) auctions in this environment. The theoretical analysis derived from GMOT provides testable hypotheses for this scenario. Note that we have not attempted to find the optimal method. Given the theoretical results in GMOT this would involve adding second-price elements (or lower) to the all-pay auction. However, for many bidders, first-price auctions are much easier to understand. The formats we have compared are easy to implement and are easily understood by the bidders.[36]

Our main result provides support for the theoretical predictions: all-pay auctions are the preferred mechanism to raise money for charities. With three bidders and independent private values in the range [0,500] our results show that compared to all-pay auctions winner-pay auctions are expected to reduce revenues by more than 100 and lotteries by almost 50. The first result was replicated in additional sessions with five bidders and a lower public good return from the charity's revenue.

Extrapolating this to auctions in the field gives an indication of the potential gains to be made. For example, on June 24, 1999, Eric Clapton's legendary *1956 Fender Stratocaster* 'Brownie' raised $497,500 for the 'Crossroads Centre' in a winner-pay auction.[37] Though a caveat is required because of the many differences between our laboratory environment and this case in the field, it may be informative to speculate on the consequences of our laboratory results. Our estimates indicate that the proceeds of this one guitar could have been at least $100,000 higher, had an all-pay format been used.

An important next question concerns the extent to which theoretical results and observations in the lab can be extrapolated to the field in this way. At least Carpenter *et al.*'s (2008) field

[36] For example, the all-pay auction can be implemented as follows. People are invited to donate money to charity. It is announced that the person who donates the most, wins the prize.
[37] http://www.collectors.com/articles/article_view.chtml?artid=980&universeid=273&type=1.

experiment shows that the all-pay auction may not always dominate the winner-pay auction. New experiments, both in the lab and in the field, may reveal under which circumstances the all-pay auction is the preferred fundraising mechanism. We believe that our study provides a suitable starting point for such endeavors. As argued by Levitt and List (2006), laboratory experimentation is a useful tool for providing qualitative evidence, and is often the preferred first step when ranking mechanisms: "… the lab can be used to rank mechanisms within broad areas, such as charitable fundraising" (Levitt and List, 2006, p. 41). This is precisely what we have done in this paper.

There are at least three other potentially interesting avenues for further research. First, we modeled charity in the experiment by having each subject receive €0.50 (or €0.30) for every €1 of revenue. It would be interesting to know to which extent our results carry over to a situation where the proceeds of the auction or lottery are transferred to a charitable organization such as Greenpeace. Second, we have restricted the analysis to the case where everyone values the proceeds equally. People who are not interested in the charity know a priori that in an auction, someone with the same value for the good, who does care about the charity, would outbid them. In some auction formats this would lead them to abstain from participation, in others they may still participate. It may be interesting to study whether this type of asymmetry would change our revenue ranking. Third, the lottery mechanism deserves further field research. The relative performance of this mechanism may be different when very large numbers of bidders are concerned. An overestimation of very small probabilities of winning may cause severe overbidding in very thin lotteries, which could increase the expected revenue from this mechanism in the field.[38]

[38] We are grateful to an anonymous referee for pointing this out.

Appendix A: Instructions

The instructions are computerized. Subjects could read through the html-pages at their own pace. Below is a translation of the Dutch instructions for the treatment with a first-price winner-pay auction, starting without a charity. Horizontal lines denote page breaks.

WELCOME

You are about to participate in an economic experiment. The instructions are simple. If you follow them carefully, you may make a substantial amount of money. Your earnings will be paid to you in euros at the end of the experiment. This will be done confidentially, one participant at a time.

Earnings in the experiment will be denoted by ‘experimental francs’. At the end of the experiment, francs will be exchanged for euros. The exchange rate will be 0.5 eurocent per franc, or 1 euro for each 200 francs.

These instructions consist of 11 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. In some cases a page is larger than your screen. If so, you can use the scroll bar to scroll up and down. At the bottom of your screen, you will see the button ‘ready’. You can click this when you have completely finished with all pages of the instructions.

ROUNDS

Today’s experiment consists of 28 rounds, preceded by 3 practice rounds.

The 28 rounds are split in 4 blocks of 7. In rounds 1-7 and 15-21 you can only earn money for yourself. In rounds 8-14 and 22-28 you may also make money for yourself but you can also earn money for other participants. Other participants can also make money for you in these rounds. How this works will be explained below.

In every round, you will be member of a group. This group consists of you and two other people. The group composition is unknown to you and to other participants. You will not know who is in your group. Others will not know whether you are in their group. In addition, we will make new groups in every round. Thus, the members of your group will change from round to round. In the rounds where you can make money for other participants, this money will only be given to the other members of your group in the round.

In the practice rounds, you will not be in a group. The computer will randomly simulate the choices by other group members. Therefore, these rounds will reveal nothing about others’ choices. The practice rounds are only meant to help you learn about the problem at hand and about the computer program. Any earnings in the practice rounds will not be paid.

AUCTION

In this experiment you will participate in auctions. In these auctions you may try to obtain a fictitious good. In the remainder of these instructions we will explain the way in which the auction is organized and the rules you must abide by.

YOUR VALUE

Before you participate in the auction in any round, you will be given a value for the fictitious good.

This value can be any number (randomly determined by the computer) between 0 and 500 francs (which is between 0 and 2.5 euro).

Note the following about the values:

1. Your value is determined independently of the values of other participants;
2. Any value between 0 and 500 is equally likely;
3. The only thing you will know about anyone else's value is that every number between 0 and 500 is equally likely;
4. Similarly, no one else will know anything about your value except that every number between 0 and 500 is equally likely.

YOUR EARNINGS

If you obtain the good in a round, than your value for that round is your revenue. If you do not obtain the good, your revenue for that round is equal to 0 francs.

To determine your earnings for a round, you need to subtract your costs from the revenue, hence:

Earnings in round = revenue in round minus costs in round

In addition to your earnings from the auctions, we will give you 1500 francs as a starting capital.

Therefore, your total earnings in the experiment are (in addition to the 5 euro show-up fee you received when you arrived):

1500 francs + your earnings in rounds 1-28.

At the end of today's experiment your earnings in francs will be exchanged for euros (200 francs are equivalent to 1 euro).

YOUR EARNINGS

Though unlikely, it may happen that your earnings in the experiment become negative.

If your earnings do become negative, the following will happen:

1. You must remain seated until the end of the experiment and may tell no one that your earnings are negative
2. Your earnings from the experiment are zero. You may only keep your 5 euro show-up fee.
3. The computer will make all decisions for you.
4. You will need to confirm the computer's decision in every round (but you cannot change this decision).

Whether your earnings become negative is in your own hands, however.

If someone's earnings become negative, we will make this known to everyone who is in a group with this individual in the remainder of the experiment. We will do so by walking by your table with a note. If we show the note to you, you will know that someone in your group has negative earnings (and his or her decisions have been taken over by the computer).

THE AUCTION

In the auction, you submit a bid for the good. The other members of your group also submit bids. The group member with the highest bid gets the good and pays her or his bid. If two participants submit the same (highest) bid, the computer will randomly determine which one obtains the good.

Your earnings are therefore:

If you submit the highest bid or win the random draw: your earnings = **your value minus your bid**

If you do not submit the highest bid: your earnings = **0**.

MAKING MONEY FOR YOUR GROUP

In some rounds (rounds 8-14 and 21-28) you may earn money for the other members of your group. Other group members may also earn money for you.

To be more precise, in each of these rounds, 150% of the auction revenue will be split equally across the group members. For example, if the revenue is 100 francs, a total of 150 francs will be earned. You will receive 50 francs out of this. The division across group members does not depend on individual values or bids.

These earnings will not affect your own earnings. You may make money for yourself in exactly the same way as in rounds 8-14 and 22-28. The organizers of the experiment will pay for the additional earnings in your group.

At the top left corner of your screen, you will be shown how much money you earned from the group in the previous round. Remember that the group composition changes from round to round, however.

YOUR SCREEN

This is an example of what your screen will look like during the experiment.[39]

The screen consists of five windows. The large window at the bottom half briefly summarizes the rules you just read.

At the top, you see four windows. The left one gives information about the current round. It shows the round number, your earnings in this round and your earnings to this point. If applicable, it also shows the earning made by other participants for you.

---

[39] The Dutch/English translation of the key terms are as follows: "ronde" = "round"; "extra bijdrage" = "additional earnings with charity"; "verdienste" = "earnings"; "waarde" = "value"; "uw bod" = "your bid"; "vul … bevestiging" = "enter your bid and press `bevestiging´"; "u heeft geboden" = "your bid was"; "u heeft het hoogste bod" = "your bid was the highest"; "u betaalt" = "you pay"; "u ontvangt" = "you receive"; "uw resultaat" = "your profit"; "de groepsleden …" = "your group members submitted the following bids".

The window in the middle is for you to indicate your decision. We will explain this shortly.

The small window in the upper right corner shows what you need to do. Below it, there is a summary of the previous round.

ENTERING YOUR DECISION

You will indicate your decision in the central window at the top of your screen. [40] It shows your value for this round. You need to enter your bid in the field below it. Then, you must click the button 'Confirm' ['Bevestigen']. In the example above you cannot enter anything. Later you will have an opportunity to practice.

If your earnings become negative, the computer will enter bids for you. This will not change your earnings. You will have to click to confirm in every round, however. You will need to remain seated until the end of the experiment. We stress again, that it is in your own hands whether or not your earnings become negative. As mentioned above, if someone in your group has negative earnings, we will let you know.

PRACTICE ROUNDS

This brings you to the end of the instructions. You may still page back, if you like.

[40] The Dutch/English translation of the key terms are presented in footnote 39.

When you have finished, please click the button 'ready', below. When everyone has finished, we will start the practice rounds. As mentioned, you will not be in groups in the practice rounds (the computer will simulate others; decisions) and there will be no earnings in these rounds.

Please, remain quietly seated until everyone is ready.

Appendix B: Theoretical results

This appendix summarizes theoretical results on equilibrium bidding for WP, AP, and LOT, and shows how they have been applied to our parameters. For WP and AP the equilibrium bids in our experiments follow directly from the literature (see propositions 1 and 2, below). A new result relative to the existing literature is our equilibrium characterization of LOT in proposition 3.

The theory is based on the following assumptions. Suppose that $n \geq 2$ risk neutral bidders (numbered i = 1, …, n) bid for an indivisible object in an auction. Each bidder independently draws a value for the object from the same differentiable probability distribution F on the interval $[\underline{v}, \bar{v}], 0 \leq \underline{v} < \bar{v}$. Bidder i's value v_i is private information. If bidder i pays b_i and the auction's revenue equals R, then her utility equals $u_i = v_i I_i - b_i + \alpha R$, where $I_i = 1$ [$I_i = 0$] if she wins [does not win] the object.

PROPOSITION 1 (ENGERS & MCMANUS, 2007). For WP, the symmetric equilibrium bidding function is characterized by:

$$b^{WP}(v) = v - \int_{\underline{v}}^{v} \left(\frac{F(x)}{F(v)} \right)^{\frac{n-1}{1-\alpha}} dx, v \in [\underline{v}, \bar{v}]. \qquad \blacksquare$$

Straightforward calculations show that the assumed uniform distribution of values U[0,500] yields: $b^{WP}(v) = \frac{n-1}{n-\alpha} v$, which reduces to eq. (1) in the main text for n=3.

PROPOSITION 2 (GMOT). The symmetric equilibrium bidding function of AP is given by:

$$b^{AP}(v) = \frac{1}{1-\alpha}\left(vF(v)^{n-1} - \int_{\underline{v}}^{v} F(x)^{n-1}dx \right), v \in [\underline{v}, \bar{v}]. \qquad \blacksquare$$

For our parameters this reduces to $b^{AP}(v) = \frac{v^n(n-1)}{500^{n-1}n(1-\alpha)}$, which gives eq. (3) when n=3.

PROPOSITION 3. The symmetric equilibrium bidding function b^{LOT} of LOT follows from the following integral equation:

$$\int_{\underline{v}}^{\bar{v}}\int_{\underline{v}}^{\bar{v}}...\int_{\underline{v}}^{\bar{v}} \sum_{i=1}^{n-1} b^{LOT}(v_i)\left(\sum_{i=1}^{n} b^{LOT}(v_i)\right)^{-2} dF(v_1)dF(v_2)...dF(v_{n-1}) = \frac{1-\alpha}{v_n}, v_n \in [\underline{v}, \bar{v}] \quad \text{(B1)}$$

PROOF. Suppose that bidders i = *1, ..., n-1* bid according to b^{LOT}. Then bidder n maximizes

$$U(b_n) \equiv \int_{\underline{v}}^{\bar{v}}\int_{\underline{v}}^{\bar{v}}...\int_{\underline{v}}^{\bar{v}} \left\{ v_n b_n \left(\sum_{i=1}^{n-1} b^{LOT}(v_i) + b_n \right)^{-1} + \alpha\left(\sum_{i=1}^{n-1} b^{LOT}(v_i) + b_n \right) \right\} dF(v_1)dF(v_2)...dF(v_{n-1}) - b_n$$

with respect to the number b_n of lottery tickets that she buys. The first term in the integral equals the value of the object times the probability of winning it while the second term refers to the utility from the revenue transferred to charity. It is readily verified that (B1) satisfies the first-order condition of this maximization problem for $b_n = b^{LOT}(v_n)$. The second-order condition is satisfied as well because $U''(b_n) \leq 0$ for all $b_n \geq 0$. Therefore, (B1) characterizes the symmetric equilibrium bidding function of LOT. ■

As explained in the main text, we numerically derived the equilibrium bid $b^{LOT}(v_i)$ for values starting at 0 and with increments of 10. We then fit the polynomial in eq. (5) to describe the relationship between value and equilibrium bids in the lottery.

References

Bulow, J., Huang, M., Klemperer, P., 1999. Toeholds and takeovers. *Journal of Political Economy* 107, 427–54.

Carpenter, J., Holmes, J., Matthews, P.H., 2008. Charity auctions: A field experiment. *Economic Journal* 118, 92–113.

Carpenter, J., Holmes, J., Matthews, P.H., 2007. Endogenous participation in charity auctions. *Working paper*, Middlebury College.

Chua, C., Berger, I., 2006. Charity auctions on the internet: An exploratory study. Working paper, Ryerson University.

Corazzini, L., Faravelli, M., Stanca, L., 2007. A prize to give for: An experiment on public good funding mechanisms. Working paper, University of Edinburgh.

Cox, J.C., Roberson, B., Smith, V., 1982. Theory and behavior of single-object auctions. In: Smith, V.L. (Ed.), *Research in Experimental Economics, Vol. 2*. JAI Press, Greenwich.

Cramton, P., Gibbons, R., Klemperer, P., 1987. Dissolving a partnership efficiently. *Econometrica* 55, 615–632.

Davis, D.D., Razzolini, L., Reilly, R., Wilson, B.J., 2006. Raising revenues for charity: Auctions versus lotteries. In: D.D. Davis, R.M. Isaac (eds.), *Research in Experimental Economics, Vol. 11*. JAI Press, Greenwich.

Davis, D.D., Reilly, R., 1998. Do too many cooks always spoil the stew? An experimental analysis of rent-seeking and the role of a strategic buyer. *Public Choice* 95, 89–115.

Elfenbein, D.W., McManus, B., 2007. A greater price for a greater good? The charity premium in online auctions. Working paper, John M. Olin School of Business.

Engelbrecht-Wiggans, R., 1994. Auctions with price-proportional benefits to bidders. *Games and Economic Behavior* 6, 339–346.

Engers, M., McManus, B., 2007. Charity auctions. *International Economic Review* 48, 953–994.

Faravelli, M., 2007. The important thing is not (always) winning but taking part: Funding public goods with contests. Working paper, University of Edinburgh.

Goeree, J.K., Maasland, E., Onderstal, S., Turner, J.L., 2005. How (not) to raise money. *Journal of Political Economy* 113, 897–918.

Graham, D.A., Marshall, R.C., 1987. Collusive bidder behavior at single-object second-price and English auctions. *Journal of Political Economy* 95, 1217–1239.

Isaac, R.M., Schnier, K., 2005. Silent auctions in the field and in the laboratory. *Economic Inquiry* 43, 715–733.

Isaac, R.M., Walker, J.M., Thomas, S.H., 1984. Divergent evidence on free riding: An experimental examination of possible explanations. *Public Choice* 43, 113–149.

Kagel, J.H., Harstad, R.M., Levin, D., 1987. Information impact and allocation rules in auctions with affiliated private values: A laboratory study. *Econometrica* 55, 1275–1304.

Kagel, J.H., Levin, D., 1993. Independent private value auctions: Bidder behavior in first, second and third price auctions with varying numbers of bidders. *Economic Journal* 103, 868–879.

Krishna, V., Morgan, J., 1997. An analysis of the war of attrition and the all-pay auction. *Journal of Economic Theory* 72, 343–362.

Landry, C., Lange, A., List, J.A., Price, M.K., Rupp, N.G., 2007. Towards an understanding of the economics of charity: Evidence from a field experiment. *Quarterly Journal of Economics* 121, 747–782.

Lange, A., List, J.A., Price, M.K., 2007. Using lotteries to finance public goods: Theory and experimental evidence. *International Economic Review* 48, 901–927.

Ledyard, J.O., 1995. Public goods: A survey of experimental research. In: Kagel, J.H., Roth, A.E. (Eds.), *The Handbook of Experimental Economics*. Princeton University Press, Princeton.

Levitt, S.D., List, J.A., 2006. What do laboratory experiments tell us about the real world? Working paper, University of Chicago.

Maasland, E., Onderstal, S., 2007. Auctions with financial externalities. *Economic Theory* 32, 551–574.

McAfee, R.P., McMillan, J., 1992. Bidding rings. *American Economic Review* 82, 579–599.

Morgan, J., 2000. Financing public goods by means of lotteries. *Review of Economic Studies* 67, 761–784.

Morgan, J., Sefton, M., 2000. Funding public goods with lotteries: Experimental evidence. *Review of Economic Studies* 67, 785–810.

Myerson, R.B., 1981. Optimal auction design. *Mathematics of Operations Research* 6, 58–73.

Noussair, C., Silver, J., 2006. Behavior in all-pay auctions with incomplete information. *Games and Economic Behavior* 55, 189–206.

Orzen, H., 2005. Fundraising through competition: Evidence from the lab. CeDEx Working paper 2005–04.

Popkowski Leszczyc, P.T.L., Rothkopf, M.H., 2007. Charitable intent and bidding in charity auctions. Working paper, University of Alberta.

Potters, J., De Vries, C.G., Van Winden, F., 1998. An experimental examination of rational rent-seeking. *European Journal of Political Economy* 14, 783–800.

Singh, R., 1998. Takeover bidding with toeholds: The case of the owner's curse. *Review of Financial Studies* 11, 679–704.

Vickrey, W., 1961. Counterspeculation, auctions, and competitive sealed tenders. *Journal of Finance* 16, 8–37.

Zelmer, J., 2003. Linear public goods experiments: A meta-analysis. *Experimental Economics* 6, 299–310.