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Abstract:

When conducting electronic auctions, sellers obviously wish to maximize their revenue and one tool economic theory suggests they might use is an entry fee. By charging bidders a certain amount for entering an auction, the seller can theoretically extract more surplus from those bidders that choose to enter the auction. The problem a seller faces is that the use of an entry fee might discourage entry. This paper uses economic experiments to address the question of whether or not entry fees can be used by an auctioneer in conjunction with an auction format bidders tend to prefer to raise revenue in the presence of the possibility for buyers to choose between entering the preferred auction with an entry fee or a less preferred alternative auction with a lower fee. Our results show that even though buyers appear to have quite strong preferences for certain auction formats, the preferences are not strong enough to be profitably exploited by entry fees.

1 Introduction

While auctions have been used as mechanisms of exchange for thousands of years it seems as though they have truly flourished on the internet. Internet auction sites such as e-Bay have expanded into billion dollar businesses and are revolutionizing many markets for used goods and novelty items or collectibles[1]. With the presence of so many different auction sites and sellers one should expect increasing competition between sellers. Consequently, sellers will be looking for different ways they might be able to increase their revenue.

The fact that it is quite inexpensive for a seller to modify a given auction mechanism when the auction is conducted on the Web creates the possibility for the sellers to increase their revenue by trying to find the mechanism that yields them the highest revenue which may take the form of finding the one that attracts the most bidders. The basic issue of the revenue generation properties of standard auction formats in an on-line setting was examined in Lucking-Reiley (1999). That paper investigated the theoretical claim of revenue equivalence between first price sealed bid and Dutch auctions and then between second price sealed bid and English auctions. The findings were that the Dutch auction raised more revenue than first price while the English and second price were equivalent. There was no comparison made across the Dutch/first price auction and the second price/English auction group. These results in many respects just replicate what had been found much earlier using laboratory experiments in Coppinger et al. (1980) and Cox et al. (1982) which did include the cross group comparison finding that first price and Dutch auctions raised more money than second price and English auctions.

Ivanova-Stenzel and Salmon (2004) and Ivanova-Stenzel and Salmon (2003) (ISa and ISb respectively) examined revenue generation in electronic auctions in the presence of endogenous entry choice on the part of the bidders to determine if this might allow English auctions to raise more revenue than first price auctions in the field[2]. The idea is that if bidders possess preferences between auction formats themselves they may well be more willing to enter auctions using a

preferred format even if there are likely to be more other bidders involved. Those papers show that bidders may indeed prefer ascending auctions enough over first price sealed bid auctions to lead to English auctions yielding more revenue than first price auctions which is a reversal of the standard laboratory result. Engelbrecht-Wiggans and Katok (2003) uses a different approach to investigate a similar issue and their findings largely corroborate those in ISa and ISb though their results also point to some difficulties subjects have in evaluating the value of participating in auctions. There have of course been many other studies examining various aspects of auctions on the internet which are summarized in Bajari and Hortacsu (2003a).

Besides the choice of an appropriate auction format, sellers might also try to increase their revenue by introducing an optimal entry fee. This is a standard component of the traditional optimal auction design under the assumption of symmetric independent private values as developed in Myerson (1981). The key idea behind the standard optimal auction design is that the seller constructs their auction such that there is a minimum value, v_0, for which a bidder would find it profitable to participate in the auction.

There are two different ways to accomplish this task. The first would be a reserve price, r, which would be set by $r = v_0$. The second way would involve using an entry fee, e, such that $e = \int_0^r G(y)dy$ where we are integrating over the possible bidder values in the range 0 up to r and $G(x)$ is the distribution function of the second highest value among the bidders given that x is the highest[3]. Using either a reserve price or an entry fee is intended to allow the seller to recover more surplus from the bidders than they would from an auction without a reserve price or entry fee by forcing the bidders to pay more on average. Though they are typically used separately, it would be possible to use them in combination and the point would still be to make sure the bidder with the value v_0 is just excluded from the auction.

Levin and Smith (1994) provides an alternative theory of the use of entry and reserve prices by showing that when the number of participants in an auction is endogenously

determined, entry and reserve prices may or may not be beneficial to the seller depending upon the environment. In the context of independent private values, they prove that optimal entry is maintained when the seller does not use either a reserve price or an entry fee. Engelbrecht-Wiggans (1993) shows that if the number of bidders is not fixed, then it might be the best for the seller to set a reserve price (close to his value for the object) but not to charge an entry fee.[4] In the present study we seek to experimentally characterize the effect of entry fees on bidder entry decisions and therefore on seller revenue.[5]

We report the results of a series of experiments that were designed to study the question of how the format of the auction itself influences a bidder's entry decision and whether or not a seller may be able to exploit any revealed preferences for auction formats through the use of a well chosen entry fee. There is existing theoretical work that examines the problem of competing auctioneers such as McAfee (1993) and Peters and Severinov (1997) but in those studies auctioneers compete only along the dimension of offering differing reserve prices. Our interest is in allowing auctioneers to compete primarily based on offering differing auction designs. Our particular focus will be looking at bidders' choices between the most common on-line auction formats; the sealed bid first price (henceforth, SB1P) and sealed bid second price auctions (henceforth, SB2P)[6] as well as the ascending or English auctions (henceforth, A)[7]. In companion papers (ISa and ISb) we use these same experiments to measure the intensity of the bidders' preferences for the different auction formats and provide some explanations for the observed behavior. Here we report the results of those experiments as they apply to the issue of how an entry fee affects the revenue of auctioneers when bidders are allowed to choose between competing auctions. Section 2 will describe the experiments performed for this analysis. Section 3 will discuss the results and section 4 will conclude.

2 The experimental design

A full description of the experiments for this paper can be found in ISa and ISb. We

describe here the most relevant portions of the experimental design for the issue of examining the impact of the entry fees on revenue generation.

The subjects participated in several private value auctions meaning that the bidders were informed only about their own private value and therefore did not know the private value of the other bidders. The bidders' private values were independently drawn from a uniform distribution over the integers on the interval [0, 100]. These values were denoted in a fictitious currency termed ECU, or Experimental Currency Unit, with an exchange rate of 1 ECU=0.04 Euro. There were 10 participants in each experimental session who were randomly re-paired in each round to bid against a new opponent.

An experimental session was divided into two phases. In the first phase the subjects participated in two different auction types for 10 consecutive rounds. All auctions consisted of two competing bidders. The idea for this phase was to allow subjects to figure out how to bid in these auctions as well as to understand the two formats well enough to form preferences between them. The two auction types used varied between the sessions. In six sessions the subjects played a sealed bid first price auction (SB1P) and an ascending auction (A). In five different sessions the two auction formats are the first price (SB1P) and second price auction (SB2P). Finally, in one session the subjects played the second price (SB2P) and ascending (A) auction. In each round of this first phase, subjects would observe their value for that round and then submit their bid in a SB1P (or SB2P) auction. Before observing the results of this auction, the subjects would participate in the other auction type, either A or SB2P depending on the treatment, against the same opponent and using the same value. In the case of an ascending auction, the type the bidders participated in was a Japanese or ascending clock auction[8]. After both auctions for that round were concluded, the bidders were informed of the outcomes for both auctions at the same time. They were informed whether or not they became the buyer, the price paid in the auction (regardless of whether or not they won), their profit in each auction as well as their cumulative profit overall. At the end of this phase subjects were typically informed about the average buyer's

profit for both auction types.

In the second phase of the experiment the participants were repeatedly allowed to choose between competing in either of the two auction mechanisms they experienced in the first phase. In each round of this second phase, subjects were asked which format they wished to enter prior to observing their value for that round but knowing that regardless of which format they chose, they would be bidding against a single competitor. In each round of the second phase, one subject was not allowed to choose so that we could be sure to have an even number of subjects playing each type of auction. Those choosing an auction format were matched against each other with this extra bidder completed any odd set. In order to enter into an auction, though, subjects were required to pay an entry price for the chosen auction format. In the first 10 rounds of this phase the entry prices for both auction formats were the same (1.40 ECU). The preferred auction design was identified for each individual as the one they chose in at least five of the first 10 rounds. In the remaining 20 rounds, the entry price of the preferred auction type was varied across rounds using a grid consisting of entry prices ranging from .7 to 14 ECU with an increment of .7 plus or minus a small noise term.

After all participants made their choices, a chance move determined whether the auction round would be actually played (with probability 20%). This was a session wide determination, not specific to any player. At the end of each actually played auction round subjects were informed whether or not they became the buyer, about the price, which has to be paid by the buyer, the entry price they paid for the chosen auction type and how much they had earned in this auction round. An entry price was only charged to a subject if the auction was conducted. If the auction round was not actually played, no entry prices were charged. Table 1 summarizes the characteristics of our experimental design.

Table 1 approximately here

3 Results

The issue we are interested in investigating is whether or not auctioneers can exploit preferences bidders might have for different auction mechanisms by charging entry fees. In order to do that, we first need to establish some benchmark results on what auction formats tend to be preferred and also on the strength of those preferences.

When subjects were allowed to choose to enter one of two auction formats for the same price they overwhelmingly preferred either the ascending or the second price auction over the first price. In fact there was only one subject in the SB1P vs. A treatment who chose the first price auction exclusively. In the SB1P vs. SB2P treatment this was never the case as all subjects chose the second price at least twice. Altogether only 5 out of 60 (SB1P vs. A) and 7 out of 50 (SB1P vs. SB2P) subjects chose to enter the sealed bid first price auction more often than the alternative. As shown in table 2 the average number of times the ascending and the second price auction were chosen were 7.87 and 7.46, respectively, with a median of 9 in both auction types. In interpreting these numbers it is important to realize that since one subject was held out in each of the rounds of this phase and there were 10 total rounds in which subjects chose between auction formats with equal entry prices, each subject made 9 choices. Since the median number of times the ascending or second price was chosen was 9, this represents a strong tendency for subjects to choose it exclusively. In total, 39 (of 60) subjects chose the ascending auction and 27 (of 50) the sealed bid second price auction exclusively when the alternative was the sealed bid first price**.** The average number of choices for the first price auction in both experiments was 1.13 and 1.54 with a median of 0.

The first sessions we ran were the ones for the SB1P vs. A treatment and found this overwhelming preference for the ascending auction. We then conducted the SB1P vs. SB2P sessions to determine if these observed preferences were based on the method of eliciting bids or on the strategic differences between the formats. In both the ascending and second price auctions, the weakly dominant strategy is for bidders to bid their value which is quite easy to do and most subjects can learn this rule quickly. Much more sophisticated analysis is required to find the

equilibrium bid function in the first price auctions and this strategy depends on the risk preferences of the individual. It was possible then that the result we observed of the preference for the ascending auction was based on the strategic simplicity of the auction. It was of course also possible that the observed preference was based on the fact that subjects just liked something about the clock mechanism. The fact that the subjects overwhelmingly choose both the second price and ascending over the first price indicates that bidders have very strong preferences between the different auction formats due to the strategic differences rather than due to the method of collecting the bids. The last row of table 2 shows the preferences bidders have between the two strategically equivalent formats and we find a weak preference for the second price perhaps indicating a dislike for the clock format.

Table 2 approximately here

With such a strong preference established, one might be tempted to suggest that sellers could exploit these preferences through the use of entry fees. We will look at this issue in two ways. The first will be to examine how high of entry fees bidders were willing to pay on average. The second will be to compute the revenues sellers might expect from conducting these auctions with varying entry prices. To aid in the interpretation of the entry prices bidders were willing to pay, it is useful to point out that given our environment the optimal reserve price (without entry free) according to standard theory would have been $r = 50$ and the equivalent optimal entry fee (with no reserve price) would therefore have been $e = \sum_{x=0}^{50} \frac{x+1}{101} = 13.129$ ECU. It is important to note though that the implementation of the entry price in our experiments is different than the implementation in the standard optimal auction design. In our experiments, our subjects did not know their value prior to making their entry choice and obligating themselves to paying the entry fee while in the optimal auction design they know their value prior to deciding to participate.

Subjects who reveal a preference for the ascending or the sealed bid second price auction were willing to pay on average a maximum entry price of 6.61 and 7.47 ECU[9]. Note that this is

significantly lower than the theoretically optimal level that ignores entry choice. A histogram of the number of subjects choosing the ascending and the sealed bid second price auction at each possible entry price is displayed in figure 1. The vertical dotted line represents the average maximum entry price subjects were willing to pay for their preferred auction format.

Figure 1 approximately here

Another measure of whether this revealed willingness to pay is high or low, is based on comparing the surplus subjects expect to make in the different auctions. Theoretically, the expected surplus to bidders would have been the same in all institutions were subjects bidding according to the respective risk neutral Nash equilibria of each institution. In reality, however, as one can see in table 2 the average winner surplus bidders experienced in the first phase varied substantially between the auction types[10]. More precisely, the winning bidders earn on average 17.70 ECU more in the ascending than in the first price and 19.87 ECU more in the SB2P compared to the first price auction. These differences are highly significant in both treatments as a $t-$Test results in a rejection of the null-hypothesis that the winner's surplus differentials are equal to zero with a *p*-value of 0.000. Because each auction involves only two bidders, subjects expect to win half the time. This implies expected surplus differentials of 8.85 and 9.93 ECU, respectively. So, if subjects were concerned only with expected profitability and were willing to pay up to the entry price that yields the same average surplus between the two formats, they should have been willing to pay up to 10.25 for the ascending auction and 11.33 for the sealed bid second price auction[11]. In fact, just fewer than 10 subjects per treatment were willing to pay entry prices of at least this level. Most were only willing to pay far less. The solid vertical line in the histogram represents this cut-off price. At this line, expected surplus from the two formats are equal. As is made clear in figure 1, the subjects were willing to pay for their preferred auction format up to a level that is on average substantially less than would be implied by the expected surplus differential. In ISa and ISb, we argue that the observed willingness to pay still represents strong preferences for the ascending and second price auctions once the risk attitudes of the

bidders are properly accounted for.

For the SB2P vs. A treatment the same computations lead to an expected surplus differential of 0.31 indicating that subjects should be indifferent between the two auction formats and therefore always choose the auction with the lower entry price. The results show that bidders behave in-line with this prediction. In this treatment, subjects who revealed a preference for the ascending auction were willing to pay an average entry price of 2.96 for it while those who preferred the second price were willing to pay on average an entry price of 1.45. The average price paid for the ascending is so high due to two outlier subjects[12] as the median price subjects were willing to pay was 1.42 which was also the median price subjects were willing to pay for the second price. This indicates that subjects were essentially indifferent between the two mechanisms since the default entry price for the alternative auction was always 1.4.

We can now examine the core question of the paper which is whether or not an auctioneer can exploit this willingness to pay for a preferred format to increase his revenue. Figure 2 shows another reason why an auctioneer running either a second price or ascending auction might want to use an entry fee as it shows the expected revenue or profit an auctioneer expects in a first price auction versus the second price or ascending auctions for different possible entry prices on the latter two while assuming a constant entry price of 1.4 on the first price auction. Due to the fact that bidders bid above the risk neutral Nash equilibrium in the first price auction, that format raises significantly more revenue for the auctioneer than either of the other two alone. An auctioneer who wants to run either of the other two might, however, be able to use an entry fee to make up the difference. The graphs in figure 2 show how high the entry fee has to be in order for the ascending or second price auctions to raise as much money per auction as the first price which is around 10-12 ECU's. This per auction expected revenue is calculated by taking the average revenues in each auction type over both phases of the experiment and adding two times the relevant entry price. As discussed above, very few bidders were willing to pay an entry fee of the level of the 10-12 required to equalize the revenue between the formats which should indicate

that when bidders have an option, they would in general not pay entry fees of this level and auctioneers could therefore not raise their profits high enough through this particular mechanism to compensate for the per auction difference in revenue.

Figure 2 approximately here

Setting an entry fee alone, however, is not the only way an auctioneer might exploit the preferences bidders have for the ascending and second price auction formats. Due to the bidders' preference for these formats, an auctioneer may be able to use a lower entry price than necessary to equalize the revenue on a per auction basis but be able to conduct enough additional auctions to make up for the difference. Figure 3 characterizes an auctioneer's ability to do so. Consider two competing auctioneers, one who always runs first price auctions with an entry fee of 1.4 and a competitor who runs either a second price or ascending auction format at multiple different entry prices. Figure 3 shows the total revenue each of these auctioneers should expect for each entry price on the ascending and second price formats used in the experiments. These expected profits are found by taking the number of auctions each auctioneer would be able to conduct given the number of bidders who actually chose each format at each entry price and then multiplying this by the average profit and adding in the entry prices. The clear pattern is that the predicted revenue raised by either the ascending or second price auction is strictly decreasing in the entry price. The highest total revenue is found with the entry price of .7 which is below the entry price for the first price auction. The reason for the higher revenue is that virtually all bidders choose to enter the ascending or second price for such a low entry fee. As the entry price rises, there are still more bidders choosing the ascending or second price formats than the first price for a while, but the number is diminishing and the drop in revenue due to bidders choosing their outside option is not compensated for by the increase in the entry price. After the entry price for the ascending or second price is set above 4, then the first price auctioneer is able to conduct enough auctions such that with the revenue per auction edge, he is making more money.

Figure 3 approximately here

These two figures combined with figure 1 make it clear that there are two forces pushing the total expected revenue in opposite directions. As the entry price for the preferred format is increased, per auction revenue increases, but the number of auctions an auctioneer is able to conduct decreases. The net effect is that the bidders' willingness to shift to the other auction format outweighs the possible revenue increase coming from the entry price. Consequently these results suggest that an auctioneer will not be able to use entry fees to increase their revenue when the bidders have an alternative they can choose at a lower entry price.

4 Conclusion

In this study we try to experimentally examine the degree to which sellers can use entry prices to raise their revenue in on-line auctions by taking advantage of potential preferences bidders might have for different auction formats. The key component of the analysis was an experiment designed to allow subjects to endogenously choose between competing auction formats while carefully controlling their expectations about the differences between the formats. In our experiments, subjects first gain experience with the two competing auction types through 10 rounds of auctions with each auction having just two bidders. The next phase of the experiment allows the bidders to choose between each auction format knowing that they will face a single competitor and that they will have to pay an entry price for either auction. By varying this entry price we can examine the intensity of any preference bidders may have for auction formats and determine whether or not a seller could use an entry price to increase their revenue.

The results show that although our subjects overwhelmingly preferred the ascending and second price auction formats when the entry price was the same as the entry price for a first price auction, this preference was not one that could be profitably exploited through the use of an entry price. This leads to an important implication for on-line auctioneers in electronic markets. While the use of an entry price may increase the revenue collected given a fixed pool of bidders, this price will likely effect the entry choice of potential bidders such that fewer will choose to

participate which will then cause a decrease in total revenue. Our results suggest that in a private-value environment when endogenous entry decisions are possible the set of optimal auction for sellers is likely to include only those without an entry fee.

At this point we can be clear about why we chose the two bidders setting. With more than two bidders per auctions the profit differential between the formats shrinks relatively rapidly making the observation of strong preferences difficult. We therefore wanted to observe these preferences in a setting in which the differentials were large giving the seller his best possible opportunity for profitably exploiting any preferences between formats. Our finding is that even in the two bidders setting with very strong preferences, a seller is not able to exploit those preferences with entry fees. Consequently they will certainly not be able to do so for situations involving larger numbers of bidders.

These results are quite important for the design of on-line markets. In on-line and electronic auctions, it is typically the case that bidders have multiple sellers they could choose among to make a purchase. Assume that one seller is operating in a preferred venue due to the design of their mechanism, the ease of using their site or some similar advantage over competing sellers. Such a seller might think they could take advantage of their situation by charging a small entry fee to buyers to extract the extra surplus derived from the better venue. Our results show quite clearly that such an approach would not be effective as bidders are willing to give up surplus by choosing a less preferred venue to avoid paying an entry fee. This effect is strong enough to dominate any positive effect on revenue from the entry fee itself. The only advantage the seller will receive from the superior venue will be a greater number of participants which is not such a bad consolation prize.

One issue we did not explicitly allow for in our design was the possibility of seller's endogenously choosing entry prices. One might be tempted to think that with strategic sellers a different result could be obtained. We do not see this as likely. If there were two sellers, one using an ascending format and the other a first price (call those auctioneers A and FP

respectively), regardless of the entry price chose by A, FP will do best by choosing an entry price equal to 0. As we have shown, given that FP has chosen a low entry price, A does strictly better by doing the same. Thus a Bertrand-like pricing game would ensue with both auctioneers being driven down to entry fees of effectively 0. Thus allowing for strategically competing sellers would be unlikely to change this result. A more interesting experiment would involve allowing strategic sellers to compete by choosing auction formats when facing strategic bidders and when the number of bidders per auction is not fixed at two, which is a topic we expect to investigate in the future.

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Treatment	Compared Auction Formats		# of sessions	# of subjects
	Type 1	Type 2		
SB1P vs. A	SB first price	Ascending	6	60
SB1P vs. SB2P	SB first price	SB second price	5	50
SB2P vs. A	SB second price	Ascending	1	10

Table 1: Summary of experimental sessions.

	Number of Choices (Phase 2)				Average Winner's	
	Average		Median		Surplus (Phase 1)	
Treatment	**Type 1**	**Type 2**	**Type 1**	**Type 2**	**Type 1**	**Type 2**
SB1P vs. A	1.13	7.87	0	9	19.32	37.02
SB1P vs. SB2P	1.54	7.46	0	9	11.84	31.70
SB2P vs. A	5.3	3.7	7.5	1.5	32.12	31.50

Table 2: Summary of entry choices in the first 10 rounds of phase 2 compared with the average winner surplus from phase 1.

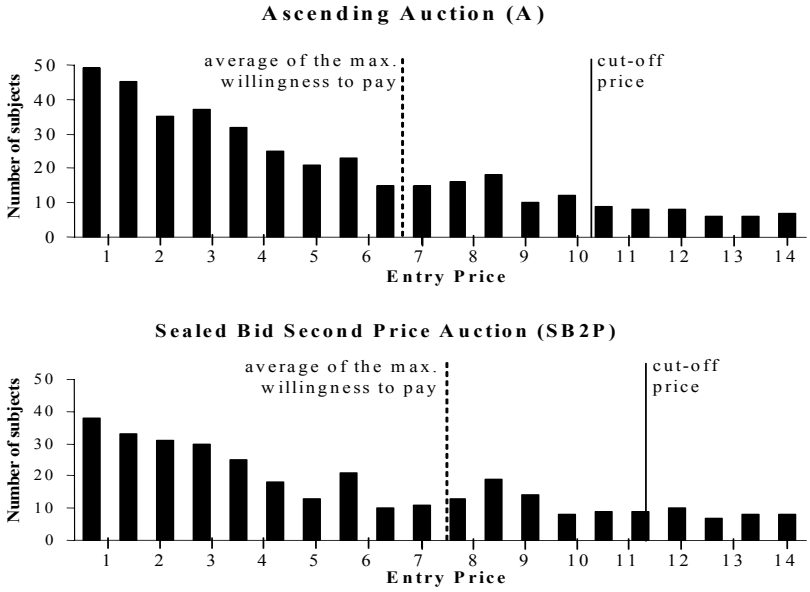

Figure 1: Histograms showing the number of subjects who were willing to pay each entry price for the ascending and second price auctions.

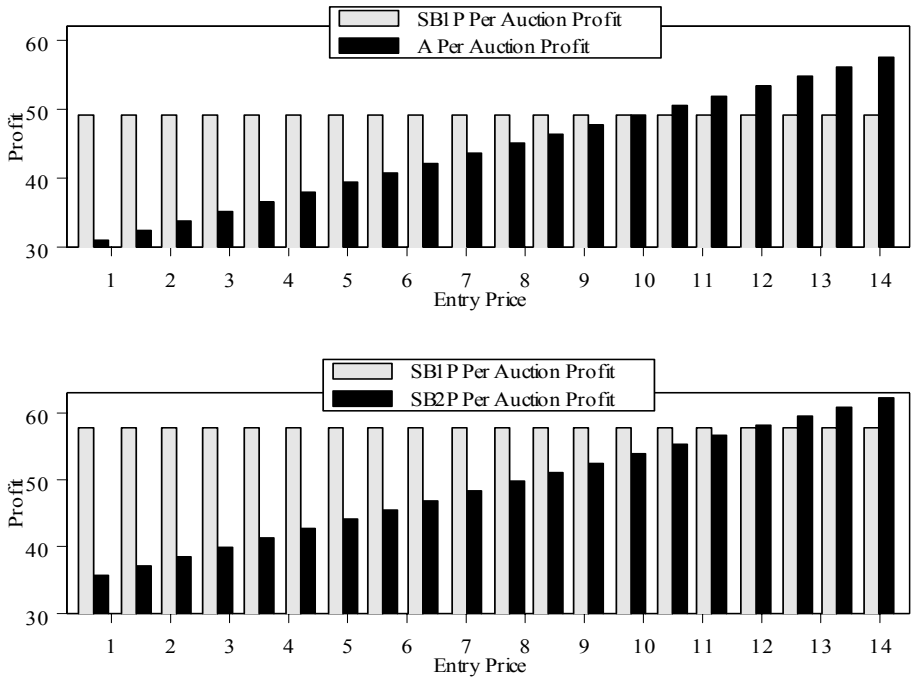

Figure 2: Expected profits per auction assuming the entry price of the generally preferred format is raised while the entry fee for the first price is kept constant at 1.4.

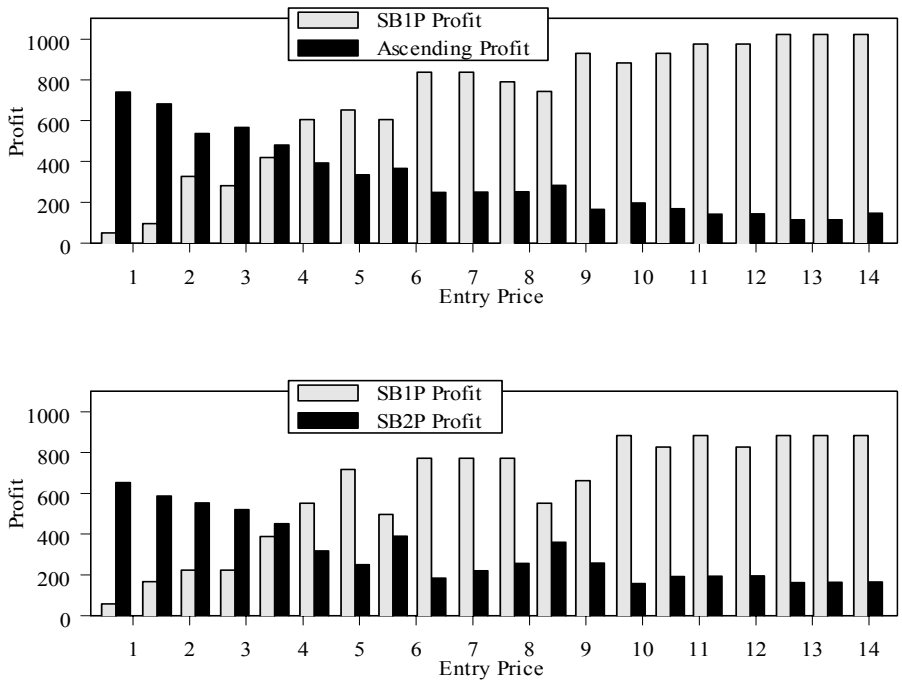

Figure 3: Total profit potentially raised by an auctioneer for each entry price level of the preferred auction.

Notes

[1] For an extensive survey of on-line auctions see Lucking-Reiley (2000).

[2] An idea also suggested in Engelbrecht-Wiggans (2001). That paper provided a theoretical argument that the additional cost of information necessary to participate in sealed bid auctions could encourage greater entry into ascending auctions leading to the latter raising more revenue.

[3] $G(x)$ can also be interpreted as the probability that a bidder who draws a value of x will win the auction. Note that this is also a function of the number of bidders in the auction, n. In general the more bidders in the auction, the lower the probability of any bidder with a value of x winning. So as n rises the optimal entry fee falls though the optimal reserve price, r, remains the same.

[4] Actually, Engelbrecht-Wiggans demonstrates that the seller might slightly increase his profit by using an appropriately adjusted entry fee which should be small enough not to scare away any bidders. Since this adjustment has a rather minor effect on his profit, the seller might as well ignore it. A Similar argument is made against the use of entry fees and reservation prices in Engelbrecht-Wiggans (1987).

[5] There are empirical papers that deal with the issue of setting of optimal reserve price, for instance, Bajari and Hortacsu (2003b) and Katkar and Lucking-Reiley (2000). But they deal with the question whether sellers should use a secret reserve price or an observable minimum bid.

[6] In a sealed bid auction bidders submit their bids simultaneously in a sealed bid manner, meaning bidders do not know the bids others are making. In a first price auction, the object is sold to the highest bidder at price equal to his bid. In a second price auction, the object is sold to the highest bidder at the price of the second highest bid (the highest non-winning bid).

[7] There are two similar versions of ascending auctions. In the clock ascending auction, the price starts low and all bidders indicate whether or not they are in at that price. The auctioneer then raises the price in a continuous clock manner and bidders decide when they wish to irrevocably exit the auction. The auction closes when there is a single remaining bidder and that bidder pays the price at which the last bidder dropped out. In the oral outcry version, bidders submit bids to top the current high bid until no bidder wishes to continue bidding. The difference between these formats is subtle and is explored further in Isaac et al. (2003a) and Isaac et al. (2003b).

[8] The price started at 0 and began increasing at the rate of 1 every 2 seconds. The auction ended when one of the bidders clicked on a button to indicate they were withdrawing from the auction with the remaining bidder winning the auction at the price the other bidder dropped out at.

[9] For details on how this is computed see ISa.

[10] Note that the experiment was designed such that the information on the expected surplus in both mechanisms from the first phase only should have been the primary determinant of subject choices of auction mechanisms in the second stage. Since only 20% of the second phase auctions were conducted, subjects would not have been able to update their expectations of the two formats much in the second phase. Thus the first phase surpluses are the most salient ones. Also, these were reported to subjects at the end of phase 1.

[11] This numbers are calculated by adding the entry price for the sealed bid first price auction, 1.4, to the corresponding expected profit differential.

[12] These two subjects chose the A auction only once for a very high entry price (8.4) although for all other

entry prices they chose the second price auction.