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Sudden Termination Auctions – An Experimental Study

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Abstract:

The design of markets has become a major issue due to the capability of online operators to implement almost any set of market rules overnight. With this study we contribute to the literature of market design by presenting a theoretical and experimental analysis of sudden termination auctions. Our main focus is on the second price candle auction that has a positive termination probability at any time in the course of the auction. The candle auction is rarely used, probably because implementation is technically demanding. However, it proves to be a faster and equally efficient alternative to standard hard close auctions.

Keywords: auctions, termination rules, electronic markets

JEL No: C73, C9, D44

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1. Introduction

Due to the growing importance of online auction institutions and due to the possibility to design and re-design electronic auction easily, auction design has emerged as a popular topic in economic research.[1] Roth and Ockenfels (2002) point out that the termination rule of an auction may be an important aspect of auction design, because it can have a substantial effect on the bidder's behavior. They observe that on eBay, which runs a *hard close auction*[2], most of the bidding takes place in the last few minutes before the deadline. In contrast, they find that on Amazon, which runs a *soft close auction*[3], the deadline effect cannot be observed, i.e. the bidding is less concentrated towards the end and bids rise get closer to the final price at an earlier stage. Late-bidding is also reported by a number of other authors (e.g. Bajari and Hortacsu 2003; Hayne, Smith, Vijayasarathy 2003; Wilcox 2000) and has been experimentally confirmed by Ariely, Ockenfels, and Roth (forthcoming).

In this paper, we study a class of ending rules that are meant to influence the impact of the deadline effect in the framework of an exogenous termination auction. The general *sudden termination auction* rules we consider are characterized by (1) a fixed termination interval and (2) a probability distribution of sudden termination over the time interval. Thus, the set of sudden termination auctions includes the simple hard close auction, where the entire termination probability mass is set on the upper interval boundary. Another subset of the sudden termination auctions, the *candle auctions*,

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[1] See Ockenfels, Reily and Sadrieh (2006) for an overview.

[2] The auction ends at a pre-specified fixed termination time.

[3] Whenever necessary, the time of termination is automatically extended after an incoming bid to guarantee a minimum reaction time for the other bidders.

assign a strictly positive and increasing termination probability to each point in the termination interval[4].

Obviously, there are numerous other termination probability distributions that may be of interest. However, the only other one that we consider is the *coin close auction* that allows every bidder to submit one final bid with a 50 percent probability. This specific termination rule is of special interest because it represents the smallest possible deviation from the hard close rule. Hence, a considerable difference in bidding behavior between the coin close and the hard close auctions will indicate the crucial impact of stochastic termination in the ending rule[5].

Our experimental design allows us to discover whether late bidding is substantially decreased by introducing a positive termination probability in early stages. If this is the case, we should observe less *sniping* (high frequency of bids in the termination stage) in the candle auction than in the coin close auction and less sniping in the coin close than in the hard close auction. It seems plausible that bidders will submit more "serious" bids earlier when there is a risk of early termination. In fact, we will show that all bidders bid their value in the first stage with a positive termination probability, when we consider the only symmetric equilibrium in weakly dominant strategies. Bidding in the stages with zero termination probability is arbitrary in these equilibria. Hence, the termination risk in the candle auction that is already present from the first stage, provides bidders with an incentive to reveal their true value from the start.

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[4] As Cassady (1967) reports, Samuel Pepys, a high clerk in Great Britain, mentions an auction in his diary in which two ships (the Half-Moon and the Indian) were sold in November 1660. This auction was run with ascending open bids, where bidding was only permitted as long as a burning candle set on the pier did not die out.

[5] Ockenfels and Roth (forthcoming) also find a crucial impact of a stochastic termination in hard close auctions. Note, however, that they model the stochastic termination differently than we do. In their model, the termination is an independent stochastic event for each bidder.

Obviously, we do not expect to observe behavior that is completely in line with equilibria predictions. If this was the case, a simple one stage hard close auction (a sealed bid second price auction) would provide the fastest efficient mechanism. Numerous empirical and experimental studies, however, indicate that one stage sealed bid auctions are not efficient (e.g. Kagel and Levin (1993) and Kagel (1995). Based on findings by Ariely, Ockenfels and Roth (forthcoming) there is reason to believe that allowing bidders to adjust there bids over multiple stages increases observed efficiency, even in hard close auctions in which all but the last stage are strategically not decisive. This phenomenon is attributed to subjects learning during one (multistage) auction and not only between repeated auctions. Taking together the positive effect of having multiple stages and the incentive effect of positive termination probabilities from the start, we hypothesize that candle auctions lead to even higher efficiency levels than corresponding multi-stage hard close auctions. An immediate consequence of a higher efficiency level is that either revenues or bidder profits or both are also higher in candle auctions than in hard close auctions.

We find strong support for the hypotheses that the frequency of bids is higher in the early stages in candle auctions than in hard close auctions. Bidders in candle auctions recognize the strong incentive to bid their true valuation early on. While median bids even in the one to last stage of the hard close auctions are below 40% of the valuations, they reach 100% of the valuations in the very first stage of candle auctions. The result of our coin close treatment indicates that subjects clearly perceive the incentive to bid their valuation as soon as they are confronted with a threat of termination. In this treatment, we observe bids below 20% in the second to the last stage of the auction, while median bids reach 100% in the one to the last auction. Hence, the comparison of our treatments reveals that “serious” bidding in multi-stage hard close auctions only sets in when bidders must fear that the auction might be immediately closed.

Candle auctions also lead to less overbidding for high values than observed in the hard close and the coin close auctions. In fact, in candle auctions, overbidding is a decreasing function of bidders’ values. It seems that bidders recognize that the risk of incurring a loss due to overbidding is correlated to their value. We observe a similar relationship between overbidding and values also in the hard close and coin close treatment. While overbidding also decreases with the values, the level of overbidding in these two treatments is higher than in the candle auction.

However the different behavior of bidders in candle auctions does not lead to significantly different levels of efficiency, revenue or profits than in the hard or the coin close auctions. Hence, since key success parameters are indistinguishable, the auctioneer can steer the speed of the auction by choosing the termination probability profile without loosing efficiency or revenue. In our view, this is an auction design element that has been ignored in the literature so far.

In the next section, we describe the game and the equilibria followed by the experimental design in section 3 and detailed result in section 4. We conclude our findings in section 5.

2. The Game

To handle the construct of the sudden termination auctions in a feasible way, we refer to a discrete format[6]. Thus a candle auction is a dynamic auction with a fixed amount T of *bidding stages*. In each bidding stage t, every bidder has the opportunity to submit his[7] first bid or to raise his previous bid. The auction ends *after* any bidding stage t with the termination probability $q_t > 0$. The main design element in the candle auction is the increasing termination probability, i.e. $q_t < q_{t+1}$ for all $t < T$ and $q_T = 1$.

The other sudden termination auction types we consider are the hard close auction and the coin close auction. While the set of sudden termination auctions includes auctions with arbitrary termination probabilities for all stages $t < T$, it is required that the termination probability in T is $q_T = 1$.[8] If $q_t = 0$ for all stages $t < T$, the auction is called a hard close auction.[9] We will call the case in which $q_t = 0$, for all stages $t < T-1$ and $q_{T-1} > 0$, a coin close auction. The last conducted stage t_L is called the *terminal stage*. A stage t_H with some termination probability $q_t > 0$ is called a *hazard stage*.

We study a second-price format in which at any time t the current price is equal to the second highest bid submitted in the previous stage. The *current holder(s)* at time t is (are) the bidder(s) who has (have) submitted the highest bid. In each stage all bidders are informed on the current price and on their status as current holders. They are not informed on the bids of the other bidders.

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[6] To avoid problems arising from continuous time interaction in markets.

[7] For simplicity we refer to the buyer with female pronouns and to the bidders in general with male pronouns.

[8] This guarantees that the game is finite.

[9] Obviously, if $q_1 = 1$ and $T = 1$, we have the case of a standard single-stage sealed-bid auction.

When the auction ends, the current holder receives the item and pays the current price. Ties are broken by assigning the item with equal probabilities to one of the current holders. The payoff of the buyer - the bidder who receives the item- depends on his valuation of the item. We consider a private value environment and, thus, the payoff of the buyer equals the difference between her induced private value and the price. All other bidders have a payoff of zero.

The auction is symmetric in that the distribution of the private values is identical for all n bidders $i = 1, \ldots, n$. The private values v_i are identically and independently drawn from a uniform distribution that is common knowledge, $v_i \in [v_{\min}, v_{\max}]$. The bidders face no liquidity constraints.

> Proposition 1: In the terminal stage of any second price sudden termination auction, the symmetric equilibrium in weakly dominant strategies for all bidders is to bid according to $b^*(v) = v$.

Proof. Without loss of generality, consider the decision of bidder i with value v_i bidding b_i. Assume that all other bidders j submit bids according to $b^*(v_j) = v_j$, $j = \{1, \ldots, n\}\backslash i$ and let $y = max\ v_j$. Let b_h be any bid $b_h > v_i$. Let b_l be any bid $b_l < v_i$. In the terminal stage, bidder i can expect the following payoffs depending on his chosen bid:

(1) For $b_i = b_h$ $\quad E[\pi_i(b_h, y) \mid t_L] = P(y < v_i)(v_i - y) - P(v_i < y < b_h)(y - v_i)$

(2) For $b_i = b_l$ $\quad E[\pi_i(b_l, y) \mid t_L] = P(y < b_l)(v_i - y)$

(3) For $b_i = v_i$ $\quad E[\pi_i(v_i, y) \mid t_L] = P(y < v_i)(v_i - y)$.

Submitting a bid $b_i = v_i$ leads to the highest expected payoff (3) in the terminal stage, because bidder i faces a positive probability of a loss when bidding b_h [$P (v_i < y < b_h)$

> 0 in (1)], and a lower winning-probability when bidding b_l [$P(y < b_l)$ in (2) $< P(y < v_i)$ in (3)]. Hence, bidding $b_i = v_i$ in the terminal stage is the best response to all other bidding $b^*(v_j)$.

Trivially for all others it is true that there is no bid that will induce a payoff higher than zero as long as the bidder with the highest value bid $b(v) = v$. Since bidders ex ante do not know whether they have the highest valuation, bidding $b^*(v) = v$ is a weakly dominant strategy in the terminal stage.

> Proposition 2: In any hazard stage of a second price sudden termination auction, the symmetric equilibrium in weakly dominant strategies for all bidders is to bid according to $b^*(v) = v$.

Proof. If the hazard stage is a terminal stage, Proposition 1 holds. If the hazard stage is not a terminal stage, a bid above the value cannot be an equilibrium bid because it precludes an equilibrium bid in the terminal stage. Bidding below the value has neither an advantage nor a disadvantage because the allocation of the object is not decided in this stage and bidding will be adjusted in the upcoming terminal stage. But bidding below the own value entails an expected payoff loss, since ex ante bidders are not informed whether a hazard stage is the terminal stage.

> Corollary: In any hazard stage of a second price candle auction, the symmetric equilibrium in weakly dominant strategies for all bidders is to bid according to $b^*(v) = v$ in the very first stage.

In the candle auction, the very first stage is a hazard stage. Thus, the candle auction provides bidders with an incentive to reveal their true value from the start. Equilibrium bidding is expected in the fifth stage in the coin close auction and in the sixth stage in the hard close auction, because these stages are the first hazard stages, correspondingly.

3. The Experimental Design

We conducted three treatments that varied only in the auction termination rule. In the *Hard Close* treatment (HC) each auction terminates after exactly six stages, i.e. $q_t = 0$ for all $t < T$, $q_T = 1$ and $T = 6$. In the *Coin Close* treatment (CC) each auction ends either in the fifth or the sixth stage with ex ante equal probability, i.e. $q_t = 0$ for $t < T$-1, $q_{T\text{-}1} = 0.5$, $q_T = 1$ and $T = 6$. In the *Candle Auction* treatment (CA) each auction can terminate after any stage with a linearly increasing termination probability, i.e. $q_t = t/T$ for all t and $T = 20$. In the CA we chose $T = 20$ in order to keep expected auction durations as similar as possible across treatments. Matching the duration perfectly is not possible due to the discreteness of the problem and the relative small number of stages that are feasible in a laboratory setting. Additionally the expected auction durations are shown in table 1 with an overview of the other setup parameters.

Treatment	HC	CC	CA
Type	Hard Close Auction	Coin Close Auction	Candle Auction
T	6	6	20
q_t	$q_1 = \ldots = q_5 = 0$; $q_6 = 1$	$q_1 = \ldots = q_4 = 0$; $q_5 = 0.5$; $q_6 = 1$	$q_t = 0.05\, t$
E(t)	6	5.5	5.29
n	3	3	3
$v_{\min}, v_{\max}$	100,200	100,200	100,200
Observations	12	12	12

Table 1: Experimental settings

All auctions involved three bidders with i.i.d. integer private values drawn from [100, 200]. Subjects were randomly and anonymously matched before each auction. The random draws were organized in such a way that 6 out of 18 subjects in each session represented an independent observation group. A total of 16 auctions were played by each subject. Since 216 subjects took part in 12 sessions we collected data on 12 independent observation groups per treatment.

The experiment was programmed and conducted with the software z-Tree (Fischbacher, 1999) and took place in the Magdeburger Experimental Labor (Maxlab) with undergraduate students from the University of Magdeburg. Almost all subjects were students of the faculty of economics and management. After the instructions were read aloud[10], the students were randomly assigned to the terminals. They receive an endowment of 20 ECU to avoid negative payoffs in the first auctions. Bids could be placed between 0 and 200 ECU. At any time all subjects had knowledge about their ECU balance that is calculated by adding the payoff of each auction to the endowment. At the end of a session one ECU was transferred into 10 Euro Cents.

4. The Experimental Results

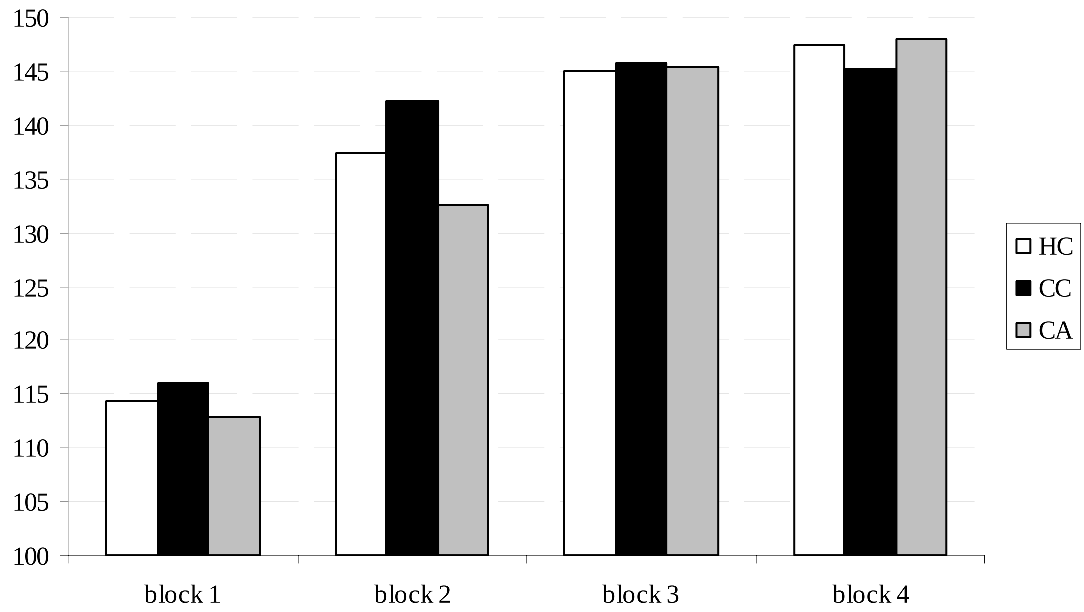
REVENUE, EFFICIENCY, PROFITS, AND PRICES

Figure 1 shows the development of the average revenues. To enhance the comparability of the data, we split the experiment into four blocks of four subsequent auctions each. It is obvious that the average revenue sharply increases in all three treatments, especially going from block 1 to block 2. This seems to indicate a strong experience effect for all

[10] Instructions are in the appendix.

three auction formats. Interestingly the auction format neither has an effect on the total revenue nor on the development of the revenue across blocks. We find no significant differences in average revenues. Hence, none of the formats seem to support the bidders learning process more than the others. Towards the end of the experiment, in all treatments the observed revenues are close to the expected equilibrium revenue of 150 ECU. Again, we see no significant differences between the treatments and conclude that the termination rule in this experimental setting has no effect on the auction revenue.

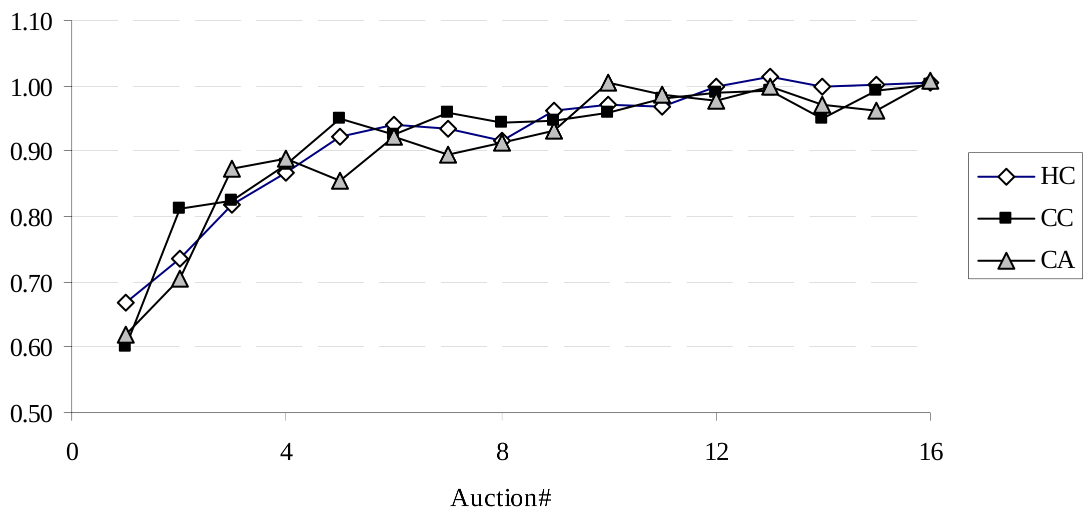
Figure 1: Average Revenue



The results concerning the efficiency of the auction formats are completely analogous to the results on the revenue. Just over 50% of the auction outcomes are efficient in the first block with no differences across treatments. The frequency of efficient outcomes increases rapidly to almost 90% in all treatments. In the last block of the experiment only 10% of the auctions end inefficiently, with no more than 2% surplus loss compared to an efficient market.

Similarly prices converge rapidly to the equilibrium price in all three formats. Figure 2 shows the development of relative prices, i.e. the ratio of observed to equilibrium prices, over the 16 auctions. Evidently there is no difference between average relative prices in the three treatments. In all treatments prices start at about 60% to 65% of the equilibrium price and reach 100% as from the tenth auction. In the last four auctions there is no significant difference between observed and equilibrium prices in any of the treatments. This is closely related to the fact, that observed bidding moves closer to equilibrium bidding with experience. Correspondingly, the bidder profits are almost at equilibrium level towards the end of the experience. This holds true for all three treatments. Furthermore, we find no treatment differences regarding bidder profits.

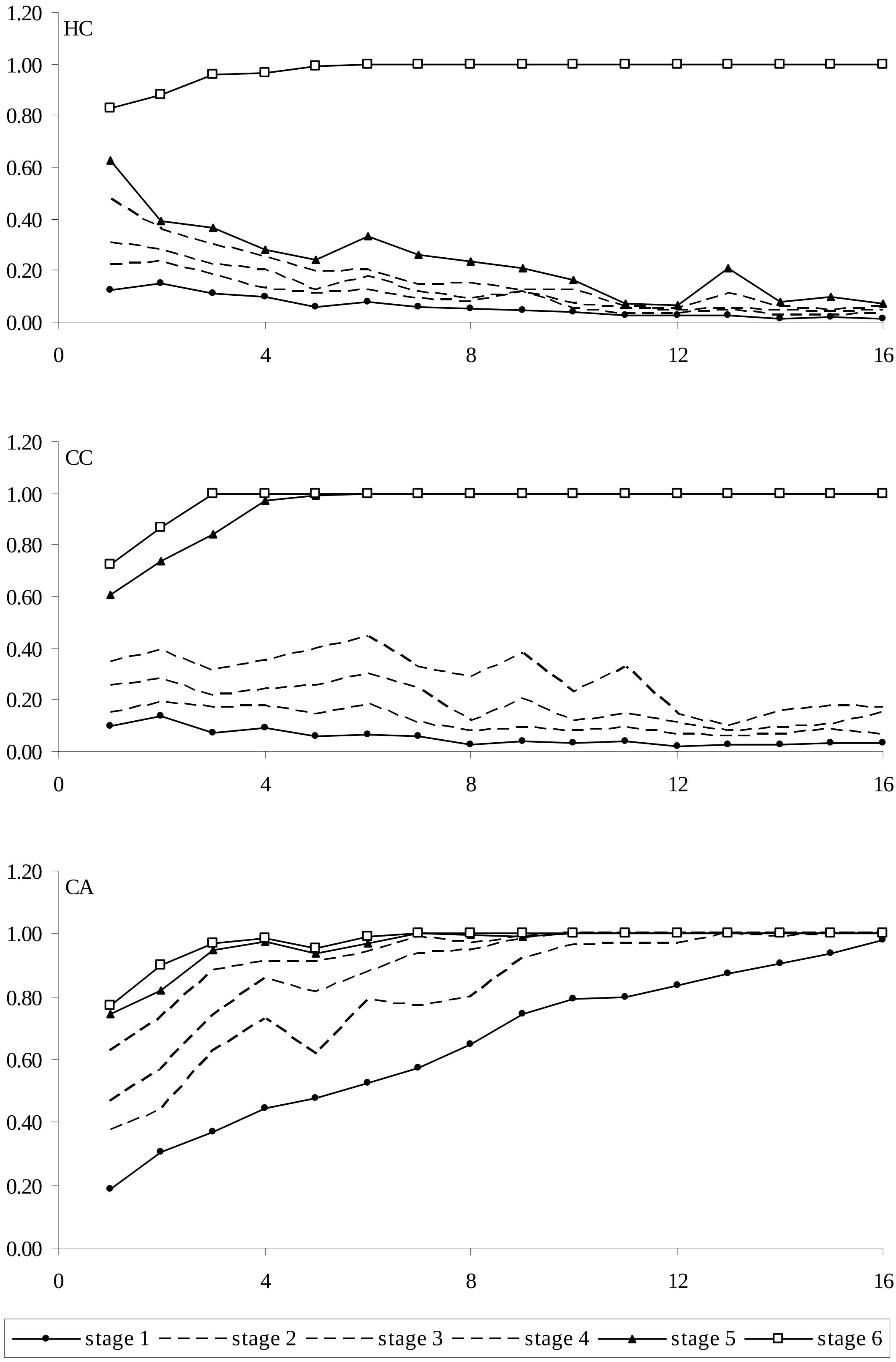
Figure 2: Convergence to equilibrium prices



BIDDING DYNAMICS

So far we have shown that the termination rule has no effect on the auction outcome. Observed revenue, efficiency, profit, and relative prices are indistinguishable across treatments. The question remains whether our treatment variable has any effect on bidding behavior.

Figure 3: Median - Ratio of bid to value in the first six stages



To answer this question, we examine the bidding dynamics. Figure 3 shows median relative bids observed in each of the six first stages in all three treatments[11] where a relative bid represents the bid as a percentage of the bidder's value.

The first panel shows that experienced subjects in the HC increase their bids from stage to stage, starting below 20% of their value in stage 1 and reaching almost 100% in stage 6. The data show a clear pattern of late "serious" bidding, i.e. making the most substantial leap in the bid level from about 20% to almost 100% in the last stage. It seems that subjects are aware of the fact that only the last stage bid is decisive for the auction outcome[12]. Thus, in the HC, only the last stage bids can be considered as "serious" bids.

The second panel in Figure 3 shows the median relative bids in the CC for each stage. Again, we find experienced subjects sequentially raise their relative bids from less than 20% of their value in stage 1 to almost 100% in stage 6. However there is an important difference in the bidding behavior of subjects in CC compared to subjects in HC. While bidding in HC only gets "serious" in the last stage, bidding in CC is "serious" in the last two stages. This is evident because in the CC the most significant leap in the bidding level occurs in the fifth stage from about 40% to 100% of the value. Note that about three-fourth of the experienced bidders in the CC place their final bid[13] in the fifth stage. In contrast, even less than one-tenth of the experienced bidders in the HC place their final bid in the fifth stage. Thus, the existence of an additional hazard stage in CC speeds up the auction, because final bids are placed earlier.

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[11] Note, for the CC and CA we only take those auctions into consideration that actually reach stage 6. Auctions terminated earlier are simply left out of this analysis.

[12] This holds as long as bids do not exceed their private values in earlier stages.

[13] A final bid is a submitted bid that is not raised in later stages.

The last panel in figure 3 displays the median relative bids in the first six stages of the CA. It is immediately evident that experienced bidders in the CA do not exhibit a substantial leap in their bidding at any stage. Unlike the other two treatments, bids of experienced bidders in the CA are high from the start. Stage 1 median bids increase during the experiment to 100% of the value. The fact that every stage is a hazard stage obviously leads to "serious" bidding from the start.

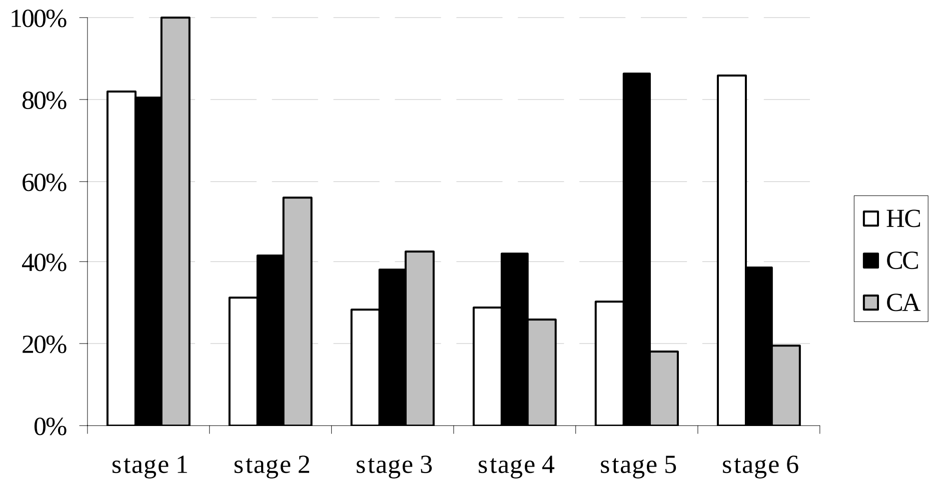
While this effect is qualitatively in line with the theoretic prediction, we only observe equilibrium bidding in about one-third of the cases with experienced bidders. This is due to the fact that in the weakly dominant strategy equilibrium of candle auctions the bidders bid their valuation from stage 1. Even though observed bids reach equilibrium level rather quickly, they are rarely at that level from the very start. Due to the rather low termination probability in stage 1, this deviation from equilibrium behavior leads to only small losses in efficiency and payoffs. With experience, bidders in the CA learn to bid their value already in the first stage (the median bids reach 100% of the value). The crucial result is that bidders in the CA reveal their true values much more quickly than in either of the other treatments.

The empirical literature on hard close auctions reports strong evidence for sniping, i.e. high frequency of late bids. The discussion above has shown that bidders final bids arrive later, the later the first hazard stages arrives. Figure 4 shows that the frequency of bids also follows this pattern. In the HC with only one hazard stage at the end, there are peaks in bidding frequency in stage one[14] and in stage six. This corresponds to the typical sniping behavior. In the CC the second peak in bidding frequency is in stage 5,

[14] The high frequency of bids in a very early stage has also been observed in field data. This phenomenon is not of specific interest in our study but we would like to note that a number of explanations have been put forward. Easley and Tenorio (2004) show that jump bidding may be a reason for early bids. Stryszowska (2004) suggests that the early bidding may be used as a coordination advice in multiple auction setting.

the first hazard stage. The frequency drops drastically to stage six. In the CA we observe no second peak in bidding frequency. Evidently, bidders do not wait until the last stage to submit the final bid, making the price discovery process much smoother in the CA than in the HC or the CC.

Figure 4: Frequency of bids – block 3 and 4 pooled

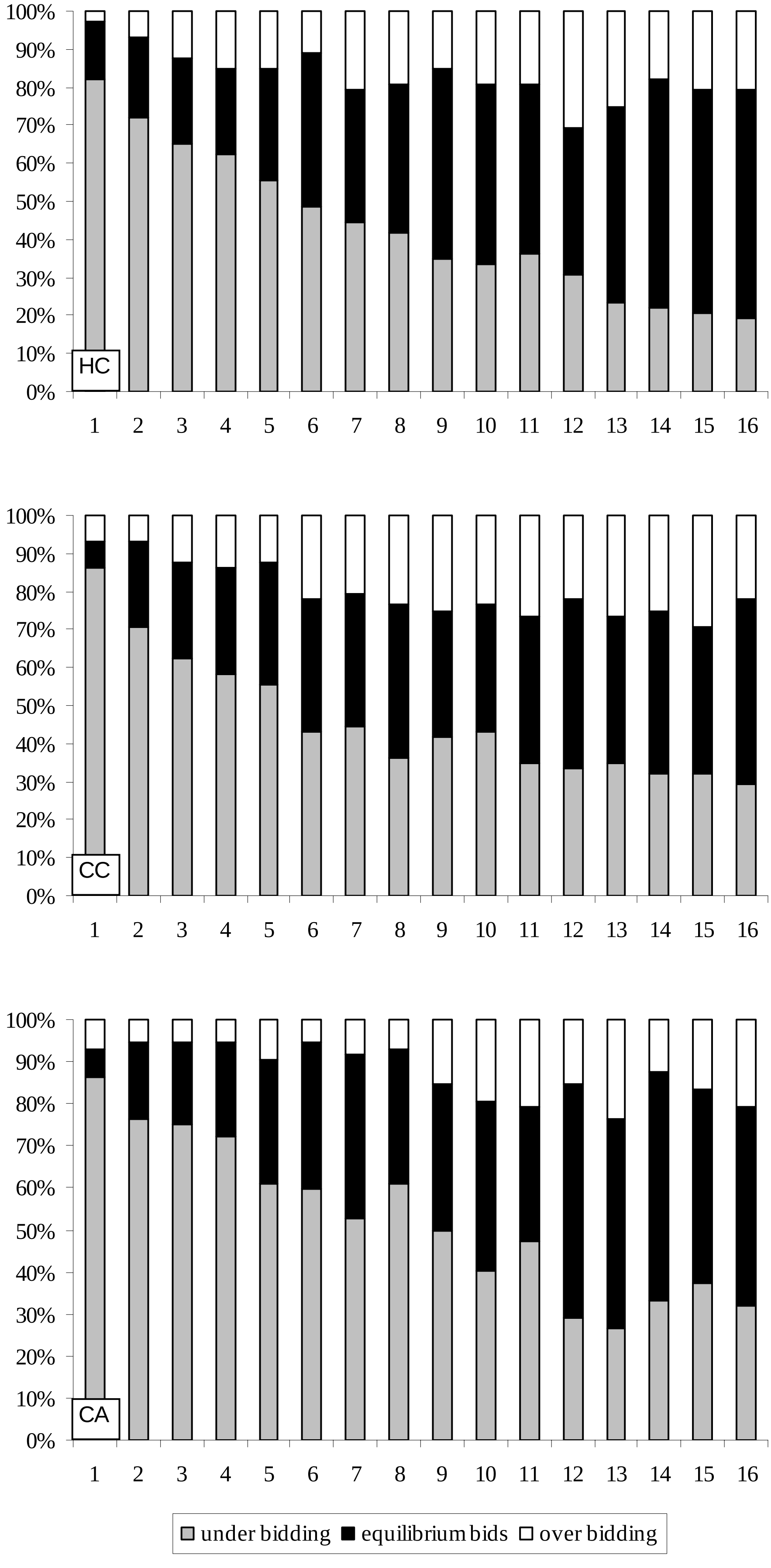


OVERBIDDING

It is known from the literature on second price auction experiments that subjects learn to bid their values with experience. The result on efficiency that we presented above indicates that we also observe a tendency towards bidding the value. Figure 5 shows that the percentage of last submitted bids that are equal to the value increases with experience in all three treatments.

While more than 80% of all bids are below the bidder's value in the first auction underbidding drops to about 20% to 30% in the last auction. However, the remaining 70% to 80% of bids are not all equal to the value. Instead, we observe an increasing portion of bidders who overbid their values with experience.

Figure 5: Distribution of final bids over auction periods



It is not surprising to observe overbidding by experienced bidders because it is frequently observed in second price auctions[15]. One possible explanation is that overbidding is due to the illusion that an overbidding is almost risk free. This illusion is sustained because the probability of the negative feedback from overbidding is small (Kagel, Harstad, and Levin 1987). Alternatively, bidders may have a spite motive, i.e. bidders have a utility of reducing the surplus of other bidders (Morgan, Steiglitz, and Reis 2003).

Figure 6: Number of overbidders dependending on the value

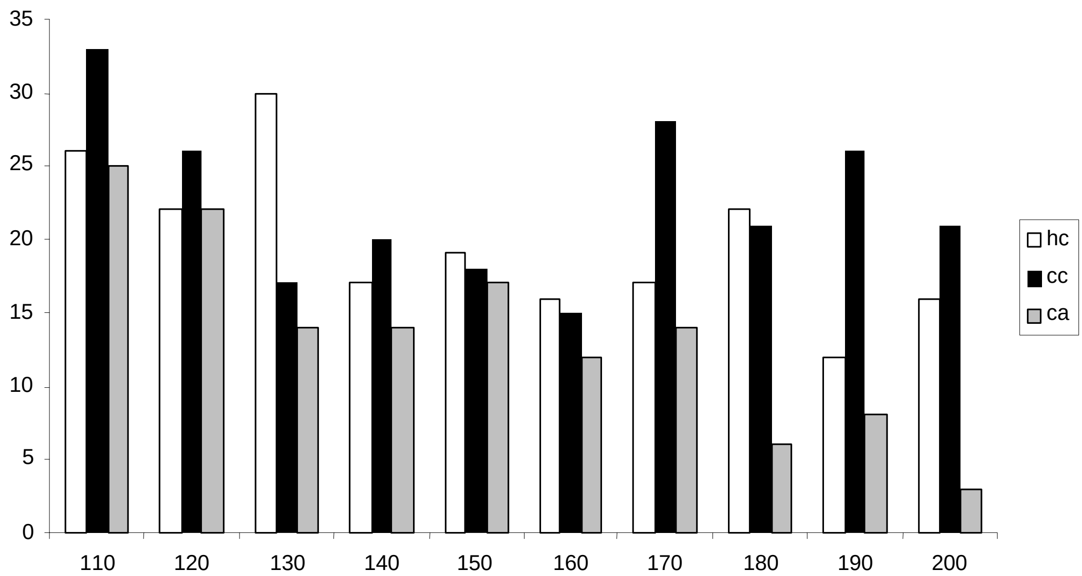


Figure 6 shows a correlation between values and overbidding. The higher the value, the lower is the frequency of overbidding in all three treatments. This result significantly holds true for the CA and the HC where the Spearman Rank Correlation coefficient is above 80%. In the CC, the coefficient is not significantly different from zero. It makes sense that subjects with high values overbid less frequently because their probability of

[15] Kagel and Levin (1993) conducted one of the first second price auction experiments and observe a substantial frequency of overbids. Also Harstad (2000) reports that experience only has a small effect on reducing the overbidding behavior. Further on, Garratt, Walker, and Wooders (2004) observe overbidding in field experiments on eBay.

receiving the item is higher. Thus, their expected loss from overbidding is greater than that of subjects with low values. Surprisingly, this phenomenon has not yet been mentioned in the experimental literature, as far as we know. Since overbidding with high values is much more frequent in the CC and the HC than in the CA, we can speculate that this behavior is induced by the high intensity of bidding in the final stages.

5. Conclusions

Adding to the literature on market design, in this study we introduce the concept of sudden termination auctions. A sudden termination auction is characterized by a fixed termination interval and a probability distribution of termination. Using a second price private value setting, we analytically and experimentally examine three variants of sudden termination auctions, the hard close auction, the coin close auction and the candle auction. The three formats differ only in the distribution of termination probabilities.

Theoretically, all three formats should lead to the same efficient outcome. We observe very similar outcomes concerning revenues and efficiency in our experiment. Experienced bidders - in fact - reach almost full efficiency in all three treatments. Hence, from a market design perspective, none of the three formats seems to dominate the others at first glance. A more careful look at the bidding behavior, however, reveals a substantial and significant difference between formats. While bidding in hard and coin close auctions remains restrained for many stages, candle auctions induce serious bidding from the very first stage on. Hence, if the objective of market design is to create a “fast” allocation mechanism that allows for re-bidding, then candle auctions have an advantage over hard close auctions.

In contrast to sealed bid auctions, candle auctions provide the opportunity for re-bidding. Theoretically, in the private value setting, this is not clearly advantageous. Empirical observations, however, indicate that bidders may prefer having the opportunity for re-bidding (Ivanova Stenzel and Salmon (2004)). On the other hand, candle auctions can be used to reduce the auction duration compared to hard close auctions. For example, it is imaginable that a candle auction with the same maximum time interval as a hard close auction results in an equally efficient outcome, while having a substantially shorter expected duration. In our experiment we keep expected durations equal and find a similar performance. The question weather the result extends to the case that maximum durations are equal remains open for further research.

Finally, we note that in our experiment the bidders were informed that the auction is taking place. Hence, we could not observe efficiency losses due to informational deficiencies. In online auctions, bidders often discover the auction at different times. Using candle auctions instead of a corresponding hard close auction with the same maximal duration would increase the risk of auction termination before decisive bidders arrive at the side. To avoid this problem, either early announcement or hybrid formats can be used.

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Appendix

Instructions (Translation)

Please read the following instructions carefully and get in touch with the supervising staff if you have questions concerning contents. If you have any questions during the experiment, please attract attention to yourself by hand signal.

The Auction

In this experiment, you participate in an auction. Thereby you give bids via a computer terminal. Your payoff depends on your success, i.e. it depends on your decision and on the decisions of the other participants. For easier handling, it is bidded not in Euro but in *points*. One point corresponds to 10 Cents. At the beginning, you get a deposit of 20 points.

What does the auction look like? In this auction, *one* commodity will be auctioned. The bidder with the highest bid obtains this commodity. The commodity's price corresponds to the second highest bid. You are the *bidder* in this auction. For you, the commodity has a *private value* that is between 100 and 200 points. This value will be randomly assigned to you by the computer, whereby every value in the interval is of same probability. This value is known only to you and not to the other bidders.

How can you bid? An auction lasts several bidding rounds. In every bidding round, you give *one* bid and confirm it afterwards by pressing the OK button. This bid is unknown to other bidders. In every bidding round, you can increase or keep, but not decrease, your bid! Furthermore, in every auction, you cannot bid more than 200 points. After the first round, you will find the second highest bid of the preliminary round to the right on the screen. In the top left-hand corner, you get the information whether you are the highest bidder or not.

How long does an auction last?

This is the treatment variable:

Hard Close Treatment	*One* auction lasts for six bidding rounds.
Coin Close Treatment	*One* auction lasts for at most six bidding rounds. The first five bidding rounds take place with a probability of 100 %. The last bidding round takes place with a probability of only 50 %. That means that the auction can already be finished after the fifth bidding round.
Candle Auction Treatment	*One* auction lasts *maximal* for 20 bidding rounds. After each bidding round it is possible that the auction ends. This so-called termination probability turns out to be as follows:

Termination Probability	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
Bidding Stage	1	2	3	4	5	6	7	8	9	10

Termination Probability	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Bidding Stage	11	12	13	14	15	16	17	18	19	20

Example: You are in the fifth round. The termination probability amounts to 25%. That means that with a probability of 25 % the auction is finished after the fifth round.

Whose bid is accepted? The highest bid after the last bidding round is accepted. In this case, the bidder gets the commodity and pays the price, which corresponds to the second-highest bid.

If there are two or more bidders with the same highest bid, it is randomly selected whose bid will be accepted. In this case, the price corresponds to the highest bid.

How is the payoff calculated? If a bid is not accepted, the bidder's payoff is 0 points. If a bid is accepted, the bidder's payoff is calculated as follows: Private Value – Price = Payoff.

Example:

1. A bid with the private value 145 will be accepted. The bidder pays the price in an amount of 21 points. Thus, his benefit corresponds to 145- 21 = 124 points.
2. A bid with the private value 185 will be accepted. The bidder pays the price in an amount of 196. Thus, his "benefit" corresponds to 185-196 = - 11, i.e. if the price is higher than the private value, there can be a loss.
1. A bid with the private value 187 will be accepted. The bidder pays the price in an amount of 187. Thus, his "benefit" corresponds to 187-187 = 0.

Does the auction take place only once? All in all, the auction takes place 16 times one after another. After having finished the experiment, you will get your payoff.

Who are the other bidders? There are three bidders in each auction, you and two other participants. The auction group changes after each auction.

What happens then? You take a seat at the terminal you were assigned by lots. If you have any questions, please raise your hands.

After having finished all auctions, you will get your payoff.

Please leave the instructions after the experiment at your place/terminal.