// NO.19-061 | 12/2019

DISCUSSION PAPER

// KARL-MARTIN EHRHART
AND MARION OTT

How the Auction Design Influences Procurement Prices: An Experiment

How the Auction Design Influences Procurement Prices: An Experiment☆

Karl-Martin Ehrhart[a], Marion Ott[b]

[a]*karl-martin.ehrhart@kit.edu, Karlsruhe Institute of Technology (KIT), ECON*
[b]*marion.ott@zew.de, ZEW – Leibniz Centre for European Economic Research*

Abstract

The targeted design of auctions has to take behavioral regularities into account. This paper explores whether procurement auction formats can take advantage of bidders' willingness-to-pay-willingness-to-accept disparity. In a laboratory experiment, we compare four different second-price auction formats for procuring a good. The four formats are a sealed-bid auction and three different descending-clock auctions. We assume that a bidder's willingness-to-accept exceeds his willingness-to-pay and that, depending on the auction format, a bidder's reference-state shifts such that the bidder's perspective moves from a willingness-to-accept perspective towards a willingness-to-pay perspective, thus inducing aggressive bids. In line with the prediction, auction prices decline across the four formats. In particular, we observe the lowest prices in those two clock auction formats that, at every auction stage, select a bidder as the current leading bidder. We conclude that mechanisms influence the reference state and that auctions that foster reference-state shifts lead to lower payments for the buyer. These results support and generalize findings on sales auctions. However, not all of our findings on procurement auctions mirror findings on sales auctions. Bidders overbid in sealed-bid procurement auctions, which does not mirror the commonly observed overbidding in sealed-bid sales auctions.

Keywords: Procurement auction, experiment, WTP-WTA disparity, reference-dependence
JEL: D44, H57, D91, C92

1. Introduction

Understanding drivers of price differences between auction formats is crucial for choosing an appropriate auction design. The buyer in a procurement auction usually prefers low prices and therefore prefers an auction format that induces aggressive bidding. We predict that certain auction formats induce lower bids and, thus, lower auction prices, and test this prediction on auction prices in a laboratory experiment. The results suggest that certain auction design elements influence bidding and thereby provide guidance for the design of successful procurement auctions.

☆Financial support from the Deutsche Forschungsgemeinschaft, SFB 504, at the University of Mannheim, is gratefully acknowledged. We thank Thomas Gottfried for programming excellent experimental software and Susanne Abele for helpful discussions.

Procurement auctions are prevalent, but most auction experiments focus on sales auctions. In standard theory with expected profit-maximizing bidders, most results on procurement auctions (i.e., reverse auctions) are just an inversion of those on sales auctions. However, some experiments find behavioral regularities that deviate systematically from theoretical predictions. Non-standard preferences and motives are included in theories in order to capture such bidding behavior and are tested, again with sales auctions. Yet, it may be unclear whether and how the impact of these motives translates from sales auctions to procurement auctions. As an example, this paper reveals that the commonly observed tendency to bid above the private valuation in second-price sealed-bid sales auctions (cp. Kagel and Levin, 2016) does not translate to underbidding in procurement auctions, although common behavioral explanations predict underbidding. In procurement auctions, the joy of winning or spite motives, which capture overbidding in sales auctions (e.g., Andreoni et al., 2007; Bartling and Netzer, 2016; Cooper and Fang, 2008), would generate underbidding. Instead, this paper and Bernard (2006) find overbidding in second-price sealed-bid procurement auctions. Thus, motives for deviating from bidding the valuation appear to differ between sales and procurement auctions. Therefore, procurement auctions require a separate experimental analysis.

We investigate predictions for procurement auctions when bidders have a willingness-to-pay-willingness-to-accept (WTP-WTA) disparity,[1] e.g. because they are loss averse. A bidder's WTP-WTA disparity influences his valuation and, therefore, his bidding behavior, when his reference state shifts during an auction. Ehrhart et al. (2015) predict an effect on prices in sales auctions, which is supported by their experimental results. Guided by arguments by Knetsch (2010), we translate the behavioral prediction for sales auctions into a prediction for procurement auctions. Our main experimental result supports our hypothesis and thereby extends the insights by Ehrhart et al. (2015) on sales auctions to a procurement setting.

The basic procurement setting that determines our design is the following. A bidder's valuation for the good in a procurement auction is determined by his costs. These costs can be production costs that arise for the winner of the auction or they can be opportunity costs that arise for the losers of the auction. Our experimental design implements the latter kind of good. As an example, consider a food store chain that procures wine via an auction. The

[1] Experiments on the WTP-WTA disparity find that the average WTP for buying a lottery ticket is less than the average WTA for selling the same lottery ticket, and that this difference is larger than what wealth effects can explain (e.g., Knetsch and Sinden, 1984; Marshall et al., 1986).

bidders are the owners of vineyards that can either sell all their wine to the food store chain in the auction or rely on their own marketing. The winner's payoff is the auction price, and the losers' payoffs are the risky prices they will realize for their wines. Further settings in which the bidders' valuations are largely determined by their uncertain opportunity costs are auctions in the strategic sourcing of electricity, hotel room nights, or global car hire as conducted by GlaxoSmithKline (Beall et al., 2003).

We implement four experimental procurement auction formats that have in common that bidding (down to) the indifference price – the price at which the bidder is indifferent between selling and not selling the good – is a weakly dominant strategy. Each auction design defines one main treatment in the experiment. The four auction formats are a sealed-bid second-price auction and three different descending-clock auctions. We predict that auction prices decline when comparing the sealed-bid auction, the descending-clock auction without leading-bidder selection, the descending-clock auction with random leading-bidder selection, and the descending-clock auction with first-to-bid leading-bidder selection.

The sealed-bid second-price auction asks bidders for their WTA. We argue that a bidder's reference state in this auction is his before-the-auction state of owning the good. In contrast, for the descending-clock auctions, we hypothesize that a bidder's subjective reference state shifts from the before-the-auction state towards the after-the-auction state of having won the auction and, thus, not owning the good anymore. As a consequence, the indifference price at which the bidder quits a descending-clock auction is not his WTA but has moved towards his (lower) WTP. Thus, he will bid more aggressively. Design components of a descending-clock auction may foster such a shift of the reference state. Design components in our experiment are whether and how to assign the leading-bidder position during a descending-clock auction. Assigning a leading-bidder position means that, at every price, one bidder is told that he will win the auction if no new bids arrive in the next auction round. Our experimental design explores whether assigning a leading-bidder position or making the position prominent (by giving it to the fastest bidder instead of assigning it randomly) leads to lower bids.

Our main finding is that auction prices decline across the four main treatments, as predicted. The mean price in the fourth treatment undercuts that of the first by 13%. The strongest price decline occurs when leading bidders are assigned.

In our main setting, bidders have private uncertain valuations for the procured good, that is, the good is a lottery for the bidder, and he has private information about his lottery. First, as we argue above, in the considered procurement setting, valuations, i.e., opportunity costs, are uncertain. Second, lottery tickets are a typical good for which the WTP-WTA disparity has been detected (e.g., Knetsch and Sinden, 1984; Marshall et al., 1986).

In experimental setups with induced certain valuations – in contrast to setups with uncertain valuations (i.e., lotteries) – no WTP-WTA disparity is to be expected (Kahneman et al., 1990; Coursey et al., 1987). Therefore, to reveal potential confounding factors for our main finding, we additionally conduct three treatments with procurement auctions with private certain valuations.

As a further point of comparison, we complement our four main treatments by one treatment with a sealed-bid sales auction and private uncertain valuations. Comparisons with this sealed-bid sales auction support that a WTP-WTA disparity and a reference-state shift underly our main finding. First, contrasting bids in the sealed-bid procurement auction with bids in the sealed-bid sales auction, we find higher bids in the procurement auction. This is evidence in favor of a WTP-WTA disparity because these two sealed-bid auctions – which have no dynamic price adjustment and therefore preclude a shift of the reference state – ask for the WTA and the WTP, respectively. Second, the mean prices in the three descending-clock procurement auctions lie in between those of the sealed-bid procurement auction and those of the sealed-bid sales auction. This again is in line with a WTP-WTA disparity and a reference shift in the descending-clock auctions.

2. Experimental Design

2.1. Organization of the Experiment

The experiment consists of eight treatments: the four main treatments with procurement auctions and private uncertain valuations, PA1 to PA4, one treatment with a sales auction and private uncertain valuations, SA1, and three treatments with procurement auctions and private certain valuations, PA1c, PA2c, and PA4c (see Table 1).[2]

Students from various disciplines were randomly invited to participate in the experiment. Every group of three subjects participated in one auction. We chose this one-shot setting to induce the subjects to concentrate on one auction. In practice, many procurement auctions are one-shot auctions. Moreover, our auction formats are simple and easy to understand.

[2]As no difference was predicted between auctions with private certain valuations, we skipped a potential treatment PA3c.

Table 1: Overview of the treatments

Treatment	Auction format	Private valuation	No. of subjects (total: 288)
PA1	PAF1	uncertain	36
PA2	PAF2	uncertain	36
PA3	PAF3	uncertain	36
PA4	PAF4	uncertain	36
SA1	SAF1	uncertain	36
PA1c	PAF1	certain	36
PA2c	PAF2	certain	36
PA4c	PAF4	certain	36

Subjects were seated at separated computer terminals. They received printed instructions, which were read aloud by an experimental assistant. When all subjects had answered several questions regarding the instructions correctly, they were given their private information, and the auction began. Subjects could not identify their group members. The sessions lasted less than one hour. At the end of a session, the subjects were paid in cash according to their profits in the game. The conversion rate was 5 Euro for 100 Experimental Currency Units (ECU). The mean, minimum, and maximum payments realized were €10.9, €5.5, and €17.9, respectively.

2.2. Valuations, Information, and Auction Formats

Three bidders compete in an auction. In the main treatments PA1 to PA4, each bidder is provided with one good and has private but incomplete information about his valuation. We call this setting, in which the good is a lottery, a private uncertain valuations setting.[3] In treatment SA1, each bidder demands one such good. In treatments PA1c, PA2c, and PA4c, the bidders are each provided with one good and have private certain valuations. Table 2 displays the discrete uniform distributions or certain valuations of the three bidders. The subjects know that their opponents' bounds on valuations or valuations differ from theirs. To prevent bidders from taking their (expected) valuation as an anchor, the (expected) valuations lie between two feasible bids, which are multiples of five.

We implement four procurement auction formats PAF1 to PAF4: one sealed-bid auction and three descending-clock auctions that differ with respect to the selection of the current leading bidder. The auction winner is paid the price. The unsuccessful bidders receive the realization of their private valuation lottery or their private certain valuation. In all descending-clock

[3]Experimental and theoretical analyses of auctions with private uncertain valuations are, e.g., by Ehrhart et al. (2015), Haile (2003), Lange et al. (2011), McGee (2013), Thompson and Leyton-Brown (2007).

Table 2: Bidders' private information about their individual valuations

Bidder	Valuation in PA1 to PA4, and SA1	Valuation in PA1c, PA2c, and PA4c
B1	$U\{112, 113, \ldots, 312\}$	212
B2	$U\{117, 118, \ldots, 317\}$	217
B3	$U\{122, 123, \ldots, 322\}$	222

auctions, a starting price of 350 ECU and a constant decrement of 5 ECU are set. The four procurement auction designs are:

Auction format PAF1 is a second-price sealed-bid auction (Vickrey, 1961), described as a clock auction to keep the descriptions of all auctions as similar as possible.[4] Bidders submit their lower bidding limit once. A mechanism outbids these bids against each other, as in a descending-clock auction. The bidder with the lowest bid sells the good. The price equals the second-lowest bid. Ties are broken randomly.

Auction format PAF2 is a descending-clock auction in which the price decreases in discrete decrements, and bidders are asked at every price whether they accept it. A bidder who does not accept the price within 50 seconds quits the auction unobserved by the others. The process stops when only one or no bidder accepts the price. If only one bidder remains, this bidder sells at the price of the penultimate stage. If no bidder remains, the winner is randomly drawn from those who accepted the previous price and is paid that price.

Auction format PAF3 is like PAF2, but at every price, a current leading bidder is randomly chosen from the set of accepting bidders. The process stops when none of the other bidders accepts the next price within 50 seconds. The last leading bidder sells at the price of the stage before the end, that is, the price at which he became leading bidder.

Auction format PAF4 is like PAF3, but at every price level, the bidder who first accepts the price is the current leading bidder.

In the descending-clock auctions, each price level is shown for at least five seconds to enable subjects to recognize the current price and, potentially, their leading-bidder position.

The auction SAF1 has the same format as PAF1 but as a sales auction. The auction winner receives the realization of his valuation lottery and pays the price (and all subjects in SA1

[4] Describing sealed-bid auctions as clock auctions with a one-time bid submission at the beginning may reduce deviations from the weakly dominant strategy (cp. Seifert, 2006; Ehrhart et al., 2015), which are common in sealed-bid auctions but not in clock auctions (cp. Kagel and Levin, 2016).

receive a lump-sum payment of 10 euros).

Treatments implement auction formats, as given in Table 1.

3. Theory and Hypotheses

3.1. Theoretical Benchmark

Consider a setting with n bidders with private uncertain valuations. The auction formats PAF1 to PAF4 and SAF1 are strategically equivalent. Strategic equivalence holds because a bidder's optimal bidding limit is his indifference price, that is, the price at which he is indifferent between winning and not winning the auction.

Proposition 1. *A bidder will bid his indifference price in PAF1 and SAF1 and will quit auctions PAF2 to PAF4 when the auction price falls below his indifference price.*

In equilibrium, the bidder with the lowest indifference price sells the good and receives the second-lowest indifference price in PAF1 to PAF4. In SAF1, the bidder with the highest indifference price buys the good and pays the second-highest indifference price. With three bidders, we thus expect in every auction a price equal to the median indifference price.

Thus, prices will not differ between auction formats if all bidders are expected-utility maximizers. For an expected-utility maximizer, the indifference price in all auctions is his certainty equivalent of his valuation lottery. However, for a bidder with a WTP-WTA disparity, the indifference price may depend on the reference state and, therefore, on the way an auction inquires the indifference price. This gives rise to the hypotheses presented in the next section.

The proof of Proposition 1 is given in Appendix B. There, we also discuss the impact of discrete bid decrements on equilibrium prices and show the comparability of PAF1 and SAF1. As a point of reference, we derive the equilibrium prices for risk-neutral bidders, which in all treatments are 210 and 215. (With private certain valuations, these are independent of the risk attitude.)

3.2. Hypotheses

According to Proposition 1, bidders bid their indifference price in all four treatments PA1 to PA4. We hypothesize that bidders have a WTP-WTA disparity and that an auction format may influence a bidder's reference state. Then, bidders will construct their indifference prices differently in the different auction formats. According to Knetsch (2010, p. 184) "The choice of measure of the valuation for particular cases will largely depend on whether the basis for people's valuation is the reference state being before the change or after the change." Assume the reference state shifts during a procurement auction from the before-the-auction state of owning the good towards the after-the-auction state of not owning the good in case of winning. Then, the indifference price will decrease because it shifts from being a WTA statement towards being a statement about the (lower) WTP. Note that the reverse holds for a sales auction. Table 3 illustrates the shift and its consequences.

Table 3: Valuation measures (cp. Knetsch, 2010) and reference-state shifts in clock auctions

Auction	Change in case of winning	Valuation measure with the reference state before the change	after the change
Procurement	Cede the good	WTA to cede the good	WTP to avoid delivering the good
Sales	Receive the good	WTP to get the good	WTA to forgo the good
		$\xrightarrow[\text{during a clock auction}]{\text{Shift of the reference state}}$	

We expect that the occurrence and strength of a reference-state shift differ between the treatments PA1 to PA4 for the following reasons (which generalize arguments by Ehrhart et al., 2015). The sealed-bid auction in PA1 asks the bidders for their indifference price for ceding the good when they are in a state of owning it. That is, bidders are asked for their WTA to cede the good. The auction proceeds by determining the final outcome without further interaction with the bidder. The auctions in PA2 to PA4 are descending-clock auctions in which bidders at each stage decide to accept the current price or to leave the auction. This multi-stage process, in which bidders repeatedly reconsider their indifference price, permits a shift of the reference state from the objective state of not selling the good towards a subjective state of being close to winning the auction and, thus, selling the good. Being the current leading bidder in PA3 or PA4 fosters this reference-state shift. Being assigned a leading-bidder position increases the awareness of the potential ownership change, which is necessary for the change of perspective: "It is not ownership per se, but awareness of ownership that causes reference point shifts." (Strahilevitz and Loewenstein, 1998). The shift is promoted in PA4, where achieving the leading-bidder position by an own prompt bid further strengthens the awareness of getting closer to selling (cp. the source-dependence effect by Loewenstein and Issacharoff, 1994). The reference state influences bidding because the indifference price of a bidder with the reference state of selling the good is his WTP to avoid delivering the good. If this bidder's WTP is lower than his WTA, he will submit a lower bid when his reference state shifts towards that of selling the good.

Therefore, we predict the following order of prices in our strategically equivalent auctions when bidders bid their indifference prices.

Hypothesis 1. *Auction prices decrease from PA1 to PA4.*

We complement this main hypothesis by a second hypothesis that derives from our assumption of a WTP-WTA disparity and reference-dependent preferences. While the procurement auction in treatment PA1 asks bidders for their WTA, the sales auction in treatment SA1 asks for the WTP. To compare all bids in these treatments, we use each bid's deviation from the expected value of the bidder's lottery, $\Delta_b = b - \mathrm{E}[V]$. A bidder's deviation Δ_b is the same in the two auctions if he is an expected-utility maximizer. However, the bidder's Δ_b is higher in the procurement auction than in the sales auction if he has a WTP-WTA disparity.

Hypothesis 2. *WTA >WTP: Δ_b in PA1 is higher than in SA1.*

The WTP-WTA disparity and reference-state shifts motivate our design and our hypotheses. The strength of the approach of basing the hypotheses on comparisons across strategically equivalent auction formats[5] is that it allows excluding many other factors as relevant for treatment differences.[6] Such factors that have been considered in the literature are the following. Risk aversion, spiteful bidding, the joy of winning or another extra utility from winning (e.g., Andreoni et al., 2007; Bartling and Netzer, 2016; Cox et al., 1982; Cooper and Fang, 2008; Jones, 2011; Malmendier and Lee, 2011; Kagel and Levin, 2016) cannot capture differences between any of our auction formats. Duration of being the high bidder or time in the auction (e.g., Heyman et al., 2004; Malmendier and Lee, 2011) and rivalry (Ku et al., 2005) cannot capture differences between our descending-clock auctions, and it is unlikely that subject misconception (Plott and Zeiler, 2005) of lotteries or mechanisms causes differences between the descending-clock auctions. Further drivers of high bids in sales auctions are competitive arousal due to social facilitation or time pressure, escalation of commitment (Ku et al., 2005; Haruvy and Popkowski Leszczyc, 2010), loser regret and fear of losing in repeated first-price auctions

[5]We call two auctions strategically equivalent if their sets of relevant strategies (bids in a sealed-bid auction and minimum bids in a descending-clock auction) are the same and if each combination of strategies leads to the same outcome in both auctions.

[6]Some of them might influence bidding in all our treatments, but in the same way.

(e.g., Engelbrecht-Wiggans, 1989; Filiz-Ozbay and Ozbay, 2007; Delgado et al., 2008), and charitable motives (Goeree et al., 2005). They do not apply to our auctions, either because of our design (second-price auction, slow progress) or because of our standard anonymous laboratory environment.

4. Experimental Results

We present our main results on treatments PA1 to PA4. Then, we compare them with the treatment SA1, with procurement auctions when valuations are certain, and with findings on sales auctions by Ehrhart et al. (2015) and discuss our results.

There are twelve independent prices per treatment and 36 independent bids in the sealed-bid treatments. We apply a significance level of 5%.

4.1. Main Results

We find a trend: the mean auction price decreases from PA1 to PA4. The median price in PA3 is, however, by a decrement lower than in PA4. Table 4 contains the mean and median prices in all treatments, and Figure 1 provides further details. The range of the means of the prices in PA1 to PA4 covers 31.2 ECU, which amounts to 15.6% of the individual valuation intervals' spread of 200 ECU, or six decrements. A Jonckheere-Terpstra test rejects equality of prices in the four treatments in favor of declining prices from PA1 to PA4.[7]

Table 4: Average auction prices (in ECU)

Treatment	PA1	PA2	PA3	PA4	SA1	PA1c	PA2c	PA4c
Mean price	235.0	225.4	205.4	203.8	185.8	235.8	220.4	217.1
Median price	230	217.5	205	210	195	237.5	220	215

Result 1. *The average auction price decreases significantly from PA1 to PA4.*

Pairwise comparison of prices reveals statistically significant differences between PA1 and PA3/PA4 and between PA2 and PA3/PA4.[8] Hence, there is no evidence of an effect of auction

[7] H_0: $p_{\mathrm{PA1}} = p_{\mathrm{PA2}} = p_{\mathrm{PA3}} = p_{\mathrm{PA4}}$; H_1: $p_{\mathrm{PA1}} \geq p_{\mathrm{PA2}} \geq p_{\mathrm{PA3}} \geq p_{\mathrm{PA4}}$ with at least one strict inequality, $JT = 256$, z-value $= -3.2393$, p-value $= 0.001$.

[8] Kruskal-Wallis test: $\chi^2 = 11.711$, df $= 3$, p-value $= 0.008$. Dunn's test (in brackets: p-values adjusted for multiple comparisons with the Holm method): H_0: Prob$(p_{PAi} > p_{PAj}) = 1/2$, H_1: Prob$(p_{PAi} > p_{PAj}) > 1/2$, for all $i < j$. PA1 vs. PA2: $p = 0.223$ (0.446), PA1 vs. PA3: $p = 0.003$ (0.016), PA1 vs. PA4: $p = 0.004$ (0.018), PA2 vs. PA3: $p = 0.022$ (0.09), PA2 vs. PA4: $p = 0.027$ (0.08), PA3 vs. PA4: $p = 0.465$ (0.465). With the Holm adjustment, PA2 and PA3/PA4 differ significantly only at a ten percent level.

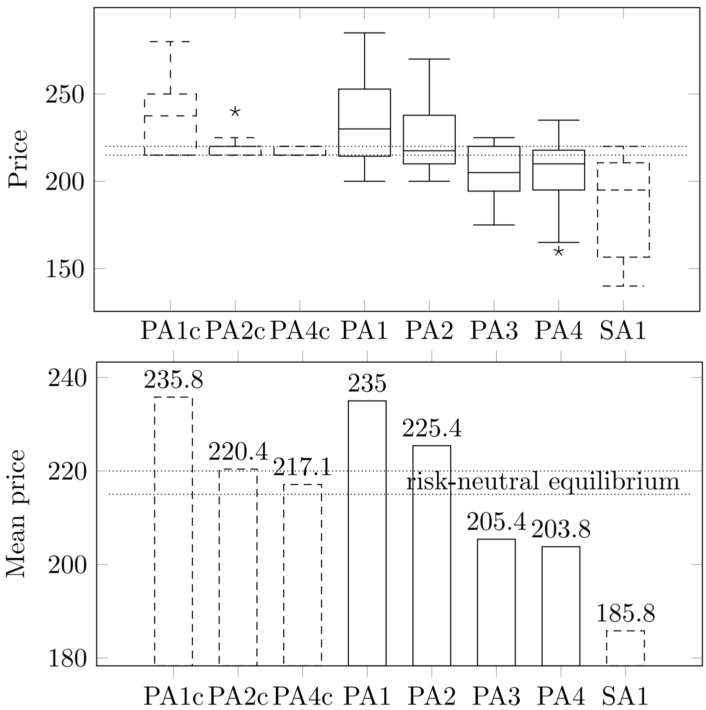

Figure 1: Boxplot of the prices and plot of the mean prices in all treatments (solid lines: main treatments; dotted lines: risk-neutral equilibrium prediction; boxplots show the median, first and third quartiles, whiskers with maximum 1.5 interquartile ranges, and outliers (⋆))

dynamics alone or of an effect of bidders' influence on becoming the leading bidder, whereas a significant effect results from assigning leading bidders.

The ranking of all groups' prices in increasing order supports these results (see Table A.7 in Appendix A). The groups with the lowest ranks from PA4, PA3, PA2, and PA1 have ranks 1, 3, 8, and 8, respectively. Prices strictly below 200 occur only in auctions PA4 and PA3 (by four and three groups). In contrast, prices strictly above 235 are achieved only in auctions PA2 and PA1 (by three and five groups, respectively).

The impact of the auction format is also evident when comparing the auction prices with the prices 215 and 220, which are the equilibrium prices when bidders are risk-neutral utility maximizers. In PA4, seven auctions end below and one above the risk-neutral prediction, whereas in PA1, the ratio is three to eight (see Table 5).

We do not observe irrational bidding in the sense that subjects bid below the lower bound of their valuation distribution. In PA1 and PA2, two (6%) and three (8%) bidders bid above the upper bound of their interval, and in PA3 one bidder does not submit a bid (none of these bids is decisive for a price). In PA4, all bidders bid within the boundaries of their intervals.

Susceptibility of subjects to aggressive bidding appears to differ between descending-clock

Table 5: Location of the observed auction price relative to the equilibrium price with risk-neutral bidders

		$<$	$=$	$>$	Sum
Treatment	PA1	3 (25.0%)	1 (8.3%)	8 (66.7%)	12
	PA2	5 (41.7%)	2 (16.6%)	5 (41.7%)	12
	PA3	8 (66.7%)	2 (16.6%)	2 (16.6%)	12
	PA4	7 (58.3%)	4 (33.3%)	1 (8.3%)	12
Sum		23 (47.9%)	9 (18.8%)	16 (33.3%)	48

auctions. In PA2, nine subjects bid at least one full decrement below their expected valuation, and in PA3 and PA4, this number increases to 14 and 15 subjects. This amounts to 29%, 45%, and 60% of those subjects in PA2, PA3, and PA4 that reveal the necessary information to judge whether their bidding limit is above or below their expected valuation.

4.2. Evaluation and Discussion

4.2.1. Comparison of the Treatments PA1 to PA4 with the Treatment SA1

Hypothesis 2 predicts higher bids in PA1 than in SA1, and also we find a statistically significant difference.[9] The difference amounts to 49.3 ECU (see Table 6), which is about 10 price steps or 25% of the valuation intervals' spread of 200 ECU.

Table 6: Deviation $\Delta_b = b - \mathrm{E}[V]$ of all 36 bidders in PA1 and SA1 (#: number of)

Treatment	# Observations	# ($\Delta_b < 0$)	# ($\Delta_b > 0$)	Mean Δ_b	Median Δ_b
PA1	36	12	24	20.8	15.5
SA1	36	27	9	−28.5	−14.5

Result 2. *WTA $>$ WTP in this auction setting.*

To get an impression of the relative location of prices we compare the prices of PA1 to PA4 with those of SA1. The mean and median prices in the descending-clock auctions are between those in PA1 and SA1 (see Table 4 and Figure 1). Prices differ significantly both between SA1 and PA1 and between SA1 and PA2.[10]

Irrational bids above the valuations' upper boundary do not occur in SA1. Three bidders (8%) bid below the lower boundary. This reverses – and is in line with – the pattern in the procurement auctions.

[9] Wilcoxon-Mann-Whitney test on Δ_b in PA1 vs. SA1 (one-tailed): sample sizes: 36, 36; $p < 0.001$.

[10] Pairwise Wilcoxon-Mann-Whitney tests (one-tailed; with continuity correction): SA1 vs. PA1: $p < 0.001$, SA1 vs. PA2: $p = 0.002$, SA1 vs. PA3: $p = 0.058$, SA1 vs. PA4: $p = 0.077$.

4.2.2. Results on Auctions with Private Certain Valuations

Treatments PA1c, PA2c, and PA4c serve to detect potential confounding factors because, with private certain valuations, no WTP-WTA disparity is expected.[11] We find that prices differ between these treatments.[12] While almost all prices in PA2c and PA4c (with two and no exceptions) are within the equilibrium range, the prices in PA1c are on average (and in seven groups) above the equilibrium prediction (see Figure 1).

The overbidding in PA1c[13] is surprising because one might expect that the commonly observed high percentage of overbidding in sealed-bid second-price sales auctions (sometimes attributed to the joy of winning or spite motives) translates into underbidding in procurement auctions. A potential reason for the overbidding in PA1c might be that procurement auctions trigger profit-targeting strategies. In sealed-bid auctions, bidders arguably focus on making a profit by selling their good and therefore overbid their valuation. If profit targeting causes overbidding in PA1c, it might also influence bidding in PA1, depending on how profit targeting translates from certain to uncertain valuations.

There is no indication of overbidding in the descending-clock auctions. Profit targeting may vanish in descending-clock auctions because the binary decision at each stage – whether to quit or to bid – makes bidders realize that accepting a lower profit dominates making zero profit once their targeted profit is out of reach.

We conclude for the main treatments that the price differences between PA1 and PA3/PA4 may be driven by reference-state shifts in PA3/PA4 and/or overbidding in PA1, while differences between PA2 and PA3/PA4 are not driven by a misunderstanding of the mechanisms.[14]

4.2.3. Comparison of the Results on Procurement Auctions with Sales Auctions

Our main finding on procurement auctions mirrors that by Ehrhart et al. (2015) for sales auctions. Their auction format A1 equals SAF1, and A2 to A4 reverse PAF2 to PAF4. They find increasing prices across their treatments with auctions A1 to A4 and private uncertain

[11] Arguments by Kahneman et al. (1990) and Coursey et al. (1987) are collected in Ehrhart et al. (2015).

[12] Kruskal-Wallis test, PA1c, PA2c, and PA4c: $\chi^2 = 6.0816$, df = 2, p-value = 0.048.

[13] Sign test (binomial test, two-tailed). 21 of 36 bids are above the prediction (+), 13 are in line with the prediction (=), and 2 are below (−). p-value = $\Pr(21; 23, 0.5) < 0.001$.

[14] Plott and Zeiler (2005) remark that valuation bidding with certain valuations might not provide evidence of understanding the mechanism (i.e., of the absence of misconceptions). Bidders might simply bid their given valuation, e.g., due its prominence or due to anchoring. Our design does not allow valuation bidding and might thereby eliminate such anchoring. Furthermore, in the design by McGee (2013), the individual symmetric valuation lotteries are characterized by their center z but he does not report clustering of bids at the salient valuation z in his English auctions.

valuations. This analogy of results provides further evidence that design differences influence bidding as predicted by WTP-WTA disparity and reference-state shifts.

In both the sales and the procurement setting the effect of auction dynamics alone appears small, whereas the strongest effect results from assigning a leading bidder. In the sales auctions, becoming the leading bidder by the own effort appears important, whereas this is not the case in the procurement auctions.

4.2.4. Discussion

In our framing, the winning bidder sells his good, and the others keep their good. The WTA and WTP perspectives are straightforward. Alternatively, the winning bidder in a procurement auction might have to produce the good, whereas unsuccessful bidders have zero costs. Our arguments in Table 3 can be adjusted to this different framing. In the two frames, the reference-state shift from a before-the-auction state of having the good or of having no costs to an after-the-auction state of not having the good or incurring the costs, respectively, causes a shift from reporting the WTA to lose the good or money towards reporting the WTP to avoid delivering the good or incurring the costs. A difference between these frames is that our frame involves an ownership change in the good's dimension, whereas the second frame involves a change in the monetary dimension. Whether this different framing results in different bidding behavior is an open empirical question.

There are many ways in which auction formats may trigger reference-state shifts. The choice of auction formats in this paper is motivated by having simple auctions that are used in practice and for which a hypothesis on the order of auction prices can be derived. Furthermore, we decided to keep close to the design by Ehrhart et al. (2015) to be able to compare the results to sales auctions.

Our treatment differences appear to be driven by bidders who are prone to aggressive bidding, which we attribute to their WTP-WTA disparity and reference-state shifts influenced by the mechanism. Although we have uncertain valuations, risk aversion does not capture our observation of decreasing prices. A risk-averse bidder with uncertain valuations bids the same amount (the risk premium) below his lottery's expected value in all our auctions. In a related setup by McGee (2013) with uncertain valuations and English open-outcry and first-price sales auctions, the measured risk attitude is not predictive for the observed bidding above the lottery's expected value.[15]

Arguments by Engelmann and Hollard (2010), who distinguish between valuation uncertainty and trade uncertainty, appear related to ours. Trade uncertainty might capture our observations. If being the leading bidder makes the bidder more comfortable with the state of trading (or teaches him about trading), he might bid more aggressively in auctions that emphasize this state.

Our study involves valuation uncertainty. A potential reason why the WTP-WTA disparity arises with uncertain valuations but not with certain valuations is the following: A necessary condition for the exchange asymmetry or the WTP-WTA disparity to occur is the evaluation of the exchanged goods and associated gains or losses in separate consumption dimensions (cp. Kőszegi and Rabin, 2009). This separation occurs when different goods are exchanged or when a good/lottery is traded for money, but not when money is traded for money (as with induced valuations).

5. Conclusion

Our experiment identifies a potential driver of price differences between strategically equivalent procurement auction formats: the WTP-WTA disparity and the auction's influence on the reference state. Auction formats that foster reference-state shifts lead to lower payments for the buyer. In particular, assigning a leading bidder leads to more aggressive bids.

For bidders both in sealed-bid and descending-clock auctions, this study suggests that before the auction begins the bidders should make themselves aware of not only their WTA but also of their WTP, i.e., their indifference price conditional on winning.

References

Andreoni, J., Che, Y.K., Kim, J., 2007. Asymmetric information about rivals' types in standard auctions: An experiment. Games and Economic Behavior 59, 240–259.

Bartling, B., Netzer, N., 2016. An externality robust auction: Theory and experimental evidence. Games and Economic Behavior 97, 186–204.

Beall, S., Carter, C., Carter, P.L., Germer, T., Hendrick, T., Jap, S., Kaufmann, L., Maciejewski, D., Monczka, R., Petersen, K., 2003. The role of reverse auctions in strategic sourcing. CAPS Research.

[15] In McGee's setting with recurring auctions, he also finds no indicators that giving scope to experience has an effect on overbidding.

Bernard, J.C., 2006. Finding and retaining the dominant strategy: The second-price, English and 'sealed offer' English auctions. Journal of Economic Behavior & Organization 60, 553–561.

Cooper, D.J., Fang, H., 2008. Understanding overbidding in second price auctions: An experimental study. Economic Journal 118, 1572–1595.

Coursey, D.L., Hovis, J.L., Schulze, W.D., 1987. The disparity between willingness to accept and willingness to pay measures of value. Quarterly Journal of Economics 102, 679–690.

Cox, J.C., Roberson, B., Smith, V., 1982. Theory and behavior of single object auctions, in: Smith, V. (Ed.), Research in Experimental Economics. Greenwich, CT: JAI Press. volume 2, pp. 1–43.

Delgado, M.R., Schotter, A., Ozbay, E.Y., Phelps, E.A., 2008. Understanding overbidding: Using the neural circuitry of reward to design economic auctions. Science 321, 1849–1852.

Ehrhart, K.M., Ott, M., Abele, S., 2015. Auction fever: Rising revenue in second-price auction formats. Games and Economic Behavior 92, 206–227.

Engelbrecht-Wiggans, R., 1989. The effect of regret on optimal bidding in auctions. Management Science 35, 685–692.

Engelmann, D., Hollard, G., 2010. Reconsidering the effect of market experience on the "endowment effect". Econometrica 78, 2005–2019.

Filiz-Ozbay, E., Ozbay, E.Y., 2007. Auctions with anticipated regret: Theory and experiment. American Economic Review 97, 1407–1418.

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

Haile, P.A., 2003. Auctions with private uncertainty and resale opportunities. Journal of Economic Theory 108, 72–110.

Haruvy, E., Popkowski Leszczyc, P.T.L., 2010. The impact of online auction duration. Decision Analysis 20, 99–106.

Heyman, J.E., Orhun, Y., Ariely, D., 2004. Auction fever: The effect of opponents and quasi-endowment on product valuations. Journal of Interactive Marketing 18, 7–21.

Jones, M.T., 2011. Bidding fever in eBay auctions of Amazon.com gift certificates. Economics Letters 113, 5–7.

Kagel, J.H., Levin, D., 2016. Auctions: A survey of experimental research, in: Kagel, J.H., Roth, A.E. (Eds.), The Handbook of Experimental Economics. Princeton, NJ: Princeton University Press. volume 2. chapter 9, pp. 563–637.

Kahneman, D., Knetsch, J., Thaler, R., 1990. Experimental tests of the endowment effect and the Coase theorem. Journal of Political Economy 98, 1325–1348.

Kőszegi, B., Rabin, M., 2009. Reference-dependent consumption plans. American Economic Review 99, 909–936.

Knetsch, J., Sinden, J., 1984. Willingness to pay and compensation demanded: Experimental evidence of an unexpected disparity in measures of value. The Quarterly Journal of Economics 99, 507–521.

Knetsch, J.L., 2010. Values of gains and losses: Reference states and choice of measure. Environmental and Resource Economics 46, 179–188.

Ku, G., Malhotra, D., Murnighan, J.K., 2005. Towards a competitive arousal model of decision-making: A study of auction fever in live and Internet auctions. Organizational Behavior and Human Decision Processes 96, 89–103.

Lange, A., List, J.A., Price, M.K., 2011. Auctions with resale when private values are uncertain: Evidence from the lab and field. International Journal of Industrial Organization 29, 54–64.

Loewenstein, G., Issacharoff, S., 1994. Source dependence in the valuation of objects. Journal of Behavioral Decision Making 7, 157–168.

Malmendier, U., Lee, Y.H., 2011. The bidder's curse. American Economic Review 101, 749–787.

Marshall, J., Knetsch, J., Sinden, J., 1986. Agents' evaluations and the disparity in measures of economic loss. Journal of Economic Behavior & Organization 7, 115–127.

McGee, P., 2013. Bidding in private-value auctions with uncertain values. Games and Economic Behavior 82, 312–326.

Plott, C.R., Zeiler, K., 2005. The willingness to pay-willingness to accept gap, the "endowment effect," subject misconceptions, and experimental procedures for eliciting valuations. The American Economic Review 95, 530–545.

Seifert, S., 2006. Posted Price Offers in Internet Auction Markets. Heidelberg: Springer.

Strahilevitz, M., Loewenstein, G., 1998. The effect of ownership history on the valuation of objects. Journal of Consumer Research 25, 276–289.

Thompson, D.R.M., Leyton-Brown, K., 2007. Valuation uncertainty and imperfect introspection in second-price auctions. Proceedings of the Twenty-Second AAAI Conference on Artificial Intelligence, 148–153.

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

Appendix A. Ranked Auction Results

Table A.7: Ranked auction results of all groups in the treatments PA1 to PA4

Rank	Price [ECU]	Treatment	Group number	Winning bidder	Rank	Price [ECU]	Treatment	Group number	Winning bidder
1	160	PA4	8	3	27	220	PA1	5	3
2	165	PA4	3	2		220	PA2	5	3
3	175	PA3	9	3		220	PA3	3	1
4	185	PA3	8	2		220	PA3	10	1
5	190	PA3	2	1		220	PA4	1	2
6	195	PA4	11	1		220	PA4	7	2
	195	PA4	12	1	33	225	PA1	7	1
8	200	PA1	4	3		225	PA1	10	2
	200	PA1	8	1		225	PA2	1	2
	200	PA2	2	2		225	PA3	6	1
	200	PA3	1	2		225	PA3	12	1
12	205	PA3	4	3	38	235	PA1	1	3
	205	PA3	7	1		235	PA2	3	3
	205	PA3	11	2		235	PA4	4	2
	205	PA4	5	1	41	240	PA1	11	1
16	210	PA1	3	2		240	PA2	4	2
	210	PA2	6	2	43	250	PA1	12	1
	210	PA2	9	2	44	255	PA1	9	2
	210	PA2	10	1	45	260	PA2	12	2
	210	PA2	11	2	46	270	PA2	7	3
	210	PA3	5	1	47	275	PA1	6	2
	210	PA4	9	2	48	285	PA1	2	1
	210	PA4	10	1					
24	215	PA2	8	2					
	215	PA4	2	3					
	215	PA4	6	1					

Appendix B. Proof of Proposition 1 and Impact of the Decrement

Proof of Proposition 1. Consider a single-item procurement auction with n bidders, whose wealth before the auction is $w_1, w_2, \ldots, w_n$. Bidders' valuations for the good are private and independent but uncertain. Bidder i's uncertainty about his valuation is modeled by the random variable V_i with distribution $F_i(\cdot)$ and support $[\underline{v}_i, \bar{v}_i] \subset \mathbb{R}$, $i = 1, 2, \ldots, n$.

Let $u_i : \mathbb{R} \rightarrow \mathbb{R}$ denote an expected-utility maximizing bidder's von Neumann-Morgenstern increasing utility function. Let b_{max} denote the maximum possible bid with $b_{max} > \bar{v}_i$, and let $H_i^k(x) = \Pr(\min_{j \neq i} b_j \leq x)$ denote the distribution of bidder i's beliefs about his opponents' lowest bid in the auction of type $k \in \{\text{PAF1, PAF2, PAF3, PAF4}\}$. Bidder i may update $H_i^k(\cdot)$ in the course of PAF2, PAF3, and PAF4. Bidder i's strategy $b_i \in [0, b_{max}]$ in a sealed-bid or a descending clock auction is characterized by his bid in PAF1 or his bidding limit in PAF2, PAF3, and PAF4. In what follows, we skip the index i.

The objective of a bidder with wealth w and the uncertain valuation V is to choose b to maximize his expected utility

$$U(b) = H^k(b) \int_{\underline{v}}^{\bar{v}} u(w+v)\, dF(v) + \int_{b}^{b_{max}} u(w+x)\, dH^k(x).$$

The first-order condition $\partial U(b)/\partial b = 0$ gives the following equation for the optimal bid b^*:

$$\int_{\underline{v}}^{\bar{v}} u(w+v)\, dF(v) = u(w+b^*). \tag{B.1}$$

The second-order condition $\partial^2 U(b)/\partial b^2 = -u'(w+b^*) < 0$ is fulfilled for all increasing utility functions. The solution b^* does not depend on i's belief about his opponents and constitutes a weakly dominant strategy (with respect to expected utility). Updating the beliefs in the course of an auction has no impact on the optimal bidding limit b^*. The optimal b^* equals the price p, at which the bidder is indifferent between owning the good, $\int_{\underline{v}}^{\bar{v}} u(w+v)\, dF(v)$, and giving up the good for p, $u(w+p)$. This indifference price equals his certainty equivalent at wealth w. For example, a risk-neutral bidder, whose utility is given by $u(x) = x$, bids his expected valuation $b^* = \int_{\underline{v}}^{\bar{v}} v\, dF(v) = E[V]$. The same b^* maximizes an expected-utility maximizer's utility in all auction formats $k \in \{$PAF1, PAF2, PAF3, PAF4$\}$.

Next, consider a bidder whose WTA exceeds his WTP. As for an expected-utility maximizer, his optimal bidding limit is given by his indifference price. Shifting the reference state from that of not selling to the state of selling during an auction means to adjust the indifference price downwards, such that bidding down to the current indifference price is a feasible strategy throughout a descending-clock auction.

For the proof on the sales auction see Ehrhart et al. (2015). ■

Impact of the price decrement and risk-neutral prediction in PAF1 to PAF4. The price decrement of 5 ECU does not have an impact on rational bidding in PAF3 and PAF4. A bidder accepts all prices above his optimal bidding limit b^* derived from (B.1) and quits when the price falls below b^*, independent of the decrement. For risk-neutral bidders B1, B2, and B3 with expected valuations 212, 217, and 222, we get bidding limits of 215, 220, and 225. The current leading bidder cannot bid the next price step. Equilibrium prices thus are 215 (if B2 is leading bidder at 220) and 220 (if B1 is leading bidder at 220).

In PAF1 and PAF2, b^* marks a bidder's indifference price. He may deviate from b^* by less than one decrement, due to the discrete decrement and the tie-breaking rule of randomly choosing the winner. A bidder with b^* between two price steps can choose the next feasible bid above or below b^*, b^*_+ or b^*_-. The outcome from these two bids differs only in case of a tie with one of them. If a bidder expects the lowest of the opponents' bids to equal b^*_+, he is better off choosing b^*_- to win for sure at the same price b^*_+. If he expects the lowest of the opponents' bids to equal b^*_-, he is better off choosing b^*_+ to avoid winning at b^*_-.

For risk-neutral bidders B1, B2, and B3 in PAF1 and PAF2, b^* equals 212, 217, and 222. Optimal feasible bids are 210 or 215 for B1, 215 or 220 for B2, and 220 and 225 for B3. Equilibrium prices therefore are 215 and 220. If, for example, B2 considers a tie with k other bidders at 215 and at 220 equally likely, he would bid 215 because the gains from avoiding the tie at 220 exceed those from avoiding a tie at 215: $3 - 3/(k+1) > 2/(k+1) \iff k > 2/3$.

Comparability of SAF1. Ehrhart et al. (2015) show in their Appendix A.2 that a risk-neutral bidder or a constant absolute risk-averse bidder has the same indifference price b^* in PAF1 as in SAF1 (for all w_i). With discrete price steps, similar to the argument given above for PAF1, optimal feasible bids of risk-neutral bidders are 210 or 215 for B1, 215 or 220 for B2, and 220 and 225 for B3. Equilibrium prices therefore are 215 and 220.[16]

Appendix C. Translated Instructions

Instructions for all treatments consist of two pages each. The instructions for treatments PA1 to PA4 share a common first page. The instructions for treatments PAi and PAic for $i \in \{1, 2, 4\}$ share a common second page. The first page differs. We provide the first page for PA1 to PA4 and give the adjustments for PA1c, Pa2c, and PA4c in brackets. In Treatment SA1 we conduct a sales auction and thus the instructions differ from those of the other treatments.

First Page of the Instructions of Treatments PA1 to PA4 [P1c, P2c, P4c]

Instructions You are going to participate in an experiment on selling. In this experiment, you will make your decisions as a bidder at your computer terminal, isolated from the other participants. You may earn money in cash. How much you earn depends on your decisions and on the decisions of the other participants. The monetary units in the experiment are called currency units (CU).

[16] If, e.g., B2 considers a tie with $k = 1$ opponents at 215 and at 220 equally likely, he would bid 215 because the gains from avoiding the tie at 220 exceed those from avoiding a tie at 215: $-(E[V] - 220)/(k+1) = 3/2 > 1 = E[V] - 215 - (E[V] - 215)/(k+1) \iff k < 3/2$. The reverse holds for ties with $k = 2$ opponents.

Point of Departure Imagine that you are the owner of a cruise ship. The use of this ship yields profits and it thus has some value for you. You also have the opportunity to sell the ship, via a selling process that will be explained to you in detail in the following. Besides you, 2 other ship owners, who own one ship each, will participate in this selling process, but only **one** ship can be sold.

If you do not sell the ship, the value of the ship for you, **W**, will be realized only through its use. Calculations show that the value **W** of the ship for you lies uniformly distributed between $\mathbf{W_0}$ and $\mathbf{W_1}$. This means, that the ship has a value for you of at least $\mathbf{W_0}$ and at most $\mathbf{W_1}$, where all values (integers) from $\mathbf{W_0}$ to $\mathbf{W_1}$ have equal probability.

Please note: The boundaries $\mathbf{W_0}$ and $\mathbf{W_1}$ are different for every ship owner. Your individual boundaries $\mathbf{W_0}$ and $\mathbf{W_1}$ will be communicated to you on your screen directly before the selling process; the boundaries of the other bidders, however, are unknown to you.

[PA1c, Pa2c, and PA4c: Your ship has the value **W** for you. You will learn this value directly before the selling process at your screen.
Please note: The value **W** is different for every ship owner. The values of the other ship owners are, however, unknown to you.]

Payoff

1. If you do **not** sell your ship, its value for you will be determined immediately after the end of the selling process by drawing a value **W** from your uniform distribution over $\mathbf{W_0}$ to $\mathbf{W_1}$, which will then correspond to your **payoff**.

   [PA1c, Pa2c, and PA4c: If you do not sell your ship, you will receive a **payoff** equal to the value **W** of your ship.]

2. If you sell your ship at the price **P**, this selling price corresponds to your **payoff**.

Your payoff will be converted into Euro and paid to you in cash at the end of the experiment, whereby 1 CU corresponds to 5 Euro Cents. The payment will be individual and anonymous.

Second Page of the Instructions of Treatment PA1 and P1c

Selling process The process by which the ship is to be sold has the following rules.

You submit an offer **A** exactly **once**, at the beginning of the selling process. With this offer you express the **minimum** amount of CU you want to have for the ship.

An offer has to be **a multiple of 5 CU**.

When submitting your offer, you do not know the offers of the other two vendors, and they do not know your offer.

When all 3 vendors have submitted their offers, the automatic selling process begins, which bids the offers against each other and thereby determines which vendor sells the ship.

The selling process starts with the highest offer, which is thus eliminated. The price is then gradually decreased by 5 CU at each step. If the price reaches the size of another offer, this offer also quits the process. The selling process may end in two ways, depending on the offers:

1. If the lowest and the second lowest offer differ, the selling process stops when the price reaches the second lowest offer. We denote the remaining lowest offer by $\mathbf{A}^*$ and the price at which the selling process stops by **P**, where **P** equals the second lowest offer. The vendor who submitted offer $\mathbf{A}^*$ is accepted as seller and sells his ship for the price **P**. In this case we have $\mathbf{P} > \mathbf{A}^*$. That means that the seller receives for his ship more than what he asked for with his offer $\mathbf{A}^*$.

2. If at least two vendors have submitted the lowest offer $\mathbf{A}^*$, the process stops at price $\mathbf{P} = \mathbf{A}^*$. One of these vendors is then randomly selected as the seller at the price $\mathbf{P} = \mathbf{A}^*$. In this case the selling price equals the offer of the vendor who sells the ship.

Please note: You are only allowed to submit **once** an offer at the beginning of the selling process, and it may not be changed afterwards!

Before the selling process begins, you will be asked some questions on the screen concerning the rules. This is to ensure that all participants have understood the instructions.

Second Page of the Instructions of Treatment PA2 and P2c

Selling process The process by which the ship is to be sold has the following rules.

The selling process starts at a price of **350 CU**. You will be asked on your screen whether you are willing to sell your ship at this price. If this is the case, please click on the OK-button on your screen or press the enter key. You have 50 seconds to do this. If you are not willing to sell at this price, do nothing until the 50 seconds are over. With this you will automatically exit the selling process. On the screen you can always see how many seconds are left until the 50 seconds are over. Every vendor of a ship decides without knowing the decisions of the other vendors.

If at least two vendors are willing to sell for the price of 350 CU, the price will be reduced by **5 CU**. Those vendors that are still in the selling process then again have 50 seconds to decide whether they are willing to sell their ship for 345 CU. If again at least two vendors agree, the price will again be reduced by 5 CU.

The price will be reduced by 5 CU until at a price **P** at least vendors are still in the selling process but at the next price **P − 5 CU** only one or no vendor remains. That is, at the price **P − 5 CU** either all or all but one vendors quit the selling process. The selling process stops and the vendor who was the last to accept a price or one of those who were the last to accept the price, if there are several of them, will sell his or her ship. The price for the ship in both cases is **P CU**:

1. There is only one vendor who has accepted the price **P − 5 CU**. That is, at the price **P − 5 CU** all but one vendor have quit. In this case, this vendor sells his or her ship at the price **P**.

2. There are several vendors who have accepted the price **P CU** but none of them has accepted the price **P − 5 CU**. That is, at the price **P − 5 CU** all vendors have quit. In this case, one of the vendors who have accepted the price **P CU** is randomly selected and sells his or her ship at the price **P**.

Before the selling process begins, you will be asked some questions on the screen concerning the rules. This is to ensure that all participants have understood the instructions.

Second Page of the Instructions of Treatment PA3

Selling process The process by which the ship is to be sold has the following rules.

The selling process starts at a price of **350 CU**. You will be asked on your screen whether you are willing to sell your ship at this price. If this is the case, please click on the OK-button on your screen or press the enter key. You have 50 seconds to do this. If you are not willing to sell at this price, do nothing until the 50 seconds are over. With this you will automatically exit the selling process. On the screen you can always see how many seconds are left until the 50 seconds are over. Every vendor of a ship decides without knowing the decisions of the other vendors.

If two or more vendors are willing to sell for the price of 350 CU, then one of these vendors will be randomly selected as the **current leading vendor**, whom we call **LV350**. You will always be informed whether you are the current leading vendor or not.

The price will then be reduced by **5 CU**. Those vendors that are still in the selling process then again have 50 seconds to underbid the current leading vendor **LV350** by accepting the new price of 345 CU. The current leading vendor **LV350** cannot bid in this round but of course stays in the selling process.

If at the price 345 CU no vendor signals his or her willingness to sell the ship for this price, then the current leading vendor **LV350** sells his or her ship at the price 350 CU.

If one or several vendors signal their willingness to sell at 345 CU, then among these a new current leading vendor **LV345** is randomly selected. Then, the price is again reduced by 5 CU to 340 CU. The vendors who are still in the selling process, including the previous leading vendor **LV350**, again have 50 seconds to underbid the current leading vendor **LV345** by accepting the price 340 CU.

If at least one vendor accepts the price 340 CU, then there is a new current leading vendor **LV340** and the price is reduced to 335 CU and so on.

Before the selling process begins, you will be asked some questions on the screen concerning the rules. This is to ensure that all participants have understood the instructions.

Second Page of the Instructions of Treatment PA4 and P4c

Selling process The process by which the ship is to be sold has the following rules.

The selling process starts at a price of **350 CU**. You will be asked on your screen whether you are willing to sell your ship at this price. If this is the case, please click on the OK-button on your screen or press the enter key. You have 45 seconds to do this. On the screen you can always see how many seconds are left until the 45 seconds are over.

The vendor who is the first to accept the price 350 CU becomes **current leading vendor**. We call this vendor **LV350**. The other vendors then cannot accept the price 350 CU anymore. You will always be informed whether you are the current leading vendor or not.

The price will then be reduced by **5 CU**, even if the 45 second have not yet passed, and you will see the new state of the auction process for 5 seconds on your screen. The vendors then have the opportunity for up to 45 seconds to underbid the current leading vendor **LV350** by accepting the new price 345 CU. The current leading vendor **LV350** cannot bid in this round.

If at the price 345 CU no vendor signals his or her willingness to sell the ship for this price, then the current leading vendor **LV350** sells his or her ship at the price 350 CU.

If a vendor signals his or her willingness to sell at 345 CU, then this vendor becomes the new current leading vendor **LV345**. Then, the price is again reduced by 5 CU to 340 CU. Again, all vendors but the current leading vendor **LV345** can accept this price and the one who accepts the price first is the new leading vendor and so on. However, if at 340 CU no vendor accepts the price, then the current leading vendor **LV345** sells his or her ship at the price 345 CU.

Before the selling process begins, you will be asked some questions on the screen concerning the rules. This is to ensure that all participants have understood the instructions.

Instructions of Treatment SA1

Instructions You are going to participate in an experiment on auctions. In this experiment, you will make your decisions as a bidder at your computer terminal, isolated from the other participants. In the auction you may earn money in cash. How much you earn depends on your decisions and on the decisions of the other participants. The monetary units in the experiment are called currency units (CU).

Point of Departure Imagine that you are the owner of a ship that offers cruises. This is why you are participating in an auction in which the cruise ship "One World" will be auctioned **once**. Besides you, 2 other bidders will participate in this auction.

If you purchase the ship through the auction, its value **W** will result from its use in your fleet. However, calculations show that the value of the ship for you, **W**, lies uniformly distributed between $\mathbf{W_0}$ and $\mathbf{W_1}$. This means that the ship has a value for you of at least $\mathbf{W_0}$ and at most $\mathbf{W_1}$, where all values (integers) from $\mathbf{W_0}$ to $\mathbf{W_1}$ have equal probability.

Please note: The boundaries $\mathbf{W_0}$ and $\mathbf{W_1}$ are different for every bidder. Your individual boundaries $\mathbf{W_0}$ and $\mathbf{W_1}$ will be communicated to you on your screen directly before the auction; the boundaries of the other bidders, however, are unknown to you.

Payoff

1. If **you** are awarded the ship for the price **P**, the value of the ship for you will be determined immediately after the auction by drawing a value **W** from the uniform distribution on $\mathbf{W_0}$ to $\mathbf{W_1}$. Your profit from the auction will then be calculated as:

$$\mathbf{G = W - P}$$

   Please note: If you pay more for the ship than it is worth to you, that is, if P > W, then your profit from the auction will be negative, that is, G < 0.

2. If you are not awarded the ship, your profit from the action equals zero, i.e.:

$$\mathbf{G = 0}$$

Your profit will then be converted into Euro, whereby 1 CU corresponds to 5 Euro Cents. The payoff you receive is 10 Euros plus your profit from the auction in Euros, i.e.:

Payoff = €10 + Profit from the auction

The payment will be individual and anonymous.

Auction The auction by which the ship is to be sold has the following rules.

You submit a bid **B** at the beginning of the auction exactly **once**. Your bid expresses the maximum CU you are willing to pay for the ship.

The minimum bid $\mathbf{B_{min}}$ for the ship is **0 CU**. That means that you have to bid at least 0 CU; that is, $\mathbf{B} \geq \mathbf{B_{min}} = 0$. The bid must be **a multiple of 5 CU**, that is, $\mathbf{B} = 0, 5, 10, 15, 20, \ldots$

When submitting your bid, you do not know the bids of the other bidders, and they do not know your bid.

When all 3 bidders have submitted their bids, the automatic bidding process begins, which places the bids against each other and thereby determines which bidder is awarded the ship. In this auction, the price starts at the minimum bid of $\mathbf{B_{min}} = 0$.

The auction price is gradually increased by 5 CU at any one time. If a bid is exceeded by the auction price the bid quits the auction. The bidding process may end in two ways, depending on the bids:

1. If the highest bid and the second highest bid differ, the bidding process stops when the auction price has reached the second highest bid. We denote the remaining highest bid by $\mathbf{B}^*$ and the price at which the bidding process stops by **P**, where **P** equals the second highest bid. The bidder who submitted the bid $\mathbf{B}^*$ is awarded the ship and must pay the price **P**. In this case $\mathbf{P} < \mathbf{B}^*$. That means that the bidder pays less than his bid $\mathbf{B}^*$.

2. If at least two bidders have submitted the same bid $\mathbf{B}^*$ which is the highest bid, the bidding process stops at the price $\mathbf{P} = \mathbf{B}^*$. One of these bidders is then randomly selected to be awarded the ship at the price $\mathbf{P} = \mathbf{B}^*$. In this case the bidder who is awarded the ship has to pay his bid.

Please note: in this auction you are only allowed to submit a bid **once**, and it may not be changed afterwards!

Before the auction begins, you will be asked some questions on the screen concerning the rules. This is to ensure that all participants have understood the instructions.

Download ZEW Discussion Papers from our ftp server:

http://ftp.zew.de/pub/zew-docs/dp/

or see:

https://www.ssrn.com/link/ZEW-Ctr-Euro-Econ-Research.html
https://ideas.repec.org/s/zbw/zewdip.html

//
IMPRINT

ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH Mannheim

ZEW – Leibniz Centre for European Economic Research

L 7,1 · 68161 Mannheim · Germany
Phone +49 621 1235-01
info@zew.de · zew.de