Could we overcome the Winner’s Curse by (behavioral) Auction Design?

PRELIMINARY AND INCOMPLETE VERSION

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Abstract

The Winner’s Curse (WC) is a non-equilibrium behavior involving systematic and persistent overbidding in common-value auctions resulting in significant losses. It is one of the most robust findings in laboratory experiments. We developed an auction mechanism where our payment rule internalizes the adverse selection problem thus simplifies the bidders’ task resulting with sincere bidding being a no-regret equilibrium. Multiple payments rules may induce sincere bidding as equilibrium. Of these rules some may be regarded as more efficient in that they are based on a sufficient statistic and thus “minimal” in the way they use bidders’ reporting. However, given that we are concerned with the WC, a natural question is whether less minimal rules that induce sincere bidding can help bidders find their way to equilibrium bidding. We study this possibility as well. Our main experimental findings are that the minimal payment rule inducing sincere bidding induces an overbidding bias and fares worse in overcoming the WC than the English auction. The less efficient payment rules address the overbidding bias and better mitigate the WC than the minimal payment rule and, remarkable for a sealed-bid design, can match the performance of the English auction.

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1 Introduction

The Winner’s Curse - systematic losses resulting from overbidding as bidders do not account for the adverse selection conditional on bidding - is a robust finding in experimental auction research. Since Bazerman and Samuelson (1983) and Kagel and Levin (1986) reported it for first-price auctions in common-value environments, it has been replicated widely, see, e.g., Lind and Plott (1991). It has also been observed in other auctions formats (e.g., second-price auction and English auction) and in a wide range of common-value environments; see, e.g., Goeree and Offerman (2002), Levin, Kagel, and Richard (1996), Charness and Levin (2009), Ivanov, Levin, and Niederle (2010). For a study challenging it, see Hansen and Lott (1991).

Recently behavioral explanations have been suggested by Eyster and Rabin (2005) and Crawford and Iriberri (2007) that allow for inconsistent belief formation while maintaining best-response behavior given beliefs. Inconsistent belief formation models, however, do not explain all deviations from equilibrium bidding as has been argued for common-value models by Charness and Levin (2009) and Ivanov, Levin, and Niederle (2010) and for the first-price private-value auction by Kirchkamp and Reiß (2011). In particular equilibrium deviations, i.e. overbidding relative to the equilibrium bid leading to the Winner’s Curse, seem to arise due to cognitive limitations as suggested by Charness and Levin (2009) studying individual choice and Charness, Levin, and Schmeidler (2011) studying the relation between the complexity of the adverse selection problem and the abundance of the Winner’s Curse.

In this paper we attempt to overcome the Winner’s Curse by behavioral auction design that is directed at simplifying bidder’s task of formulating and following the equilibrium bid strategy. We suggest that it is direct mechanisms inducing sincere bidding, i.e. allowing each bidder to report the signal in equilibrium truthfully, that are easiest to follow. This is a response to the observation that in many of the cited experimental studies involving pure common-value auctions a bidder’s signal is ex-ante unbiased to the common-value and bidders bid lower than but close to their signal (as if in private-value auctions). Such bidding almost surely results in losses, i.e. the Winner’s Curse, as the highest signal is quite biased. Under the adverse selection explanation a mechanism inducing sincere bidding would take care of the adverse selection problem and, thus, overcome the Winner’s Curse ceteris paribus.

The paper is organized as follows. In section 2 we present our theoretical framework and introduce auction formats that induce sincere bidding. In section 3 we describe our experimental design and in section 4 we report the results. Section 5 concludes with a short summary of our main findings.

2 Theoretical Considerations

The principle that we adopt for behavioral auction design is the simplicity of bid submission from a bidder’s point of view. Since there seems nothing simpler for a bidder in a common-value auction than the submission of the observed signal as a bid, we first introduce an auction mechanism where sincere bidding is an ex-post equilibrium in a general common-value framework. Second, we demonstrate how this generally characterized auction mechanism can be applied to
two prominent common-value models, the mineral-rights model and the signal-average model. Depending on the specific common-value model there can exist other auction mechanisms where sincere bidding is a Bayesian Nash equilibrium but no ex-post equilibrium where we give an example.

2.1 Common-Value Framework and Ex-post Equilibrium Auction

Consider a general common-value framework where \((V, X) := (V, X_1, ..., X_n)\) denotes a vector of \((n+1)\) random variables that are drawn from a joint distribution function and where, without loss of generality, we order the \(X_i\)'s such that \(X := \{X_1 \geq X_2 \geq ..., \geq X_n\}\) and \(X_{-i} := \{X_1 \geq X_2, ..., X_{i-1} \geq X_{i+1}, ..., \geq X_n\}\) with \(x\) and \(x_{-i}\), respectively, denoting the vectors of realizations.

Assume that there exists a finite expected value conditional on realizations \(E[V|x] := h(x)\) with \(\partial h(x)/\partial x_i \geq 0\), for all \(i = 1, 2, ..., n\). Consider a common-value auction with \(V\) denoting the pure common-value and with \(n \geq 2\) risk-neutral bidders where each bidder \(i\) privately observes signal \(X_i\). Let the common-value auction be a direct auction where bidder \(i\) reports her signal \(\tilde{x}_i\) with \(\tilde{x} := (\tilde{x}_1, \tilde{x}_2, \tilde{x}_3, ..., \tilde{x}_n)\) and let the replacement mapping \(\phi(\cdot)\) replace the highest reported signal by the second-highest reported signal, \(\phi(\tilde{x}) := (\tilde{x}_2, \tilde{x}_3, ..., \tilde{x}_n)\).

Proposition 1 states that it is possible to induce sincere bidding in this general framework with a direct auction that allocates the object to the highest bidder for a price equal to the expected common-value conditional on the highest reported signal replaced by the second-highest one, \(p = h(\phi(\tilde{x}))\). Specifically, this direct auction induces sincere bidding as an ex-post equilibrium.

**Proposition 1** The direct auction where the highest bidder wins and pays \(h(\phi(\tilde{x}))\) induces sincere bidding, this is \(\tilde{x} = x\), as BNE with no regret equilibrium.\(^1\)

**Proof.** Consider a deviation by bidder \(k = 1, 2, ..., n\) assuming that all other bidders report their true signal. Bidder 1 wins by reporting truthfully and her expected payoffs are:

\[
E[\pi_{1\cdot}(x)] = E_{x_{-1}}\{[E[V|x] - h(\phi(x))]x_1\} \\
= E_{x_{-1}}\{[h(x) - h(\phi(x))]x_1\} \\
= E_{x_{-1}}\{[\int_{x_1}^{x_2} \frac{\partial h(x)}{\partial x_1} dx_1]x_1\} > 0.
\]

Bidding higher will neither affect the outcome nor the price and bidding lower when it matters will result in zero payoffs rather than strictly positive. Any bidder \(k \geq 2\) loses by bidding truthfully and earns zero. Bidding lower does not matter so consider a deviation up that matters this is \(\tilde{x}_k > x_1\). Note that in such a case \(\tilde{x} := (\tilde{x}_k, x_{-k})\) and \(\phi(\tilde{x}) := (x_1, x_{-k}) > (x_1, x_{-1})\), so that \([h(x) - h(\phi(\tilde{x}))] < 0\). By deviating and winning bidder \(k\) earns expected payoffs of:

\[
E[\pi_{k\geq2}(x)] = E_{x_{-k}}\{[E[V|x] - h(\phi(\tilde{x}))]x_k\} \\
= E_{x_{-k}}\{[h(x) - h(\phi(\tilde{x}))]x_k\} < 0.
\]

\(^1\)We use ex-post equilibrium with no regret vis à vis realization of others bidders private signals. There may be regret on the part of the winner or losers vis à vis realization of the common value \(V\).
Thus, a loser also does not wish to deviate.

This direct auction, that we refer to as the Sophi auction in the following, sets the price as a function of the reported signals. In equilibrium where signals are reported sincerely, this does correct for the adverse selection so that the Sophi auction allows unsophisticated bidders, who typically ignore it, to avoid the Winner’s Curse by reporting sincerely. This contrasts with the more complex equilibrium strategies in the English auction for common-value environments where generally bidders (with the possible exception of the lowest signal holder) do not drop at their signal. Typically they drop at a lower clock price as each bidder in her turn corrects for the adverse selection inferred at the clock price. Importantly in either auction, Sophi or English, the bidder with the highest signal is the high bidder due to the monotonicity of equilibrium bid strategies and receives the object in exchange for paying price \( p = h(\phi(\bar{x})) = E[V|\bar{x}_2, \bar{x}_3, ..., \bar{x}_n] \) as recorded in the corollary.

**Corollary 2** The Sophi auction and the English auction are allocation and price equivalent.

**Proof.** In the English auction the highest signal holder wins the object and the price is set by the second-highest signal holder who, following Milgrom and Weber (1982), drops at precisely \( h(\phi(\bar{x})) \).

### 2.2 Two Common-Value Models

We show how sincere bidding can be induced with the Sophi auction in two common-value models that differ in the specification of the common value. The information structure of signals is the same in either model and follows the setup in Kagel and Levin (1986) and Levin, Kagel, and Richard (1996). Specifically let the random variable \( C \) be distributed uniformly on interval \([a, b]\) and denote its realization by \( c \). Assume that the private signals \( X_i (i = 1, ..., n) \) are i.i.d. conditional on the center of signals, \( c \), with the uniform distribution on \([c - \varepsilon, c + \varepsilon]\).

#### 2.2.1 Mineral-Rights Model

In the mineral-rights model we denote the common-value by \( V \) and assume that it is identical to the center of signals, \( V \equiv C \), so that signals are symmetrically distributed around the common value. The specification of the Sophi auction reduces to identifying the price rule that gives the common-value’s expected value conditional on the reported signals where the highest reported signal is replaced by the second-highest reported signal. It is well-known that the average of the highest signal and the lowest signal is a sufficient statistic for the common-value in the mineral-rights model with our uniform assumption. With replacing the highest reported signal by the second-highest reported signal, the price that a winner pays in the Sophi auction is

\[
p_{\text{Sophi}} = h(\phi(\bar{x})) = E[V|\phi(\bar{x})] = \frac{\bar{x}_2 + \bar{x}_n}{2}
\]
2.2.2 Sincere Bidding with a Non-Minimal Payment Rule

Proposition 3 The average pricing rule \( p(x) = \frac{x_2 + x_3 + x_4}{4} \) induces sincere bidding as a BNE in the mineral-rights model.

Proof. Assume that all but the \( k^{th} \) bidder \((k = 1, 2, ..., n)\) bid sincerely their signal and consider a deviation by the \( k^{th} \) bidder. For the winner, \( k = 1 \), in equilibrium, the expected payoff is

\[
\pi_W = E_{x-1}\{[(V|x) - \frac{x_2 + x_2 + x_3 + x_4}{4}]|X_1 = x_1\}
\]

\[
= E_{x-1}\{[\frac{x_1 + x_4}{2}] - \frac{x_2 + x_2 + x_3 + x_4}{4}]|X_1 = x_1\}
\]

\[
= E_{x-1}\{\frac{2(x_1 - x_2) - (x_3 - x_4)}{4}|X_1 = x_1| > 0
\]

as we show below in (*). Bidding higher (i.e. \( b_1(x_1) > x_1 \)) will neither affect the outcome nor the price. Bidding lower (i.e. \( b_1(x_1) < x_1 \)) either does not matter or results in zero profits rather than positive profits. For any loser, \( k > 1 \), bidding lower than their signals (i.e. \( b_k(x_k) < x_k \)) does not matter and bidding higher when it matters means \( b_{k>1}(x_k) > x_1 \) and results in the expected payoff

\[
\pi_k = E_{x-k}\{\frac{x_1 + x_4}{2} - \frac{x_2 + x_3 + x_4 - x_k}{4}|X_k = x_k\}
\]

\[
= E_{x-k}\{\frac{(x_k + x_4) - (x_2 + x_3)}{4}|X_k = x_k\} \leq E_{x-k}\{\frac{(x_4 - x_3)}{4}|X_k = x_k\} < 0.
\]

(*). It remains to show that \( E\{\frac{2(x_1 - x_2) - (x_3 - x_4)}{4}|X_1 = x_1\} > 0 \). Given that \( X_1 = x_1 = x \), the random variable \( V \in [x - \epsilon, x + \epsilon] \). Consider the case of a given \( V = v \), we compute \( E\{\frac{2(x_1 - x_2) - (x_3 - x_4)}{4}|X_1 = x_1, V = v\} \). \( E\{x_1|x_1 = x, V = v\} = x \). \( E\{x_1|x_1 = x, V = v\} = \int_{v-\epsilon}^{v} (n-1)\frac{f(t)}{F(x)}(F(t))^{-n-2}dt = x - \int_{v-\epsilon}^{v} \frac{f(t)}{F(x)}(F(t))^{-n-1}dt = x - \frac{1}{n} \frac{[t-(v-\epsilon)]^{n-1}}{(v-\epsilon)^{n-1}} - x \frac{[t-(v-\epsilon)]^{n}}{(v-\epsilon)^{n}} \).

\( E\{x_3|x_3 = x, V = v\} = \int_{v-\epsilon}^{v} (n-2)\frac{f(t)}{F(x)}(F(t))^{-n-3}dt = \int_{v-\epsilon}^{v} \frac{f(t)}{F(x)}(F(t))^{-n-2}dt = x - \frac{2}{n} \frac{[t-(v-\epsilon)]^{n-1}}{(v-\epsilon)^{n-1}} - x \frac{[t-(v-\epsilon)]^{n}}{(v-\epsilon)^{n}} \).

\( E\{x_4|x_4 = x, V = v\} = \int_{v-\epsilon}^{v} (n-3)\frac{f(t)}{F(x)}(F(t))^{-n-4}dt = \int_{v-\epsilon}^{v} \frac{f(t)}{F(x)}(F(t))^{-n-3}dt = x - \frac{3}{n} \frac{[t-(v-\epsilon)]^{n-2}}{(v-\epsilon)^{n-2}} - x \frac{[t-(v-\epsilon)]^{n-1}}{(v-\epsilon)^{n-1}} \).

Collecting terms: \( E\{\frac{2(x_1 - x_2) - (x_3 - x_4)}{4}|X_1 = x, V = v\} = \frac{1}{4} \frac{[2x-(v-\epsilon)]^{n}}{(v-\epsilon)^{n}} - \frac{[x-(v-\epsilon)]^{n}}{(v-\epsilon)^{n}} = \frac{[x-(v-\epsilon)]^{n}}{(v-\epsilon)^{n}} > 0. \)

Since the last result holds for all \( V = v \), by integration \( E\{\frac{2(x_1 - x_2) - (x_3 - x_4)}{4}|X_1 = x_1\} > 0. \)

2.2.3 Signal-Average Model

In the signal-average model we denote the common-value by \( W \) and assume that it is given by the average of signals, \( W \equiv \frac{1}{n} \sum_{j=1}^{n} X_i \). In this model, there is no uncertainty about the common value if signals are reported sincerely since the realized common-value is simply the average of realized signals. It follows that the common-value’s expected value conditional on reported signals after signal replacement is trivially given by

\[
p_{\text{SigAv}} = h(\phi(x)) = E[V|\phi(x)]
\]

\[
= \sum_{j=1}^{n} \frac{\bar{x}_j}{n} - \frac{\bar{x}_1 - \bar{x}_2}{n}
\]
3 Experimental Design

In the experiment we focus our attention on the auction design as our main treatment variable to explore if direct auctions that induce sincere bidding can mitigate the Winner’s Curse. We also vary the common-value model across treatments and increase the number of competing bidders after twenty market periods.

3.1 Treatments

Table 1 summarizes our treatment conditions. In our four main treatments 1-4 we implement the mineral-rights model and in treatments 5-6 we look at the signal-average model. In both common-value models we use the English auction as a basis for comparison. Using the English auction as the benchmark auction instead of the first-price auction is compelling since the English auction allows bidders to avoid the Winner’s Curse better than the first-price auction (Levin, Kagel, and Richard, 1996). Thus, comparing the performance of our behaviorally motivated auction designs to that of the English auction provides a stronger test of overcoming the Winner’s Curse. To have the possibility of studying the mitigation of Winner’s Curse we intended to create an abundancy of Winner’s Curse situations in our benchmark treatment. For that we selected a relatively large signal range parameter of $\varepsilon = 18$ so that the common value given the unbiased signal $x$ falls into the interval of $[x - 18, x + 18]$.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CV model</th>
<th>Auction price rule $(n = 4)$</th>
<th>Signal range parameter $\varepsilon$</th>
<th>Number of sessions (subjects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) English-MR</td>
<td>mineral-rights</td>
<td>second-highest bid (clock at last drop-out)</td>
<td>18</td>
<td>4 (68)</td>
</tr>
<tr>
<td>2) Sophi-MR</td>
<td>mineral-rights</td>
<td>$\frac{b_{(2)} + b_{(4)}}{2}$</td>
<td>18</td>
<td>4 (58)</td>
</tr>
<tr>
<td>3) Sophi-All-MR</td>
<td>mineral-rights</td>
<td>$\frac{b_{(2)} + b_{(3)} + b_{(4)}}{3}$</td>
<td>18</td>
<td>5 (77)</td>
</tr>
<tr>
<td>4) Sophi-All-MR2</td>
<td>mineral-rights</td>
<td>$\frac{b_{(2)} + b_{(3)} + b_{(4)}}{4}$</td>
<td>36</td>
<td>2 (27)</td>
</tr>
<tr>
<td>5) English-AV</td>
<td>signal-average</td>
<td>second-highest bid (clock at last drop-out)</td>
<td>18</td>
<td>1 (9)</td>
</tr>
<tr>
<td>6) Sophi-AV</td>
<td>signal-average</td>
<td>$\frac{b_{(2)} + b_{(3)} + b_{(4)}}{4}$</td>
<td>18</td>
<td>1 (15)</td>
</tr>
</tbody>
</table>

Table 1: Treatment Conditions

Treatment ‘Sophi-MR’ implements the Sophi auction in the mineral-rights model where the winner’s payment is the average of the second-highest report and the lowest report. This auction is efficient in the sense of making only minimal use of bidders’ reports. To see if minimal use matters, treatments 3 and 4 employ a modified Sophi auction that uses all reports for setting the price. In both of the modified Sophi auction treatments, ‘Sophi-All-MR’ and ‘Sophi-All-MR2’, the price is given by the average of all reported signals, after replacing the highest report by the second-highest one, which also induces sincere bidding (Proposition 3).

A comparison of the payment rules used in treatments ‘Sophi-MR’ and ‘Sophi-All-MR’ and displayed in table 1 shows that the price set in the modified Sophi auction of treatment ‘Sophi-All-MR’, with the same set of reports, is always higher than that in the Sophi auction used in
'Sophi-MR' due to the inclusion of higher reports in the former. With the same parametrization of the common-value model this puts bidders in treatment 'Sophi-All-MR' at a disadvantage and biases comparisons of bidders’ payoffs and the frequencies of the Winner’s Curse. To address this bias treatment 'Sophi-All-MR2' implements a slightly modified parameterization of the common-value model such that the expected earnings of bidders in this treatment are equal to those in treatments 'English-MR' and 'Sophi-MR'.

The treatment 'Sophi-All-MR' that implements the basic parametrization of the common-value information structure used in all other treatments allows us to study if equilibrium deviations, particularly overbidding, is affected by the minimal use of bidders’ reporting. Likewise a comparison of equilibrium deviations in 'Sophi-All-MR' to those in 'Sophi-All-MR2' allows us to evaluate if the modification of the information structure’s parameterization affects bidding behavior in a substantial way. Moreover, the comparison allows to test the comparative-statics prediction that the seller revenue is higher under the Sophi-All auction.

3.2 Basic Setup and Procedures

To facilitate comparisons to the literature on common-value auctions our experimental design closely follows the setup of Kagel and Levin (1986) and Levin, Kagel, and Richards (1996) that implemented the mineral-rights model and studied the first-price auction and the English auction. In each of our treatments subjects were randomly matched into auction groups and bid for a fictitious object with a pure common-value. If the number of participants did not allow all bidders to be matched for an auction group, then some participants were assigned the status of inactive bidders. We employed a rotation rule to minimize the frequency of any subject’s inactivities. There were four bidders in each auction group in market periods 1-20. If there were sufficiently many non-bankrupt subjects left at the end of market period 20, there were up to 10 more market periods in groups of seven bidders.

In all of our treatments except for treatment 'Sophi-All-MR2' the center of signals is uniformly distributed on interval $[50, 250]$ and, conditional on the realized center $c$, private signals are uniformly distributed around it on $[c - 18, c + 18]$. In treatment 'Sophi-All-MR2' the domain of private signals was extended to $[c - 36, c + 36]$ to correct the earnings bias and the center of signals was drawn from $[25, 275]$ to avoid an excessive amount of boundary data. Before the experiment we randomly generated all common-values and private signals that were used in the experiment. We used different series of the information structure in each session of a treatment, but used the same set of series across treatments to improve comparisons across treatments.

The number of subjects per session was fifteen on average and varies between twelve and seventeen due to variation in the show-up rates across sessions. We admitted all shown-up subjects to the experiment to have as much data as possible. Note that the possibility of uncontrolled bankruptcies in our experiment leads the number of subjects participating in an experimental session to change over the course of the experiment in a session-specific way even with the same subject numbers at the beginning of the sessions.

Subjects were randomly allocated to their cubicles and received written instructions at the beginning of any experimental session. After all subjects in a session finished reading instructions they participated in two trial rounds to make themselves more familiar with the auction situation.
and the computer interface. The common-values and private signals used in both trial periods were the same in each session; in the treatment ‘Sophi-All-MR2’ we used appropriately scaled parameters to account for the modification of the information structure. After the conclusion of the trial periods, there were twenty market periods in groups of four bidders and then up to another ten market periods in groups of seven bidders if possible.

All experimental sessions were conducted in the Behavioral and Experimental Laboratory (BEElab) at Maastricht University. In total, there were 254 participants in the experiment. The sessions required between 60 and 90 minutes of time. The appendix provides the translated instruction and sketches of the input and feedback screens. In each session, a show-up fee of 4 EUR was paid and subjects were given a starting balance of 10 EUR to cover some losses except for treatment ‘Sophi-All-MR2’ where the starting balance was increased to 20 EUR to account for the larger domain of signals that can imply larger losses in equilibrium. At the end of each market period, subjects’ winnings and losses were added to their balance. If the balance dropped into the negative during the experiment, subjects were excluded from the experiment and paid the show-up fee. All subjects with a non-negative balance were paid their capital balance at the end of the experiment in cash where 1 Experimental Currency Unit was worth 1 Euro. The experiment was fully computerized and programmed and conducted with the software z-Tree (Fischbacher, 2007).

3.3 Equilibrium Bid Predictions

In all treatments with any Sophi auction, the equilibrium bid is equal to a bidder’s signal. In the English auction equilibrium bidding behavior is more complicated as information is revealed throughout the auction. Specifically a bidder drops out of the auction at a clock price equal to the expected common value conditional on all observed signals during the bidding process that are inferred from the dropping behavior of the competitors. Specifically equilibrium drop out values, that we also refer to as bids, under the uniform distribution in the region where $a + \varepsilon < x_n < x_1 < b - \varepsilon$ (with $a \in \{25, 50\}$, $b \in \{250, 275\}$, and $\varepsilon \in \{18, 36\}$ depending on the treatment) are given by

$$d_n(x_n) = x_n$$

for bidder $n$ with the lowest signal dropping first and

$$d_i(x_i) = \frac{d_n + x_i}{2}$$

for any other bidder.

4 Experimental Results

We present the analysis of our laboratory data as follows. We begin with providing an overview of the aggregated Winner’s Curse data. Then we proceed to exploring differences between treatments in more detail. For the data analysis we have discarded all auction data where the signal of at least one of the bidders in any auction is sufficiently close to the boundaries of the common-value’s support such that the signal’s vicinity to the boundary allows to update the
expected common-value.\textsuperscript{2} The number of auctions remaining for data analysis is reported in parentheses below the treatments’ names in Table 2.

4.1 Overview of Winner’s Curse Data

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual profits</td>
<td>2.24</td>
<td>0.43</td>
<td>-0.31</td>
<td>4.33</td>
<td>2.49</td>
<td>-1.18</td>
</tr>
<tr>
<td>Equilibrium profits</td>
<td>2.59</td>
<td>3.10</td>
<td>1.16</td>
<td>2.84</td>
<td>1.49</td>
<td>1.39</td>
</tr>
<tr>
<td>Auction share with negative exp.profits</td>
<td>0.35</td>
<td>0.48</td>
<td>0.54</td>
<td>0.35</td>
<td>0.41</td>
<td>0.65</td>
</tr>
<tr>
<td>Share: bid &gt; $E[V</td>
<td>x]$ (winning bid)</td>
<td>0.42</td>
<td>0.62</td>
<td>0.57</td>
<td>0.51</td>
<td>0.47</td>
</tr>
<tr>
<td>(lowest bid)</td>
<td>(0.99)</td>
<td>(0.99)</td>
<td>(0.99)</td>
<td>(0.95)</td>
<td>(1.00)</td>
<td>(1.00)</td>
</tr>
<tr>
<td>Bankruptcy share</td>
<td>0.27</td>
<td>0.40</td>
<td>0.40</td>
<td>0.30</td>
<td>0.22</td>
<td>0.27</td>
</tr>
<tr>
<td>Share periods ‘out’</td>
<td>0.13</td>
<td>0.24</td>
<td>0.22</td>
<td>0.11</td>
<td>0.14</td>
<td>0.11</td>
</tr>
<tr>
<td>Auction share won with high signal</td>
<td>0.58</td>
<td>0.64</td>
<td>0.63</td>
<td>0.65</td>
<td>0.41</td>
<td>0.65</td>
</tr>
<tr>
<td>Average bid</td>
<td>-</td>
<td>150.2</td>
<td>146.7</td>
<td>141.4</td>
<td>-</td>
<td>135.1</td>
</tr>
<tr>
<td>Equilibrium bid</td>
<td>-</td>
<td>146.0</td>
<td>144.2</td>
<td>140.9</td>
<td>-</td>
<td>131.8</td>
</tr>
</tbody>
</table>

Table 2: Winner’s Curse Aggregate Statistics

Table 2 reports various Winner’s Curse statistics. Since we want to study the mitigation of the Winner’s Curse it is essential to create it in our benchmark treatments. The third row of the table shows the share of auctions where the auction price exceeds the expected common value conditional on the signal realization so that the expected (bidder) profit is negative. As expected for the English auction, observed bidding behavior leads to negative expected bidder profits in 35\% of the auctions in the mineral-rights model (English-MR) and in 41\% of the auctions in the average-signals model (English-AV). Similarly the actual profits accruing to an auction winner on average (first row) in the English auction falls short of the equilibrium predictions in the mineral rights model (second row). The abundancy of the Winner’s Curse in terms of negative profits also reflects in our bankruptcy data. The seventh row displays the share of bidders that went bankrupt over the course of the major part of the experiment, periods 1-20, with four bidders. In both common-value models around a quarter of subjects went bankrupt in the English auction and the share of periods that bankrupt subjects could not participate in due to their exclusion from the experiment was 13\% in the mineral-rights model and 14\% in the average-model as shown in the eigth row.

Looking at the corresponding statistics for the Sophi auction (Sophi-MR and Sophi-AV) shows that the Winner’s Curse is alive and well there, too; in fact, it is much stronger than

\textsuperscript{2}Specifically we discard the data for any auction where for at least one of the bidders $i$ the signal satisfies $x_i - \varepsilon < 50$ or $x_i + \varepsilon > 250$. In treatment Sophi-All-MR the common-value boundaries of 50 and 250 are replaced by 25 and 275.
expected. Comparing the statistics obtained for the Sophi auction to these of the English auction in either common-value model shows that the English auction fares better in overcoming the Winner’s Curse. E.g., the share of auctions with negative expected bidder profits is 35% in English-MR but 48% in Sophi-MR and 41% in English-AV as compared to 65% in Sophi-AV.

The aggregate statistics on bidding behavior suggest that the reason why the Sophi auction does worse than the English auction in overcoming the Winner’s Curse may be due to larger bids relative to the expected common value under the Sophi auction. Specifically the share of bids exceeding the expected common value, displayed in the fourth row of the table, is larger in the Sophi auction, 62% in Sophi-MR and 60% in Sophi-AV, than in the English auction where it is 42% in English-MR and 47% in English-AV. When moving from the Sophi auction to the Sophi-All auction the share of bids exceeding the expected common values drops somewhat. This points into the direction that bidding behavior is, perhaps, somewhat closer to the equilibrium when computing the auction price as the average of all bids, after replacing the highest one by the second-highest, in the treatments Sophi-All-MR and Sophi-All-MR2. We explore overbidding relative to equilibrium bidding further below.

There is one sense in which bids in any of the Sophi auctions are closer to equilibrium bids than bids in the English auction. Under any of these auction formats, the equilibrium bid function is monotonic increasing so that the bidder with the highest signal wins the auction in equilibrium. The ninth row of the table summarizes the share of auctions where the bidder with the highest signal won the auction in the experiment. As can be seen, the bidder with the highest signal wins the auction more often in any of the Sophi auctions as compared to the corresponding English auction treatment.

The second line of the table shows the profit that an auction winner receives on average in equilibrium. In line with the comparative-statics predictions of increasing seller revenue, i.e. decreasing bidder profits, when moving from the Sophi auction to the Sophi-All auction that computes the winner payment as the average over all bids after bid replacement, the auction winner’s actual profits in the experiment are lower on average in treatment Sophi-All than in treatment Sophi-MR (first row). Similarly the comparative-statistic prediction of decreasing seller revenue, i.e. increasing bidder profits, when moving from treatment Sophi-All-MR to treatment Sophi-All-MR2 is born out by the data. Stunningly the average bidder profit that bidders received in treatment Sophi-All-MR2 exceeds that equilibrium prediction by roughly 150%.

Next we formally test for treatment differences regarding the Winner’s Curse. We quantify the severity of the Winner’s Curse as the expected winner profit conditional on actual bidding. In the mineral rights model with four bidder we have:

$$\pi^W(\bar{x}, x) := E[CV|x] - (\bar{x}_2 + \bar{x}_4)/2.$$  

To see if there are any treatment differences we regress the expected winner profit $\pi^W_\tau$ in auction trial $\tau$ on treatment dummy variables that indicate in which treatment the expected winner profit was observed with OLS. We use the English auction as the benchmark auction in the regression. The regression equation is

$$\pi^W_\tau = \beta_0 + \beta_1 I_{\text{Sophi-MR}}^\tau + \beta_2 I_{\text{Sophi-All-MR}}^\tau + \beta_3 I_{\text{Sophi-All-MR2}}^\tau + \nu_\tau$$  

(1)
Table 3 provides the regression results.

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>coefficient $\beta$</th>
<th>$\sigma_\beta$</th>
<th>$t$</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.939</td>
<td>0.539</td>
<td>5.45</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Sophi-MR</td>
<td>-2.227</td>
<td>0.832</td>
<td>-2.68</td>
<td>0.008</td>
</tr>
<tr>
<td>Sophi-All-MR</td>
<td>-2.899</td>
<td>0.787</td>
<td>-3.73</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Sophi-All-MR2</td>
<td>1.437</td>
<td>1.282</td>
<td>1.12</td>
<td>0.263</td>
</tr>
</tbody>
</table>

Table 3: Regression results of equation 1

As can be seen from the table, bidders’ profits per auction are significantly smaller in treatments Sophi-MR and Sophi-All-MR than in the English auction. Further we do not find any significant difference in bidders’ profits between treatments English auction and Sophi-All-MR2.

4.2 English-MR vs Sophi-MR

The Sophi auction intends to allow bidders that ignore the adverse selection effect overcoming the Winner’s Curse through simple sincere bidding. The Winner’s Curse statistics given in Table 2 show that we observed the opposite in the experiment. The Sophi auction fares worse than the English auction in both common-value models. E.g., bidders in the treatment English-MR earned on average 2.24 EUR per auction as compared to 0.43 EUR in Sophi-MR. This pronounced difference in winner earnings is particularly striking since both auction formats are price equivalent for each realization theoretically. By the hypothesized mitigation of the Winner’s Curse with the Sophi auction we expected to find the opposite ranking via less equilibrium deviations, lower prices, and, hence, higher bidder profits in the Sophi auction. To uncover why the data is inconsistent with our hypothesis we explore the determination of prices in both of these auctions in the data in more detail. We begin with the mineral-rights model.

Recall that in the mineral-rights model the equilibrium price under either auction format, English or Sophi, is the average of the second-highest signal and the lowest signal. The Sophi auction’s payment rule computes this average directly and sincere bidding ensures that bids equal signals. In the English auction the determination of the equilibrium price is more involved as the equilibrium relies on the lowest bidder dropping at his signal and on every other bidder dropping at the average of the lowest observed bid, which is the lowest signal, and the own signal value; with this equilibrium dropping strategy the second-highest bidder drops at the average of her (the second-highest) signal and the lowest signal giving the same price as in the Sophi auction. Since the price is predicted to be the same in either auction for each realization of signals, we can use deviations from equilibrium bidding to trace back the differences in earnings to differences in bidding behavior while controlling for differences in common-value realizations.

Ideally we would compare the distributions of equilibrium bid deviations observed in either treatment. Unfortunately this is not possible since the highest bid cannot be observed in the English auction because the auction ends with the second-highest bidder dropping out of the auction. Instead we compare the censored distributions of equilibrium deviations where we obtain the one for the Sophi-MR by dropping the high bid in each auction. We refer to a positive equilibrium deviation, a bid exceeding its equilibrium prediction, as overbidding. Figure
Figure 1: Censored overbidding distributions in treatments English-MR and Sophi-MR (n = 4)

1 depicts the censored distributions for both treatments. The comparison of distributions clearly shows that there is much more overbidding under the Sophi-Auction; a comparison with the Kolmogorov-Smirnov test indicates that the difference is highly significant, \( p < 0.001 \). The average (censored) overbid is -0.81 EUR in English-MR and 2.09 EUR in Sophi-MR where the difference is significant (\( t \)-test, \( p < 0.001 \); Mann-Whitney-\( U \) test, \( p < 0.001 \); two-tailed).

4.3 Overbidding with the Sophi Payment Rules

We have observed an increase in overbidding relative to the equilibrium bid when moving from the English auction to the Sophi auction. The increase in overbidding is consistent with the explanation the subjects may be under the erroneous impression, similarly to overbidding in second-price private value auctions, that increasing the bid beyond the signal would increase the probability of winning the auction, a necessary condition for making a profit, at little cost as the payment required is the average of two bids, the lowest one and the second-highest one. The non-minimal rule partly addresses this problem by basing the price on the average of all signals, after replacement of the high bid. Therefore the increase in price by basing it on more higher bids than only the lowest bid could mitigate the overbidding bias. Here we compare overbidding data across Sophi treatments and test this overbidding-reduction hypothesis.

To facilitate the comparison of overbidding data across Sophi treatments we normalize overbidding relative to the signal range since the signal range parameter varies across treatments, \( \varepsilon \in \{18, 36\} \). The normalized overbid of bidder \( i \) in auction trial \( \tau \) is given by

\[
d_{i\tau} := \frac{b_{i\tau} - x_{i\tau}}{2\varepsilon_{\tau}}.
\]

Figure 2 shows the time paths of the quartiles of normalized overbidding in the experiment over the course of the experiment for the Sophi treatments. (If a marker is missing such as in period 2 in the treatment Sophi-All-MR2, then this is because all auction data is classified as boundary
data.) Clearly the large majority of bidders in the Sophi-MR treatment repeatedly submitted bids exceeding the signal value. In comparison, the less efficient payment rules of Sophi-All-MR and Sophi-All-MR2 seem to induces less overbidding. Furthermore equilibrium deviations seem to increase in the last five rounds of the experiment in the treatments Sophi-All-MR and Sophi-All-MR2.

![Figure 2: Normalized overbidding quartiles in the Sophi treatments.](image)

To formally confirm that non-minimal payment rules yield less overbidding, reducing the overbidding bias as compared to the Sophi auction, we regress normalized overbids on dummy variables that indicate if the observation was generated in a treatment using the non-minimal payment rule (treatments Sophi-All-MR and Sophi-All-MR2) and on a dummy variable indicating if the observation was obtained in the treatment Sophi-All-MR2. This specification of dummy variables allows us to quantify any general effect of non-minimal payment rules on overbidding. The coefficient of treatment Sophi-All-MR2 allows to test if there is a treatment-specific change of overbidding when in the treatment Sophi-All-MR2. We estimate the following regression equation by OLS,

\[ d_{it} = \beta_0 + \beta_1 I_{it}^{\text{Non-minimal}} + \beta_2 I_{it}^{\text{Sophi-All-MR2}} + \nu_{it} \]  

where the dependent variable is the normalized overbid of bidder \( i \) in auction trial \( t \). Table 4 summarizes the regression results and shows that there is significantly less overbidding with the
non-minimal payment rules thus reducing the overbidding.

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>coefficient $\beta$</th>
<th>$\sigma_\beta$</th>
<th>$t$</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.117</td>
<td>0.014</td>
<td>8.15</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Non-minimal payment rule</td>
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<td>0.019</td>
<td>-2.41</td>
<td>0.016</td>
</tr>
<tr>
<td>Sophi-All-MR2</td>
<td>-0.064</td>
<td>0.029</td>
<td>-2.21</td>
<td>0.027</td>
</tr>
</tbody>
</table>

Table 4: Regression results of equation 2

5 Concluding Remarks

In this paper we introduced payment rules that induce sincere bidding in a common value framework to address the adverse selection problem that bidders face. The payment rules inducing sincere bidding are not unique and can differ in the amount of bidder-reported information used for setting the price. We find that the minimal payment rule (Sophi auction) fares worse in overcoming the Winner’s Curse than the English auction since the Sophi auction induces more overbidding. We also find that the non-minimal payment rules (Sophi-All) reduce the overbidding bias and lead to higher bidder profits after correcting for the revenue advantage and can match the performance of the English auction.
A Appendix

A.1 Experimental Procedures

Participants were recruited by email and could register for the experiment on the internet. At the beginning of the experiment participants were assigned to their cubicles randomly. Then they received written instructions about the experiments. The experiment was computerized using the software z-Tree (Fischbacher, 2007). After treatment, participants answered a short on-screen questionnaire and were paid their earnings in cash.

A.2 Instructions

The instructions of the pilot experiment are in German. In the following we provide a translation to English.

A.2.1 General information for participants

You are participating in a scientific experiment that is sponsored by the research institute METEOR and the National Science Foundation. If you read the following instructions carefully then you can – depending on your decisions – gain a considerable amount of money. It is, hence, very important that you read the instructions carefully.

The instructions that you have received are for your private information only. During the experiment no communication is permitted. Whenever you have any question, please raise your hand. We will then come to you and answer your question at your seat. Not following this rule leads to the exclusion from the experiment and all payments.

During the experiment we do not talk about Euro, but about ECU (Experimental Currency Unit). Your entire income will be determined in ECU first. The total amount of ECU that you will have obtained during the experiment will be converted into Euro and paid to you in cash at the end of the experiment. The conversion rate will be shown on your screen at the beginning of the experiment.

A.2.2 Information regarding the experiment

Today you are participating in an experiment on auctions. The experiment is divided into separate rounds. In the following we explain what happens in each round.

1. In each round you are a buyer and bid for a fictitious object that is auctioned off. Next to you, another three participants bid for the same object. There are, hence, four bidders in total in your auction in each round. In each round you will be allocated randomly with three other participants for the auction, so that your co-bidders change randomly in each round.

2. The precise value of the object at the time you make your bids will be unknown to you and any other bidder. Instead, each of you will receive information as to the value of the object which you should find useful in determining your bid since it allows
you to narrow down the value of the object. The process of determining the value of the object and the information you will receive about it will be described in sections 6 and 7 below.

3. The high bidder gets the object and receives a round income equal to the difference between the value of the object and the price of the object, that is:

\[
\text{round income of the high bidder} = \text{value of the object} - \text{price of the object}
\]

[In Sophi instructions: The price of the object is equal to the average of the second-highest bid and the smallest bid.

Example: If the second-highest bid is 150 ECU and the smallest bid is 130 ECU, then the price of the object is 140 ECU since this is the average of the second-highest bid and the smallest bid, \((150 + 130) : 2 = 140\) ECU. ]

[In SPA instructions: The price of the object is equal to the second-highest bid. ]

Caution: If the price is greater than the value of the object, then the round income is negative so that the high bidder makes a loss.

If you do not make the high bid, your round income is 0 ECU, so that your income from the experiment neither increases nor decreases from bidding in the auction.

4. You will be given a starting capital balance of 10 ECU at the beginning of the experiment. Any profit earned by you will be added to this sum, and any losses incurred will be subtracted from this sum. At the end of the experiment, the net balance of these transactions will be converted into Euro and paid to you in cash.

The starting capital credit balance, and whatever subsequent profits you earn, permit you to suffer losses in one auction to be recouped in part or in total in later auctions. However, should your net balance at any time during the experiment drop to zero or even less, you will no longer be permitted to participate. Instead we will give you your show-up fee of 4 EUR and you have to leave the experiment. (Of course, you are permitted to submit bids in excess of your capital credit balance.)

5. After all bidders have submitted their bids, you will be shown all bids, the price of the object, and the value of the object on the screen. We will also show you whether a profit or loss was earned by the high bidder.

6. The value of the auctioned object \((W)\) will be assigned randomly and will lie between 50 and 250 ECU (including 50 and 250). The value of the object is the same for any bidder. For each auction, any value within this interval has an equally likely chance of being drawn. The value of the object can never be less than 50 ECU or more than 250 ECU. The object values \(W\) are determined randomly and independently in each auction. As such a high \(W\) in one round tells you nothing about the likely value in the next round whether it will be high or low. It doesn't even preclude drawing the same \(W\) value in later rounds.

7. Private information about the value of the object:

Although you do not know the precise value of the object at the time of bidding, you
will receive information which will narrow down the range of possible values of the object. **This will consist of a signal value which is selected randomly from all values between** $W - 18$ **and** $W + 18$. **Any value within this interval has an equally likely chance of being drawn and being assigned to one of you as your signal value.**

Example: Suppose that the value of the auctioned item is 128.16 ECU, then each of you will receive a signal value which will consist of a randomly and independently drawn number that will be between 110.16 ECU ($= W - 18 = 128.16 - 18$) and 146.16 ECU ($= W + 18 = 128.16 + 18$). Any number in this interval has an equally likely chance of being drawn. The diagram illustrates this example geometrically.

As an example, the following six signal values were randomly selected by the computer for illustration ($W = 128.16$ ECU):

116.21 ECU, 129.05 ECU, 124.83 ECU, 141.71 ECU, 124.74 ECU, 131.57 ECU.

You will note that some signal values were above the value of the auctioned object, and some were below the value of the object. Over a sufficiently long series of signal values, the average of the signal values will equal the value of the object (or will be very close to it). **For any given signal value, however, your signal value is most likely either above or below the value of the object.**

Please also note that the selection of signal values is such that the value of the object must always be larger than or equal to your signal value minus 18 and be smaller than or equal to your signal value plus 18. The interval of object values that are possible with your signal value will be show to you on the screen at the time of bidding.

You may receive a signal value below 50 ECU (or above 250 ECU). This is no problem with the software, but indicates that the value of the object is close to 50 ECU (or 250 ECU) relative to the interval width of ±18 ECU.

8. At the time of bidding you know your own signal value only. **The signal values of all other bidders are unknown to you.** Similarly any other bidder knows his/her own signal value only and not the signal value of anyone else. After all bidders have submitted their bids, you will be shown all of the signal values drawn along with the bids on the screen.

9. Please note that any bid less than 0 ECU and any bid exceeding 500 ECU will not be accepted. Any bid in between these two values is acceptable. Bids must be rounded to the nearest cent to be accepted. In case of ties for the high bid, chance determines who will receive the object.
10. Every participant will receive, in addition to the earnings from the experiment, a show-up fee of 4 EUR.

11. In case it is not possible to allocate all participants in groups of four, at most three participants will be designated as "inactive bidders". The designation of "inactive bidders" follows a rotation rule that keeps the number of rounds as an inactive bidder per participant over the course of the experiment as small as possible. All participants that are designated as inactive bidders in any given round will be informed about it before bidding in the corresponding round; all participants that are not informed about it are designated "active bidders" where all rules apply as described above. Inactive bidders will receive a signal value, will submit a bid, and will be shown the outcome of a randomly chosen auction with active bidders. Further, inactive bidders will receive a round income of 0 ECU.

**Summary of the main points:**

1. The high bidder wins the auction and earns the value of the object minus the price of the object as round income.
2. The price of the object equals the (only in Sophi instructions: average of the second-highest and the smallest bid) [only in SPA instructions: second-highest bid.]
3. Profits will be added to your starting balance of 10 ECU, losses subtracted from it. Your balance at the end of experiment will be converted in Euro and paid in cash. If your balance turns negative at any time during the experiment, you are no longer allowed to bid.
4. Your private signal value is randomly drawn and lies between \((W - 18)\) ECU and \((W + 18)\) ECU. The value of the object can never be smaller than your signal value–18 or greater than your signal value+18.
5. The value of the object will always lie between 50 ECU and 250 ECU.

A.2.3 Screens

The next two pages sketch the input screen and the feedback screen used in the experiment.
The object value is unknown to you and lies between 50 and 250 ECU.

The object value is also unknown to any of the other 3 bidders.

To narrow down the object value, you receive a signal value that lies between (object value-18) and (object value+18).

To narrow down the object value, any of the other bidders receives a signal value between (object value-18) and (object value+18).

Your randomly determined signal value for this auction is: 155.14

Therefore, the object value of this round cannot be smaller than your (signal value-18) = 137.14 ECU

Therefore, the object value of this round cannot be greater than your (signal value+18) = 173.14 ECU

Please submit your bid for the auctioned object: 155.14

Please note: Your income in this round if you submit the high bid is: Income = ( object value - price ) ECU

[Only in Sophi auction treatments: ] The price is equal to the average of the second-highest bid and the lowest bid.

[Only in second-price auction treatment: ] The price is equal to the second-highest bid.

Your income in this round if you do not submit the high bid is: Income = 0 ECU.
The object value is unknown to you and lies between 50 and 250 ECU.

The object value is also unknown to any of the other 3 bidders.

To narrow down the object value, you receive a signal value that lies between (object value-18) and (object value+18).

To narrow down the object value, any of the other bidders receives a signal value that lies between (object value-18) and (object value+18).

Your randomly determined signal value for this auction is: 155.14

Therefore, the object value of this round cannot be smaller than your (signal value-18) = 137.14 ECU

Therefore, the object value of this round cannot be greater than your (signal value+18) = 173.14 ECU

Please submit your bid for the auctioned object:

Please note:

Your income in this round if you submit the high bid is: Income = ( object value - price ) ECU

[Only in Sophi auction treatments: ] The price is equal to the average of the second-highest and the lowest bid.

[Only in second-price auction treatment: ] The price is equal to the second-highest bid.

Your income in this round if you do not submit the high bid is: Income = 0 ECU.

<table>
<thead>
<tr>
<th>All bids</th>
<th>All signal values</th>
</tr>
</thead>
<tbody>
<tr>
<td>190.00</td>
<td>159.89</td>
</tr>
<tr>
<td>160.00</td>
<td>143.64</td>
</tr>
<tr>
<td>155.14</td>
<td>155.14</td>
</tr>
<tr>
<td>145.00</td>
<td>160.99</td>
</tr>
</tbody>
</table>

[If high bidder:] You submitted the high bid of 190.00 ECU and receive the fictitious object.

[If not high bidder:] Your bid of 155.14 ECU is lower than the high bid of 190.00 ECU, so that you do not receive the fictitious object.

In this round, the object value is 160.59 ECU

The price of the object is 152.50 ECU.

[If Sophi auction:] This is the average of the second-highest bid (160.00 ECU) and the lowest bid (145.00 ECU).

[If second-price auction:] This is the second-highest bid (160.00 ECU).

[If not high bidder] In this round, the high bidder made a profit[or: loss] of 8.09 ECU.

[If high bidder:] Your income in this round = object value - price = 160.59 - 152.20 = 8.09 ECU.

[If not high bidder:] Your income in this round = 0 ECU.

[If high bidder] In this round you made a profit that increases[or: loss that decreases] your ECU account balance.

[If not high bidder:] In this round you neither made a profit nor a loss so that your ECU account balance does not change.

[If not high bidder:] Your [if not high bidder: old and] new ECU account balance amounts to 18.04 ECU.

Go on!
### A.2.4 Average Actual Profits

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average actual profits (std. dev.)</th>
<th>Average profits with equil. bids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-20</td>
<td>1-10</td>
</tr>
<tr>
<td>(Rds.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) English-MR</td>
<td>2.24</td>
<td>1.26</td>
</tr>
<tr>
<td></td>
<td>(8.56)</td>
<td>(8.51)</td>
</tr>
<tr>
<td>2) Sophi-MR</td>
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<tr>
<td></td>
<td>(9.82)</td>
<td>(7.83)</td>
</tr>
<tr>
<td>3) Sophi-All-MR</td>
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<td>(8.81)</td>
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<td>(3.50)</td>
<td>(4.12)</td>
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Table 5: Average Actual Profits of Bidders per Auction in EUR
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