Implementing the Efficient Auction: Initial Results from the Lab

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Abstract

The *efficient auction* is designed to induce truthful bidding for bidders with affiliated values. Herein we implement the auction in the lab, and observe that inexperienced people can bid systematically in this more complex environment, albeit yielding a flatter bid function than the truthful one.

Key Words: auction, affiliation, experiments, valuation

JEL Classification Numbers: C9, D44

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Michael Margolis and Jason F. Shogren*

1. Introduction

Over the past two decades, Vickrey's (1961) second-price auction has been widely used in the lab to elicit values for private value goods like neoteric food products.[1] The auction is demand revealing and efficient in theory, is relatively simple to explain to people (for example, highest bidder wins, pays second-highest bid), and each person's bid depends only on his or her own value for the good rather than on every bidder's value, as in first-price auctions.[2] But if bidders have *affiliated values* over a good—that is, if the value to one bidder depends in part on information available only to some other bidders—then the auction is neither demand revealing nor efficient (Milgrom and Weber, 1982; McAfee and McMillan, 1987). Affiliated value auctions occur, for example, in the sale of oil drilling rights, in which each firm has its own information and the winner's ultimate costs could best be estimated if all information were pooled (Porter, 1995).

Dasgupta and Maskin (2000) address the problem posed by affiliated values by constructing a clever generalization of the Vickrey auction. In their *efficient auction*, each bidder expresses his or her bid as a function of what other bidders say (unverifiably) about their private information. The auctioneer takes these contingent bids and calculates each bidder's bid, then determines the high bidder and the price, which is based on all bid functions other than the high

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[1] Lab auctions have been used to value neoteric agricultural and commercial products prior to field marketing such as genetically modified products, irradiated food products, safer food, growth-hormone-treated meat and dairy products, vacuum-packaged meat, and fresh foods and produce (see Shogren, 2004, for an overview). Affiliation might arise in these repeated auctions if posted prices transform independent private values into affiliated values because the prices signal potential common outside options or commonly perceived, but unknown, characteristics of the product (Harrison et al., 1995).

[2] Truthful bidding is the weakly dominant strategy. A person who underbids risks foregoing a profitable purchase; overbidding risks making an unprofitable purchase.

bidder. Given affiliation, the key is that the auction once again separates what bidders pay from what they say, such that efficiency is achieved—the bidder with highest value wins the auction.

An open question is how to implement the efficient auction, which is more complex to explain to bidders than the classic Vickrey auction. We say this because laboratory tests of the second-price auction reveal that bidders, especially inexperienced ones, frequently do not make rational bids at the individual level (see Kagel, 1995). If bidders have difficulty with the second-price auction, they might find the efficient auction even more challenging. Herein we examine an experimental design that implements the efficient auction in a one-shot, two-person setting. Recognizing that strictly rational behavior is unlikely, we purposefully set a low baseline and ask whether inexperienced bidders without feedback can do better than random. Overall, the results suggest our implementation of the efficient auction can induce systematic bidding behavior in a one-shot setting. Subjects, however, showed a strong tendency to bid near the *expected* value of the good, underweighting their private information relative to the optimal bid.

2. Experimental Design

To minimize subject confusion (given observed behavior in pilot tests), we do not ask bidders to submit a bid function; rather, we ask each bidder to submit two bids—one for the lowest value signal that might be received by the other bidder and another for the highest value signal. We then create a linear bid function (bidding line) by plotting the two bids on a chart and running a line from one to the other.[3] We explain the efficient auction to our inexperienced subjects in five steps—the resale value, bids, auction winner, auction price, and payoffs.[4] We describe each step below as if we are explaining it to the subject:

Step 1. Resale value. The resale value is the price the monitor will pay you to buy back the product. You will not know your resale value until the end of each round. At the beginning

[3] Nothing in the proof that the auction is efficient rules out constraint to linear bid functions (Dasgupta and Maskin, 2000).

[4] Exact experimental instructions appear in the appendix.

of the round, you will be given a piece of private information denoted *PvtInfo(You)*. This *PvtInfo(You)* will be determined randomly from a value between $1 and $20, in one dollar ($1) increments {1, 2, 3, …, 10, 11, 12, …, 18, 19, 20}. Each amount has an equal chance to be selected. The other bidder will also be given his or her private information, *PvtInfo(Other bidder)*. His or her *PvtInfo(Other bidder)* will also be determined randomly from a value between $1 and $20, in one dollar ($1) increments {1, 2, 3, …, 10, 11, 12, …, 18, 19, 20}. Each amount has an equal chance to be selected.

Your resale value is the sum of your private information and half the other bidder's information: *Resale Value(You)* = *$PvtInfo(You)* + [0.5 x *$PvtInfo(Other bidder)*]. For example, if your true private information is $5 and the other bidder's true private information is $20, your resale value is *Resale Value(You)* = $5 + [0.5 x $20] = $15; or if it is $11 for you and $12 for the other bidder, *Resale Value(You)* = $11 + [0.5 x $12] = $17. Overall, your resale value could range from a low of $1.50 ($1 for you, $1 for other bidder) to a high of $30 ($20 for you, $20 for other bidder). Likewise, the other bidder has a resale value that is determined by his or her true private information and your true private information.

Step 2. Bids. You will be asked to submit two bids once you receive your true private information. The other bidder is asked to do the same. Given your revealed *$PvtInfo(You)*:

Bid-Low(You) = $__________ If the *reported $PvtInfo(Other bidder)* = $1

Bid-High(You) = $__________ If the *reported $PvtInfo(Other bidder)* = $20

These two bids will be combined to create your bidding line (See Figure 1). For example, suppose *Bid-Low(You)* = $7, if the *reported $PvtInfo(Other bidder)* = $1; *Bid-High(You)* = $19, if the *reported $PvtInfo(Other bidder)* = $20. Likewise, the other bidder's bids are conditional on what you report as your private information. He or she will also create a bidding line based on your private information.

Step 3. Auction winner. The winner of the auction is determined by where the two bidding lines intersect (See Figure 2). If the two bidding lines intersect above the *bids are equal* line, then your bid is greater than the other player's and you win. If the bidding lines intersect below the line, then your bid is lower than the other player's, and he or she wins. The example in the figure shows that your bid is greater, so you win.

Step 4. Auction price. The auction price is then determined by what we call the sorting line (See Figure 3). The sorting line starts from the origin. If you win, your auction price is set by where the other player's bidding line intersects the sorting line. If the other player wins, his or her auction price is set by where your bidding line intersects the sorting line.

Step 5. Payoffs. Your payoff for the auction is then determined. If you win, your payoff for that round is: *Payoff(you win) = Resale Value(You) – Auction price*. If you lose, your payoff for that round is: *Payoff(you lose)* = $0.

3. Results

We are interested in two questions about our bidders' behavior. First, did they use truthful bid functions? Second, did the auctions produce efficient outcomes? A positive answer to the first question implies a positive answer to the second, but not the reverse—a positive answer to the second question does not imply a positive answer to the first.

A truthful bid function reveals both the bidder's private information and the dependence of his or her resale value on the other bidder. That means the low bid is equal to the bidder's private value, and the high bid is equal to what the bidder's resale value would be if the other bidder's private value is at the upper limit. Within each round, the only treatment that varies among subjects is the private information. In the context of regressing each bid on a constant term and private information, the hypothesis of efficient behavior is $\boldsymbol{\beta}^{L}=(\beta_{L},1)$ and $\boldsymbol{\beta}^{H}=(\beta_{H},1)$, where $\boldsymbol{\beta}^{i}$ denotes the regression coefficients for outcome $i \in \{Highbid, Lowbid\}$ and β_i is the product of the resale line slope and the top (H) or bottom (L) of the private information range, e.g., β_{H}=$10 in the Step 1 example.

Table 1 presents results of that regression. While our subjects' actual behavior is not perfectly described by the optimal bidding strategy, their bidding behavior was systematic. The first four columns present coefficient estimates for individual rounds (the first and fourth only in each of the two treatments). In each round, truthful bid hypothesis could be rejected in the OLS estimates for at least one of two bids, and in the SUR[5] estimates for the two bids combined. The final two columns present panel method estimates for the combined rounds in each session.[6] The truthful bidding hypothesis is not straightforward to test in the panel context because the β_i vary across rounds, but it is clear from the standard errors that the low bids are not optimal. The high bids are not statistically far from the optimum, but this seems to be an indication of noisy data. In no case is a coefficient tightly estimated near its optimal value.

In almost every sample and statistical treatment, the coefficient on private value is *below* one. The only exceptions are the high bids from the first session. This means that, in general, bidders did not respond as strongly as they should to their private signals; instead, they offered bids that were about what the average subject offers. While this behavior might indicate that bidders lacked confidence in their understanding of the auction and preferred to avoid behavior that appeared extreme, it is consistent with observed bidding behavior in the classic second-price auction (see Kagel, 1995). For example, Shogren et al. (2001) estimated regression lines flatter than the perfect-revelation line, with positive intercepts and slopes below unity for both the second-price auction and its variant, the random *n*th-price auction.

This imperfection of subjects' behavior need not, however, translate into inefficient outcomes. We assess the efficiency of the auction by (a) randomly pairing subjects within each round, (b) determining the winner, and (c) classifying the simulated two-player auction as efficient if the winner had the higher private value. We replicated this 500 times with resampling. Overall, 57.66 percent of the simulated auctions were efficient, with bootstrap standard errors of around 10% (see Table 2 for round by round results.) While subjects did not perform significantly better by bootstrap criteria, they performed better than a coin flip in every single round.

Overall, the results from this initial exploration suggest this relatively complicated auction can stay afloat in conditions involving inexperienced bidders and no feedback. If bidders gain experience through many trials and more information on payoffs through computer

[5] OLS stands for Ordinary Least Squares and SUR for Seemingly Unrelated Regression.

[6] We present the random effects for the first and fixed effects for the second because Hausman's test for the hypothesis maintained in random effects estimation was rejected for the second session only.

implementation, one can expect greater efficiency levels for the efficient auction. Given that the efficient auction works in the lab setting, it should also work in the "real world" with more reinforcement of rational bidding behavior.

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Figure 1. Bid Line

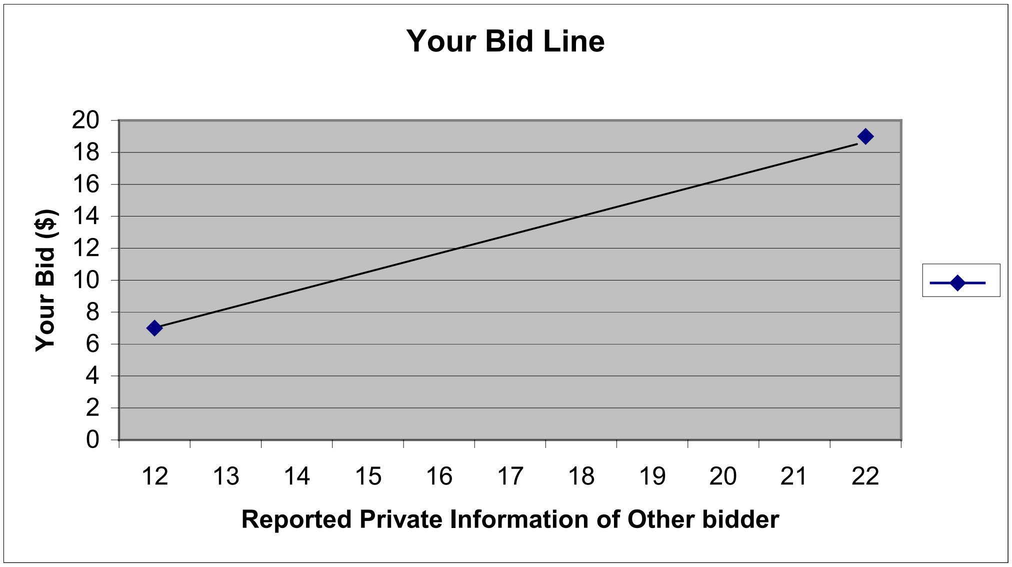

Figure 2. Bid functions and the determination of winner and loser

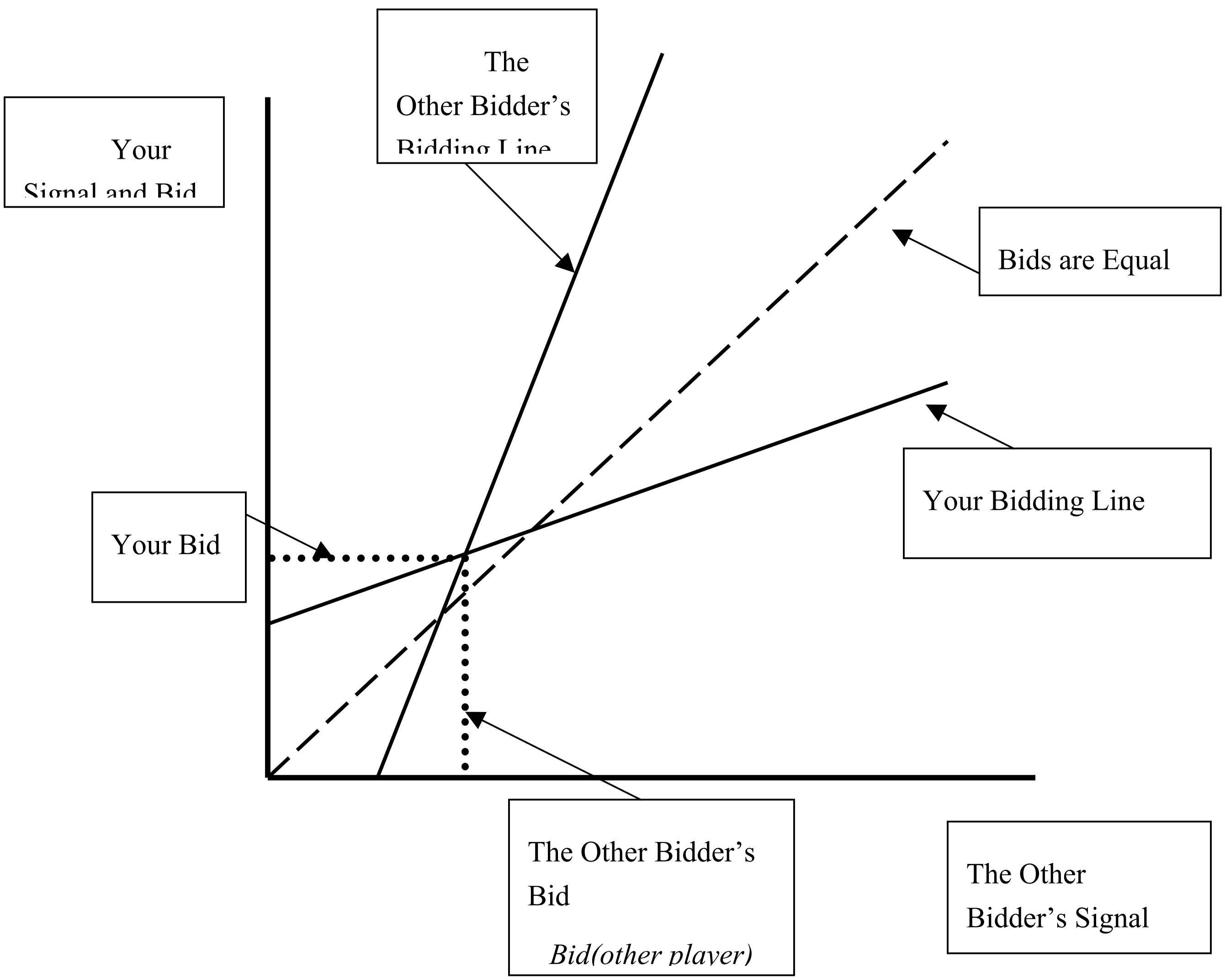

Figure 3. Determination of market price

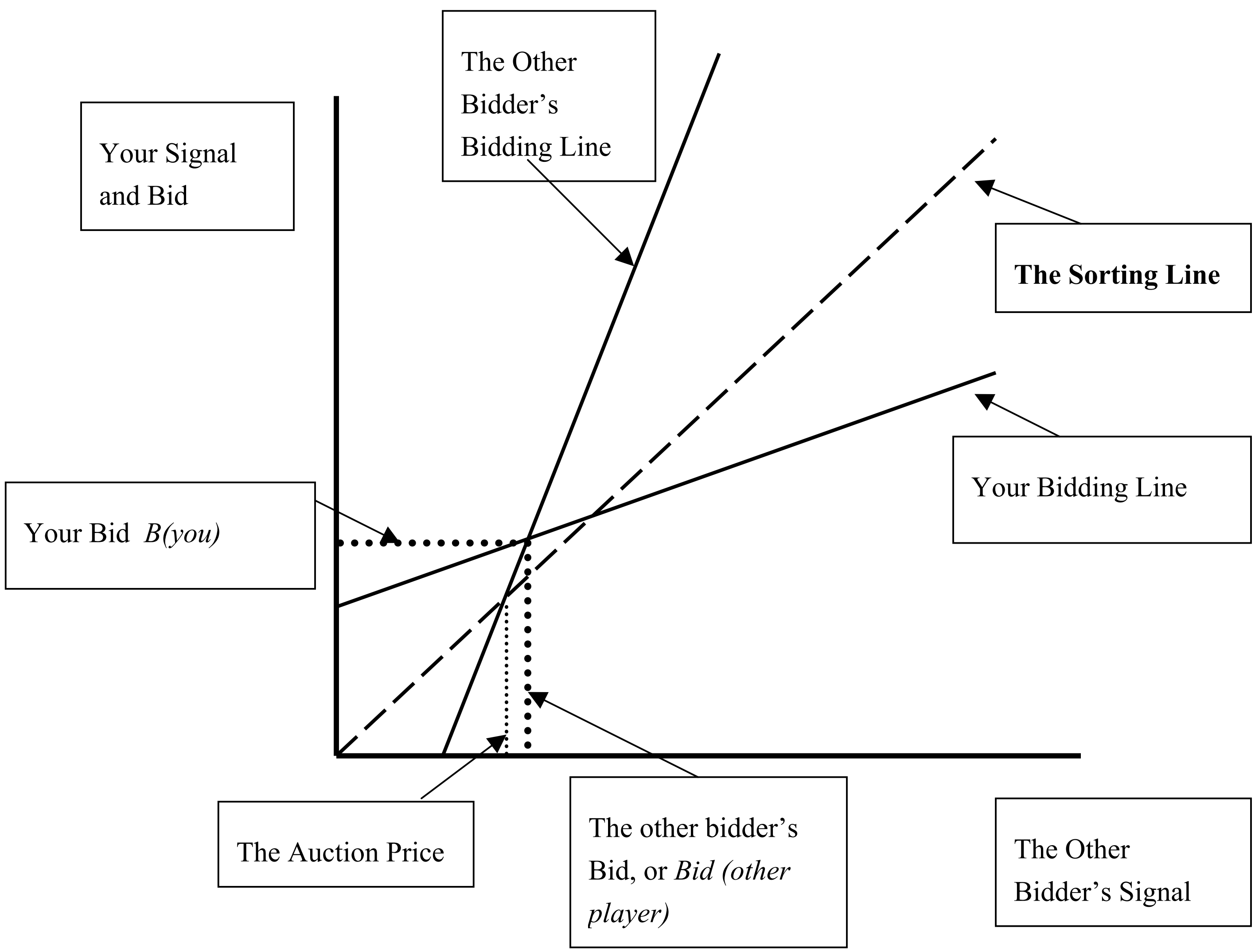

Table 1: Coefficients of regression of HIGHBID and LOWBID on PRIV (Private signal)

	0-1	0-4	1-1	1-4	0-RE	1-FE
HIGHBID						
Constant	0.165	-80.80	12.57	8.98	28.59	
	(7.77)1.	(157.51)	(1.88)	(0.929)	(21.1)	
PRIV	1.46	10.88	0.700	0.559	-0.1700	1.23
	(0.469)	(14.37)	(0.292)	(0.312)	(1.476)	(1.35)
LOWBID						
Constant	1.98	4.46	6.452	3.83	4.197	
	(7.15)	(3.69)	(1.82)	(0.805)	(1.28)	
PRIV	0.892	0.465	0.467	0.841	0.614	0.709
	(0.431)	(0.336)	(0.282)	(0.270)	(0.92)	(0.084)
TEST OF TRUTHFUL BID HYPOTHESIS						
HIGBID	$F_{2,50}$=8.44	$F_{2,50}$=0.87	$F_{2,50}$=0.63	$F_{2,50}$=6.84		
	p = 0.007	p=0.4268	p=0.536	p=0.002		
LOWBID	$F_{2,50}$=30.43	$F_{2,50}$=26.33	$F_{2,50}$=15.43	$F_{2,50}$=0.29		
	p = 0.000	p = 0.000	p = 0.000	p = 0.748		
SUR	χ^2_4=75.54	χ^2_4=58.72	χ^2_4=37.98	χ^2_4=17.07		
	p = 0.000	p = 0.000	p = 0.000	p =0.002		

Numbers in parentheses ( ) are the lowest estimated standard errors, i.e., SUR standard errors in Columns 1–4, GLS standard errors in Column 5, OLS standard errors in Column 6. Robust standard errors were approximately the same in all cases.

Table 2: Mean efficiency of simulated auctions

SESSION: ROUND	% Efficient	Bootstrap SE
0:1	0.564	0.091
0:2	0.512	0.095
0:3	0.581	0.099
0:4	0.559	0.099
1:1	0.587	0.092
1:2	0.604	0.097
1:3	0.568	0.101
1:4	0.639	0.093

APPENDIX: Experimental Instructions

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Instructions

Welcome. This is an experiment in decisionmaking that will take approximately an hour to complete. At the end of the experiment, you will be paid in cash for participating. How much you earn depends on your decisions and chance.

- **Please do not talk** and do not try to communicate with any other participants during the experiment. If you have a question, please raise your hand. Anyone who does talk to another participant during the experiment will be asked to leave and forfeit any moneys earned.
- You can leave the experiment at any time without penalty.

OVERVIEW:

- You are in an Auction for a product. The highest bid wins the auction.
- If you win the auction, you buy the product at the **Auction Price** and sell it back to the monitor at your **Resale Value.**
- Your **payoff** (total gain or loss) is
  - **Resale Value – Auction Price**
- If you lose the auction your payoff is zero.
- Your take-home pay at the conclusion of the experiment will be the sum of all your payoffs plus $10.

- There is one other bidder in each auction—you do not know who he or she is.
- There will be many rounds of the auction.
- In each round, you will be matched with a different other bidder.
- Everyone is receiving identical instructions, so you know that the other bidder's payoffs depend on you in the same way yours depend on him or her.

The auction has five parts that you need to understand:

Part I. Resale Value

RESALE VALUE. The resale value is the price the monitor will pay you to buy back the product.

- You will not know your Resale Value until the end of each round.
- At the beginning of the round, you will be given a piece of **Private Information** denoted *PvtInfo(You)*.
- This *PvtInfo(You)* will be determined randomly from a value between **$1 and $20, in one dollar ($1) increments {1, 2, 3, …, 10, 11, 12, …, 18, 19, 20}**. Each amount has an equal chance to be selected.
- The other bidder will also be given his or her private information, *PvtInfo(Other bidder)*. His or her *PvtInfo(Other Bidder)* will also be determined randomly from a value between **$1 and $20, in one dollar ($1) increments {1, 2, 3, …, 10, 11, 12, …, 18, 19, 20}**. Each amount has an equal chance to be selected.
- Your Resale Value is the sum of your private information and half the other bidder's information.

Resale Value(You) = $PvtInfo(You) + [0.5 x $PvtInfo(Other bidder)]

- For example, if your true private information is $5 and the other bidder's true private information is $20, your resale value is

Resale Value(You) = $5 + [0.5 x $20]

= $15

or if it is $11 for you and $12 for the other bidder

Resale Value(You) = $11 + [0.5 x $12]

= $17

- Overall, your **RESALE VALUE** could range from **a low of $1.50** ($1 for you, $1 for other bidder) to **a high of $30** ($20 for you, $20 for other bidder).

- Likewise the other bidder has a resale value too, which is determined by his or her true private information and your true private information

PART II. BIDS

You will be asked to submit two bids once you receive your true private information. The other bidder is asked to do the same.

Given your revealed $PvtInfo(You):

Bid-Low(You) = $__________ If the *reported $PvtInfo(Other bidder)* = $1

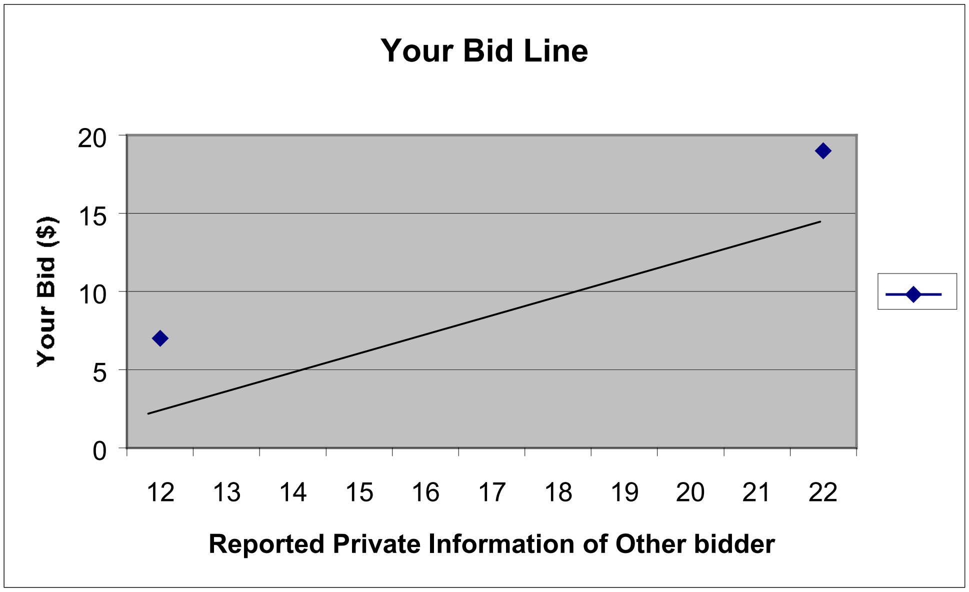
Bid-High(You) = $__________ If the *reported $PvtInfo(Other bidder)* = $20

These two bids will be combined to create your BIDDING LINE

For example, suppose

Bid-Low(You) = $7 If the *reported $PvtInfo(Other bidder)* = $1

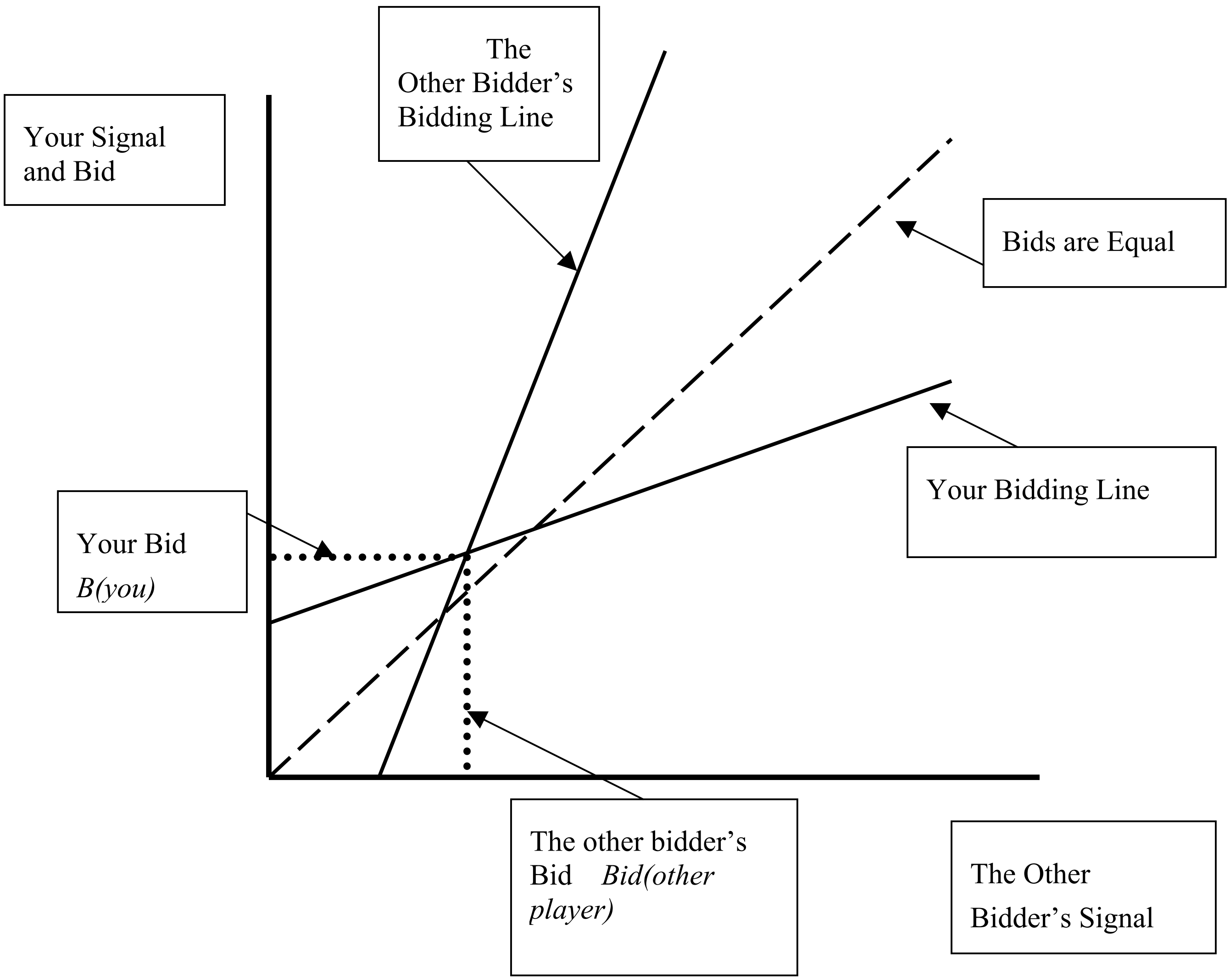
Bid-High(You) = $19 If the *reported $PvtInfo(Other bidder)* = $20



Likewise the other bidder's bids are conditional on what you report as your private information. He or she will also create a bidding line based on your private information.

PART III. Who Wins the Auction?

- The winner of the auction is determined by where the two Bidding Lines intersect.
- If the two bidding lines intersect above the sorting line, then your bid is **greater** than the other player, **and you win**
- If the bidding lines intersect below the sorting line, then your bid is **lower** than the other player, **and he or she wins**
- The example below shows that your bid is greater, so you win


The
Other Bidder's
Bidding Line
Your Signal
and Bid
Bids are Equal
Your Bidding Line
Your Bid
B(you)
The other bidder's
Bid Bid(other
player)
The Other
Bidder's Signal

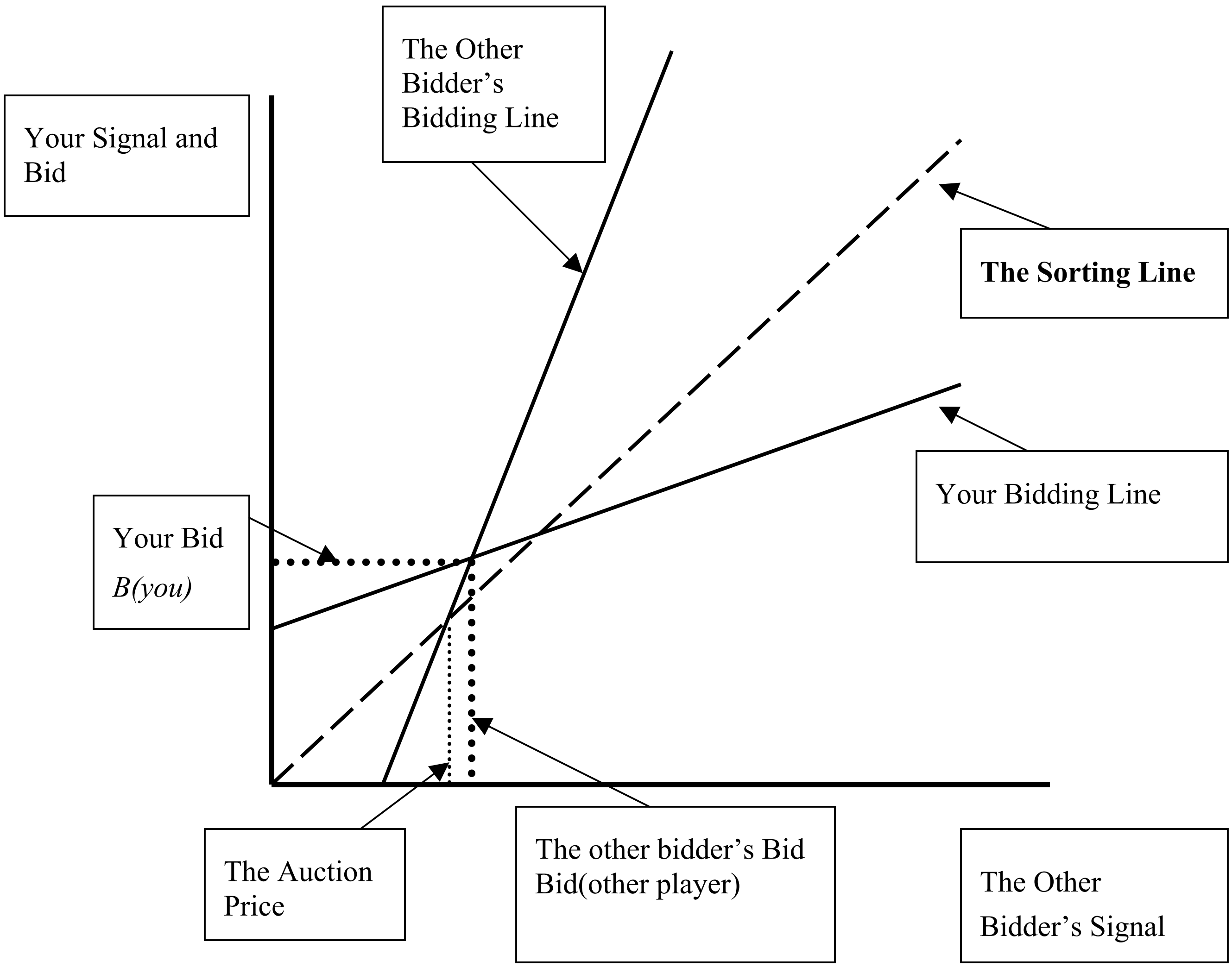
PART IV. AUCTION PRICE

- The **auction price** is then determined by what we call the **SORTING LINE**.

The SORTING LINE starts from the origin

  - If you win, **your Auction price** is set by where the other player's Bidding Line intersects the Sorting Line

  - If the other player wins, **his or her Auction price** is set by where your Bidding Line intersects the Sorting Line


The Other Bidder's Bidding Line
Your Signal and Bid
The Sorting Line
Your Bidding Line
Your Bid
B(you)
The Auction Price
The other bidder's Bid
Bid(other player)
The Other Bidder's Signal

PART V. PAYOFFS

Your **payoff** for the auction is then determined:

- If you **win**, your payoff for that round is:

Payoff(you win) = Resale Value(You) – Auction price

- If you **lose**, your payoff for that round is:

Payoff(you lose) = $0.

Summary: Each round has 9 steps:

Step 1. Your true private information is revealed only to you:

$PvtInfo(You) = $___

Step 2. You make two bids. Which bid is used in the auction depends on what the other bidder decides to report to you about his or her reported private information

Bid-Low $__________ if the other bidder reports $1

Bid-High $__________ if the other bidder reports $20

Your BID LINE is the determined given these two bids

The other bidder makes his or her bids in a similar way—his or her auction bid will depend on your reported private information.

Step 3. Your bid and the other player's bid are determined by where the two Bidding Lines intersect

Your Bid = $________

The other player's Bid = $______________

Step 4. The winner of the auction is the player with the highest bid

Step 5. If you are the winner, your AUCTION PRICE is calculated by where the other player's Bidding line intersects the SORTING LINE

Step 6. If you win, your payoff for that round is then calculated as

Payoff = Resale value – Auction price.

If you lose, your payoff is $0.

End of round.

Are there any questions at this point?

Please complete the following questions.

1. Each auction has how many bidders ________________?

2. You bid against the same other bidder in each round? YES NO

3. For each auction, you submit how many bids? 1 2 3

4. Whoever has the highest bid wins the auction? YES NO

5. Your BID is determined by the intersection of:

   a) Your Bidding LINE and your private information.

   b) Your Bidding LINE and the other bidder's Bidding line.

   c) the other bidder's Bidding LINE and your private information.

   d) the other bidder's Bidding LINE and the other bidder's private information.

6. If you win the auction, your AUCTION PRICE is determined by where:

   a) Your Bidding LINE and the SORTING LINE cross

   b) The other bidder's Bidding LINE and the SORTING LINE cross

7. Your RESALE VALUE is determined by the $1 Flat Payment plus:

   a) Your private information and the other bidder's private information

   b) Your private information alone

   c) The other bidder's private information alone