

## The Sealed Bid Auction Experiment:

This is an experiment in the economics of decision making. The instructions are simple, and if you follow them carefully and make good decisions, you may earn a considerable amount of money that will be paid to you in cash at the end of this experiment.

It is important that you read these instructions carefully, both so that you can understand the game that you are about to play, and because we will ask you a series of review questions after you have finished reading these instructions. We will pay you up to \$5 for answering the questions correctly, so it is in your best interest to read these instructions carefully. You will be allowed to refer to the instructions as you answer the questions and as you participate in the experiment.

You will participate in an auction experiment. The computer will be the auctioneer, and there will be two automated bidders. You will only be interacting with these two automated bidders, **not** with the other human bidders in the room. We will refer to the two automated bidders as “robots.” During the course of this experiment, you will take part in \_\_\_\_\_ different auctions. In each auction, there are four items for sale, which are named **A**, **B**, **C**, and **D**. As a participant, you will bid on packages that include combinations of these four items. For example, you might bid on the package **AD**, or the package **C**, or the package **ABD**. Each package is worth a certain amount to you, which is called your **value** of the package. The automated bidders may have different values for the packages than you do. If you win a package at the end of an auction, your profit will be the difference between your value and the price you pay for the package. If you do not win any package, your profit will be zero. If you win a package at the end of an auction,

$$\text{your profit} = \text{your value} - \text{your final price.}$$

You will be paid based on your total profit. The exchange rate is

$$\text{\$1} = \text{\pounds} \underline{\hspace{2cm}},$$

where  $\pounds$  is the fictitious currency used in the experiment.

### Menus and Bidding

At the beginning of each auction, you will select which packages you would like to bid on, and how much you would like to bid for each of those packages. You will be given a menu to help you make your choices. An example of a menu is shown in **Figure 1** on the following page. The menu will show your value of each package. As mentioned above, your values may be different from those of other bidders. The menu will also have a blank space next to each package, where you can type in the amount that you wish to bid for that package, if you wish to bid on it at all.

You can choose to bid on as many or as few packages as you want, and you can bid on a single item multiple times, by bidding on several packages that contain that item. It is OK to not bid on anything. No matter how many packages you bid on, you will never win more than one package. Once you have submitted a bid for a package, you must be prepared to pay the amount that you have bid.

Figure 1: An example of a menu

Auction		2		Remaining time [sec]: 178	
Package	Your Value	Bidding price			
A	5	<input type="text"/>			
B	9	<input type="text"/>			
C	6	<input type="text"/>			
D	5	<input type="text"/>			
AB	16	<input type="text"/>			
A C	11	<input type="text"/>			
A D	10	<input type="text"/>			
BC	15	<input type="text"/>			
B D	14	<input type="text"/>			
CD	11	<input type="text"/>			
ABC	22	<input type="text"/>			
AB D	21	<input type="text"/>			
A CD	16	<input type="text"/>			
BCD	20	<input type="text"/>			
ABCD	27	<input type="text"/>			

**Submit your bids**

Example: Suppose that Bidder 1 bids for package **ABCD** at price £70 and for **AB** at price £50, Bidder 2 bids for package **CD** at price £40, and Bidder 3 bids for **CD** at price £30, as summarized in Table 1.

Table 1: Submitted bids.

	Package	Price
Bidder 1	<b>ABCD</b>	£70
Bidder 1	<b>AB</b>	£50
Bidder 2	<b>CD</b>	£40
Bidder 3	<b>CD</b>	£30

In this example, Bidder 1 bids for items **A** and **B** twice, in package **ABCD** and package **AB**. However, the auctioneer cannot sell items **A** and **B** to Bidder 1 twice, as she has only one unit of each, so Bidder 1 cannot get both **ABCD** and **AB**. Bidder 1 might get **ABCD**, or **AB**, or nothing.

### Winning bid determination

Once all bidders have submitted their bids, the auctioneer will choose the combination of submitted bids that yields the highest revenue. The auctioneer only has one unit of each item to sell, and will never give more than one package to each bidder. For example, the auctioneer will not give both **AB** and **D** to Bidder 1, because Bidder 1 can only win one package, and the auctioneer will not give **AB** to Bidder 1 and **B** to Bidder 2, since she only has one unit of **B** to sell.

Example: In the example presented above, we will examine how the auctioneer would choose winning bids. Consider the three possible assignments of the four goods:

- 1). Sell package **ABCD** to Bidder 1. The revenue is £70.

Bidder 1	<b>ABCD</b>	£70
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- 2). Sell package **AB** to Bidder 1 and **CD** to Bidder 2. The revenue is £90.

Bidder 1	<b>AB</b>	£50
Bidder 2	<b>CD</b>	£40

- 3). Sell package **AB** to Bidder 1 and **CD** to Bidder 3. The revenue is £80.

Bidder 1	<b>AB</b>	£50
Bidder 3	<b>CD</b>	£30

As the 2nd assignment yields the highest revenue (£90), the **winning bids** are Bidder 1's bid for **AB** and Bidder 2's bid for **CD**.

If two or more combinations tie for the highest revenue, one of them will be selected based on the following criteria, which are used in decreasing order of importance:

- 1 An assignment maximizing the number of winners;
- 2 An assignment chosen randomly using a fair lottery.

The auctioneer will then, one at a time, choose each of the winning bidders as a **pivotal bidder**. The auctioneer examines the bids again, but excludes (ignores) the bids of the pivotal bidder. The auctioneer determines the allocation of goods that maximizes revenue, using the same rules as before, but not considering any bids placed by the pivotal bidder. Once this new allocation has been determined, the auctioneer compares the revenue generated by this allocation with the revenue generated when no bids were excluded.

Example: Suppose that bidders submit the following bids, just as in the previous example:

	Package	Price
Bidder 1	<b>ABCD</b>	£70
Bidder 1	<b>AB</b>	£50
Bidder 2* (pivotal bidder)	<b>CD</b>	£40
Bidder 3	<b>CD</b>	£30

Let Bidder 2 be the pivotal bidder. Thus, the auctioneer will exclude all of Bidder 2's bids when she considers all possible assignments.

- 1). Sell package **ABCD** to Bidder 1. The revenue is £70.

Bidder 1	<b>ABCD</b>	£70
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- 2). Sell package **AB** to Bidder 1 and **CD** to Bidder 2. The revenue is £90.

<del>Bidder 1</del>	<del><b>AB</b></del>	<del>£50</del>
<del>Bidder 2</del>	<del><b>CD</b></del>	<del>£40</del>

- 3). Sell package **AB** to Bidder 1 and **CD** to Bidder 3. The revenue is £80.

Bidder 1	<b>AB</b>	£50
Bidder 3	<b>CD</b>	£30

The 2nd assignment is not available, because the auctioneer should exclude the bid of the pivotal bidder, Bidder 2. In this case, the 3rd assignment yields the highest revenue. Therefore, when Bidder 2 is pivotal, the highest revenue that the auctioneer can obtain is £80.

## Price Adjustments

The amount that the winning bidders are required to pay at the end of the auction depends on the additional revenue that each bidder generated, which is calculated by comparing the original revenue obtained by the auctioneer, versus the revenue obtained by the auctioneer when the given bidder was pivotal.

Example: Suppose that the following bids are submitted:

	Package	Price	status
Bidder 1	<b>AB</b>	£50	winning
Bidder 2	<b>CD</b>	£40	winning
Bidder 3	<b>ABCD</b>	£60	
Bidder 3	<b>AB</b>	£30	

As shown in the table, the bids from Bidder 1 and 2 are the winning bids, because they generate the highest revenue  $£50 + £40 = £90$ .

However, the auctioneer does not ask Bidder 1 to pay £50. Suppose that Bidder 1 were chosen as a pivotal bidder, and so his bids are ignored. The winning bids then become Bidder 2's bid on **CD** and Bidder 3's bid on **AB**.

	Package	Price	status
Bidder 1	<del>AB</del>	<del>£50</del>	<del>winning</del>
Bidder 2*	<b>CD</b>	£40	winning
Bidder 3	<b>ABCD</b>	£60	
Bidder 3*	<b>AB</b>	£30	winning

Then the auctioneer calculates the revenue that those winning bids would generate, which is  $£40 + £30 = £70$ . Thus, the additional revenue that Bidder 1 generates is £20, since  $£90 - £70 = £20$ . This £20 is the price adjustment for Bidder 1. Therefore, Bidder 1 pays £50 and receives £20 back. His final price is £30.

Similarly, Bidder 2 might not have to pay £40. When Bidder 2 is the pivotal bidder, the winning bid is Bidder 3's bid on **ABCD**.

	Package	Price	status
Bidder 1	<b>AB</b>	£50	winning
<del>Bidder 2</del>	<del>CD</del>	<del>£40</del>	<del>winning</del>
Bidder 3*	<b>ABCD</b>	£60	winning
Bidder 3	<b>AB</b>	£30	

The revenue to the auctioneer would be £60. Therefore, the additional revenue that Bidder 2 generates is £30, since  $£90 - £60 = £30$ . The price adjustment for Bidder 2 is £30. Bidder 2 pays £40 and receives the adjustment of £30. Thus, Bidder 2's final price is £10.

Notice that your final price depends on other bidders' bids, which you cannot observe during the auction.

### Some notes

- **Time limit** In each auction, bidders have to submit their bids within 3 minutes. There is a count-down clock at the top-right corner of the menu window.
- **Negative profit** If you bid an amount for a package that is higher than your value of that package, your profit (value – final price) may be negative. If you bid amounts that are lower than your values, your profit will never be negative.
- **Tab key** When you input your bids on the menu, you may find the Tab key useful. The cursor jumps from one blank space to the next each time you hit the Tab key on the left-hand side of the keyboard. This allows you to input your bids without using the mouse. Of course, you are also free to use the mouse to change the position of the cursor, if you prefer.

## Value Determination

At the beginning of each auction, each bidder's values of the different items will be randomly selected from  $\{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ . Each value is equally likely to be drawn. For you, **A** and **B** are goods that give you greater value when they are bought together. For example, if your value of **A** is £3 and your value of **B** is £5, your value of **AB** might be £9. As you can see, your value of **AB** is greater than the sum of your values of **A** and **B**.<sup>1</sup>

In a similar way, your value of **ABC** would be greater than the sum of your values of **A**, **B**, and **C**. This relationship does not exist for you between any other goods. So, for example, your value of **AD** is just the sum of your values of **A** and **D**. For you, only packages that include both **A** and **B** have this added value. During this auction, one of the robots will also derive greater value from packages that contain both **A** and **B**, while the other robot will get added value from packages that contain both **C** and **D**.

## The automated bidders

While you won't know the individual bids of the robots, you will know a little bit about their strategies. Both of the robots that you will be interacting with will use the same strategy.

When a robot examines his menu, he always chooses to bid exactly his value for each package, and to bid on all the packages.

## Conclusion

As mentioned before, your profit is given as follows:

$$\text{your profit} = \text{your value} - \text{your final price.}$$

In a moment, we will ask you to complete a few review questions, and we will pay you according to the number that you answer correctly, in addition to the money that you earn during the auction itself.

Are there any questions before we begin the review questions?

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<sup>1</sup>Specifically, the values of packages that contain **AB** are given as follows:

$$\text{value of } \mathbf{AB} = ((\text{value of } \mathbf{A})^\rho + (\text{value of } \mathbf{B})^\rho)^{1/\rho}$$

$$\text{value of } \mathbf{ABC} = ((\text{value of } \mathbf{A})^\rho + (\text{value of } \mathbf{B})^\rho)^{1/\rho} + (\text{value of } \mathbf{C})$$

$$\text{value of } \mathbf{ABD} = ((\text{value of } \mathbf{A})^\rho + (\text{value of } \mathbf{B})^\rho)^{1/\rho} + (\text{value of } \mathbf{D})$$

$$\text{value of } \mathbf{ABCD} = ((\text{value of } \mathbf{A})^\rho + (\text{value of } \mathbf{B})^\rho)^{1/\rho} + (\text{value of } \mathbf{C}) + (\text{value of } \mathbf{D})$$

For each auction,  $\rho$  is a fixed number between 0 and 1.

# Review Questions:

Remember that you are free to use the instructions to answer these questions, and that we will pay you for your correct answers.

## Q.1 Winning Bids

Let us find winning bids, given the following submitted bids.

	Package	Price
Bidder 1	<b>A</b>	£50
Bidder 2	<b>B</b>	£20
Bidder 2	<b>AB</b>	£60
Bidder 3	<b>CD</b>	£50

Hint: There are 2 assignment patterns. These assignments are marked below, with the winning bids marked with an asterisk (\*). Which assignment gives the highest revenue?

	Package	Price
Bidder 1*	<b>A</b>	£50
Bidder 2*	<b>B</b>	£20
Bidder 2	<b>AB</b>	£60
Bidder 3*	<b>CD</b>	£50

	Package	Price
Bidder 1	<b>A</b>	£50
Bidder 2	<b>B</b>	£20
Bidder 2*	<b>AB</b>	£60
Bidder 3*	<b>CD</b>	£50

Revenue = £\_\_\_\_\_.

Revenue = £\_\_\_\_\_.

Which of the following is the set of winning bids?

- a) Bidder 1's **A**, Bidder 2's **B** and Bidder 3's **CD**.
- b) Bidder 2's **AB** and Bidder 3's **CD**.

## Q.2 Price adjustment and Payments

Suppose that the auction terminates with the following bids.

	Package	Price
Bidder 1 (winning)	<b>A</b>	£15
Bidder 2	<b>AB</b>	£15
Bidder 2	<b>ABC</b>	£30
Bidder 3 (winning)	<b>BCD</b>	£40
Bidder 3	<b>D</b>	£20

**Q.2.1** How much is the revenue to the auctioneer without any price adjustment?

The revenue to the auctioneer is £\_\_\_\_ + £\_\_\_\_ = £\_\_\_\_\_

### Q.2.2 How much is the price adjustment to Bidder 1?

When Bidder 1 was a pivotal bidder and excluded, the winning bids were Bidder 2's bid on **ABC** and Bidder 3's bid on **D**. They were indicated by the asterisks \* in the table below.

	Package	Price
<del>Bidder 1 (winning)</del>	<del><b>A</b></del>	<del>£15</del>
Bidder 2	<b>AB</b>	£15
Bidder 2*	<b>ABC</b>	£30
Bidder 3 (winning)	<b>BCD</b>	£40
Bidder 3*	<b>D</b>	£20

If Bidder 1's bid was ignored, then the highest revenue would be  $\pounds \underline{\quad} + \pounds \underline{\quad} = \pounds \underline{\quad}$ .

Then, subtract the amount from £55. That is,  $\pounds 55 - \pounds \underline{\quad} = \pounds \underline{\quad}$ .  
This is the price adjustment to Bidder 1.

### Q.2.3 How much is the final price that Bidder 1 pays in the end?

Hint: He pays the price and then receives the price adjustment.

He pays  $\pounds \underline{\quad}$  as the price for **A** and receives  $\pounds \underline{\quad}$  as the price adjustment.

Thus, Bidder 1's final price is  $\pounds \underline{\quad} - \pounds \underline{\quad} = \pounds \underline{\quad}$ .

## Q.3 Value Determination

Which of the following is true?

- a) My value of **AB** is more than the sum of my values of **A** and **B**.
- b) My value of **CD** is more than the sum of my values of **C** and **D**.
- c) Any package that contains **AB** is worth more to me than any package that does not contain **AB**.
- d) None of the above

## Answer Sheet

Your name: \_\_\_\_\_

Your PC # : \_\_\_\_\_

Date: \_\_\_\_\_

For multiple choice questions, please just circle the most correct answer. For the free-response questions, please write your answer neatly in the space provided. Illegible answers will not receive credit. You may notice that there are some blank spaces on the questions sheet that do not have blanks on the answer sheet. These extra blanks are just to help you find the answer, but you only need to record the answers that this answer sheet asks for. Only this answer sheet will be graded, so please record on this sheet all answers that you want graded.

Q1        (a)                (b)

Q2.1      The total revenue is \_\_\_\_\_.

Q2.2      The price adjustment to Bidder 1 is \_\_\_\_\_.

Q2.3      Bidder 1's final price is \_\_\_\_\_.

Q3        (a)                (b)                (c)                (d)