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Teaching Auction Theory to Finance Students

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Auctions are generally taught in economics courses in a discussion of game theory or mechanism design. While the topic is important from a theoretical perspective, it is also crucial to students' understanding of how capital markets work, yet few instructional techniques exist for incorporating auctions into classroom discussions in finance courses. This article summarizes a great exercise/game that allows students to learn about auctions through participation in a series of actual auctions. The exercise is designed for a single class period of eighty to ninety minutes. We have used the game as an introduction to courses in both corporate finance and financial markets and institutions both at the undergraduate and graduate levels. It has been well received by students at numerous universities.

INTRODUCTION TO THE EXERCISE

Prior to the start of class, students are given a handout to assist them in taking notes on the game. This handout can be located at www.jfcr.org/jitfvols.html. This document leads them through the exercise and allows them to focus on participating in the exercise rather than furiously scribbling. The handout identifies the main points of the discussion that follows, and it provides them with the rules of the game and space to answer several key questions of importance under each auction mechanism used.

To introduce and motivate the exercise we emphasize types of financial securities and transactions that are typically sold via auction (or auction-like) mechanisms, offering a very brief introduction into several areas that will receive greater attention later in the course: US government bond issues, share repurchases, (contested) corporate acquisitions, initial public offerings, and most importantly, stock, bond, currency and derivative markets. (Additional examples from economics can be mentioned, such as government contracts, mineral rights, fine art, and eBay.) So many finance examples may seem a little overwhelming for undergraduate students in their first finance class, but it gives them a quick exposure to financial terminology without requiring much detail.

After the importance and relevance of auctions has been established, it is much easier to deliver a quick introduction to auctions and the game itself. In addition to the definitions of *Bid Price* (the price a buyer is willing to pay) and *Ask Price* (the price a seller is willing to accept), it is important for the students to understand that a *Reservation Value* is the maximum value that one ascribes to an asset. The concept of reservation value is very important for the duration of the lesson.

Another (typically) new concept for both undergraduates and graduate students is the variety of auction mechanisms available to sellers when they offer their items for sale. The following list of mechanisms is discussed briefly: (1) Open outcry (oral) vs. Sealed bid (confidential), (2) First-price (the highest bidder pays the highest price bid) vs. Second-price

(the highest bidder pays the second highest price bid), (3) Ascending-bid, or English-style (bids increase until only one bidder is left) vs. Descending-bid, or Dutch-style (start at a high asking price and then decrease; first acceptance ends auction), (4) Single-unit (one item for sale) vs. Multiple-unit (more than one identical items for sale), and (5) One-way (one seller, multiple potential buyers) vs. Two-way (multiple sellers, multiple buyers). This auction game uses the first three of these. To further emphasize that these methods are actually used in the marketplace, we provide one or more example press release(s) from actual financial transactions such as the one below:

CARY, N.C., May 16, 2002 (Reuters) - SpectraSite Holdings Inc. (NasdaqNM:SITE -News) said on Thursday it expects to receive \$350 million from private equity firm Welsh, Carson, Anderson & Stowe, and will cut back on its use of towers. The company's shares rose 16 percent. The Cary, North Carolina-based owner and operator of towers that transmit wireless telephone calls said it expects to use up to \$340 million of the infusion from Welsh, Carson, which already holds a 22 percent interest in the company, to buy back debt through a "Modified Dutch Auction." It said it expects to use the remainder to refinance part of its senior credit facility.

Before the game begins, students are instructed to look for and record the answers to a few important questions:

1. Under various auction mechanisms, what is the optimal bidding strategy?
2. Under various auction mechanisms, who is the winning bidder?
3. Under various auction mechanisms, how much does the seller receive?

At this point, the class is divided into 10 to 20 teams, each of 2 to 4 students. The game is scalable to nearly any class size, but is best with at least 10 teams (bidders). Each team is then provided a score card with private information (related to their own reservation values) for a series of land auctions and a series of gold mine auctions. From the scorecard, students usually deduce that the purpose of the game is to create value for their team by purchasing items at a price below their reservation value. If students ask about their goal in the game, simply telling them to "play as if real money were at stake" normally induces them to attempt profit-maximizing behavior. For the actual Excel file used to generate scorecards with reservation values, visit www.jfcr.org/jitfvols.html.

The spreadsheet includes enough scorecards for 20 teams, plus one master sheet for the instructor. The professor need only open the file and print the document. It is pre-formatted to produce 21 sheets of paper. The instructor's master sheet is produced first, and it contains a summary of the information included on each group's scorecard. For the Series A – "Land" Auctions, each group's reservation value is provided for each parcel of land. For the Series B – "Gold Mine" Auctions, the actual value of mined gold is provided for the instructor. Of course, the value added for each successful bidder is dependent upon both of these pieces of information – along with the price they are willing to pay. The key point to appropriate use of the scorecards is that only the successful bidder should record his/her profit (loss) for each round played.

SERIES A - "LAND" AUCTIONS

Students are told that each team is a firm interested in developing various (independent) parcels of land (properties). Since different firms may have different plans for a given property, reservation values may differ across teams for a given property, as well as differ across properties (just as they would in a market auction). For each property, a team knows only its own reservation value, but knows that value with *certainty*.

Four auction mechanisms are used to sell the properties (with at least one property per mechanism). In each, the professor acts as auctioneer (as well as referee). The first mechanism is open-outcry, ascending-bid (OOAB) [we sometimes refer to this as the "fine art style" auction due to its likely familiarity to students via television or films] where the auctioneer begins at a low price and increases bids (in increments of ten) until there is only one remaining bidder. Students are instructed on how the mechanism works, and (as for all the auctions) they are given a minute or two to quietly discuss bidding strategy amongst their team. They are also asked to use a single bidder for each team. Then the OOAB auction commences for the first property. Once the successful bidder and sales price for the first property is identified, the winning team - and the winning team only - is told to record their "profit" on their scorecard. Of course, all other bidders' profits are zero. A second and third property may also be sold using the same OOAB mechanism. If so, students are invited (as for all the auctions) to spend a few more seconds quietly discussing with their teammates whether to adjust their bidding strategy. A short discussion of results so far can then take place. Each winning team is asked to explain their bidding strategy to the class, and whether it worked out for them. Students generally quickly agree that the optimal strategy is to continue to bid until the team's reservation value is reached.

The second auction mechanism is then introduced. Teams will next bid on properties using a sealed-bid, second-price (SBSP) auction, sometimes called a Vickrey auction. Bidding slips are distributed, and the mechanism is explained. Each team writes down their bid for the next property (as well as their team number) and submits it to the instructor. Each team is allowed only a single bid. The bidding team who submits the highest bid is identified and awarded the property; the price they pay is the *second* highest bid. A tie in the bidding can be broken using a die. The winning bidder records their profit. Up to two more properties may then be sold using the same SBSP mechanism, after allowing a short quiet discussion of bidding strategy among teammates.

Another short discussion of results so far can now take place. Each winning team for an SBSP auction is asked to explain their bidding strategy to the class and whether it worked out for them. Answers certainly vary! The net effect of the two mechanisms used thus far is that they are very similar. For the OOAB auction, the optimal bidding strategy is to *bid up to your reservation value*. The team with the highest reservation value will then win the property, and the price they pay will be (approximately) the second-highest reservation value amongst the bidders (the point at which the second highest valuing bidder will drop out). For the SBSP auction, the optimal bidding strategy is to *bid your reservation value*. The team with the highest reservation value will then win the property, and the price they pay will be the second-highest reservation value. Note

that an initially counterintuitive mechanism (SBSP) results in a very "easy-to-bid" strategy.

The third auction mechanism is then introduced. Teams will bid on properties using a sealed-bid, first-price (SBFP) auction. Each team writes down and submits a single bid for the next property (as well as their team number). The highest bidding team is identified and awarded the property; the price they pay is the highest bid (the price they bid). Again, a tie in the bidding can be broken using a die. The winning bidder records their profit. Up to two more properties may then be sold using the same SBFP mechanism.

Another short discussion can now take place (or be put off until after the fourth auction mechanism). Each winning team for an SBFP auction is asked to explain their bidding strategy to the class and whether it worked out for them. The optimal strategy for what initially seems an intuitive auction mechanism is actually quite complicated. It is (assuming a Nash equilibrium and risk-neutrality) to bid your best estimate of the second-highest reservation value, assuming your reservation value is the highest. In particular, this requires bidding below your reservation value. Students often bid their reservation value; this actually guarantees that they cannot receive a positive profit (no better than not participating)! If bidders bid optimally, this results in the auction price equaling an estimate of the second-highest reservation value.

The fourth (and final) auction mechanism is now introduced. Teams will bid on properties using an open-outcry, descending-bid (OODB) auction. Here, the instructor begins the auction by asking a very high amount for a property, then lowering the asking price by increments of ten until a bidder is identified willing to pay that price. That first bidder is awarded the property at that price bid, and asked to record their profit. Up to two more properties can be auctioned in this manner.

A final discussion on the land auction follows. The SBFP and OODB auctions are essentially the same. Imagine the auctioneer is about to run the OODB auction, but has to step out of the room, so asks the teams to just write down the price at which they would have actually jumped in to bid; this generates the SBFP auction. Overall lessons to be learned include that optimal bidding strategies vary with the mechanism, that some mechanisms (the first two) allow easier implementation of optimal strategies, and that the outcome (assuming optimal bidding) is fairly robust to the mechanism chosen. The outcome is that (approximately) the second-highest reservation value (or an estimate of that value) is paid, even if the seller has no idea of the true value, and the buyer is typically the team with the highest value of the property.

Typical Results - Land Auctions

For the OOAB and SBSP auctions, students are sometimes hesitant until a few rounds have been completed. Some teams win a property because they were confused with the rules or purpose of the exercise. Some winning bidders lose money because they have a poor (sub-optimal) bidding strategy. Some bidders overpay because they really just want to own a piece of land, and are frustrated with not buying anything. It is not unusual for a "winning" team to lose money.

For the SBFP and OODB auctions, winning bidders typically follow one of two strategies. The first strategy is to bid their reservation value because it was identified to be an optimal strategy for the first two auctions. The second strategy,

recognizing that a positive profit requires bidding below their reservation value, is to bid only a single bidding increment below their reservation value. Table 1 summarizes results from an actual recent classroom series of land auctions.

Table 1. Typical Land Auction Results (Thousands).

Property	Team	Reservation		Price	Profit
		Value			
Open Outcry - Ascending Bid					
A1	1	880	870	870	10
A2	8	480	480	480	0
A3	12	430	440	440	-10
Sealed Bid - Second Price					
A4	12	960	960	960	0
A5	10	460	460	460	0
A6	6	660	700	700	-40
Sealed Bid - First Price					
A7	1	430	430	430	0
A8	6	530	530	530	0
A9	10	770	770	770	0
Open Outcry - Descending Bid					
A10	5	860	850	850	10
A11	2	950	940	940	10
A12	3	500	500	500	0

SERIES B - "GOLD MINE" AUCTIONS

In the final auctions of the class session, teams bid on newly discovered gold mines. Teams cannot know the exact value of the gold contained in any mine until it has been excavated, so each team has sent their own internal team of geologists to provide them with an *estimate* of the value of the gold each mine contains. The geologists cannot tell the exact value of the gold mine, but they can guarantee that the value of the gold mine lies within a two million dollar range (with a uniform distribution of estimation errors). Students are provided their team's ranges for the various gold mines on their scorecard.

Students participate in a series of up to three SBSP auctions and up to three OOAB auctions. The main difference between the gold mine auctions and the land auctions is that in the gold mine auctions, bidders are *uncertain* of their reservation value. Of course, this is more indicative of the situation where most firms bid on assets - the true value of the asset is unknown at the time of purchase. The actual value of the gold mine is announced right after the conclusion of the bidding, after the winning bidder has been identified.

Afterward, a short discussion (which may be worth repeating for emphasis at the next class meeting) should note that there is information contained in the auction process - other bidders "tip their hand" about their reservation values. This value-relevant information is critical for optimal bidding. Toward the end of the OOAB auction, only two bidders are likely bidding. Why are other teams not bidding? (They may even be laughing or jeering.) They are revealing that their geologists' estimates are lower, probably much lower! Who

typically wins this auction? It is the team whose geologists had the bad luck to have a very high estimate (and whose bidders fail to realize that the majority of geologists were more pessimistic than theirs). Appropriate bidding in the face of this *winner's curse* problem is to incorporate that pessimistic information, lowering one's bid below what it would be otherwise. For these particular gold mine auctions, the optimal bidding strategy is to bid around 100 to 200 (thousand) above the bottom end of their team's estimation range (the exact number depends upon the number of teams).

The discussion is followed by a comparison of cumulative scores over all the auctions, for all the teams. The difficulty of achieving a positive cumulative score is primarily due to the competitive nature of the auction mechanisms.

Typical Results - Gold Mine Auctions

The results of the gold mine auctions can be summarized very easily: *shareholder wealth destruction on a massive scale*. From Table 2, it can be seen that students begin to recognize that they should bid more conservatively but do not realize how conservative they must be to avoid taking massive losses. Add three zeroes to the game, and one can see how a manager could lose their job very quickly if they overbid.

Table 2. Typical Gold Mine Auction Results (Values in Thousands)

Gold Mine Team	Mine		
	Value	Price	Profit
Open Outcry - Ascending Bid			
B1	1	8590	9900 -1310
B2	4	5780	6800 -1020
B3	8	3980	4600 -620
Sealed Bid - Second Price			
B4	6	7840	8600 -760
B5	2	6170	6600 -430

LEARNING POINTS FOR STUDENTS

Learning Point #1 – *Auctions are Competitive; It's Tough to Make Money*: Very few (if any) of the teams earn a positive cumulative profit. Those who score zero are congratulated; it is a good score.

Learning Point #2 – *Auctions May Generate Valuable Information, Even in Silence*: Near the end of the auctions - particularly the gold mine auctions - the bidding usually consists of two teams battling it out in a series of back-and-forth bids. These teams are ignoring the information contained in the other geologists' estimates! All but two teams are saying nothing (in some cases, there may be jeers or catcalls), yet the high bidder ignores the silence and over-relies on their own private information.

Learning Point #3 – *Winner's Curse*: The winner's curse occurs in auctions with reservation value uncertainty. It states that if Learning Point #2 above is ignored, the high bidder tends to pay too much. This exercise demonstrates this point beautifully.

Learning Point #4 – *Empire Building*: At some point in the game, many teams feel a desire to buy a piece of land or a mine despite the fact that they know they'll probably lose money. Emphasize that CEOs feel the same or even more pressure to *do something*. It is important to be disciplined in bidding.

Learning Point #5 – *Who Ultimately Wins Most Auctions?*: The seller!

LEARNING POINTS FOR INSTRUCTORS

Learning Point #1 – *When to Present this Topic*: On the first day of the semester, the order of business is typically administrative tasks such as reviewing the course syllabus, schedule of classes, the textbook and other required materials, etc. We use this exercise on the second day in which the class meets for the semester. The exercise is used for two reasons: (1) auctions are ultimately how prices are determined for financial assets (the auction results can be extended to lead to a discussion of financial market efficiency), and (2) a game facilitates the class' process through Tuckman's (1965) four-stage model of group dynamics (Forming, Storming, Norming, and Performing). More simply, it gets students talking and interacting with one another; more importantly, it gets them interacting with the instructor.

Learning Point #2 – *Encourage Students to Take Notes*: The auction exercise is preceded by a suggestion from the instructor that each student take diligent notes. Some students internalize this advice while others do not. Students with better notes typically perform better on test questions.

Learning Point #3 – *Testing the Material*: To test the material covered in the auction game, we typically recreate a four or five-bidder auction where the student is given the reservation values. In multiple choice questions, the student is required to identify who would win an auction under the rules of particular mechanism, how much one of the bidders should bid under the rules of particular mechanism, or how much the seller should anticipate the winning bid to be. The winner's curse is generally tested as a short answer question.

MODIFYING THE GAME

The auction game offers a rich set of lessons, and a wealth of material. Depending upon the instructor style and the level of the students, tradeoffs can be made. For example, as few as four land auctions might be run (one auction per mechanism) if the instructor wishes to spend more time discussing the nature of the auctions and optimal bidding strategies. As another example, the game can easily be expanded to fit two hours by including both detailed discussions and multiple auctions under each mechanism.

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