# KELLOGG SCHOOL OF MANAGEMENT

## Strategic Decision-Making

DECS-452 Professor Bob Weber
Week #9

Next week, we'll finish our discussion of multi-item auctions by looking at the first FCC broadband spectrum auction. I'll be running through the paper "Making More from Less: Strategic Demand Reduction in the FCC Spectrum Auctions," which can be found at http://www.kellogg.northwestern.edu/faculty/weber/papers/pcs_auc.htm. Attached are the first few pages, which I'd like you to read in preparation for our next class.

We will discuss ethics in our last class. In preparation, please read "Winning the Battle, or Winning the War?" (attached). Put yourself in the shoes of the coach of a professional sports team, facing the choice between blatantly losing a game in order to clinch a post-season playoff berth, or trying your best to win while risking having the season come to an abrupt end.

Which path would you take? What explanation would you offer in the post-game press conference?

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## The RCA Transponder-Lease Auction

"In a hushed Sotheby Park Bernet auction hall, as tense cable television executives signaled with paddles, a sale of telecommunications satellite facilities for their booming industry brought $90.1 million in winning bids yesterday." Thus did *The New York Times* describe the November 9, 1981 sale of seven-year leases on seven transponders, all to be carried aboard the same satellite and each capable of relaying cable-television programming from an originating ground station to the nation's network of independent cable-television distributors. The combined sale set a record for both single-item and single-auction sales at Sotheby's, and generated nearly $20 million more than RCA Americom had expected to receive under a previously-announced price schedule.

Fifty competing firms and individuals participated in the auction. The seven identical leases were sold in sequence, with an English auction conducted for each. The winners, and final bids, in the seven rounds are given below in the order of sale:

| | |
|---|---|
| Transponder Leasing Company | $14,400,000 |
| Billy H. Batts (Faith Broadcasting) | $14,100,000 |
| Warner Amex | $13,700,000 |
| RCTV (Rockefeller Center) | $13,500,000 |
| Home Box Office | $12,500,000 |
| Inner City Broadcasting Corporation | $10,700,000 |
| UTV Cable | $11,200,000 |

Contrary to theoretical predictions, this sequence of prices does *not* appear to be the realization of an upward-drifting random sequence. What happened?

Imagine yourself as (a strategically-naive) chief executive officer of a cable television firm, preparing to bid in the sale. You have decided that you are willing to pay as much as $13.8 million (but no more) in order to obtain a lease. What instructions do you give your bidding agent, who will represent you at the auction?

The answer seems simple: "If you can obtain a lease for $13.8 million or less, do so."

Now, imagine yourself instead as the bidding agent who has just received these instructions. How can you eventually be viewed as having failed to carry them out? Obviously, if you ever bid above $13.8 million, you are risking disaster: You might win! This is easy to avoid. But there is a second risk of failure: You might come home without a lease, when at least one of the seven sells for less than $13.8 million. There is only one way to eliminate this risk: Never drop out of any round until the bidding reaches $13.8 million (your "authorization level").

Assume that each firm's agent receives the same type of instructions (although, of course, with varied authorization levels), and implements his instructions in the manner just described. Then the agent with the highest authorization level will win in the first round, and will pay an amount just above the second-highest authorization level. The agent with the second-highest authorization level will win in the next round, at a price near the third-highest authorization level. And so on. The sequence of final prices will be strictly decreasing (as, indeed, it nearly was).

But finally, assume that you are the CEO again, and that you have thought your way through the preceding analysis. Do you really want to stick with your original instruction plans? Presumably not. If you were to win in the first round (i.e., if you happened to have set the highest of all authorization levels — perhaps your company can use the satellite access more profitably than the other firms), you would pay the second-highest authorization level. By instead sitting out of the first four rounds, you should be able to win in the fifth at a substantially lower price.

We have just applied a test of "rational consistency" to the intended strategy: If it makes sense for you to use the strategy, then it should make sense for others to use it. But if the others use it, does it make sense for you? In this case, the answer is "No"; the original strategy fails the test. Therefore, the only way you can justify this strategy is through the belief that your competitors will use strategies different from yours, i.e., that they are not as clever as you are. (Perhaps this is so. The true test of an effective manager in competitive situations is his ability to "read" the opposition.)

But if all are equally clever, only one type of strategy passes the test. Send your agent to the auction with a sequence of seven successively-greater authorization levels, with the *last* equal to $13.8 million. If he loses in any round, he is authorized to compete to the next-higher level in the next round. Indeed, the only symmetric equilibrium strategy in the seven-round auction game is of this form. In using this strategy, you risk not obtaining a lease, when some sell for less than $13.8 million in the early rounds. But your *expected* profit is higher, against either clever opponents, or those who naively follow the first-described strategy.

# Making More from Less:
# Strategic Demand Reduction in the FCC Spectrum Auctions

Robert J. Weber, *The Journal of Economics and Management Strategy* 6(3), 1997

**Abstract.**

When multiple items are sold through the use of a simultaneous ascending-bid auction, bidders can find it in their mutual interests to reduce their aggregate demand for the items while prices are still low relative to the bidders' valuations. The FCC's first broadband PCS auction provides examples of how such mutual reductions might be "arranged" even when the bidders are not allowed to communicate with one another outside of the auction arena.

**Introduction.**

On December 5, 1994, the Federal Communications Commission began to accept bids for 99 licenses that would permit licensees to offer broadband personal communications services (PCS) in regions covering the United States and its territories. The auction continued for more than three months, and at its conclusion the total of the winning bids stood in excess of $7 billion. Thirty bidders were involved in the early rounds of the auction, and eighteen of them eventually acquired licenses.

For each of 48 regions, two licenses designated A and B, covering adjacent 30 MHz blocks of spectrum, were offered; for three additional regions (including New York City, Los Angeles, and Washington, DC), only single B licenses were offered, the A licenses having been previously awarded by the FCC through a non-auction-based process. Qualified bidders would eventually be allowed to hold only one of any pair of licenses. (Each region was referred to as an MTA, or "major trading area".)

**The auction format.**

Within the FCC, Evan Kwerel had suggested years earlier that licenses be allocated by auction, and in 1993 Congress had finally given the FCC a mandate to do so. However, the Congressional mandate was written in broad terms, and left the FCC to decide what particular type of auction process to use. On September 22, 1993, the FCC issued a Request For Comments (RFC) inviting outside suggestions. A common theme to a number of the resulting recommendations (and to a paper this author submitted to the FCC prior to issuance of the RFC) was that licenses should be sold via some type of simultaneous ascending-bid process, within which more than one license would be on the auction block at the same time.

The simultaneous auction procedure implemented by the FCC proceeded in discrete rounds. Following a suggestion made by Paul Milgrom and Robert Wilson, the FCC required bidders to remain active in every round in order to protect their eligibility to acquire licenses at the end of the auction. A bidder's "activity" in a round equaled the total population coverage of licenses for which the bidder was the high bidder in the previous round, added to the total population coverage of other licenses for which the bidder submitted new bids in the current round. The auction began in "Phase I", where a bidder's activity, a, in each round placed a permanent upper bound of 3a on the bidder's activity in all subsequent rounds. The FCC would later move the auction into "Phase II", where the permanent upper bound was 3a/2 , and finally into "Phase III", where the upper bound on all future activity equaled the activity in the current round. These

activity rules, in combination with an FCC-controlled minimum bid increment, served to keep bidders from laying in wait (not bidding until they saw the intentions of others). Each bidder was granted five waivers, which could be exercised to keep the bidder's activity in a specified round from imposing any upper bound on future activity. (The primary intent behind the creation of waivers was apparently to protect bidders from potential errors in a day's bid-submission process.) Bids would be submitted as integral numbers of U.S. dollars.

After every round of bid submissions, the bidders would be provided with a listing of all submitted bids on each license; the listing would identify the submitter of each bid. Then a bid withdrawal round would occur, during which a bidder could withdraw any bid that was currently the standing high bid for any license. (The primary rationale behind allowing bid withdrawals was to enable a bidder to adjust the package of licenses it was attempting to acquire as some licenses became, relative to the bidder's valuations, prohibitively expensive.) If a bid was withdrawn, the FCC would list itself as the current high bidder for the license, and would announce a minimum acceptable bid typically equal to the highest of all other bids the license had ever drawn (although the FCC reserved the right to set the re-offering price, and adjust it in future rounds, in whatever way it chose). To discourage frivolous bids, the bid withdrawer would be obliged, at the end of the auction, to pay a penalty equal to the difference between the withdrawn bid and the final winning bid, if the final bid were less than the withdrawn bid. In essence, this meant that the FCC was guaranteed to receive at the end of the auction at least the amount of the withdrawn bid for the license.

The auction would end when a round passed with no new bid submissions. Until the end, any license could be bid upon, even if several rounds had passed during which that license received no new bids.

**Strategic demand reduction.**

In the sale of a single object through an ascending-bid auction, each active bidder has an expressed demand of one unit. As long as the total expressed demand is greater than the single unit of supply, the auction price continues to rise: The auction cannot end until the aggregate expressed demand drops to one unit. However, an individual bidder has only one way to reduce its expressed demand, and that is to drop out of the auction, i.e., reduced its expressed demand from one to zero. As long as the auction price is below the bidder's current valuation of the object being sold, this act of "demand reduction" is strategically dominated by the alternative act of continuing to bid.

When more than one item is being sold, and some of the bidders have the desire to acquire more than a single item, the situation changes dramatically. It becomes possible for a bidder to gain from strategic demand reduction, even if all of the items are currently priced below the bidder's valuation.

As an extreme example, consider two bidders, each of whom desires either one or two of three items being sold. Let each bidder assign a valuation of 100 to each single item, and 200 to any pair of items. If one of the bidders is prepared to continue bidding on the two cheapest items until their prices cross the 100 threshold, the other does better by immediately reducing its demand to a single item (and letting the auction end immediately, while the prices of all three items are near zero) than by following any other bidding strategy. Demand reduction when prices are below a bidder's valuations is no longer strategically dominated by other bidding behavior.

Indeed, it is simple to construct examples where strategic demand reduction occurs in equilibrium. Consider the sale of two items, in a simultaneous ascending-bid auction involving two bidders. Assume that each of the bidders values either item at 100, and the pair at 200. And finally, consider the following strategy for a bidder:

In any round, if the bidder is not the current high bidder on either item, bid at the minimum increment for the lower-priced of the items (as long as that minimum increment leaves the price below 100). If both are priced the same, select a single one at random and bid on it. If the bidder is currently the high bidder on at least one item, don't submit any bids for the round.

If both bidders follow this strategy, the items will sell within two rounds, at prices equal to the minimum increment over the opening price. Obviously, no change in strategy by one of the bidders can improve upon this outcome. (The only prospective change that could be advantageous would have to involve the deviating bidder having some chance of winning both licenses. But this will only happen when both licenses are priced within a single bid increment of 100.) As long as the minimum bid increment is less than 100/3, the selection of this strategy by both bidders stands in equilibrium.

Of course, with multiple bidders and many more items, there is a vast number of equilibria to the bidding game. With laws against prior agreements amongst the firms, the preselection of a specific equilibrium outcome is impossible. Rather, in order to bring the auction to a conclusion at relatively low prices, the bidders must "negotiate" with one another, and reach agreements that are inherently stable, inside the auction arena. In order to negotiate, it must be possible for the bidders to communicate with one another.

**Methods of communication.**

The most obvious way of communicating one's interest is by bidding on a desired item. The format of the FCC auction provided several other ways for bidders to communicate with one another.

Perhaps the most blatant means of communications would be to encode messages using the lower-order digits of one's bids. Most of the submitted bids were in excess of $1 million. To use the lowest three or four digits of a bid to send a signal would be of relatively negligible cost. For example, assume that one bidder is competing with another on a particular license, and the second bidder is standing as the high bidder, at an attractive price, on some other license. Then a bid by the first bidder on the license in contention, with trailing digits equal to the identification number of the other license, could serve as a threat: "Top my bid here, and I'll raise the price on your license next round." Alternatively, an immediate bid on the second license, with digits pointing to the first, could be construed to mean: "Get off the first license, or I'll continue to bid here." As long as the bidders have some idea of one another's general interests, either message would be easy to read.

Properly-timed bid withdrawals could play a similar signaling role. A bidder who tops another's bid on one license, and during the bid withdrawal period withdraws a bid on another license, could be interpreted as offering the second license to the displaced bidder in return for being allowed to remain high on the bid-upon license.

Withdrawing one's own bid on several licenses could signal an intent to use the freed-up eligibility to strike elsewhere. By taking a waiver in the following round, the withdrawer could

hold the eligibility in hand long enough to see if the threatened strike elicits a response from others.

Alternatively, if bidders are all bidding near the minimum acceptable bid in each round (i.e., the current high bid plus the minimum bid increment), one could submit a bid slightly higher than the minimum acceptable bid for a license, and if high, immediately withdraw the bid. Under the FCC's rules, the license would be reoffered at a somewhat lower price in the next round, rather than at a price equal to the high bid plus the minimum bid increment. This would retard the rate of price increase by a round, and signal to others a willingness to slow the general rate of price increases while other forms of communication take place.

**Enforcement.**

What can sustain a tacit agreement among bidders concerning an allocation of licenses, when no binding agreements are legal? The force of threats can serve to stabilize an agreement. If two bidders have ceded licenses to one another, a subsequent attempt by one to violate the agreement can be immediately met with a response by the other, raising the prices of licenses held by the violator.

Of course, attempted violations would be most common in the final phase of the auction, where, under the FCC's rules, a bidder's activity level in each round bounds its activity level in all future rounds. Differing packages of licenses covering exactly the same total population were, in the actual auction, nonexistent for all practical purposes. Hence, any attack, or response, would necessitate a permanent reduction in a firm's eligibility: It could never return to the original package it held before the attack or response.

The substantial reduction of eligibility - a clear, public, and binding restriction of demand - by one bidder before others do the same, places that bidder in a very vulnerable position, since it sacrifices the ability to respond to an attack, and then return to its original holdings. In order for agreements to remain stable, the bidders must engage in a process of detente, gradually and mutually reducing eligibility as the auction approaches its conclusion. To protect their positions, bidders must hold onto a small amount of excess eligibility until the very end. This can be accomplished by continuing to bid for both licenses on some MTAs, or by bidding for licenses on small, inexpensive MTAs in which a bidder holds no real interest, until very near the end of the auction.

**A tale of two bidders: The interaction between WirelessCo and American Portable Telecommunications during the auction.**

… continued at http://www.kellogg.northwestern.edu/faculty/weber/papers/pcs_auc.htm

# Winning the Battle, or Winning the War?

Edgar Kaplan, in an editorial on ethics in *The Bridge World* (April 1978), used a particular example:

"Pittsburgh's football team played its last game knowing that its playoff berth was secure if it lost by as little as three points. Near the end of the game, it appeared that a tie score was likely. This would be a potential disaster for Pittsburgh, since in the "sudden-death" overtime the opposition might score a touchdown, winning by six points; thus, it would be in Pittsburgh's interest to concede a safety, losing the game by two points, and gaining the objective of the whole season's play. It so happened that the situation was averted by a late score, but the Pittsburgh coach acknowledged that, if necessary, he would have lost the game to win the playoff spot."

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Background details: The Pittsburgh Steelers played their last regular-season game of the 1977 season in San Diego. Cincinnati had finished playing earlier in the day, and a Pittsburgh loss would have left them with the same season record as Cincinnati's. The NFL tie-breaking rules would have ultimately chosen which of the two qualified for the playoffs by selecting the team with the better point differential against other teams in the conference. This is why the "playoff berth was secure if it (Pittsburgh) lost by as little as three points."

Interestingly, Pittsburgh ended up winning the game 10-9, with the final score being a Pittsburgh field goal in the third quarter. Clearly, "near the end of the game, it appeared that a tie score was likely" is an exaggeration. While Kaplan has passed on, I was able to reach the front office of the Steelers. Their reply was that "Joe Gordon, who was our PR/Communications director from 1968 to 1998 was just here and read your email. He said there is no way Chuck Noll would have said anything like this, even in jest. It sounds like the author did indeed take liberties with the game and the quote."

It appears that Kaplan, in order to make a point about competitive ethics, felt free to somewhat misrepresent the actual situation! (In his defense, there's the possibility that he misremembered the situation, or remembered some discussion of the situation and misattributed some part of the discussion to the Pittsburgh coach. Had San Diego not missed an extra-point kick in the first quarter, the situation described by Kaplan might well have occurred.)

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One of the most striking examples of "losing a battle to win the war" concerns the Luftwaffe's bombing of Coventry in 1940. A number of authors have claimed that Winston Churchill knew the bombing would take place, but left Coventry undefended in order to not let the Germans learn that England had broken the German military codes.

Churchill's defenders have vigorously argued that this story is apocryphal. See the (even-handed) discussion at http://www.bbc.co.uk/news/uk-11486219.

# From “The Princess Bride”

[Scene: Open area. Vizzini is seated behind a covered table. Buttercup, blindfolded, is sitting to his left. On the table is a bottle of wine and two goblets. Roberts approaches the table.]

Vizzini: So it is down to you, and it is down to me. If you wish her dead, by all means, keep moving forward.

Dread Pirate Roberts: Let me explain--

Vizzini: There's nothing to explain. You're trying to kidnap what I have rightfully stolen.

Dread Pirate Roberts: Perhaps an arrangement can be reached?

Vizzini: There will be no arrangement, and you're killing her.

Dread Pirate Roberts: Well if there can be no arrangement, then we are at an impasse.

Vizzini: I'm afraid so. I can't compete with you physically, and you're no match for my brains.

Dread Pirate Roberts: You're that smart?

Vizzini: Let me put it this way: Have you ever heard of Plato, Aristotle, Socrates?

Dread Pirate Roberts: Yes.

Vizzini: Morons.

Dread Pirate Roberts: Really. [pause] In that case, I challenge you to a battle of wits.

Vizzini: For the princess? (Pirate nods) To the death? (Pirate nods) I accept.

Dread Pirate Roberts: Good. Then pour the wine.

[Roberts pulls out a small vial, and uncorks it]

Inhale this, but do not touch.

Vizzini: I smell nothing.

Dread Pirate Roberts: What you do not smell is called iocane powder. It is odorless, tasteless, dissolves instantly in liquid, and is among the more deadly poisons known to man.

Vizzini: Hmmmm.

Dread Pirate Roberts: ( turns away from Vizzini with the goblets, and pours the poison in. Goblets replaced on the table, one in front of each. )

All right. Where is the poison? The battle of wits has begun. It ends when you decide and we both drink, and find out who is right...and who is dead.

Vizzini: But it's so simple. All I have to do is divine from what I know of you: Are you the sort of man who would put the poison into his own goblet or his enemy's? Now, a clever man would put the poison into his own goblet, because he would know that only a great fool would reach for what he was given. I am not a great fool, so I can clearly not choose the wine in front of you. But you must have known I was not a great fool, you would have counted on it, so I can clearly not choose the wine in front of me.

Dread Pirate Roberts: You've made your decision then?

Vizzini: Not remotely. Because iocane comes from Australia, as everyone knows, and Australia is entirely peopled with criminals, and criminals are used to having people not trust them, as you are not trusted by me, so I can clearly not choose the wine in front of you.

Dread Pirate Roberts: Truly, you have a dizzying intellect.

Vizzini: WAIT TILL I GET GOING! Where was I?

Dread Pirate Roberts:  Australia.

Vizzini:  Yes, Australia. And you must have suspected I would have known the powder's origin, so I can clearly not choose the wine in front of me.

Dread Pirate Roberts:  You're just stalling now.

Vizzini:  You'd like to think that, wouldn't you? You've beaten my giant, which means you're exceptionally strong, so you could've put the poison in your own goblet, trusting on your strength to save you, so I can clearly not choose the wine in front of you. But, you've also bested my Spaniard, which means you must have studied, and in studying you must have learned that man is mortal, so you would have put the poison as far from yourself as possible, so I can clearly not choose the wine in front of me.

Dread Pirate Roberts:  You're trying to trick me into giving away something. It won't work.

Vizzini:  IT HAS WORKED! YOU'VE GIVEN EVERYTHING AWAY! I KNOW WHERE THE POISON IS!

Dread Pirate Roberts:  Then make your choice.

Vizzini:  I will, and I choose -- What in the world can that be?

[Vizzini gestures up and away from the table. Roberts looks]

Dread Pirate Roberts:  What? Where? I don't see anything.

Vizzini:  Well, I - I could have sworn I saw something. No matter.

[Vizzini smirks]

Dread Pirate Roberts:  What's so funny?

Vizzini:  I'll tell you in a minute. First, let's drink. Me from my glass, and you from yours.

[They drink]

Dread Pirate Roberts:  You guessed wrong.

Vizzini:  You only think I guessed wrong! That's what's so funny! I switched glasses when your back was turned! Ha ha! You fool! You fell victim to one of the classic blunders! The most famous is never get involved in a land war in Asia, but only slightly less well-known is this: Never go in against a Sicilian when death is on the line!! Ha ha ha ha ha ha ha!! Ha ha ha ha ha ha ha!! Ha ha ha--

[Vizzini stops suddenly, and falls dead to the right]

Buttercup:  Who are you?

Dread Pirate Roberts:  I'm no one to be trifled with. That is all you ever need know.

Buttercup:  And to think, all that time it was your cup that was poisoned.

Dread Pirate Roberts:  They were both poisoned. I spent the last few years building up an immunity to iocane powder.