

Auctions and Auctioneering: Public Policy Applications

Charles Holt
University of Virginia

July 2006
Regional Greenhouse Gas Initiative (RGGI) Workshop
New York City

Auctions – A Long History

- One of the oldest economic institutions, e.g. used by ancient Babylonians in an annual auction for brides
- Romans: returning armies sold war booty at auction (auctio means to increase). Spanish: subasta comes from Latin, sub hasta or “under the spear”
- Governments have had a major role, as with the spectrum auctions run by the FCC, which have been dramatically successful in raising large amounts of revenue

English Auction (Up)

- Stamps within a decade of the first issue of postage stamps in England, stamps were being auctioned in the US to collectors
- Collectors would gather at a dealer's office and bid the price up until one interested bidder remained, “**English auction**,” where person with the highest willingness to pay wins, at a price where the bidder with the second highest bidder drops out.
- Reiley (2000) describes a proxy bid situation where the dealer in Northampton, Mass let a collector send in a “proxy bid”, you have to trust the dealer to make this a “second price auction”

Dutch Flower Auction

next to Schiphol Airport
size of 72 soccer fields



Dutch Auction: Down

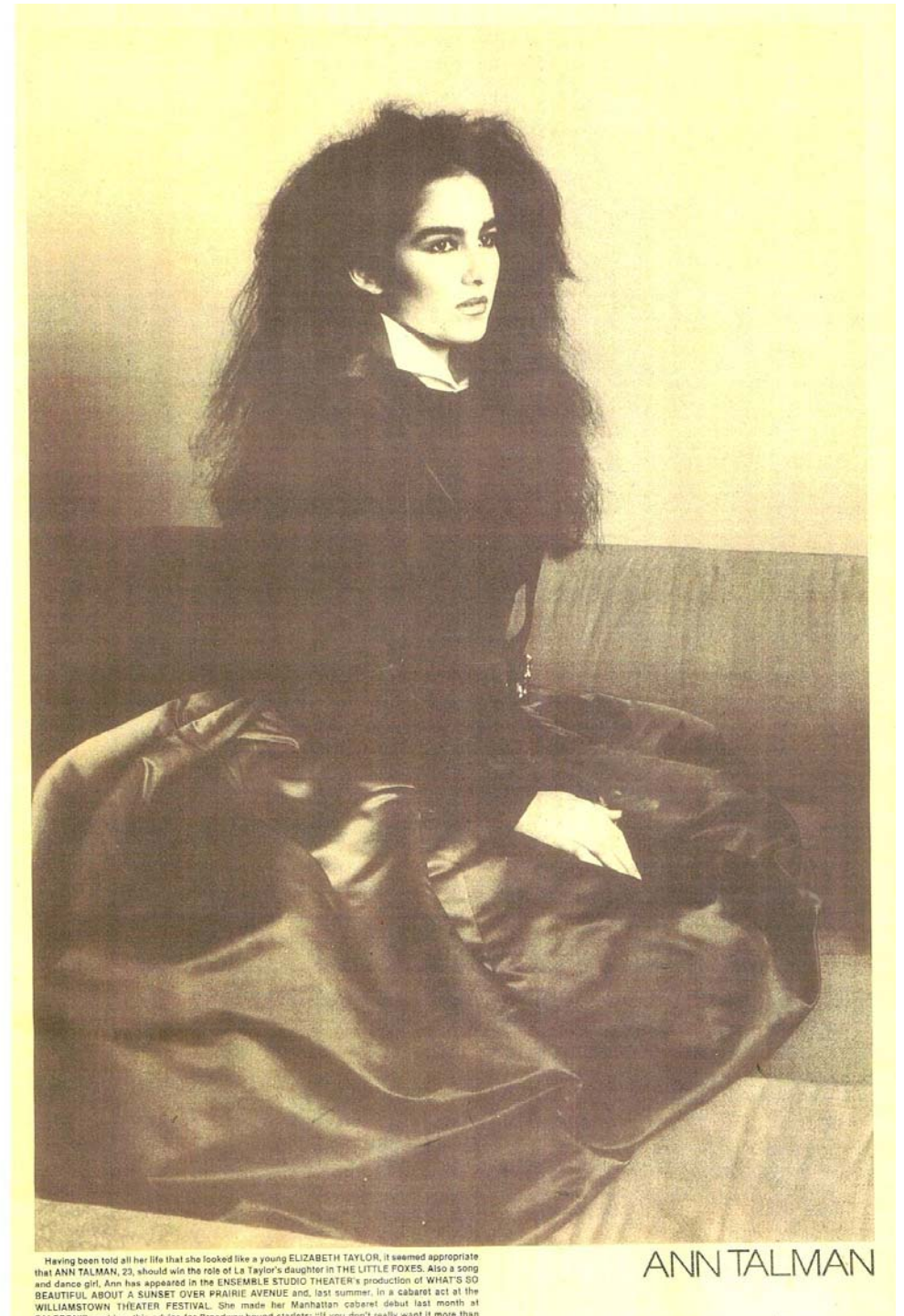
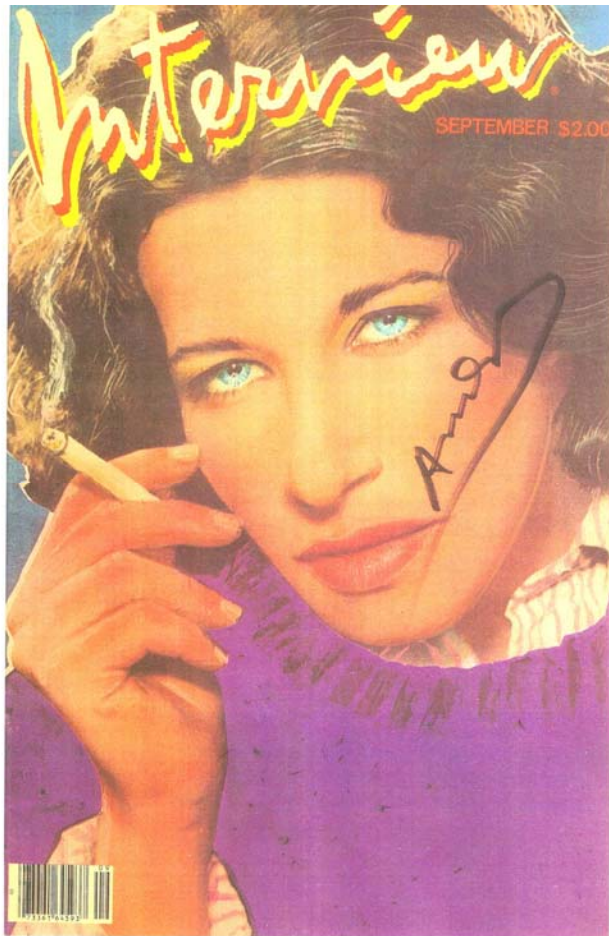
Price clock, pointer falls to lower prices, until someone presses a buy button

- 13 clocks, 3 clocks per room, with flowers on rail carts
- Auction advantage: **fast, fair, and final**, suited for for perishable commodities (flowers, fish)
- **Strategic tradeoff:** one must trade off advantage of a lower price with increased probability of loss
- Strategic situation simpler in an English auction, bid up to one's value if necessary (and if known), which is also the case with proxy bidding on Ebay

Ann Talman (left front) played Liz Taylor's daughter in *The Little Foxes*, Andy Warhol saw it and arranged a photo shoot



Ebay auction of
1981 *Interview*
signed by Andy Warhol



Having been told all her life that she looked like a young ELIZABETH TAYLOR, it seemed appropriate that ANN TALMAN, 23, should win the role of La Taylor's daughter in THE LITTLE FOXES. Also a song and dance girl, Ann has appeared in the ENSEMBLE STUDIO THEATER's production of WHAT'S SO BEAUTIFUL ABOUT A SUNSET OVER PRAIRIE AVENUE and, last summer, in a cabaret act at the WILLIAMSTOWN THEATER FESTIVAL. She made her Manhattan cabaret debut last month at the SPINNIN' and has this article for Broadway-bound starlets: "If you don't really want it more than

ANN TALMAN

Ebay Proxy Bids

- My bids: 100, 200, 300, 500 (and the price at that point was \$305.
- I had to teach at the auction close, so I bid. **\$1500** and bought it for about \$350
- **I bid my full value, but the iterated process helped me “discover” it.**
- no strategic tradeoff with proxy bidding, (and I was successful...)

“Magical Little Elf”

“Instead of having everyone sit at their computers for days on end waiting for an auction to end, we do it a little differently. Everyone has a little magical elf (a.k.a. **proxy**) to bid for them and all you need to do is tell your elf the most that you want to spend, and he’ll sit there and outbid the others for you, until his limit is reached.”

- **Auctions create economic value**
- **Auctions generate revenue**
- Both of these functions are dramatically enhanced with the Internet

Vickrey Auction

- In a 1961 *Journal of Finance* paper, Vickrey devised a sealed bid auction that, in theory, implements proxy bidding,
- The Prize is awarded to the high bidder at the second highest bid price
- Bids should reveal values if they are known, which fascinates economic theorists, but sometimes terrifies others
- New Zealand used a second price auction for spectrum, where an incumbent bid NZ 7 million for a nation-wide cellular telephone license, but only had to pay the second bid of NZ 5 thousand, which generated a public outcry

Reserve Prices

- In the New Zealand auction with a highly asymmetric situation, a carefully chosen reserve price (seller's bid) could have produced a huge revenue boost.
- Tradeoffs: reserve prices set too high may result in unsold items, and bidders don't like reserve prices, which may lower participation
- Reiley (2006) sold matched collectable cards from *Magic, the Gathering*, in ebay with and without reserve prices
- Reserve prices lower participation but raise the price conditional on a sale, as bidders with high values (above the reserve) bid up in anticipation that others will also bid higher.

Sealed versus Ascending Bids

- Strategic uncertainty and regret in sealed bid auctions, no chance to learn, but risk aversion can push bids up
- when Brazil privatized the Sao Paulo state bank with a first-price sealed bid auction, the managers of a major bank (BHSC) were shocked when the bids were opened and their winning bid of \$3.6 billion was more than 3 times the second bid, with \$2.5 billion “left on the table”
- Some timber auctions in the US were conducted with sealed bids, under the condition that losing bids would not be revealed, good seller strategy
- Sealed bid auction may yield inefficiencies, if the high-value bidder goes too low and does not win

Private versus Common Values

- The 1981 *Interview* magazine had a very high **private value** for me, and the auction outcome was, therefore efficient.
- People buying for investment and later resale may try to guess subsequent resale prices – thus the **common value** is not known
- Case of oil leases, value is not known, each bidder makes an independent estimate
- Estimates may be unbiased, but the person with the highest estimate is likely to be the high bidder, and may pay too much

Winner's Curse

- Suppose the unknown true value is 10, and the estimates for 5 bidders are 5, 9, 10, 10, 11, and 15. In a sealed bid, first-price auction, the person with an estimate of 15 will probably have the bid high, and may end up bidding above 10 if they feel like the competition from the 4 others
- Bidders adjust and bid lower (those who are still in business)
- Winning is informative, and finding out that you won should not cause you to want to change your bid.
- When I told a contractor that he had the highest bid for a complicated floor job, he looked distressed, but did not withdraw his bid.

FCC Cell Phone License Lottery

- Initial broadcast spectrum allocations were based on administrative proceedings, “beauty contests”
- Opposition to market allocations, FCC request to use auctions was denied in 1985
- First crack, in the 1980’s, the FCC conducted a lottery
- 320,000 applications for 643 licenses
- Accounting firms prepared applications for about \$600 each
- Total application costs estimated to be **\$400,000**
- Post auction value based on resales: **\$1,000,000**

Rent Seeking and Government

“with a Smokestack on its Back”

- FCC cell phone lobby: with estimated lobbying costs of about \$400,000 for licenses later valued at about \$1,000,000. Was this wasteful?
- “accountants and lawyers are people too” (but their high salaries represent real opportunity costs)
- Milton and Rose Friedman (1989), in a discussion of the unintended side effects of government policies, remark: “Every government measure bears, as it were, a smokestack on its back.”
- **Auctions generally bypass rent-seeking** value destruction (with some exceptions...)

FCC SMR Auctions

Paul Milgrom, Bob Wilson, Preston McAfee, Evan Kwerel, FCC staff, and many others worked out a simultaneous, multi-round (SMR) auction after the FCC got permission to use auctions in 1993:

- Lots of licenses, different geographic locations and/or frequency bands
- Multiple rounds (“are you between rounds”) with high bids announced as provisional winners, with required bid increments to stay active
- Bidder activity limits, “use it or lose it,” with activity being transferable across licenses
- Simultaneous close when no new bids come in
- Hope: iterations would lead to high efficiencies, and would help people discover value synergies

Creating Competition

- The FCC auctions are generally viewed as being very successful in terms of revenue generation, raising unimagined billions of dollars, and they have been copied by other governments around the world
- Auctions can fail when dominant bidders with high values are not challenged
- Good auction design creates a competitive situation, as Klemperer notes, its sometimes just a matter of good undergraduate Industrial Organization:
- Encourage entry and prevent collusion

“Defender of the Crown”

- UK ran in front with the 1st 3G spectrum auction
- 4 incumbents (2G providers), initially 4 licenses
- Klemperer recommended an “Anglo-Dutch” auction, with rounds of increasing bids, followed by a final-shootout sealed bid competition among the last 5 bidders standing, to break collusion.
- 5th license was added, so the UK went with the US practice of simultaneous ascending bids
- It was a huge success, \$34 billion (600 EU per person)
- Ken Binmore received the “Defender” medal

The “V word”

- Dutch were next, they copied the UK, US approach with simultaneous, ascending bids
- 5 incumbents, 5 licenses
- Potential entrants were allowed to make deals with incumbents
- In the end, only one weak entrant, who dropped out early after receiving a threatening letter from one of the incumbents
- Raised only \$3 billion, instead of the anticipated 10 billion based on UK prices
- Dutch word for auctions: “veiling” and consultants were later told not to use the V word.

Swiss 3G auction

- 4 licenses, 4 incumbents, and potential entrants were allowed to make joint bidding alliances with incumbents
- Klemperer: Weak bidders were deterred from entry by the simultaneous ascending auction format
- Only 4 bidders in the end, ludicrously low reserve prices
- Government tried to cancel, but backed down when threatened with lawsuits from one of the 4 bidders, which had hired lawyers and consultants
- Revenue, only 20 Eu per person

Germany and Austria: Packages

- Germans: 12 blocks, bidders could bid on groups of 2 or 3 blocks as a package
- Bids ending in “6” were intended to signal that each of 6 bidders should take 2 blocks each
- The revenue was high, as one large company that was majority owned by the German government pushed bids up to about the UK level before dropping out
- Austria followed, also with 12 blocks, 6 bidders
- The bidding stopped almost immediately, with 2 blocks per firm, at 1/6 of the per capita revenue obtained in the UK and Germany

Experiments: Pre-testing in the Lab and Field

- New auction methods provide a large scale, potential for disaster
- Need to imagine how outcomes would look
- Need to regain some control, NASA procurement officials once told me that the amounts involved are so high, that any way to get an understanding via experiments would be valuable.
- Experiments can convince policy makers of possible changes in behavior as institutional rules change
- Running experiments is good for working out details, like writing computer code

Structure of a Policy Experiment

- Students or relevant professionals (e.g. farmers)
- Read rules and provide financial incentives
- Put them in alternative environments, in lab or field situations, e.g. collecting bids, pay earnings in cash (we spend about \$70,000 at Caltech this spring in auction experiments)
- Observe and compare outcomes, e.g. auction revenue, economic efficiency, political effects

Dual Punch

- Experiments provide consultant with the confidence to make recommendations that are relatively free of assumptions
- Experiments provide the policy maker with a clearer view of how the policy might work

Binmore and Klemperer:

“We think that their experience of playing the roles of bidders within our experimental software had a significant effect on bolstering the confidence of non-economists on the auction team in the workability of the design. By contrast, mathematical equations have very little persuasive power.”

2001 Georgia Irrigation Reduction Auction

- My experience in helping design an auction (with Ron Cummings and Susan Laury of Georgia State):
- 2000 drought, severe effects on environment and possibly on Atlanta drinking water, “Dry 2k Crisis”
- 10 million in tobacco settlement money was set aside to run an “**auction-like process**” to pay farmers not to irrigate
- Irrigation permits for 50-300 acre circular irrigation arrays in Flynt River valley, issued for free, not traded
- Auction decision: driven by budget windfall, tobacco settlement
- Auction: fast, transparent, fair, and voluntary (as compared with forced reductions)

Experiments

- Run at Ga. State beginning just as law was passed, with 8-80 subjects per group, students and farmers
- **Rich instructions** (“acres”, “permits”, etc.)
- **Long instructions** (1 hour)
- **No repetition** (1 auction per session),
- **Collusion permitted**
- Induced per-acre opportunity cost of irrigated land
- Scaled up values and numbers in some experiments
- The Georgia Environmental Protection Department (EPD) officials observed some

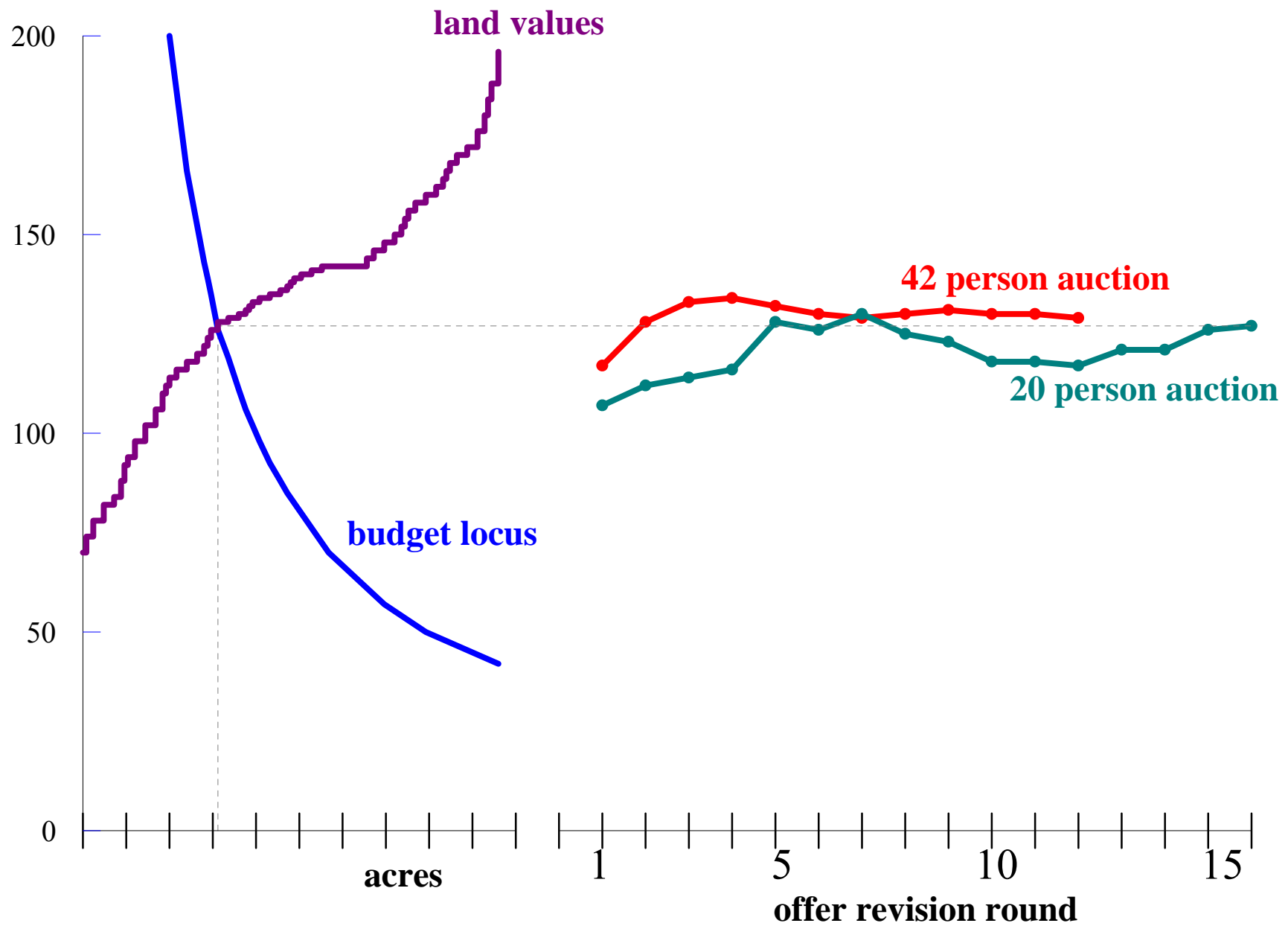
Alternative Auctions: Two Distinctions

- **Uniform Price Auction:** would have selected low bidders and paid them equal amounts per acre not to irrigate (ruled out to avoid appearance of “waste” as with the New Zealand auction)
- **Discriminative Auction:** Low bidders would be selected and paid their bid prices, so different people receive different per acre payments.
- **One Round Sealed bid:** one round submission of dollar amounts per-acre as compensation for not irrigating in the current season
- **Multi-round Sealed Bid** – bids submitted, ranked from low to high, and provisional winners are announced for each round, until auction is stopped (unknown number of rounds)

Tight Design Phase

- Experiments in May 2000 used by EPD to suggest two alternatives for public comment in June.
- We found that the multi-round auction worked best, it helped bidders learn and get serious, the closing round was not announced to provide maximum flexibility for the EPD and to force serious bidding early
- Lab tests resulted in refinements of tie-breaking rule and information withholding
- State opted for multi-round auction
- Full sized field test run in Feb. 2001, Auction run in March 2001

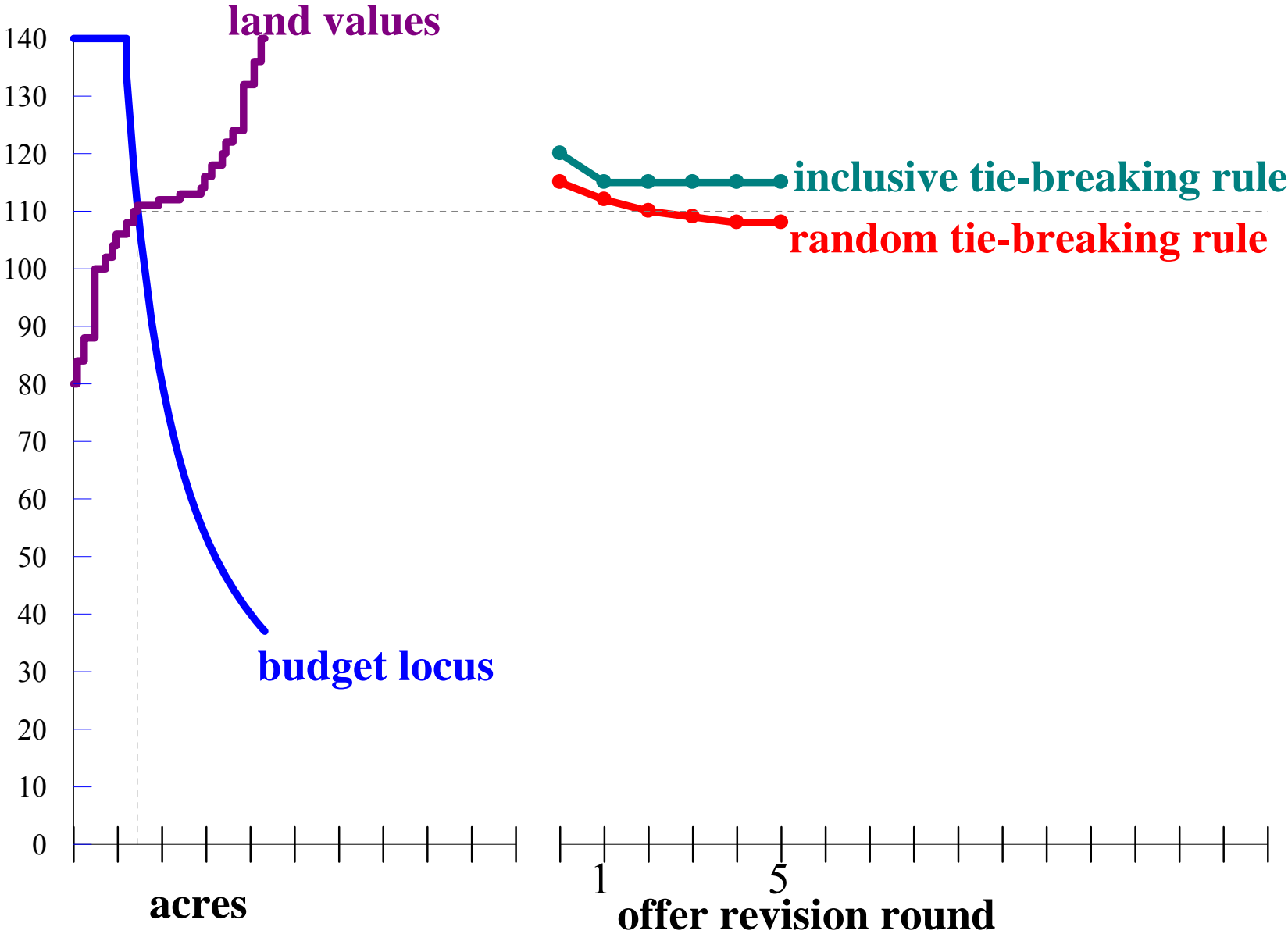
cost per acre



What If There Is a Tie at the “Maximum Accepted Offer”

- At first, our instructions were not specific
- In one session, we responded by saying that we would buy all permits at a tie price, even if we had to spend more than our budget to do so
- The result: there was a tie at the cutoff, all tied bids were included, and then we got even more bids at that price in the next round. Eventually, most offers were eventually revised to this level, and we spent much more than twice the pre-announced budgeted for that experimental session!
- A second session with a random tie-breaking rule yielded a competitive outcome, at budget.

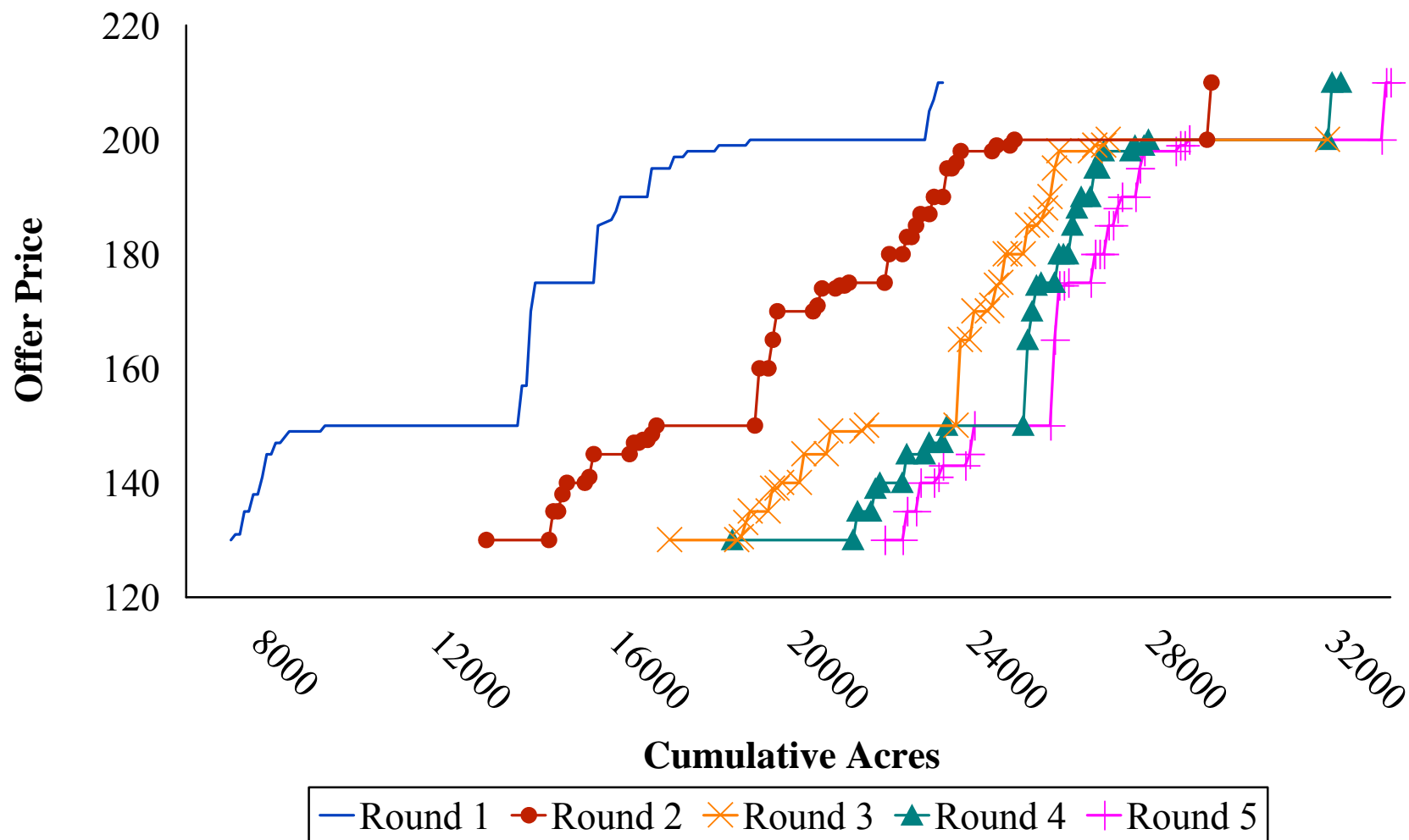
cost per acre



March 2001: one of the auction sites,
with economists wearing red hats



Offers from \$130 - \$210



Successful Georgia Auction Outcome

- Acres offered increased from round to round in the relevant range (previous slide)
- Inexpensive to run (we were free)
- Quick, one morning, ready for planting
- 33,000 acres taken out
- Low price \$135 per acre
- Only one law suit – dismissed
- They used the first year outcome to set a high reserve price of \$150 and ran a sealed bid auction the second year, which also worked well.

2004 Virginia NO_x Auction (run by Bill Shobe)

- Nitrous oxide (NO_x) emission allowances
- 1855 one-ton allowances for each of 2004 and 2005 years, tradable in 19 state area
- (5 percent of state total, the rest are “grandfathered” based on high use)
- Auction decision: driven by budget crisis
- Auction: fast, transparent, and fair (as compared with “leaking” sales to the spot market)
- Experiments were run at George Mason (neutral terminology and repetition)

- **Clock Auction** – prices are determined by a clock, starting low. At each price, bidders indicate desired quantities. Bidding stops when the total bid quantity falls to equal the available supply (revenue max at last stage)
- **Combinatorial Clock**, allows bids on blocks of allowances, so that you do not risk winning a part of a block needed for a new generation facility, the experiments also allowed bidding on multi-year combinations
- **How is the clock different?** Prices are not bid driven as in the FCC auctions, but are run up relentlessly by a clock. With a spatial dimension as in the FCC licenses, the clock that prevents aggressive jump bids by large bidders and helps small bidders coordinate responses

NOx Auction Outcome

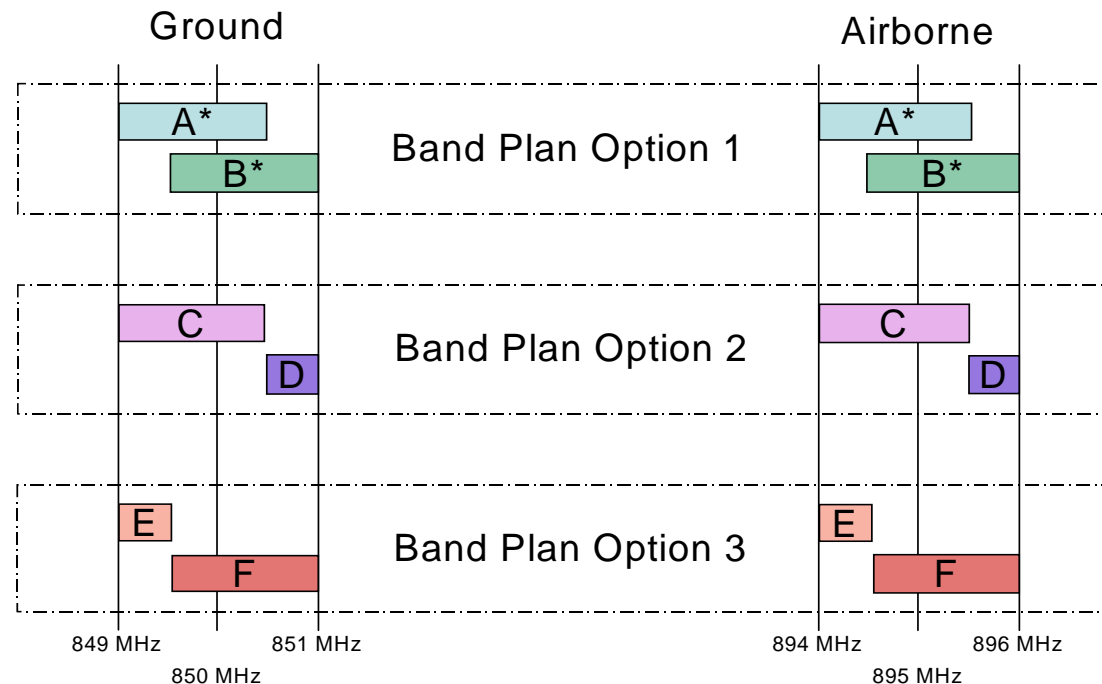
- Inexpensive to run: \$200,000
- High revenue: \$10.5 million
- High prices, 5-7 percent above spot prices on the morning of the auction
- Quick implementation: Bill Shobe had complete control, since nobody in upper management positions wanted to be associated with a first-of-kind auction with high political risks

FCC Auction 65 “Band Plan”

(2 MHz slots, with 3 possible divisions)

Air-Ground Service

800 MHz Commercial Service Band Plan



* Notes: If option 1 is implemented, licenses A and B would authorize transmission of radio waves that are vertically and horizontally polarized, respectively, and would initially share 1.5 MHz at 849.0-850.5 MHz paired with 1.5 MHz at 894.0-895.5 MHz. Once Verizon Airfone's incumbent system ceases operations in the upper 0.5 MHz of each band, licensee B would shift its operations to 1.5 MHz at 849.5-851.0 MHz paired with 1.5 MHz at 894.5-896.0 MHz. The parties may agree to a different implementation scheme, subject to the service rules.

Band Plan and Package Bidding

- Imagine the 2 MHz divided up into 4 blocks, A, B, C, and D, each .5 MHz
- One band plan has packages: ABC and D
- Another plan has packages: A and BCD
- Another has AB and CD with some overlap
- Package bidding allows bidders to avoid the “**exposure problem**” of bidding high for a combination and only getting part
- After hearing industry requests, the FCC decided to let the market determine the package structure (that maximizes sales revenue)

Air to Ground Auction 65

- Pre-made packages avoided having firms carve up the market as happened in the Austrian Auction
- 144 rounds of bidding
- The winning bids for packages ABC and D were \$31 million and \$7 million.
- bids on packages A and BCD were about \$7 million and \$27 million.
- Packages with 3 times as much bandwidth were selling for 4 times as much, some modest complementarities at about the exact same level we used for a systematic comparison of SMR and a package bidding alternative.

Combinatorial Auctioneering

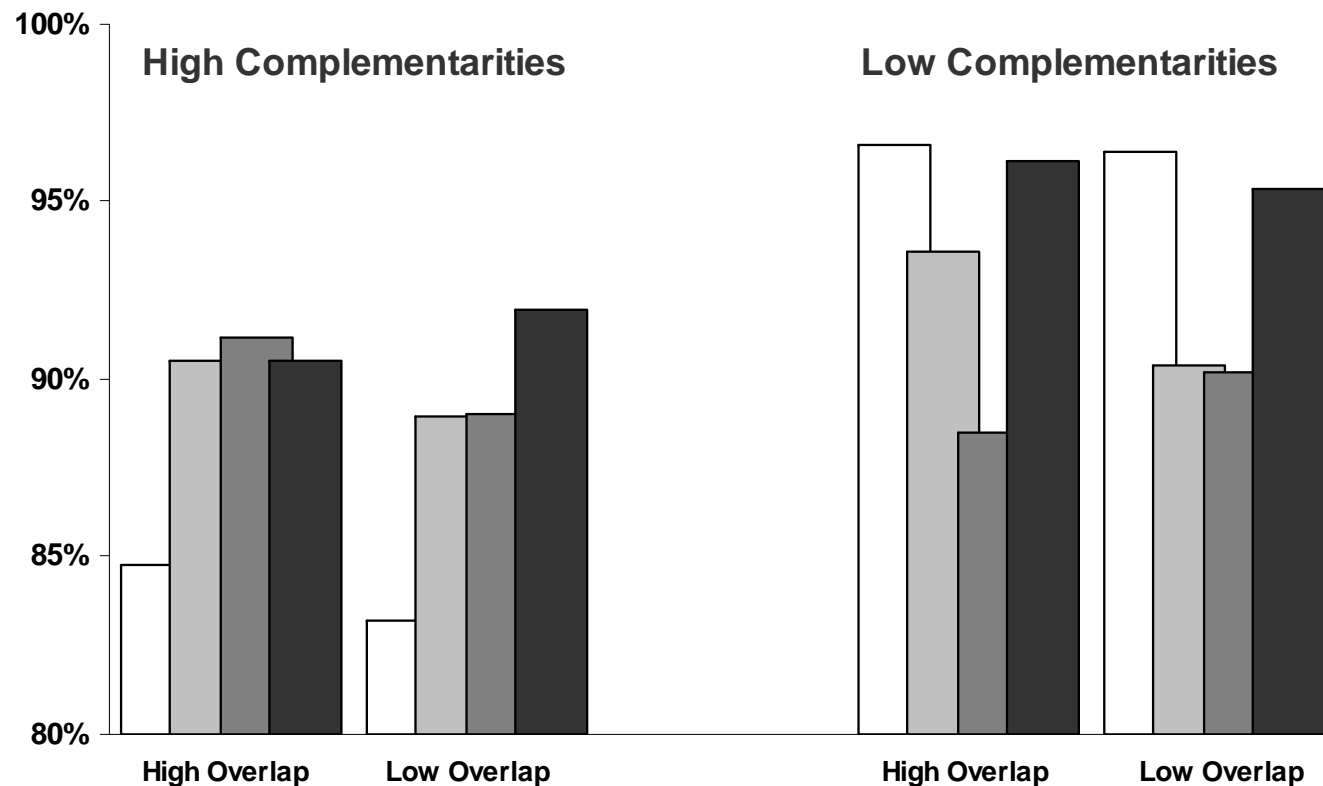
Brunner, Goeree, Holt, and Ledyard, outgrowth of a report for the FCC, with Christoph Brunner added, although our conclusions do not necessarily reflect their views

- **SMR:** simultaneous multi-round auctions, with activity rules, withdrawal penalties, etc.
- **PB:** package bidding in which bidders can bid on individual licenses and/or packages in a series of rounds, with announced provisional winners and appropriate activity rules, and RAD prices
- **“RAD” prices:** shadow prices used to convey values of individual licenses to bidders, so that the price of a package is the sum of the prices on the licenses

Four Auction Methods

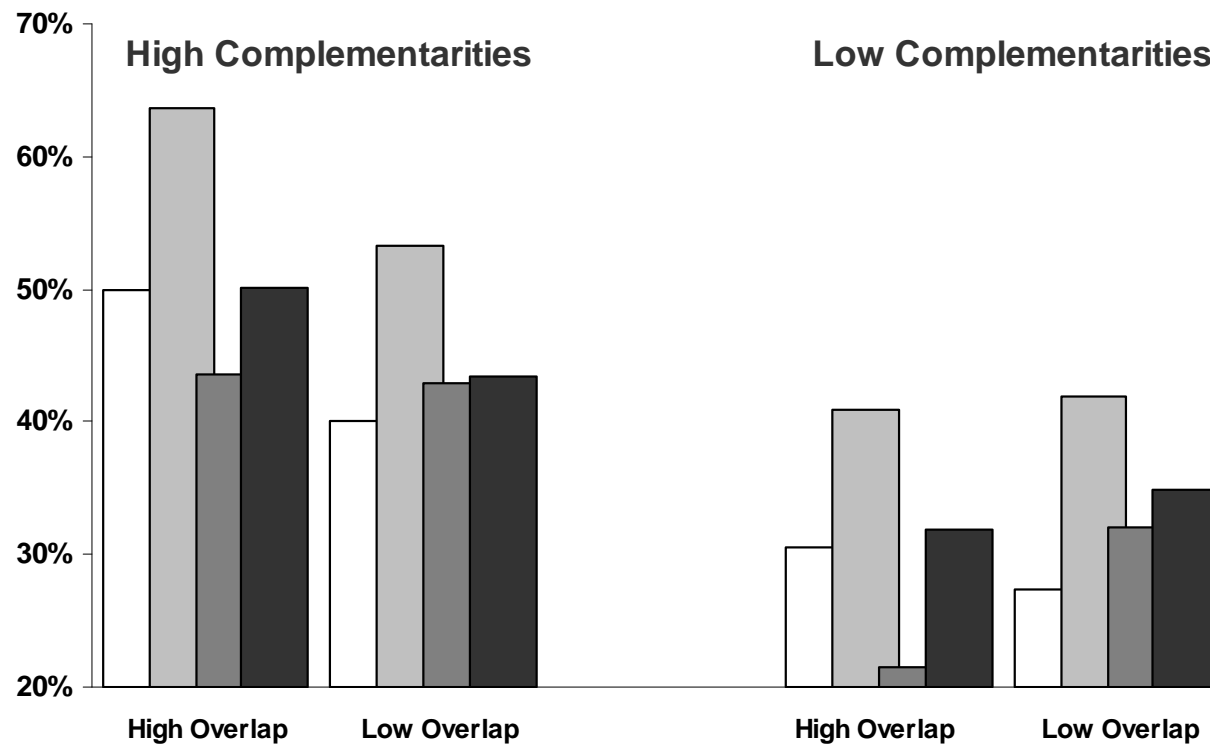
- **SMR** current FCC procedure
- **RAD** package bidding with shadow prices
- **RADX** package bidding with a requirement that a bidder can have only one winning bid (the “XOR rule” prevents overspending)
- **CC** combinatorial clock, bids are for licenses and or packages, and clock prices click up for those licenses that are included in the bids of more than one bidder,
- 48 sessions, about 500 subjects, at Caltech, with the J-auctions software developed by Jacob Goeree

With High Complementarities, Package Bidding
(three darker bars) yields higher efficiencies.
Normalized efficiencies, from left to right:
SMR (white), Clock (gray), RADX, RAD



The Combinatorial Clock (a hungry animal) yields higher revenues in all treatments.

Normalized revenues, from left to right: SMR (white), Clock (gray), RADX, RAD



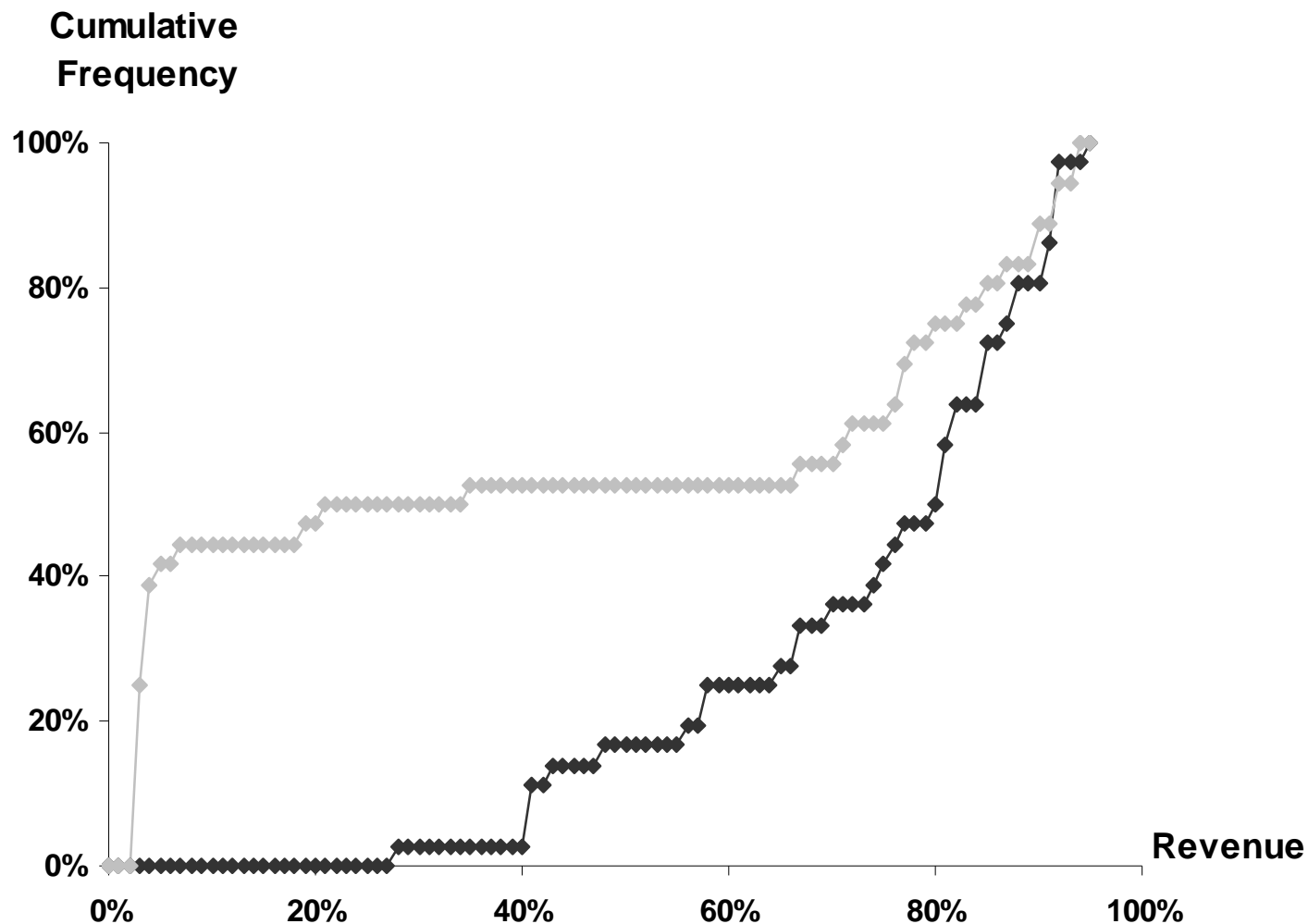
A Design with Possible Collusion

Key: random bidder values uniform [low, high]

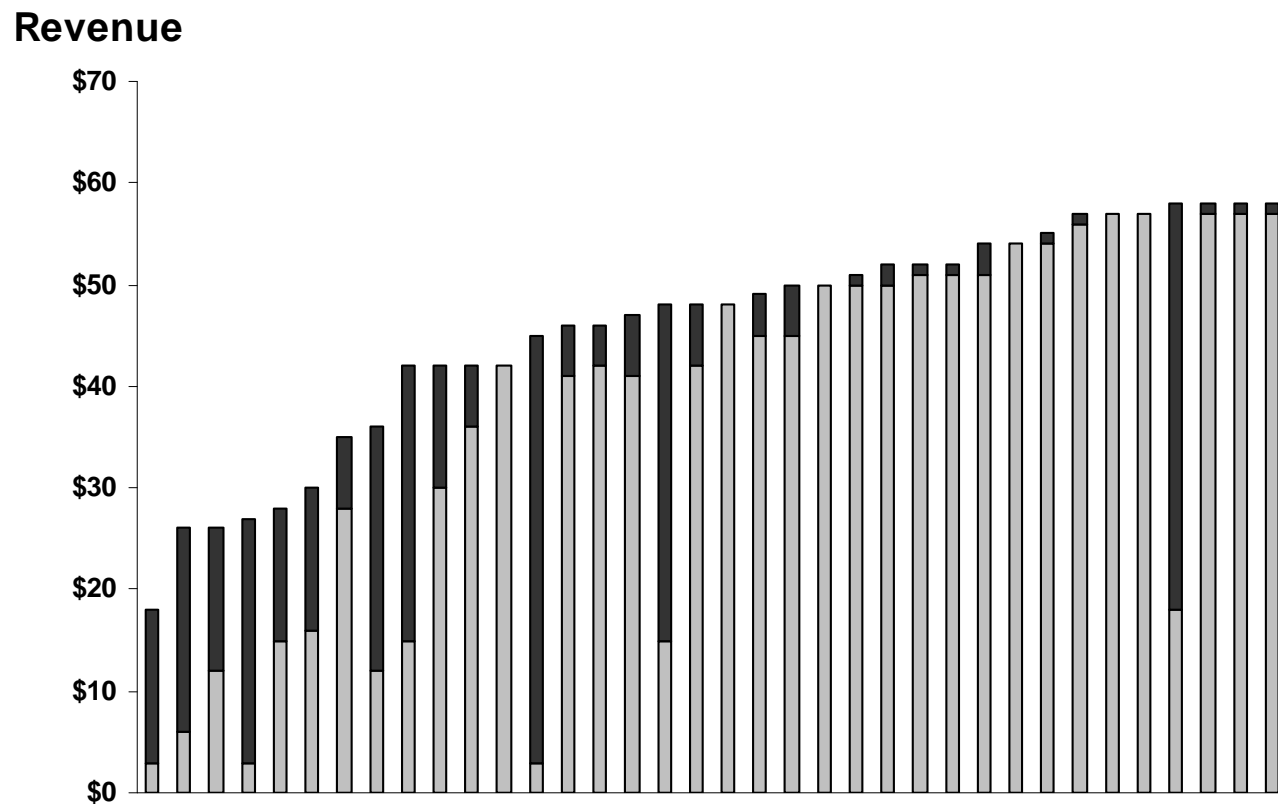
	License A	License B	License C	Activity	Synergy (α)
Bidder 1	[19,21]	[1,5]	[1,5]	3	0.5
Bidder 2	[1,5]	[19,21]	[1,5]	3	0.5
Bidder 3	[1,5]	[1,5]	[19,21]	3	0.5

- Each bidder has an incumbency advantage for one license (its easy to see how to collude)
- But acquiring all 3 would double license values (provides an incentive to defect)
- Auctions were run with a Combinatorial Clock, bidders could not see others' bids or activity

Bimodal Outcomes for Clock, Higher Revenues for Clock with Shootout (dark cumulative distribution line on right)



Revenue increments in the shootout phase of the Anglo- Dutch auctions (dark bars)



Spectrum Auction Experiments

- SMR (current FCC) auctions and RAD yield the highest efficiencies when there are minimal complementarities
- Package bidding with the one winning bid (XOR) rule does worse with minimal complementarities
- Package bidding methods yield higher revenues when there are significant complementarities
- The Combinatorial Clock yields the highest revenues in all treatments
- RAD provides a nice balance of high revenue and high efficiency across treatments
- Combinatorial Clock with a final shootout (Anglo-Dutch) breaks collusion in a dangerous situation with natural market divisions

Conclusion

- Auctions can bypass wasteful rent-seeking
- Auctions create real economic value by finding the high-value users
- Auctions promote price discovery by bringing together all buyers and releasing significant quantities
- Auctions are fast, fair, and generate high revenue when properly designed
- Emissions allowances are relatively homogeneous, so auctions should be simpler to design. I would suggest looking at clock auctions as strong candidates for generating fast, efficient, and high-revenue outcomes, i.e. maximum public benefit.