Issues in Spectrum Auction Design

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Introduction

Auctions are widely used to buy and sell goods and services.

Why use an auction, instead of posting or negotiating a price?

1. Price discovery: Buyers' willingness to pay is private information.
- Relevant when the item to be sold is unique, or market conditions are changing.
- Then past sales of similar items may not be reliable indicators of current market conditions.
- Auctions reveal bidders' willingness to pay before the price is set.

2. Efficient allocation: Identity of highest value buyer is unknown.
- Relevant when it is difficult for the seller to determine the best use of the product. An auction lets the market decide.
- A well designed auction allocates resources to those who can use them most valuably.

3. Revenue generation

US Spectrum Allocation & Assignment

A brief chronology:

- Comparative hearings
  - public interest assessment
  - overwhelmed by cellular telephone applications
- Lotteries (Reagan era)
  - political compromise
  - “unjust enrichment” and administrative nightmares
- Auctions (Clinton era and beyond)
  - market determined “assignments”
  - regulation of “allocation” (uses)
  - subsequent consolidation

Auction Design

What are the objectives?

- Simplicity
- Efficiency – broadly defined, including pricing and innovation
- Revenue ("fair return")
- Other: diversity, entry, national interests

What are the characteristics of the item being sold?

- What rules and regulations govern usage after the sale?
  E.g., Mandated or prohibited uses; access requirements and/or fees.
- Rules governing subcontracting, sales or mergers.

Who is eligible to bid?

What are the auction rules?

What is determined ex post?

- When are bids collected?
- Bankruptcy rules and withdrawal penalties.
- Detection and punishment of misbehavior, e.g., collusion.

Auction Formats

There are many possible auction mechanisms.

- Open outcry vs. sealed bid
- If open, ascending (English) vs. descending (Dutch)
- If sealed, highest bid (FPSB) vs. second-highest bid (Vickrey)
- Reserve price, announced or secret
- Differential treatment of bidders
- Entry fees or subsidies

In practice, most auctions are either first-price sealed bid (FPSB) or open outcry, ascending price (English).

Why are so many formats employed?

Which format is best, from the perspective of either the seller or the buyers, depends on the circumstances.

Multi-Unit Auctions

In many instances, multiple units are sold or procured simultaneously, rather than sequentially.

Examples: treasury bills, wholesale electricity, spectrum licenses.

Sales of multiple identical items:

- Uniform price

  All winning bidders pay lowest market clearing price.

  E.g., lowest winning bid (US treasury bills, PJM electricity) or highest losing bid (Google IPO)

- Discriminatory

  Winning bidders pay own bid (German or French treasury bills)

There is no clear ranking of the two according to expected seller revenues.

The revenue maximizing choice depends on the circumstances.

For non-identical items, there is also an issue of whether and how to bundle items, or allow package bids, to reflect complementarities.

Spectrum Auction Design Issues

Basic Problem: Lack of information about the efficient size of licenses, how much firms are willing to pay for licenses, and who should get them.

- *Complementarities from aggregating licenses across geographic markets*
  Consumers value roaming, which make adjacent licenses more valuable in combination than individually.
- *Complementarities from bundling wireless with cable, phone, and internet services*

  Consumers value the services more highly when they are bundled.
- *Complementarities from aggregating licenses in the same geographical market*

  By winning more licenses, firms have more market power.

  They may also be able to provide more services.

US Spectrum Auction Design

Solution: Simultaneous, multiple rounds, ascending price auction:

- In each round, bidders simultaneously submit bids for licenses.
- At end of each round, new bids and identities of bidders are posted.
- Standing high bid for each license at the end of each round is the larger of the previous standing high bid or the highest new bid (or fixed increment if license is bid).
- Corresponding bidder for each license is the one who submitted the standing high bid (randomized in some cases if multiple submissions).
- At the end of each round, minimum bids for the new round are posted: standing high bid plus bid increment.

All licenses are open for bidding in a round and remain open as long as acceptable bids are placed on any of the licenses.

Basic Idea: Multiple item extension of the English auction. Bidders can express their valuations for different combinations of licenses; competition forces them to eventually reveal their valuations.

Initial US Spectrum Auctions

1. Narrowband auctions sold licenses covering 1.2 MHz of spectrum.

- Licenses were used to sell paging services
- 10 national licenses sold in July 1994; 6 regional licenses sold in October 1994
- Revenues: $1.1 billion.

2. The AB broadband auction ran from December 1994 to March 1995.

- FCC divided the country into 51 major trading areas (MTA).
- Each MTA had two 30 megahertz (MHz) identical blocks of spectrum.
- Each block can be used to provide personal communications services: mobile phones, two-way paging, wireless networks.
- Firms could acquire only one block in each MTA $\Rightarrow$ duopoly.
- Revenues: $7.7 billion.

Auction Format Tradeoffs

Why might open auctions be preferable?

- Bidding reveals information about competitors' valuations, reducing uncertainty about one's own assessment, and hence reducing the risk of winners' curse. Bidding will be more aggressive.
- Also reduce ex post regret from overpayment, or from losing narrowly.
- If bidders are asymmetric, more likely to achieve efficient allocation.
- If there are multiple items, it is easier to assemble packages to realize complementarities.

Why use a sealed bid format?

- It is easier to set up and run. Open auctions involve much more communication between bidders and the seller.
- If bidders are asymmetric or risk averse, can achieve higher revenues.
- Less susceptible to bidder collusion.

Bidder Coordination In Open Auctions

Example 1: A and B are bidding for License 1. A is also bidding for License 2, and it knows B has no interest in License 2.

B wants A to stop bidding for license 1. It stops bidding for License 1 and bids for License 2.

The message to A is: “Let me have License 1 or I’ll bid up the price of License 2.”

Example 2: Both A and B are interested in Licenses 1 and 2.

A stops bidding for License 1 and, if B does not stop bidding for License 2, jumps back into the bidding for License 1.

The message to B: “If you stop bidding for License 2, I’ll stop bidding for License 1.”

Bidder Coordination

Other signaling strategies: jump bidding, code bidding

Main Point: Simple strategy of bidding up licenses until price exceeds value is probably not optimal. Better to concede some markets in order to pay lower prices in other markets.

Design Response: limit information revealed at the end of each round; limited discretion in choice of bid increments (fixed increment or limited choice of increments).

For example, in electricity auctions, bidder identities and bids are not revealed and only aggregate excess demand is reported.

Simultaneous vs. Sequential

Simultaneous sale generates more information: bidders observe prices on all licenses and can respond to this information in making decisions about which licenses to pursue and how much to bid for them.

Simultaneous sale is flexible: bidders can switch to backup combinations of license if their first-choice combinations become too expensive.

Desirable Features:

- Similar licenses sell for similar prices.
- Greater information release + greater flexibility to respond to info $\Rightarrow$ more efficient aggregations of licenses.

Undesirable Features:

- Bidders may try to hide their valuations by using a "snake in the grass" strategy – not bid seriously until the very end. But if everyone adopts this strategy, bids are not informative, and auction never ends.
- *Response*: minimum bid increments; activity rules. These force bidders to bid with increasing sincerity.

Activity Rules

Example: In 2009 AWS sale, Industry Canada assigned a number of eligibility points to each license

- Proportional to MHz of the block, and
- Proportional to population of the geographical area.

Bidders chose how many points they wanted prior to the auction and posted a bond for those points.

Pre-auction financial deposit = $40,000 per point for first 300 points and $140,000 per point for additional points.

- 20 nationwide = 1,240 points = $143.6 million
- 40 nationwide = 2,480 points = $317.2 million

Eligibility in a given round falls if bidder does not maintain activity.

Given the activity rules, prices never decrease.

- Equilibrium exists.
- Auction ends in finite time.

Combination vs. Single Bids

Example: Firm A has the following valuations for Licenses 1 and 2:

- Stand-alone value of License 1 = $1 million
- Stand-alone value of License 2 = $1 million
- Combination of License 1 & 2 = $4 million.

Suppose there are only single bids on each license, and not bids for the combination.

If bidding reaches $1 million, then A is forced to bid more than its "stand-alone" values.

$\Rightarrow$ A loses if it wins only one license!

This is known as the *Exposure Trap*.

Combination bidding would allow A to submit a separate bid on each license and one for the combination.

Combination vs. Single Bids

Benefits:

- Combination bidding allows bidders to avoid the exposure trap.
- Combination bidding makes it easy for a company to obtain a national license.

Caveats:

- Complex; not transparent – especially with many licenses. Determining winning bidders is a complicated programming problem.
- Free-rider problem biases outcomes to favor large bidders who want national licenses. Each regional bidder wants another regional bidder to raise the price.

Entry

Auction design can reduce incumbency advantages.

- Incumbents value the licenses more highly than entrants, because incumbents take into account the loss of profits on existing networks if the license goes to an entrant.

Example: In Great Britain, 5 licenses were sold using the simultaneous, ascending price auction. There were only 4 incumbents. Since each firm was permitted to win no more than one license, entrants were guaranteed to win at least one license.

- Nine new firms participated in bidding
- Revenues were 39 billion Euros.

Entry

Example: The Netherlands sold 5 national licenses using a simultaneous, ascending price auction.

Five incumbent mobile phone companies; each could win one license.

Entrants anticipated that they would be outbid by incumbents for the five licenses. Hence, they did not enter, but instead struck deals with incumbents.

Result: revenue was less than 3 billion Euros; 10 billion was forecast based on UK experience.

Solution: Use a sealed bid auction or Anglo-Dutch auction. The sealed bid auction gives entrants a chance to win profitably against the incumbents. Incumbents have to bid more aggressively.

Example: Denmark used this auction successfully. The auction attracted a serious bid by a new entrant and generated revenues of 95 Euros per capita, double the amount forecast.

Entry is not assured; one solution is set asides.

2009 Canadian Spectrum Auctions

268 spectrum licenses divided into blocks and geographic tiers.

Blocks and Geographic Tiers for AWS

- **Blocks A- F**
  - B, C and D are reserved for new entrants (set-asides or "closed")
  - A, E and F available to everyone (non set-asides or "open")
- **Tier 2 and 3 service areas for AWS**
  - Tier 2 consists of 8 provincial and 6 large regional service areas;
  - Tier 3 consists of 59 regional service areas

Blocks	Pairing	Amount	Tier	# Licences
A	1710-1720 MHz / 2110-2120 MHz	20 MHz	3	59
B	1720-1730 MHz / 2120-2130 MHz	20 MHz	2	14
C	1730-1735 MHz / 2130-2135 MHz	10 MHz	2	14
D	1735-1740 MHz / 2135-2140 MHz	10 MHz	3	59
E	1740-1745 MHz / 2140-2145 MHz	10 MHz	3	59
F	1745-1755 MHz / 2145-2155 MHz	20 MHz	3	59

- Three incumbents: Bell Canada, Telus, Rogers.
- New entrants: entities with less than 10% of national wireless revenue.
- Revenues: $4.25 billion Cdn.

Entry Outcomes

In the Canadian AWS auction, set asides served their intended purpose.

- Attracted four new players: two regional cable networks (Shaw and Videotron) and two new entrants (Yak Global and DAVE).
- Yak tried to win a national network of 10 MHz licenses and DAVE tried to win a major city network of 10 MHz.

Moreover, the competition in the set aside licenses spilled over into the open licenses.

Open License Prices

Parking Strategy

- Bid on licenses you do not want to maintain eligibility for bidding later on licenses you do want.
- Entrants parked on the open licenses.

Deterrence Strategy

- Bid on the core markets of rivals so that they do not bid on your core markets.
- Incumbent bidders could not deter entrants from parking by bidding on the set aside licenses.
- They had to keep bidding to win the open licenses back or lose eligibility.

As a result, prices on open licenses rose much faster than prices on set-aside licenses.

Canada 2009 AWS Auction Results

Overview of AWS Spectrum Auction Results Overall Results			
Bidder	**Total Expenditures Non G&I Blocks**	**% of Total Non G&I Blocks**	**$/MHz/Pop Non G&I Blocks**
Rogers	$999,367,000	23.9%	$1.666
Telus	$879,889,000	21.1%	$1.820
Bell Mobility	$739,978,000	17.7%	$1.901
Videotron	$554,549,000	13.3%	$1.459
YAK Communications	$440,624,000	10.5%	$1.369
DAVE	$243,159,000	5.8%	$1.393
Shaw	**$189,519,000**	**4.5%**	**$1.004**
Bragg Communications	$25,147,000	0.6%	$0.231
NovaCap	$0	0.0%	$0.000
SaskTel	$64,600,000	1.5%	$2.207
MTS Allstream	$39,000,000	0.9%	$1.743
Others	$1,671,000	0.0%	$0.694
Sub -total	**$4,177,503,000**	**98.2%**	**$1.547**
G&I Blocks	**$77,207,327**	**1.8%**	**$0.232**
Total	**$4,254,710,327**	**100.0%**	**$1.402**

Regional Price Differences

What explains the variation in prices per MHz/pop across bidders?

- The incumbents Rogers, Bell, Telus coordinated: Rogers bid for the 20 MHz A license; Telus bid for the 20 MHz F in the west and the 10 MHz E license in the east; Bell did the opposite.
- Rogers, Telus, Bell ended up winning almost all of the open licenses but were forced to pay higher prices due to parking by entrants.
- Videotron won all 40 MHz of set aside licenses in Quebec – local cable monopoly competed in the auction rather than the market.
- Shaw pursued a market division strategy: they shared the 40 MHz in B.C. and Alberta with DAVE and Yak.
- In Saskatchewan and Manitoba, Shaw and Yak faced local incumbents – provincially owned telephone companies that wanted to keep entrants out of the wireless markets.
- Bragg and Yak were the only entrants in the Maritime provinces.

Conclusion

Auctions are a popular selling mechanism.

But they do not always function well.

In some situations, the optimal rules involve straightforward adaptations of existing methods.

Institutional details and economic circumstances can play a large role in the choice of selling method.

Moreover, the details of auction design can matter.