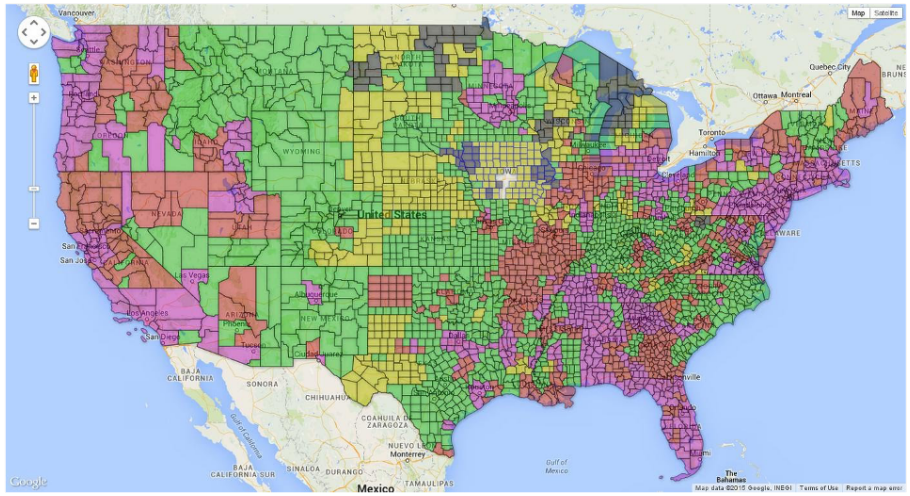
Spectrum Auction Design

Slide Credit: Gianluca Brero

November 5, 2025

Spectrum Auctions

- Used by governments to sell licenses for wireless spectrum use since the early 1990s
- A lot of research & development in the subsequent 30 years
- The most recent US auction for 5G raised approximately $81B!
- Importantly, bidders may have non-additive values for licenses



1. $80M on NYC
2. $60M on NJ
3. $200M on NYC + NJ

Evaluating Spectrum Auction Designs

- Revenue meets (or exceeds) projections
- Similar goods should sell for similar prices
- Package allocations should be sensible (e.g., adjacent licenses)
- Little or no resale after the auction; or, if resale, only at prices similar to auction prices

Can't we just use Vickrey auctions?

- 2000 Swiss Spectrum Auction
- 3 licenses up for sale
  Licenses 1 and 2 are similar, while license 3 is more valuable
- Sequential Vickrey auctions
- Bidding is not straightforward
- Why not? If others bid their values, you do better to wait for later auctions
- Outcome
  - License 1: CHF 121 Million
  - License 2: CHF 134 Million
  - License 3: CHF 55 Million

Can't we just use Vickrey auctions?

- 1990 New Zealand
- 7 identical licenses
- Simultaneous Vickrey auctions
- Is it better to bid aggressively on one or less aggressively on many?

Table 1

Winning Bidders on Nationwide UHF Lots 8 MHz License Rights			
Lot	Winning Bidder	High Bid (NZ$)	Second Bid (NZ$)
1	Sky Network TV	2,371,000	401,000
2	Sky Network TV	2,273,000	401,000
3	Sky Network TV	2,273,000	401,000
4	BCL	255,124	200,000
5	Sky Network TV	1,121,000	401,000
6	Totalisator Agency Board	401,000	100,000
7	United Christian Broadcast	685,200	401,000

Source: Hazlett (1998).

Can't we just use Vickrey auctions?

- Other undesirable (sometimes embarrassing) outcomes included:
  - A company bid 7 million NZ dollars for a license, but ended up paying only 5000 NZ dollars.
  - Another license had the highest bid of 100,000 NZ dollars, while the second-highest bid was only 6 NZ dollars.
  - A university student bid 1 NZ dollar for a TV license for a small city, and won the license because no one else bid anything. The student paid nothing for the license.
- A later New Zealand auction kept the simultaneous sealed-bid format, but switched to first-price to make losses less conspicuous.

Simultaneous Ascending Auctions

- High-level idea
  - Single-item ascending-price auctions are run in parallel.
  - During each round, bidders place new bids on any subset of licenses.
  - Prices of licenses with news bids can increase.
  - Repeat until no new bids.
- Intuitively, broadcasting prices can prevent miscoordination by guiding demand toward cheaper licenses!

Still Some Potential Issues

- Example scenario
  - 2 goods and 2 bidders.
  - Bidder 1 only wants one good, and values it at 8.
  - Bidder 1 values one of the goods at 10, and both at 20.

- Strategic Demand Reduction
  - If bidder 2 only targets the other good (not the one bidder 1 wants), both bidders win one good – for free!

Still Some Potential Issues

- Example scenario
  - 2 goods and 2 bidders.
  - Bidder 1 only wants one good, and values it at 8.
  - Bidder 2 values both goods together at 10.

- Exposure
  - Bidding proceeds on both goods until each is priced at 5, at which point bidder 2 drops out.
  - Bidder 1 wins one of the goods at $5 + \epsilon$.
  - One of the bidders (the current tentative winner) wins the other at price 5, but at a loss!
  - Bidder 1 cannot win without overpaying!

The Combinatorial Clock Auction (CCA)

- Phase 1: (Clock Phase)
  - Auctioneer announces prices for all goods.
  - Bidders submit their demands at current prices.
  - Prices for overdemanded goods are increased.
  - Repeat until there is no more overdemand.
- Phase 2: (Supplementary, Sealed-bid Phase)
  - Bidders have a "last chance" to submit bids on bundles.
  - They have learned some price information during the clock phase.
  - They are also constrained by their bids in the clock phase.
  - Use a "second-price"-type rule to determine final prices.

References

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