Auction Design for the Real World

by

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of

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Why Auction Design Matters

Public policy goals can be implemented within auction markets

- Achieving Efficient Allocations
- Preventing Monopolization
- Rewarding Innovation
- Affirmative Action

Poor design leads to inefficient outcomes

- Australian Satellite TV
- New Zealand Second Price Auction
- RCA Transponder Auction
- EPA Pollution Permit Auction

Theory: market design matters with private information

- Akerlof
- Myerson Satterthwaite
Why Auction Design Matters

Examples of Design Failures

Australian Satellite TV Auction

Australia used sealed-bid auctions for Satellite Television Services
No deposits were required
Bidders submitted many bids, and withdrew from high bids

Australian Auction Outcomes (No Deposit)

<table>
<thead>
<tr>
<th>Initial Winning Bid</th>
<th>Final Price After Withdrawals</th>
</tr>
</thead>
<tbody>
<tr>
<td>A $212,000,000</td>
<td>A $ 117,000,000</td>
</tr>
<tr>
<td>A $177,000,000</td>
<td>A $  77,000,000</td>
</tr>
</tbody>
</table>


Missing Detail: Withdrawal Penalty
Why Auction Design Matters, Examples of Design Failures, Continued

New Zealand used a second-price auction to sell radio spectrum

In a second-price auction, high bidder pays the second-highest bid

No reserve price was imposed

<table>
<thead>
<tr>
<th>New Zealand Auction Outcomes (No Reserve)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Bid</strong></td>
</tr>
<tr>
<td>NZ $100,000</td>
</tr>
<tr>
<td>NZ $7,000,000</td>
</tr>
</tbody>
</table>


Political Problem: Public sees outcome as selling for less than worth

Lesson 1: When little competition is expected, use reserve price.
Lesson 2: Don't use Second-Price Auction
Why Auction Design Matters, Examples of Design Failures, Continued

<table>
<thead>
<tr>
<th>Lot</th>
<th>Winning Bidder</th>
<th>High Bid</th>
<th>Second Bid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sky Network TV</td>
<td>2,371,000</td>
<td>401,000</td>
</tr>
<tr>
<td>2</td>
<td>Sky Network TV</td>
<td>2,273,000</td>
<td>401,000</td>
</tr>
<tr>
<td>3</td>
<td>Sky Network TV</td>
<td>2,273,000</td>
<td>401,000</td>
</tr>
<tr>
<td>4</td>
<td>BCL</td>
<td>255,124</td>
<td>200,000</td>
</tr>
<tr>
<td>5</td>
<td>Sky Network TV</td>
<td>1,121,000</td>
<td>401,000</td>
</tr>
<tr>
<td>6</td>
<td>Totalisator Agency Board</td>
<td>401,000</td>
<td>100,000</td>
</tr>
<tr>
<td>7</td>
<td>United Christian Broadcast</td>
<td>685,200</td>
<td>401,000</td>
</tr>
</tbody>
</table>

New Zealand 8 MHz UHF License Rights
Second Price Simultaneous Auction


These were similar licenses
Totalisator bid $401,000 for 6 licenses; won one license
Totalisator could have bid on license 4, would have won
Appears that allocation was inefficient
Problem is simultaneous sealed-bid tender -- won't arise with ascending auctions
Why Market Design Matters

Examples of Design Failures, Continued

RCA Transponder Auction
November 9, 1981
A Sequential Auction of Similar Items

<table>
<thead>
<tr>
<th>Order</th>
<th>Winning Bidder</th>
<th>Price Obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TLC</td>
<td>$14,400,000</td>
</tr>
<tr>
<td>2</td>
<td>Billy H. Batts</td>
<td>$14,100,000</td>
</tr>
<tr>
<td>3</td>
<td>Warner Amex</td>
<td>$13,700,000</td>
</tr>
<tr>
<td>4</td>
<td>RCTV</td>
<td>$13,500,000</td>
</tr>
<tr>
<td>5</td>
<td>HBO</td>
<td>$12,500,000</td>
</tr>
<tr>
<td>6</td>
<td>Inner City</td>
<td>$10,700,000</td>
</tr>
<tr>
<td>7</td>
<td>UTV</td>
<td>$11,200,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$90,100,000</td>
</tr>
</tbody>
</table>

TLC sued; results nullified by FCC

Sequential Items of Similar Objects Create Pricing Disparities

Sequential Auctions create high probability of bidder regret
Why Market Design Matters, Examples of Design Failures, Continued

EPA SO2 Auction

Double Auction with Sealed Bids and Discriminatory Pricing Pricing Rule:  
Match highest bid price with lowest asked price; 
Match second-highest bid with second-highest ask, and so on down.

Each successful buyer pays its bid price.

Thus, the seller with the lowest asked price gets the highest payment.

Sellers naturally bid very low, as did buyers.

Created pricing distortions and inefficient allocations.

EPA SO2 Auction, Continued

Weird pricing scheme led to bids that didn't reveal values
Major Reasons for Auctions

When Are Auctions Commonly Used?

When the value of things is uncertain
- antiques, paintings, rare wine

When the value of things fluctuates frequently
- fresh fish, foreign currencies, commodities like orange juice or tobacco
Design Issues

The M&M Auction

Each M&M is Worth Five Cents

Money is in This Envelope

The Highest Bidder Pays his or her Bid
- gets the Envelope
- not the M&Ms!

The Jar is your information, or signal, concerning the value of the envelope

First Price Sealed Bid: Write your bid on the piece of paper
Ascending (English)
Design Issues, Continued

• Details Matter
• Political Embarrassment
• Information Revelation
• Value Interdependencies
  Synergies or Complementarities
  Substitution
• Simplicity of Bidder Strategies
• Efficiency
• Collusion
• Timely Completion
• Favoring Interest Groups

Some of these conflict with each other.
The Winner's Curse

"I paid too much for it, but it's worth it."
-Samuel Goldwyn

"The bidder who most overestimates an object's value wins the bidding."

Ascending auctions let bidders see other bidders' willingness to pay
- Reduces risk of paying too much
- Encourages more aggressive bidding
- Raises prices on average

Risk of regret reduces bids
- Bid as if you have the most optimistic estimate
Value Interdependencies and the Exposure Problem

Individual Item Prices Expose a Bidder to Risk of Incomplete Packages

Classic example: Three identical items, two bidders. One item worth 1, two items worth 4, and three items worth 4. Each bidder is willing to pay 1 for 1 item, 3 for the second. Solution must entail one bidder getting 2, other getting 1.

Uncertainty exacerbates this problem--don't know if you are the bidder who values two items the most.
Details of the Simultaneous Ascending Auction

All licenses are open for bidding simultaneously
All license remain open until bidding ceases on all
Bidding occurs in rounds
Bids are announced at the end of each round
Bidders have an initial eligibility based on deposits
Bidders must keep active to maintain eligibility
  Activity = standing high bids + new bids
Insufficient activity will reduce eligibility to win
The auction proceeds in three stages
  Stage 1: bid at least 50% of eligibility
  Stage 2: bid at least 80% of eligibility
  Stage 3: bid 100% of eligibility
Bidders may never bid for more than their eligibility
Low activity will reduce eligibility
Closing Rule: No new bids received, and auction closes
Tie-breaking Rule: In event of a tie, a "high" bidder chosen arbitrarily
Withdrawal Penalty:
  License returned to auction, withdrawer owes government the difference between bid and final price, if final price is less than bid.
FCC Experience with Simultaneous Ascending Auctions

"The Greatest Auction in History"

"The Auction of the Century"

"The most dramatic example of game theory's new power. It was a triumph, no only for the FCC and the taxpayers, but also for game theory (and game theorists)." (Fortune, February 6, 1995)

"The government is smoking something to think they are going to get $10 billion for these licenses."
   MCI chairman Bert Roberts, October 20, 1993
   [$17 billion raised]

"For once, the government is doing a great job of dragging money out of people."
   -McCaw chairman Wayne Perry, June 6, 1994
<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Final Bid</th>
<th>Minority Credit</th>
<th>Winner</th>
<th>Round</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-1</td>
<td>50-50</td>
<td>80,000,000</td>
<td>0</td>
<td>Pagenet</td>
<td>37</td>
</tr>
<tr>
<td>N-2</td>
<td>50-50</td>
<td>80,000,000</td>
<td>0</td>
<td>Pagenet</td>
<td>37</td>
</tr>
<tr>
<td>N-3</td>
<td>50-50</td>
<td>80,000,000</td>
<td>0</td>
<td>McCaw</td>
<td>33</td>
</tr>
<tr>
<td>N-4</td>
<td>50-50</td>
<td>80,000,000</td>
<td>0</td>
<td>McCaw</td>
<td>33</td>
</tr>
<tr>
<td>N-5</td>
<td>50-50</td>
<td>80,000,000</td>
<td>25%</td>
<td>MTel</td>
<td>37</td>
</tr>
<tr>
<td>N-6</td>
<td>50-12½</td>
<td>47,001,001</td>
<td>0</td>
<td>AirTouch</td>
<td>24</td>
</tr>
<tr>
<td>N-7</td>
<td>50-12½</td>
<td>47,505,673</td>
<td>0</td>
<td>BellSouth</td>
<td>25</td>
</tr>
<tr>
<td>N-8</td>
<td>50-12½</td>
<td>47,500,000</td>
<td>25%</td>
<td>MTel</td>
<td>24</td>
</tr>
<tr>
<td>N-10</td>
<td>50-0</td>
<td>37,000,000</td>
<td>0</td>
<td>Pagenet</td>
<td>45</td>
</tr>
<tr>
<td>N-11</td>
<td>50-0</td>
<td>38,000,000</td>
<td>25%</td>
<td>Pagemart</td>
<td>46</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$671,006,674</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Prices for similar licenses were similar or identical

Companies purchasing two similar bands purchased adjoining bands

No evidence that "gaming" helped bidders

- jump bids apparently didn't change final prices
- jump bid by Pagemart on N-11 may have cost it US $1,000,000
### Winning Bidders by region and spectrum block

<table>
<thead>
<tr>
<th>Size (KHz):</th>
<th>50-50</th>
<th>50-50</th>
<th>50-12½</th>
<th>50-12½</th>
<th>50-12½</th>
<th>50-12½</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region\Block</td>
<td>1</td>
<td>2*</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6*</td>
</tr>
<tr>
<td>Northeast</td>
<td>Pagemart</td>
<td>PCSD</td>
<td>Mobil Media</td>
<td>Advanced Wireless</td>
<td>AirTouch</td>
<td>Lisa-Gaye Shearing</td>
</tr>
<tr>
<td>South</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Insta-Check</td>
<td>&quot;</td>
</tr>
<tr>
<td>Midwest</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Ameritech</td>
<td>&quot;</td>
</tr>
<tr>
<td>Central</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>AirTouch</td>
<td>Benbow</td>
</tr>
<tr>
<td>West</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

### Discounted Final Prices ($ millions) by region and spectrum block

<table>
<thead>
<tr>
<th>Size (KHz):</th>
<th>50-50</th>
<th>50-50</th>
<th>50-12½</th>
<th>50-12½</th>
<th>50-12½</th>
<th>50-12½</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region\License</td>
<td>1</td>
<td>2*</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6*</td>
</tr>
<tr>
<td>South</td>
<td>18.400</td>
<td>18.780</td>
<td>11.800</td>
<td>11.543</td>
<td>8.000</td>
<td>11.262</td>
</tr>
<tr>
<td>Total</td>
<td>92.599</td>
<td>90.931</td>
<td>53.669</td>
<td>53.622</td>
<td>48.718</td>
<td>53.173</td>
</tr>
<tr>
<td>Nationwide</td>
<td>80.000</td>
<td>80.000</td>
<td>47.336</td>
<td>47.336</td>
<td>47.336</td>
<td>47.336</td>
</tr>
</tbody>
</table>

* = Blocks with the 40% woman/minority credit
FCC Experience with Simultaneous Ascending Auctions, Continued

Regional Narrowband observations

Prices for similar licenses were similar, not as close as nationwide auction

- Prices higher than nationwide

- Pagemart's attempt to "game" the system may have cost it money again

Prices paid, net of bidder credits, were similar to licenses without bidder credits

Bidder Credits had little effect on prices

Four bidders successfully assembled nationwide licenses on a single frequency

No bidder made purchases on two different frequencies

Simultaneous auction design assisted in efficient allocation
Experience with Simultaneous Ascending Auctions

FCC Broadband PCS Auctions: Over $15 Billion raised

Mexico PCS: Over US $1 Billion raised

Also used in Canada, Australia, and New Zealand

New Auction Designs

MDI for the FCC

MDI 2 with new activity restrictions

Caltech 1 (Charlie Plott) Design

Caltech 2 (Ledyard et al) Design
New Applications of Multiunit Auction Technology

- Electric Power Auctions
- Electric Generation Capacity
- Airport Landing Rights
- Off-shore Oil
- Privatization of Microwave Spectrum
Market for Microwave Connections

Microwaves are used for
- High capacity phone line links (building to building)
- Connecting mobile phone towers to the system
- Line of sight communications
- Telephone exchange connections
- Satellite connections (non-conflicting use)

Two microwave transmitters

Point to point microwave links. Crossed lines are conflicts unless they occur at different heights.
Traditionally links allocated by government administration

**Problems**

- Slow bureaucracy (2+ years in Mexico required for approval)
- Complicated feasibility
  - U.S. uses private companies to establish feasibility
  - Slight reconfigurations may have dramatic effects
- No mechanism for reconfiguring connections
  - Incentive to hold existing link
  - New technology: point to multipoint
- No pricing of (occasionally) scarce resource
- Mexican legal requirement that spectrum be auctioned
  - How to price 1,000,000 unique goods?
  - Shadow prices difficult to estimate
Solution:

Create a competitive market for supply of microwave links

Microwave links are an ideal candidate for deregulation
- No serious scale economies
- Sufficient spectrum available to endow many firms
- Many major users are natural spectrum administrators

Market Design Goal in Mexico:
Create a competitive market in supply of links
Mexican Microwave Auction

<table>
<thead>
<tr>
<th>Number of Licenses</th>
<th>Type</th>
<th>Band</th>
<th>Size</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Point to Point</td>
<td>23 GHz</td>
<td>56 MHz</td>
<td>National</td>
</tr>
<tr>
<td>10</td>
<td>Point to Point</td>
<td>23 GHz</td>
<td>100 MHz</td>
<td>National</td>
</tr>
<tr>
<td>10</td>
<td>Point to Point</td>
<td>15 GHz</td>
<td>56 MHz</td>
<td>National</td>
</tr>
<tr>
<td>5 per region</td>
<td>Point to Multipoint</td>
<td>10 GHz</td>
<td>60 MHz</td>
<td>Regional</td>
</tr>
</tbody>
</table>

2.7 GHz of radio spectrum divided into 80 Licenses

Different bands are imperfect substitutes
- Propagation distance
- Scatter (size of cone)
- Volume of data transmission per MHz

Other substitutes
- Copper wire
- Fiber optics
- Satellite link
Outcomes in Mexican Microwave Market:

<table>
<thead>
<tr>
<th>Company</th>
<th>23 GHz</th>
<th>15 GHz</th>
<th>Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alestra</td>
<td>56</td>
<td>56</td>
<td>Three</td>
</tr>
<tr>
<td>Amaritel</td>
<td>368</td>
<td>112</td>
<td>Three</td>
</tr>
<tr>
<td>Bestel</td>
<td>156</td>
<td></td>
<td>Four</td>
</tr>
<tr>
<td>BNMexico</td>
<td>268</td>
<td>56</td>
<td>Three</td>
</tr>
<tr>
<td>Constel</td>
<td>56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dipsa</td>
<td>156</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Iusacell</td>
<td>200</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>M_Cable</td>
<td>112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marcatel</td>
<td></td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Miditel</td>
<td>100</td>
<td></td>
<td>Five</td>
</tr>
<tr>
<td>TCA</td>
<td>56</td>
<td></td>
<td>One</td>
</tr>
<tr>
<td>Telinor</td>
<td>100</td>
<td>112</td>
<td>All Nine</td>
</tr>
<tr>
<td>Telmex</td>
<td>156</td>
<td>56</td>
<td>All Nine</td>
</tr>
<tr>
<td>Unitel</td>
<td>56</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Telinor assembled nine regions on the same frequency. Telmex assembled nine regions, all but one on the same frequency.

The results of the auction indicate that spectrum caps were not binding. Whether a single bidder would have cornered the market in the absence of spectrum caps is unclear.

Nevertheless, the results corroborate models in which auctions do not lead to excessive concentration.