Valuing Spectrum: Lessons from Auction Experience

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6/10/2020

ECONOMIC THEORY AND AUCTIONS

▶ Given a clear objective, we know fairly well how to design mechanisms that maximize that objective in simple environments

  1. Maximize efficiency, run a Vickrey-Clarke-Groves mechanism (e.g., second price auction in single unit setting).

     ▶ Simultaneous clock auctions also tend to work well.

  2. Maximize expected revenue, run a Myerson-type mechanism (e.g., second price auction with a reserve price in single unit private value setting).

▶ In complex environments, we know little and, even in cases that we have some understanding of, mechanisms become quite complicated.

▶ Here I offer my thoughts on design issues related to the allocation of radio spectrum intended for transportation applications via an auction.

AUCTION DESIGN

- ▶ Auctions are great when leveraging competition between bidders with well-defined "values" of objects being sold and when the seller has little knowledge of these "values"
- ▶ This works especially well when bidders can build (perhaps stochastic) models for the values they attach to individual products and their bundles in a reasonable way
  - ▶ e.g., revenue per wireless subscriber in an area modeled using the usual tools: demand, cost, market structure.
- ▶ Even then there are many issues with design.
  - ▶ Prevent collusion/manipulation.
  - ▶ Develop a bidding language that it is not prohibitively complicated and yet allows bidders to express sufficiently rich preferences.
  - ▶ Define markets properly
- ▶ These issues are present here and values are likely very hard to model *at this time*. (Demand for "what" exactly?)

What might we think about when designing the market for the "safety band"?

- ▶ I will go into some details later.

1. Should access to 5.9GHz be open or restricted?

2. Should usage of this bandwidth be restricted to applications different from WiFi? (different standardization for V2V or simply just WiFi 6)

3. If restricted (closed), would it matter if it is geographically or even locally fragmented (size of license within and across regions, dispersed ownership)?

4. In any case, how "high" a concentration is "too much"? (license holdings vs product competition)

What might we think about when designing the market for the "safety band"?

5. In light of the above and other characteristics (e.g., complementarities), how should we define a market/license?

6. Should we allocate/define one or multiple nationwide licenses and/or several regional licenses?
   - Regional licenses could complement existing spectrum holdings of potential new wireless entrants
   - Nationwide allows for new entrants realizing largest possible complementarities

7. Should we allow for bandwidth to vary within/across regions?
   - Perhaps different license sizes closer to congested places

8. Do we want to sell everything now or might we wait until the most efficient usage is a bit clearer?

Property Rights Allocation via Auctions

- ▶ Coase (1959) argued in favor of allocating property rights over wireless spectrum
- ▶ Many successful auctions run in the US since early 90s generating a lot of revenue for the tax payers (generated over $100 billion)
- ▶ Mixed success abroad: collusion (Germany), failure to attract an entrant (Czech Republic)

- ▶ Design and details matter!

FIRST THINGS FIRST:

- **Step 1: What is the objective here?**

- **Step 2: What are the engineering constraints?**

- **Step 3: How do we achieve the objective respecting the constraints?**

OBJECTIVE:

1. Revenue Maximization
   - ▶ Maybe not.
2. Efficient Allocation
   - ▶ Maybe...
   - ▶ Can markets easily correct it if we get it wrong?
   - ▶ Cost of getting it wrong?
   - ▶ Externalities?
3. Ensure minimum safety/reliability standards
   - ▶ Can likely be achieved contractually
4. Improve innovation incentives
   - ▶ This might be key here! What does "efficient" mean given we currently don't know what might be possible?
5. Limit free-riding
   - ▶ Price excessive usage

QUESTION 1: OPEN VS CLOSED SPECTRUM

1. **Open:** Let the allocated spectrum be open and freely accessible
   - ▶ wifi, walkie-talkie
   - ▶ Innovation can be tested and implemented, but can it be monetized?

2. **Closed:** Allocate property rights and let private parties ration/price access
   - ▶ 2G,3G,LTE etc.
   - ▶ Innovation can be monetized. But: do we get enough "tries"?

3. **Hybrid:** concurrent open and closed (CBRS and Spectrum Access System)

ENGINEERING VS ECONOMICS

- ▶ This is clearly a market where stylized models from Econ 101 won't work - many trade-offs determined by technology
- ▶ Engineers need to chime in on the trade-off between number of licenses and size of the license
  - ▶ Minimum efficient scale
  - ▶ Low vs high power antennas and congestion
  - ▶ Interference protection
- ▶ At the same time standard IO issues are present
  - ▶ Avoid foreclosure
  - ▶ Encourage competition, limit market power

Big Deal: Unknown Value in the Future

- ▶ It seems clear that the value lies in the future
  - ▶ Need to encourage innovation and getting enough tries is important
  - ▶ Need to allow the firms to recoup their investment without fear of being "crowded out"
- ▶ Perhaps potential entrants and innovators should be asked to submit (albeit more speculative than usual) proposals before the design of any auction begins

Open Spectrum

1. More firms can innovate and try it out. ("more innovation tries")
2. Innovation might enable more efficient use of the airwaves (so as to make spectrum "less" scarce endogenously)
3. In peaks: one could potentially still use prices to allocate appropriately (or some priority mechanism...)
4. How expensive/difficult would it be to implement such a (real-time) pricing mechanism?
5. Who would be in charge of the mechanism, who would collect the proceeds? (auction off service provider rights vs state-run agency)

Closed Spectrum: Valuing it using an Auction

1. Leverages competition between buyers to elicit underlying valuation for the different spectrum licenses
2. Generates revenues for the government
3. Might result in efficient allocation (with straightforward bidding etc)
4. Mistakes in allocation can be corrected by ex-post trades (subject to some transaction costs)

▶ But: Would private parties properly internalize potential benefits of safety (i.e., saving lives, limiting injuries) when valuing the spectrum, so that the competition is meaningful?

▶ Need to address standard IO issues (even regionally): foreclosure, monopolization,...

Open/Closed Spectrum Hybrid: "Spectrum Sharing"

- ▶ Example of Auction 105: Citizens Broadband Radio Services (CBRS)
  - ▶ Split 150MHz of $\approx$ 3.5GHz spectrum into auction (70MHz) of Priority Access Licenses and General Authorized Access (80MHz). If unused, goes back to GAA.
  - ▶ The Federal Communications Commission (FCC) announced that Google, CommScope, Federated Wireless and Sony have been certified to operate as Spectrum Access System (SAS) administrators
  - ▶ The SAS is an automated frequency coordinator that facilitates sharing among tiers of authorized CBRS users. This manages access over time/space/frequency based on need and priority tier (incumbents, PALs, GAA).
  - ▶ This mechanism could presumably be augmented to allow for peak load pricing (e.g., keyword auctions).
- ▶ Is this a reasonable model at 5.9GHz frequency with only 75MHz available?

HOW TO ACHIEVE REVENUE/EFFICIENCY MAXIMIZATION?

1. To elicit market valuation (that might ignore the "public" part of the good): run an auction
   - ▶ We know how to do that **IF** markets are well defined
   - ▶ We have nice results for cases where goods (licenses) are substitutes (not likely the case here) and/or when bidding is "straight-forward"

2. Define markets:
   - ▶ Nationwide vs regional vs local: Need to get a sense of complementarities (e.g., geographical, economies of scale)
   - ▶ Should the allocated bandwidth be uniform across markets or should we allow for market-specific license bandwidth based on expected congestion/usage?
   - ▶ Set appropriate caps and explicit duration of licenses

SUMMARY

1. Current trade-off seems to be between encouraging innovation (as many tries as possible) versus guaranteed usage without interference to recoup the investment
2. We should evaluate why open access or hybrid spectrum sharing might be problematic.
3. If congestion or free riding would be the main worry, would a real-time pricing mechanism be feasible?
4. Why not open access + standardization + real-time pricing/prioritization?
   ▶ And promise to re-evaluate after a few years, when it is clear(er) if "big applications" need guaranteed access (in which case perhaps an auction can be held) or if "small usage" supports keeping open access
5. If closed (or hybrid), we need to evaluate (across and within regions) issues related to :
   ▶ License Fragmentation
   ▶ Ownership Concentration
   ▶ Compatibility/Access across licenses