Auctioning Capacity

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Overview

Microwave link market creation
- Capacity auctioned by government
- Market design of interest in its own right

Other examples of capacity supply

Bidding for capacity:

- Auctioning licence to compete
  - Shakeout model
  - An experiment
- Auctioning capacity to Cournot competitors
- Model of microwave competition and bidding
  - Bidders are also after-market buyers
  - Resale market most salient characteristic

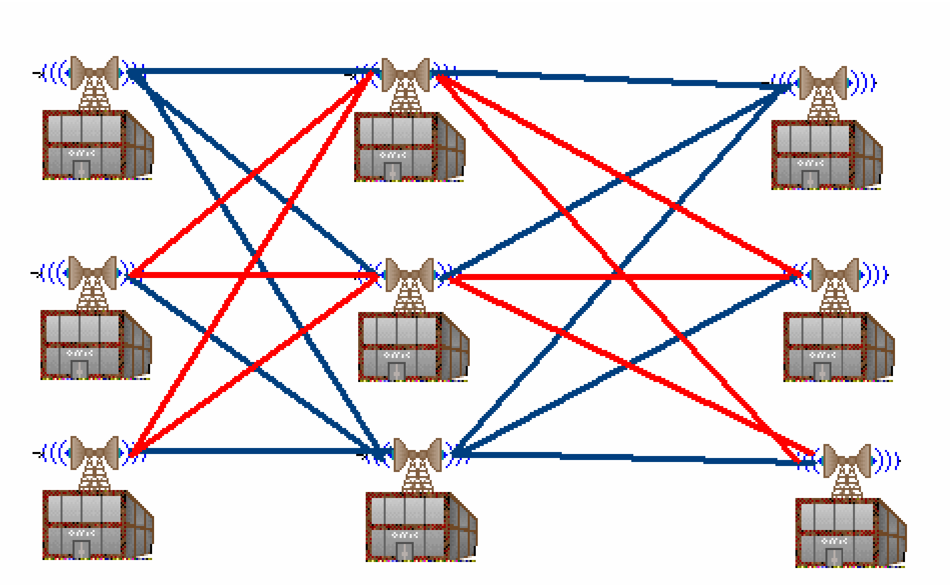
Outcome of Mexican Microwave Auction

Market for Microwave Connections

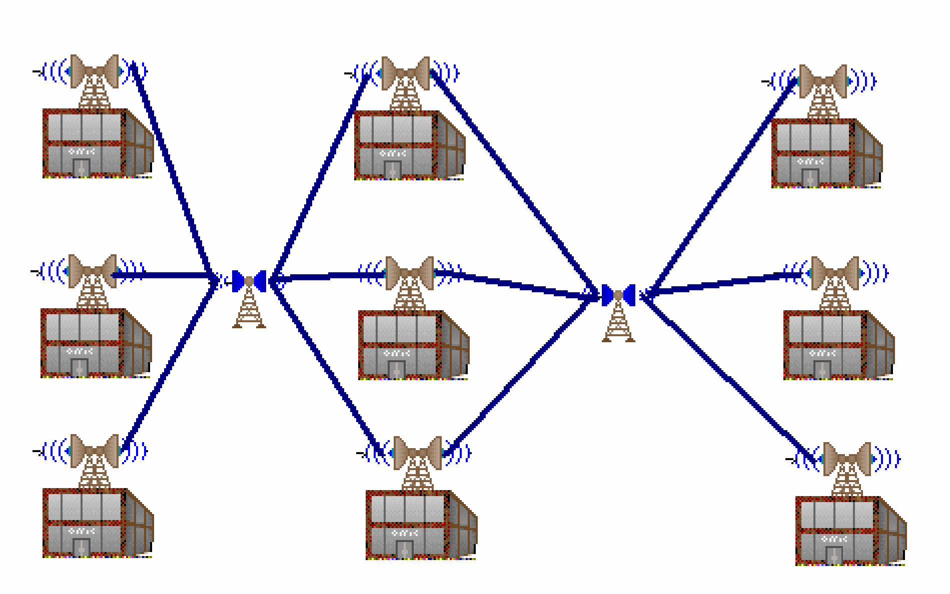
Microwaves are used for

- 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.



A point to multipoint system. Eliminates conflicts by using a central tower. (Hub and spoke system)

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

Number of Licenses	**Type**	**Band**	**Size**	**Coverage**
15	Point to Point	23 GHz	56 MHz	National
10	Point to Point	23 GHz	100 MHz	National
10	Point to Point	15 GHz	56 MHz	National
5 per region	Point to Multipoint	10 GHz	60 MHz	Regional

2.7 GHz of radio spectrum
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

Other examples of capacity auctions

- PCS auctions
- Mineral rights
- Outer continental shelf oil
- Grazing rights
- Satellite transponders
- Radio and TV spectrum (Australia and New Zealand)
- Airport landing rights
- CO^2 pollution permits
- Import quotas (Australia, New Zealand and Columbia)

Auctioning Capacity

Two extremes: selling the right to participate, and selling incremental capacity

Auctioning licenses to compete

Induces a tournament-like structure, where firms bid for the right to participate in a subsequent competition to sell to consumers.

Types will be used to denote distinct characteristics, such as marginal costs, fixed costs, quality, with higher types being better (lower cost, higher quality, etc.).

Let profits, if firm i has type t_i and other firms have types t_{-i} *be*

$$p_i(t_i, t_{-i}).$$

Suppose m licenses are sold at a price equal to the bid of the $m+1^{st}$ highest bids.

In an efficient equilibrium, the highest m types win the bidding. Let f_{m+1} be the density of the $m+1^{st}$ highest type, given a particular firm's type.

Birthdate Tournament

Qualification: You must have identification (e.g. passport, driver's license) giving the date of your birth in order to participate.

Stage 1: Bidding to enter tournament

The two highest bidders will gain entry into a tournament. Each of these bidders will pay the *third-highest* bid.

Stage 2: Tournament

Take the month and day of the birthday (e.g. 15 April is 415; 7 December is 1207).

The entrant with the highest birthday wins $10, for a net earning of $10 minus the third-highest bid.

The other entrant loses the third-highest bid and gains nothing.

In the event of a tie, each of the entrants gains $5, minus the third-highest bid.

Profits of a firm with type *t*, if it bids *B*(*r*), are

$$v(r,t)=\int_0^r \big(E[p(t,t_{-i})\,|\,t_{-i}\geq s]-B(s)\big)f_{m+1}(s\,|\,t)ds$$

which yields $B(t) = E[p(t,t_{-i}) \mid t_{-i} \geq t]$.

This candidate for equilibrium is an equilibrium if *B* is strictly increasing.

It is straightforward to show that the discriminatory auction (pay your bid) has a candidate equilibrium $B_1(t)$ satisfying:

$$B'_1(t)=[B(t)-B_1(t)]\frac{f(t\,|\,t)}{F(t\,|\,t)},$$

Thus, if B is nonincreasing around 0, so is B_1. In this case, no efficient (selects the best types with certainty) exists.

Shakeout Auction

Suppose that the market can't support m firms, and that the lowest efficiency firm will be driven out of business. Then

$$E[p(t,t_{-i}) \mid t_{-i} \geq t] = 0.$$

There is no efficient equilibrium (either discriminatory or uniform price) for the shakeout auction.

Intuition for uniform price auction:

- bid only matters if you tie with highest excluded firm
- In this event, given entry, you are the worst entrant
- In shakeout auction, this guarantees elimination
- Would prefer to lose & not pay bid

Bidding for licenses will create inefficient allocations.

Like Birthday Tournament.

Analysis of microwave competition

Standard models do a poor job, because here the spectrum buyers are also spectrum users.

Cournot downstream competition has a surprising property: bidding for capacity tends to symmetrize the industry, with small firms getting larger.

While interesting and applicable to such sales as electricity generation capacity and pollution permits, it is a poor model of microwave competition.

Example: Linear demand, costs $q^2/2k_i$, where k_i is firm i's capacity.

In this case, the auction of a small amount of capacity results in the smallest firm buying the capacity, unless the market is very close to monopoly originally.

Model:

Suppose there are n firms, firm i having value of q microwaves of $q - {q^2}/{2b_i}$.

Let x_i be the capacity of firm i, and p the market price in the after market. Suppose as well that additional units supplied to the after-market decrease p by at rate ϕ.

The assumption that additional supply to the after-market decreases price seems plausible, and provides each firm with "Cournot-like" market power in the after-market.

The model is unsatisfying in that it has a conjectural variations feel to it.

Firm i maximizes

$$p_i = q_i - {q_i^2}/{2b_i} + p(x_i - q_i).$$

This gives a first order condition:

$$0 = \frac{dp_i}{dq_i} = 1 - \frac{q_i}{b_i} - p + f(x_i - q_i).$$

In addition, p is determined by

$$\sum_{i=1}^{n}(x_i - q_i) = 0.$$

Straight-forward manipulations yield:

$$1 - p = \frac{\sum_{i=1}^{n} \frac{x_i}{1 + b_i f}}{\sum_{i=1}^{n} \frac{b_i}{1 + b_i f}} \quad \text{and} \quad q_i = \frac{b_i(1 - p + f x_i)}{1 + b_i f}.$$

This *ad hoc* model has the following properties.

- It matters who holds the capacity.
- Price decreases as capacity rises.
- Net buyers restrict purchases to drive down price.
- Net suppliers restrict sales to drive up price.
- For ϕ=0, the after-market is efficient.
- As $\phi \to \infty$, after-market vanishes.

The after-market is equivalent to an iceberg-type transactions costs model, where firms are price-takers and

$$p_i = q_i - {q_i^2}/{2b_i} + p(x_i - q_i) - f(x_i - q_i)^2.$$

Bidding is qualitatively similar.

Consider the simultaneous ascending auction for infinitesimal units. Firm i is willing to bid, if k is the next highest:

$$b_i = \frac{d\pi_i}{dx_i} - \frac{d\pi_i}{dx_k} = p + (x_i - q_i)\left(-\frac{\beta_i f^2}{1+\beta_i f} + \frac{dp}{dx_i}\left(1 + \frac{\beta_i f}{1+\beta_i f}\right)\right)$$

Effect of changing x_i on price depends on conjectures about alternative purchasers.

Since the game is one of full information, we look for a bid b with the property that

- $x_i > 0$ implies $b_i = b$,
- $x_i = 0$ implies $b_i \leq b$.

If all the after-market buyers are present in the auction, the equilibrium will be unique, with each firm purchasing its own demand, and no resale. (True in both cournot and iceberg type models.)

This outcome is efficient.

Thus, the auction tends to undo the inefficiencies of resale, rather than resale making the auction more efficient, as is usually alleged (but is not, in general, true, as Ausubel and Cramton demonstrate).

Some demanders not present in auction

When some firms that are not present in the auction will demand capacity, there will be net positive supply by bidders to the after-market.

In this case, all of the buyers will be net sellers in the resale market. There is no equilibrium in which a single bidder corners the market.

Bids Compared to After-market Prices

If ϕ is near zero (after-market nearly efficient), the bid price will exceed the after-market price, with net sellers losing money on these sales.

The losses arise because big demanders are willing to pay a premium to prevent small demanders from buying spectrum and then reselling with the consequent reduction in resale price.

In iceberg model, bid price is always less than after-market prices, because incentive to increase after-market price is swamped by the transactions cost.

Bid price less than after-market price was consistently observed in Australian and New Zealand import quota auctions.

Entry by non-users would tend to arbitrage away such differences. When bid price exceeds after-market price, however, arbitrage is not feasible.

Predictions about Who Buys

In the cournot type model, the largest demanders will be the largest suppliers when the residual demand (not represented in the auction) is concentrated, and in particular, when there is a single residual demander.

With a large, dispersed demand, the largest demanders will be smaller residual suppliers.

Effect of Spectrum Caps

Spectrum caps increase the gains from trade only when the residual market is large and concentrated.

Binding spectrum caps reduce bid prices.

Outcomes in Mexican Microwave Market:

Company	23 GHz	15 GHz	Regions
Alestra	56	56	Three
Amaritel	368	112	Three
Bestel	156		Four
BNMexico	268	56	Three
Constel	56		
Dipsa	156	56	
Iusacell	200	56	
M_Cable	112		
Marcatel		56	
Miditel	100		Five
TCA	56		One
Telinor	100	112	All Nine
Telmex	156	56	All Nine
Unitel	56		

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.

Conclusions

Auctions of the right to compete may not efficiently select participants.

The all-pay auction is theoretically a solution, although it has some undesirable political properties (payment without permit).

Auctions may improve the efficiency of resale markets, by distributing capacity to lower resale transactions costs.

Fears of auctions leading to excessive concentration appear unfounded in many environments.

Progress on understanding auctions of capacity depends on modelling

- imperfect resale
- downstream competition

Microwave market is a natural venue for free-market allocation of spectrum

- administrative assignment slow and cumbersome
- without pricing, assignment inefficient
- market will permit adaption to changing circumstances
- no major scale economies
- sufficient spectrum for competition
- raise substantial revenue