Incentive Auctions

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Incentive auctions

Auction includes essential regulatory steps to address market failures in the secondary market for spectrum
Letter from 112 economists, 6 April 2011
Motivation

Value per MHz

Year

Value of over-the-air broadcast TV

TV signal received via cable and satellite

Value of mobile broadband

Gains from trade

Explosion in use of smartphones and tablets


Year
VHF and UHF bands

**Current uses (TV broadcast)**

- **Lower VHF**
  - TV ch 2-6
- **Upper VHF**
  - TV ch 7-13
- **UHF**
  - TV ch 14-36
  - Public Safety

**Possible future uses**

- **Lower VHF**
  - TV ch 2-6
- **Upper VHF**
  - TV ch 7-13
- **UHF**
  - TV ch 14-??
  - Public Safety
  - Flexible Use
  - RA
  - RA
  - Flex. Use
Voluntary approach

For simplicity, I assume that channel sharing is only 2:1; other possibilities could also be considered, including negotiated shares with particular partners announced at qualification.

TV broadcaster freely decides to

- Continue over-the-air broadcast
- Share with another
- Cease over-the-air broadcast

Spectrum freed

0 MHz  3 MHz  6 MHz
Why voluntary?

- **More likely to quickly clear spectrum**
  - Broadcasters benefit from cooperating

- **Lower economic cost of clearing**
  - Spectrum given up only by broadcasters who put smallest value on over-the-air signal

- **Market pricing for clearing**
  - Avoids costly administrative process

- **Efficient clearing**
  - Clear only when value to mobile operator > value to TV broadcaster
Two approaches

Combinatorial exchange

Too complex due to repacking

Reverse auction to determine supply

Optimization gives mandatory repacking options

Forward auction to determine demand

Market clearing and settlement
• Mostly single channel
• Price discovery less important

=>

• Sealed-bid auction or descending clock
  – Price to cease
  – Price to share
Reverse auction to determine supply

\[ P = $30 \]

\[ S = 48 \]

\[
\begin{align*}
0 \text{ MHz} & \quad 3 \text{ MHz} & \quad 6 \text{ MHz} \\
7 & \quad 13 & \\
9 & \quad 22 & \\
31 & \quad 26 & \\
18 & \quad 41 & \\
37 & \quad 35 & \\
44 & & \\
47 & & \\
\end{align*}
\]

Price = $30/MHzPop
Reverse auction to determine supply

Washington DC

\[ P = \$20 \]

\[ S = 36 \]

Price = $20/MHzPop

0 MHz: 7
3 MHz: 9, 31
6 MHz: 13, 18, 41

0 MHz: 22
3 MHz: 37
6 MHz: 44

0 MHz: 47
3 MHz: 35
Reverse auction to determine supply

\[ P = \$10 \]

\[ S = 24 \]

Price = $10/MHzPop

0 MHz

3 MHz

6 MHz

7

9

13

18

22

26

31

31

37

35

44

47

41

Washington DC
P = $20
S = 36

Mandatory repacking

Supply = 160 MHz
• Mobile operators want large blocks of contiguous paired spectrum for LTE (4G)
  – One to four $2 \times 5$ MHz lots
• Complementaries strong both within and across regions
• Package clock auction ideal
  – Within region complementarities guaranteed with generic lots
  – Across region complementarities achieved through optimization of specific assignments
Package clock auction: Overview

• Auctioneer names prices; bidder names package
  – Price increased if there is excess demand
  – Process repeated until no excess demand

• Supplementary bids
  – Improve clock bids
  – Bid on other relevant packages

• Optimization to determine assignment/prices

• No exposure problem (package auction)
• Second pricing to encourage truthful bidding
• Activity rule to promote price discovery
Forward auction to determine demand.
Forward auction to determine demand
Broadcasters cannot negotiate ex post with operators, since it is the FCC’s repacking that creates value; ex post trades would not benefit from repacking.
Ways Congress can screw up

• Impose restrictions on which broadcasters can participate in the auction
  – Destroys competition in reverse auction
• Make repacking purely voluntary
  – Reverses status quo—FCC can relocate stations
  – Creates holdout problem in reverse auction
• Too greedy
  – Impose specific requirement on government revenue share (e.g., Treasury gets 40% of revenue)
Not too greedy: Quantity choice left to FCC

Price

Quantity

Supply

Demand

\( P_D \)

\( P_S \)

To Treasury

To TV broadcasters

\( Q_0 \)

\( Q^* \)
Too greedy constraint: Treasury must get at least 40%

Revenue share constraint causes huge social welfare loss and reduces Treasury revenues!
Ways FCC can screw up

• Impose restrictions on which broadcasters can participate in the auction
  – Destroys competition in reverse auction
• Make repacking purely voluntary
  – Reverses status quo—FCC can relocate stations
  – Creates holdout problem in reverse auction
• Adopt poor auction design
• Fail to address competition concerns
Background

Package Clock Auction
Package clock auction: Overview

• A package bid is an all-or-nothing bid for a portfolio of products
• When bidding on individual lots, a bidder is exposed to the risk of winning only some of a complementary set of products
• Package bidding eliminates the exposure problem by allowing bidders to bid on packages of products
• At the same time, package bidding can help to alleviate the demand reduction problem in which larger bidders inefficiently reduce demand in order to win spectrum at lower prices
Package clock auction: Overview

• Auctioneer names prices; bidder names package
  – Price increased if there is excess demand
  – Process repeated until no excess demand
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  – Improve clock bids
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Package clock auction adopted for several recent and upcoming auctions

• UK 10-40GHz spectrum
  – February 2008, 27 rounds, £16 million
• UK L-band spectrum
  – May 2008, 33 rounds, £8.3 million
• UK 800MHz and 2.6GHz
  – First-quarter 2012
• Netherlands 2.6GHz spectrum
• Belgium 2.6GHz spectrum
• Austria 2.6GHz spectrum
Bidder-optimal core pricing

• Minimize payments subject to core constraints
• Core = assignment and payments such that
  – Efficient: Value maximizing assignment
  – Unblocked: No subset of bidders offered seller a better deal
Five-bidder example with bids on \{A,B\}

- $b_1\{A\} = 28$
- $b_2\{B\} = 20$
- $b_3\{AB\} = 32$
- $b_4\{A\} = 14$
- $b_5\{B\} = 12$

Winners

Vickrey prices:
- $p_1 = 14$
- $p_2 = 12$
The Core

Bidder 2 Payment

b_3\{AB\} = 32

b_4\{A\} = 14

b_1\{A\} = 28

Efficient outcome

b_2\{B\} = 20

b_5\{B\} = 12

The Core
Vickrey prices: How much can each winner’s bid be reduced (while holding others fixed)?

**Problem:** Bidder 3 can offer seller more (32 > 26)!
Bidder-optimal core prices: *Jointly* reduce winning bids as much as possible (while remaining within core)

**Problem:** bidder-optimal core prices are not unique!
Core point closest to Vickrey prices
(Alternative: core point closest to linear prices)

Bidder 2 Payment

b₃{AB} = 32

b₄{A} = 14

b₁{A} = 28

b₂{B} = 20

b₅{B} = 12

Each pays equal share above Vickrey
Package clock auctions: Activity rule

• Activity rule based on revealed preference:
  *Bidders can only move toward packages that become better values*
  
  – At time $t' > t$, package $q_{t'}$ has become relatively cheaper than $q_t$
    \[ (P') \quad q_{t'}(p_{t'} - p_t) \leq q_t(p_{t'} - p_t) \]
  
  – Supplementary bid $b(q)$ must be less profitable than revised package bid at $t$
    \[ (S') \quad b(q) \leq b(q_t) + (q - q_t)p_t \]
Properties with substitutes

• Bidding on most profitable package is best
• Clock yields competitive equilibrium with efficient assignment and supporting prices
• Final assignment = clock assignment
Properties in general

• Supplementary bids needed if excess supply
• Bidder can guarantee winning its final package by raising bid by final price of unsold lots