Introduction to spectrum auctions

Auction Design and Implementation: Why Auction Design and Spectrum Packaging Matter

Prepared for the Spectrum Economics workshop at the Auditorium, SKMM Cyberjaya

Richard Marsden, DotEcon Ltd

29 April 2009

richard.marsden@dotecon.com, +44 207 467 2000
Overview

Morning session: Spectrum auctions
- Part I: Introduction to spectrum auctions
- Part II: Spectrum auctions in practice

Afternoon session:
- Spectrum auction simulation
Part I

Introduction to spectrum auctions
What is a spectrum auction?

- A spectrum auction is a sale of frequencies
  - typically leading to exclusive licences...
  - ...to provide services in some frequency range in some geographical area subject to emission limits

- Key feature is competition amongst bidders to determine outcome

- An auction reveals information about value that is not accessible to an administrator allocating spectrum
Why do governments use auctions?

- **Procedural advantages**
  - Lack of legal challenge (if carefully implemented)
  - Transparency and fairness
  - Avoids awkward administrative decisions
  - Lack of credibility of claims made in beauty parades
  - Participation costs can be kept low

- **Achieves necessary public policy objectives**
  - Efficient allocation of scarce public resources
  - Promotes price discovery where bidders uncertain about valuations due to common unknowns
  - Revenue raising (with few distortions unlike most taxes)

- **How important is revenue raising as an objective?**
Packaging of spectrum

- Spectrum auctions typically need frequencies to be packaged in some way:
  - **Fixed packaging**: Pre-packaged into lots with a frequency range suitable for a deploying particular technology or service
  - **Flexible packaging**: Frequencies sold as smaller lots which can be aggregated to form licences suitable for different types of service

- Don’t assume that auctions require one lot = one licensee!

- The most recent developments in auction design are making administrative decisions about packaging less important:
  - Auctions that can allow small lots to be aggregated without risk
  - Even auctions that allow different bandplans to be market-tested (e.g. UK 2.6GHz auction)
There are many different types of auctions

- Main distinctions
  - **Sealed bid** (one-shot) vs. **open auction** (multiple rounds leading to price discovery)
  - **Single item** vs. **multiple items** (substitutes and complements might matter)
  - **Package bidding** - where there are multiple bids, are bids across items linked or independent?
  - **First price** (pay what you bid) vs. **second price** (winning price determined by losing bids)

- There are many variations in auction format all with different implications for different types of bidders
Some examples of real auctions

- Most EU and Asian 3G auction processes used the **simultaneous multiple round auction** (SMRA):
  - Multiple lots sold simultaneously
  - Open, multiple round
  - Fixed packaging (one lot = one licence), so no complementarities
- German 3G auction had flexible packaging where bidders bought multiple 5MHz lots
- Some later processes (e.g. Danish 3G) concerned about lack of competition, so moved to **sealed bid**
- More recently, increased use of flexible packaging has led to introduction of **package bidding**:
  - Ireland, Norway and UK have all run sealed bid auctions with package bidding for minor bands
  - FCC allowed limited package bidding for the 700MHz auction (a pre-defined national package)
  - UK has pioneered a multi-round package bid format with bidder-defined packages (**combinatorial clock auction**), used for 10-40GHz, L-band and 2.6GHz
### Examples of auction formats used worldwide

<table>
<thead>
<tr>
<th>Auction</th>
<th>Year</th>
<th>Format</th>
<th>Sealed bid or Open format?</th>
<th>Fixed or flexible packaging?</th>
<th>Package bidding?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway 3.5GHz</td>
<td>2004</td>
<td>Augmented switching SMRA</td>
<td>Open</td>
<td>Flexible</td>
<td>No</td>
</tr>
<tr>
<td>Denmark 3G (one licence)</td>
<td>2005</td>
<td>First price sealed bid</td>
<td>Sealed</td>
<td>Fixed</td>
<td>No</td>
</tr>
<tr>
<td>USA AWS (2.1GHz)</td>
<td>2006</td>
<td>SMRA</td>
<td>Open</td>
<td>Flexible</td>
<td>No</td>
</tr>
<tr>
<td>UK 412MHz</td>
<td>2006</td>
<td>Sealed bid with package bidding</td>
<td>Sealed</td>
<td>Flexible</td>
<td>Yes</td>
</tr>
<tr>
<td>Singapore 2.4GHz</td>
<td>2005</td>
<td>SMRA</td>
<td>Open</td>
<td>Fixed</td>
<td>No</td>
</tr>
<tr>
<td>Indonesia 3G</td>
<td>2006</td>
<td>Sealed bid (two stages)</td>
<td>Sealed</td>
<td>na</td>
<td>No</td>
</tr>
<tr>
<td>Sweden 3.6 / 3.8GHz</td>
<td>2007</td>
<td>Augmented switching SMRA</td>
<td>Open</td>
<td>Flexible</td>
<td>No</td>
</tr>
<tr>
<td>New Zealand 2.3 / 2.5GHz</td>
<td>2007</td>
<td>SMRA</td>
<td>Open</td>
<td>Fixed</td>
<td>No</td>
</tr>
<tr>
<td>UK 10-40GHz</td>
<td>2008</td>
<td>Combinatorial clock</td>
<td>Open</td>
<td>Flexible</td>
<td>Yes</td>
</tr>
<tr>
<td>UK L-band</td>
<td>2008</td>
<td>Combinatorial clock</td>
<td>Open</td>
<td>Flexible</td>
<td>Yes</td>
</tr>
<tr>
<td>Ireland 26GHz</td>
<td>2008</td>
<td>Sealed bid with package bidding</td>
<td>Sealed</td>
<td>Flexible</td>
<td>Yes</td>
</tr>
<tr>
<td>Norway 2.6GHz</td>
<td>2008</td>
<td>Augmented switching SMRA</td>
<td>Open</td>
<td>Flexible</td>
<td>No</td>
</tr>
<tr>
<td>USA 700MHz auction</td>
<td>2008</td>
<td>SMRA w. hierarchical package bidding</td>
<td>Open</td>
<td>Flexible</td>
<td>Limited</td>
</tr>
<tr>
<td>Canada AWS (2.1GHz)</td>
<td>2008</td>
<td>SMRA</td>
<td>Open</td>
<td>Flexible</td>
<td>No</td>
</tr>
<tr>
<td>Sweden 2.5GHz</td>
<td>2008</td>
<td>Augmented switching SMRA</td>
<td>Open</td>
<td>Mixed approach</td>
<td>No</td>
</tr>
<tr>
<td>Hong Kong 2.3 / 2.5GHz</td>
<td>2009</td>
<td>SMRA</td>
<td>Open</td>
<td>Mixed approach</td>
<td>No</td>
</tr>
<tr>
<td>UK 2.5GHz</td>
<td>2009*</td>
<td>Combinatorial clock</td>
<td>Open</td>
<td>Flexible</td>
<td>Yes</td>
</tr>
<tr>
<td>Netherlands 2.5GHz</td>
<td>2009*</td>
<td>Combinatorial clock</td>
<td>Open</td>
<td>Flexible</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: This list is not comprehensive, rather it is intended as an illustration of the types of auction format in use
* Forthcoming
Why do we need so many different auctions?

- Asymmetric bidders and different competitive conditions
  - Pricing rules affect weak and strong bidders differently
  - May be difficult to create sufficient competition to discipline strong bidders in an open auction

- Common value uncertainty
  - Where there are common unknowns across bidders, open processes allow bidders to refine valuation estimates from observing the behaviour of others

- Complementarities
  - There may be strong complementarities between lots if bidders need a minimum amount of spectrum
  - Bidders face aggregation risks in auctions without package bidding
  - Increasing value to obtaining large amounts of contiguous spectrum for technologies such as LTE
Common value uncertainty and open auctions

- What is common value uncertainty?
  - Some factors common to bidders’ valuations - e.g. technological unknowns, market demand
  - If these are unknown, one bidder might revise its bid if it knew what others would be prepared to pay
- Winning may reveal information to the winner that it won because its valuation is too optimistic (winner’s curse)
- Rational bidders should bid more conservatively the greater is common value uncertainty
- Open auctions aggregate information and allow bidders to reduce valuation uncertainty (much like a conventional market)
- So why not always use open auctions?
Open versus sealed bid with asymmetries

- With strong bidder asymmetries, sealed bids will often produce greater expected revenue than open processes.
- Increase in revenue is typically at some efficiency cost, as it is the chance of losing that forces the strong bidder to increase its bid.
- May be a public policy case to use a sealed bid process to handicap an incumbent bidders and favour competitive downstream market.

<table>
<thead>
<tr>
<th>Value / price</th>
<th>Sealed bid price*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open auction price</td>
</tr>
</tbody>
</table>

Strong bidder’s guess of weak bidder’s value
Weak bidder’s guess of strong bidder’s value

*first-price auction
Winner’s curse and asymmetries

- **The wallet game**
  - Alice and Bob know there is $x$ in a wallet and have each have an informative signal of the value of $x$
  - Bob needs a new wallet
  - Alice bought a new wallet last week
  - So, Bob should *always* be prepared to bid more than Alice as he gets the money and the wallet

- **Implications:**
  - If Alice wins, this could only be because Bob has a lower estimate of $x$, in which case Alice should expect to make a loss
  - This means that Alice should not take part

- We see that strong bidders are less affected by winner’s curse than weaker bidders...
- ...even to the point that the weaker bidder might give up
New challenges for spectrum auctions

- Significant trends:
  - Spectrum increasingly licensed on a technologically neutral basis
  - Services decoupling from technologies and bands
  - Different technologies and different business cases require different amounts of spectrum
  - Wide amounts of contiguous spectrum increasingly important
  - New bands become available owing to governments trying to identify potential supply

- Spectrum managers cannot easily determine how to package spectrum into ‘operator-sized’ parcels

- Spectrum auctions increasingly determine how much spectrum different users get

- Trading and change of use allowed, so auction results not necessarily fixed for the duration of licences
Spectrum packaging and auction design are closely linked

- Regulators can use flexible packaging to allow the market to determine the size of licences and number of licensees, either on a national or regional basis.

- But using flexible packaging may expose bidders to aggregation risks:
  - Bidders may have minimum spectrum requirements, so may be ‘exposed’ to winning unwanted subsets of their demand.
  - Frequency contiguity is often important to realise high-speed broadband services.

- ... and may also raise concerns about bidder asymmetries and tacit collusion to block entry.

- These types of problems can be addressed through good auction design:
  - Activity rules or package bidding to alleviate aggregation risk.
  - Rules on bidder association and restrictions on transparency.
  - Rules to guarantee contiguous frequencies to winning bidders using latest generation of spectrum auctions.
  - Spectrum caps if competition concerns significant.
  - Flexible, market-determined band plans possible with more complex auctions.
Key messages

- Auctions are likely to become more common
- Horses for courses: different formats appropriate to different situations
- Trend to more complex auctions has been created by the new challenges in spectrum policy rather than economists with time on their hands (!)
- As a bidder, engaging in the choice of format may be useful, as some formats can favour / disfavour certain types of bidders
Part II

Spectrum auctions in practice
Understanding objectives

- Different types of buyers and sellers have different objectives
- Auction design can have a big impact on the likelihood of the government and/or bidders achieving their objectives:
  - Some rules favour incumbents, others entrants
  - Some rules might endanger cost-effective deployment of services (e.g. risk of fragmented spectrum)
  - Some rules might have more risk of bidders overpaying and becoming unviable (e.g. first price sealed bids)
  - Some rules may fail to encourage competition or even facilitate collusion
- Sellers set the rules, but bidders can be influential
  - Rules that favour entrants (e.g. first price sealed bids, spectrum caps) often appear ‘consistent’ with promoting competition
  - Rules that favour incumbents (e.g. open auctions, high transparency) often appear ‘consistent’ with efficiency objectives
  - Regulators are often distracted by secondary goals, e.g. encouraging participation in auctions, raising revenues or avoiding accusations of excessive prices
- Regulators usually don’t know that much about bidders, so auctions should be robust to a range of possible circumstances, not designed to handle just one case
## Conflicting objectives of auction participants

<table>
<thead>
<tr>
<th></th>
<th>Regulators</th>
<th>Private sellers</th>
<th>Incumbent bidders</th>
<th>Entrant bidders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Participation</strong></td>
<td>Attracting as many reliable bidders as possible</td>
<td>Attracting as many reliable bidders as possible</td>
<td>Keeping out entrants; minimising participation</td>
<td>Rules that encourage entry</td>
</tr>
<tr>
<td><strong>Rules</strong></td>
<td>Avoid loopholes that distort bidder behaviour</td>
<td>Rules designed to encourage bidders to reveal full value</td>
<td>Looking for opportunities for incumbents to leverage strength</td>
<td>Rules that constrain incumbents</td>
</tr>
<tr>
<td><strong>Results: Efficiency</strong></td>
<td>Maximise efficiency - spectrum to bidders that value it most, subject to promoting competition</td>
<td>Not relevant</td>
<td>Yes - narrow focus on bidder valuations</td>
<td>Yes - broader focus on long-term competition rather than valuations</td>
</tr>
<tr>
<td><strong>Results: Revenues</strong></td>
<td>Objectives vary depending on government priorities</td>
<td>Maximise revenue</td>
<td>Minimise price (unless barrier to entry)</td>
<td>Minimise price</td>
</tr>
<tr>
<td><strong>Results: Competition</strong></td>
<td>Maximise sustainable new entry</td>
<td>Not relevant - unless seller has remaining interest in market</td>
<td>Avoid new entry</td>
<td>Allow enough new entry for you to be successful!</td>
</tr>
</tbody>
</table>
Participation problems

- Three key ‘mistakes’ that auctioneers often make that compromise participation:
  - Using auction rules that advantage incumbents
  - Using auction rules that encourage consolidation
  - Setting reserve price too high or too low
Participation – examples of auctioneer mistakes

- 1991 UK TV franchises
  - Separate sealed bids for each region
  - Incumbent in Central region correctly anticipated that it had no challengers
  - It won the licence for 0.05 pence per pop, compared to average price of £10-15 per pop for other regions

- Swiss 3G auction
  - Four licences and eight registered bidders
  - Government has forecast high revenues but set very low reserve prices
  - Bidders consolidated to four, so licences sold at reserve

- French 3G award (not a real auction)
  - Set unrealistic high reserve price based on UK/German auctions
  - Only received two bids for four licences

- [Good for the incumbent bidder but not for anyone else]
- [Good for the remaining bidders]
- [Bad for everybody!]


Choosing the wrong rules

- Auctioneers sometimes pick the wrong format or rules
- Open auctions where a sealed bid more appropriate (or vice versa)
  - too much transparency when there are bidder asymmetries; or
  - too little when winner’s curse matters most and efficiency compromised
- More generally, getting transparency rules wrong
  - facilitating tacit coordination such as market sharing or strategic demand reduction
  - design errors that permit bid signalling
- Inflexible or inadequate activity rules causing unduly long auctions
- Inadequate collusion and/or default rules
## Rules – examples of auctioneer mistakes

- **New Zealand – mobile licences in 2000**
  - Used very small minimum bid increments and very weak activity rules
  - Auction lasted for almost 1 year, as bidders hid demand for as long as possible

- **Australia – satellite television auction**
  - Sealed bid, first price auction but no rules on default
  - Two bidders submitted multiple bids and then defaulted on the ones they did not like

- **Germany – 1800MHz spectrum auction**
  - SMRA with discretionary bid amounts to nearest German Mark
  - DT and Mannesmann used ‘bid amounts’ to signal how to split available blocks between them
  - Deprived government of revenue, although result not necessarily inefficient

- **X** – Bad for everybody
- **X** – Bad for everyone else who played fair!
- **✓** – Good for the incumbents
- **X** – Bad for entrants
Results

- Regulators should primarily be concerned about efficiency rather than about revenue or who wins spectrum
  - Effective downstream competition is likely to lead to low revenues ...
  - ... so high revenues might be a sign of competition problems down the line
  - However, media and other arms of government may be concerned about revenue

- Auctioneer cannot control revenues but it can:
  - use sensible reserve prices to reduce incentives for collusion and pre-auction mergers
  - manage expectations of auction outcome
  - use pricing rules to reduce likelihood of undesirable outcomes, such as:
    - large gaps between the amount bid and paid
    - large gaps between amount paid and highest losing bid
    - similar licences selling for very different prices

- Pricing rules can have a big impact on incentives for different types of bidders
Results – examples of auctioneer ‘mistakes’

- New Zealand – TV licences in early 1990s
  - Used sealed bid, second price auctions
  - Low competition led to some embarrassing outcomes (e.g. one bidder bid NZ$7million but paid NZ$5,000)
  - Outcome nevertheless likely to have been reasonably efficient

- Turkey – Sequential auction of telecom licences 2000
  - Reserve price for second licence set equal to first
  - One bidder deliberately bid high for first licence to ensure monopoly, as price of 2\textsuperscript{nd} licence too high for a competitive market!

\(\checkmark\) – Good for bidders
\(\times\) – Bad for everyone who played fair!
Western European 3G auctions

- Large gap in revenues primarily due to change in general market conditions..
- ..but exaggerated by poor auction design:
  - Blind faith in SMRA format
  - Ignorance of predictable participation problems
  - Mistakes in setting reserve prices
Key messages

- Rules matter:
  - Understand your objectives and those of the other participants
  - Understand how different rules may affect the outcome
- Good competitor analysis is essential
  - Categorise the potential bidders (strong, weak, regional etc)
  - Understand their objectives, likely valuations & behaviour
- Bid strategy can make a big difference:
  - Straightforward bidding is rarely the only tactic
  - Are there any ‘loopholes’ in the rules that bidders may exploit?
- Remember the bigger picture:
  - What are the general market conditions?
  - Is the auction vulnerable to low competition, either owing to bidder asymmetries or consolidation incentives?
  - Could bidders achieve the same goals by other means, e.g. trading?