



Spectrum Access and Auctions

Workshop on Spectrum Management: Economic Aspects

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ITU Regional Office for Asia and the Pacific

Aamir Riaz

International Telecommunication Union

aamir.riaz@itu.int

Run-Down

1. Auction as a way of granting Access to Spectrum
2. The organisation and mechanisms of auctions
3. Different types of auction design
4. Additional considerations for designing an auction
5. Summary

Aim

Introduce the main economic principles and market-based mechanisms of SM especially with regards to where and how the advanced market-based tools fit into the overall context of modern SM.



Auction as a way of granting access to Spectrum



Traditional methods of granting access to Spectrum

- Apart from unlicensed (commons) spectrum bands , the spectrum regulator has traditionally assigned frequencies within geographical areas to users, often via granting them a licence, which has normally been for their exclusive use
- Historically (pre commercial mobile era) three general ways WERE predominant
 - **FCFS:** Giving licence to the first applicant for it, if that is the only one (First come, first served)
 - **Beauty contests:** Asking applicants to make written requests for the licence, and allocating the licences to those making the most convincing case
 - **Reserving particular entity:** Specially for which there was excess demand at a zero or negligible price (sometimes referred to as lotteries)

In a beauty contest, typically a group of officials (*not necessarily well acquainted with all aspects of the business*) is determining the best proposal which may be optimistic or even misleading

- *Fees of spectrum recourse more to cover administrative costs*
- *Less transparency in decisions*



Why Auction?

➤ Introduction of commercial Mobile use

- A new method has displaced earlier methods. This involves the use of auctions, in the course of which licences are awarded to those offering the greatest monetary sum for them

➤ Why Administrations chose Auction instead of beauty contest for bands in demand

- Most persuasive reason is probably that they have generated substantial revenue for the state
 - *If there are monopoly rents to be made from a natural resource such as spectrum, there are good grounds for saying that they should go to the state - for potential use to finance public services, for example - rather than go as excess profits, often to overseas shareholders, as would happen under a beauty contest regime*
 - *Enables the government to divert the excess profits associated with providing mobile services from the successful operators for its own uses, for example to fund public spending on health and education*
- Efficient Spectrum Usage
 - *A benefit of the auction method is that it is likely to direct the spectrum to the more efficient operators. In an auction, firms are betting on their ability to make a profit on the licence. If they over bid, they have deceived themselves, and will pay the price. This should mean that licences tend to go to those best able to exploit them*
- However
 - *There may be cases where the value of the spectrum licence is low, for example if it covers an area where the population is very scattered. In these cases a beauty contest may be a preferred alternative*



Spectrum Access through Auction

➤ Recent Criticism and problems

• Revenue or BB growth

- *Arguments that state sees spectrum primarily as a resource to be sold to raise revenue, and restricts its availability for that end, rather than seeing spectrum as a means of extending the coverage and take up of mobile voice and broadband, and thus promoting economic growth and development.*

Studies have shown that a 10% increase in mobile voice or broadband penetration increases a country's national income by in excess of 1%. This benefit should take priority over increasing revenue form spectrum sales.

Question?

How to incorporate Auction as spectrum assignment method while including objectives, such as extending network coverage and **WITHOUT** adding complexity that adds to the risk of failure?



The organization and mechanisms of auctions



A little History of Spectrum Auctions

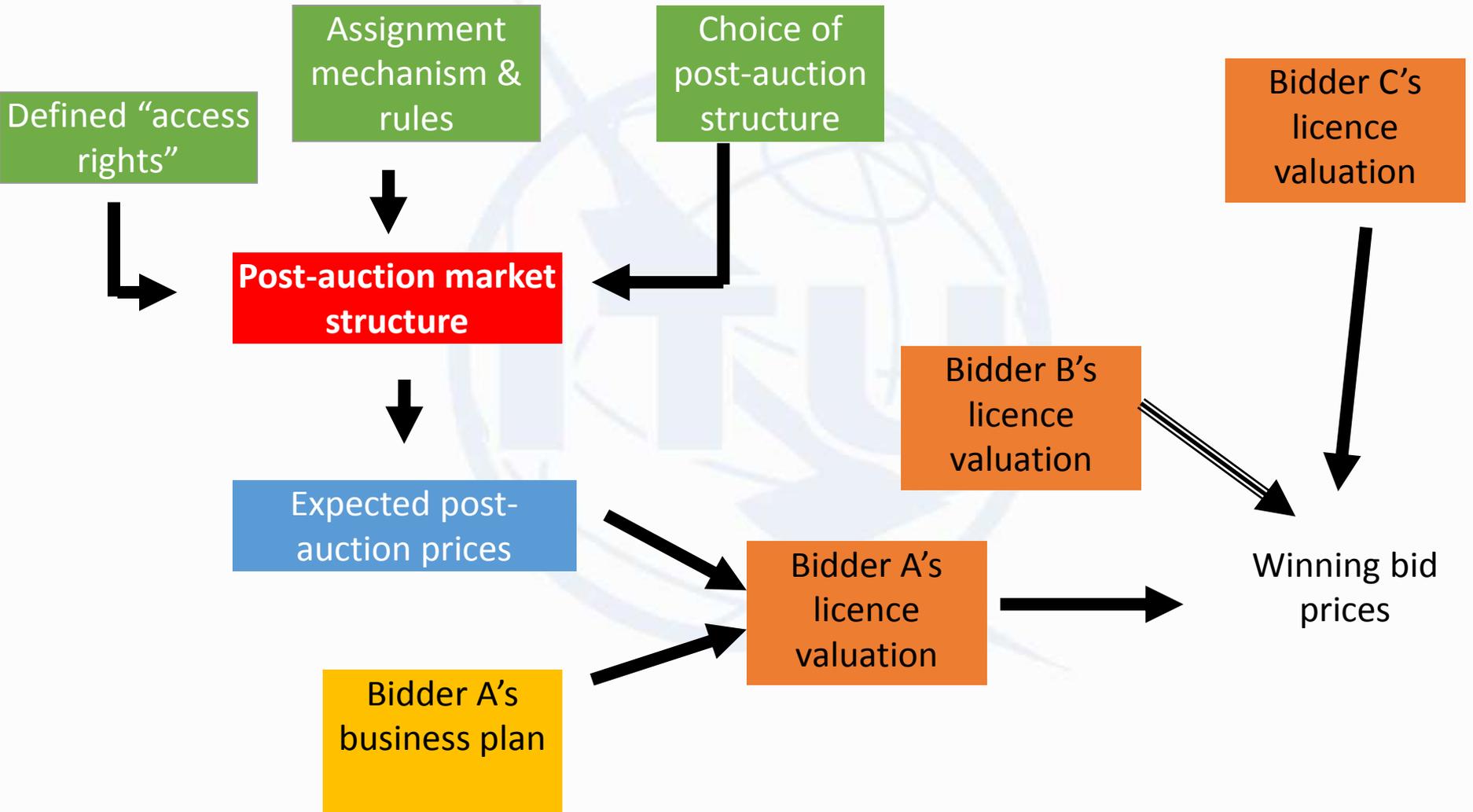
- **Practical use of this auctions started about 25 years ago, *although the notion predates that considerably***

- **In the early days, a small number of licences were auctioned**
 - in the same band,
 - their use confined to mobile services
 - Technology specific
 - Applicant could only be awarded one licence

- **Over the years there have been 2 major developments:**
 - Identical units of spectrum have been auctioned as individual lots, leaving it up to the firm to decide, within limits, how many to bid for
 - Auctions now often contain lots in several different bands, allowing firms to put together at one time a combination of holdings with different characteristics

Spectrum regulators choosing the auction route now have a wide choice of auction designs.

How Auctions work





Deciding: *How much Spectrum to Auction?*

➤ **International Influence**

- To some degree this is determined by international rules established by the ITU at World Radio Conferences;

➤ **Availability**

- It also depends on whether any spectrum which is being re-assigned has been cleared of its previous licensees

➤ **Supply may satisfy demand but priorities may be different**

- As noted, there has been a recent tendency to combine spectrum from several bands in a single award, to give bidders more choice over what to buy
- The regulator may be tempted to restrict the size of an award to create an **artificial shortage** and put the price up

➤ **Remember the Consequences**

- Spectrum shortage will push up the price of and reduce the take-up of mobile communications services, and this risks slowing down the country's growth rate

Temptation is short-sighted and should be resisted



Deciding: *When to auction spectrum?*

- **Low access frequencies:** *High demand*
 - Less choice and need a balanced approach
 - *Ever increasing demand from commercial mobile sector*
 - Decision of when depends on band clearance

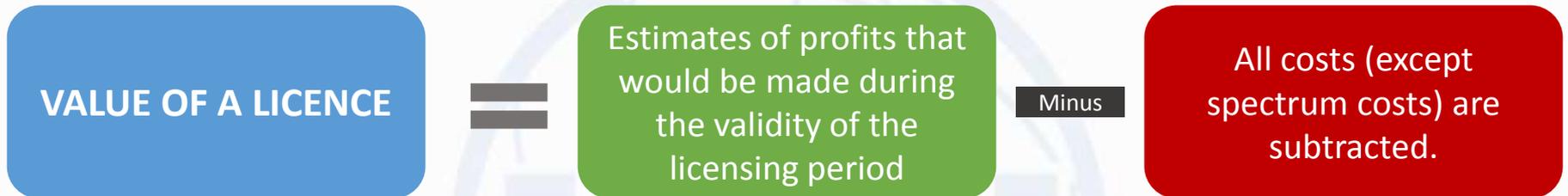
- **Higher frequencies:** *Lower demand*
 - More choice on auction's timing.
 - The choice is essentially whether it is better to hold the band in the regulator's inventory **OR** to make it available to a licensee even if that licensee will not use it immediately

- **Importance of Spectrum Trading**
 - If the spectrum is tradable, so that a licence bought for one purpose can be sold for use in another purpose,
 - **Early release** may speed up innovation
 - *depending on whether the regulator has sufficient resources to conduct non-urgent auctions.*

Delaying an auction is as detrimental to a country as is withholding it permanently

How bidders value a licence? 1/2

➤ First Step Calculation



➤ The projected revenues depend on the number of subscribers a company can get and the prices in the mobile market in each year.

- Both of these will depend upon the structure of the market (the number of operators after the current spectrum award) and, crucially, upon how intensively they compete.
- For example, they might be constantly cutting prices to seek new customers from one another, or they may tacitly or explicitly decide to collude by keeping prices and market shares at a co-ordinated level.
- Projected costs depend on equipment and running costs over the lifetime of the licence



How bidders value a licence? 2/2

➤ Second Step

- The difference between revenues and costs (profit) in each year is then discounted (*at a rate equal to the rate at which the operator can borrow money – say 10% per annum*) to produce a '**net present value.**'

This is the maximum amount the operator could bid for a one-time payment for the licence without making a loss on the deal

➤ However

- The operator will want to avoid paying as much as this, as it will want to retain some of the profit for its owners

➤ Note:

- This way of estimating the value of a licence is inevitably an inexact process, because it is based on projections into the future

Valuation going wrong: *The Winner's Curse*

- **Question: You as an operator has just been successful in an auction for a mobile licence. Should it celebrate?**

Answer = It depends!

-  You might have won because you have valued the licence accurately, and the auction has shown you to be the most efficient potential user of the spectrum

BUT

-  You might have won because you have mistakenly over-estimated the value of the licence more than anyone else. In that case, if you have bid up to your valuation, you will make losses.

For the bidder, the lesson is to take steps to avoid over-bidding, and to take account of the remaining risk in bidding

Challenges with Auction

➤ Collusion of operators:

- Non-spectrum Example: *(Consider spectrum as a freely tradable commodity)*
 - *Dealers in some antique markets have been found to collude by agreeing not to compete against one another in the public auction, but to allow one of their number to bid on behalf of all of them. They then re-auction the goods privately. The increase in prices received in the second auction over that paid in the first, public auction, is then shared among the participants.*
 - *(Consider spectrum as a freely tradable commodity)*

➤ Too Few Bidders

- In recent auctions for mobile spectrum, the number of bidders has been limited – often no more than the number of current licensees.
- Sometimes Regulator intentionally restricts new operators in market to avoid over heating/over competition.



Regulators' reaction to Challenges

- **A good regulator would never welcome the problems created by a licensee through by winner's curse**
 - Negative impact on future auctions or low interest from investors
- **Regulators design Auctions in way to ensure that collusion of bidders does not occur**
 - By taking or publishing strenuous steps to find and punish such actions.
- **Reserve Price**
 - With little excess demand for spectrum, the choice of reserve price (the price below which the licence will not be awarded) is key.
 - **Dilemma:** Too low a price, and the operators can retain excess profits; too high a price, and the spectrum will remain unused, probably for a long period

Where there is a risk either of collusion or of too few bidders, the choice of reserve price assumes great importance.



Auctions Processes

➤ Invitation to participate

➤ Pre-qualification

- Participation is usually subject to meeting specified criteria concerning financial capacity etc

➤ Designing the rules:

- This is the Key; some auctions have indeed failed as a result of poor design

➤ Implementation:

- Some are quickly over; some requires numerous rounds; some require complex software – others do not;
- Ensuring security of communications and strict adherence to stipulated rules are essential

➤ Granting the licence

- Involves the crucial step of securing payment in advance for the highest bidder
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Different types of Auction designs



Auction designs

- There are many auction designs to choose from, and here we focus on five examples:
- **Simple auction design** *(For explanation only)*
 - *Several operators competing for one licence*
 - **Clock' Auction design**
 - *Operators competing for a number of similar lots*
 - **Simultaneous ascending auction design**
 - **Combinatorial auction design**
 - *Allows operators to bid for a combination of frequencies*
 - **Incentive auction design** *(New Concept)*
 - *Ongoing in the United States*

Example I : Auction for a single discrete licence



Note: This does not generally occur, but it does illuminate very clearly some auction issues

➤ **At least three options available:**

• **First Price sealed tender:**

- *Each bidder participant writes down its bid in a sealed envelope; the bids are opened and the winner, the highest bidder, pays the price it has bid*

• **Second Price sealed tender:**

- *Each bidder participant writes down its bid in a sealed envelope; the bids are opened and the winner, the highest bidder, pays the price the runner up has bid;*
- *This may seem a dumb strategy for the seller to pursue, but the point is that bidders, knowing that they do not have to pay their own bid price, but the second price, will be willing to go higher in their bids*

• **An open ascending auction:**

- *The auctioneer calls for an initial price, which other participants can then beat in a public forum; the auction finishes when there are no other bids*

➤ **Key difference across these options**

• In the first, bidders are 'flying blind',

- *They have no information about other bids. In the open auction they can witness other bidders' behaviour, including when they drop out of the bidding .*

• In the second option what they pay depends on what is bid by the runner-up. This difference affects the risk of the winner's curse.



Example II : Clock auction

Traditionally, the rule in a spectrum auction was 'one licence per operator'. But as operators have become more diverse, with different spectrum inheritances and requirements, a more flexible design has become more appropriate

- **In a clock auction, available spectrum is divided into lots, which are broadly interchangeable or 'generic'.**
 - **The auction can start from a low price, which then ascends (an 'ascending price clock auction'), or start from a high price which then comes down (a 'descending price clock auction')**
 - **Operators bid at the opening price for as many lots as they want, or, if they are subject to caps, as many as they are allowed to bid for.**
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Example II : Clock auction (continued)

The name derives from the fact that the regulator may use a clock to set increases for spectrum lots (e.g. every 6 hours) until demand and supply are matched.

- **If there is excess demand, the regulator raises the price (and lowers it if there is excess supply); this continues until supply and demand are equal, when the auction ceases and the final price is paid by all successful bidders**
- **When the auction is over, the regulator then assigns successful bidders to particular locations in the band, in a way which maximises the efficiency of spectrum use**
- **Alternatively, the stage described above can be followed by a second stage in which operators wanting a particular position in the band can bid against one another for this privilege**



Example III : Simultaneous Ascending auction

This was widely used in the auctioning of regional licences, and in the European 3G auctions

- Suppose the firms are contending for two licences in each of 5 regions. The first round identifies the two winners in each of the five regions. In the second round, other participants are given a chance to beat the winning bids
- This is repeated until the auction finishes when no new bids are generated
- This process can take a long time, up to several months. To keep it within limits, there have to be activity rules (requiring all participants to bid with specified regularity) and minimum increments in bids
- **Problem:**
 - A problem of this design is that, because bidding takes place for each region separately, a firm may be left stranded with an incomplete regional coverage which does not fit in with its business plan



Example III : Simultaneous ascending auction: case study

- In 2000, an auction for 3G spectrum in the UK realised \$40 billion for 5 licences
- 13 bidders entered and the auction involved 150 rounds of bidding over 7 weeks
- The successful bidders were the 4 existing operators and a new operator, Hutchison Whampoa, which offered service under the brand '3'
- 5 bidders had exited by round 100, after the bid reached about \$3.5 billion; the last unsuccessful bidder exited in round 148
- Shortly after the conclusion of this auction, the stock market boom collapsed, and the UK's next simultaneous ascending auction for broadband fixed wireless access was a failure, with only 16 out of 42 licences being sold. The remainder did not meet their reserve price

See Paul Klemperer, , Auctions: Theory and Practice, 2004, available at <http://www.gqq10.dial.pipex.com/>



Example IV: A combinatorial auction

A combinatorial auction allows each operator to identify a set (or alternative sets) of licences which it wants to bid for that suits its business case.

➤ **Process:**

- The Regulator then identifies the combination of initial bids from all operators which maximise revenues. The results are announced and operators can rebid. The process ends with the round in which no new bid emerges

➤ **Positives:**

- More accurately establish the price per MHz of any particular band

Combinatorial auctions have been widely and successfully used in recent years. In order to restrict the number of combinations of combinations, lots of spectrum for sale within each band are often treated as if they were interchangeable, so bids are made without a specification of where in the band the lot is located. This is a feature shared with the clock auction described above. Such auctions are thus known as 'combinatorial clock auctions'.



Example IV: Combinatorial auction: case studies

- **In 2012, the Irish regulator used a combinatorial clock auction to assign spectrum in the 800, 900 and 1800 MHz bands, to come available for a period starting in 2013 or 2015 and finishing in 2030.**
 - Some of this spectrum was a new award; some was re-auctioned – **the regulator choosing to re-auction rather than extend existing licences.**
 - 13 lots of sub 1 GHz were available, with 15 lots of 1800 MHz spectrum.
 - As is increasingly common, bidders comprised only the 4 existing operators
 - The auction realised over \$1 billion

- **A much larger combinatorial clock auction, covering lots which would become available in 5 different bands between 2013 and 2017, was held successfully in Switzerland in 2012**



Example V : ‘Incentive auction’

The term ‘incentive auction’ has been used in the United States to describe a situation in which the auction determines not only the price at which a given amount of spectrum is sold, but also the amount of spectrum which is offered for sale

- Consider a so-called ‘two-sided’ auction in which the regulator sets a trial price and potential suppliers (the entity giving up spectrum) state what they would supply and potential customers (entity interested in more spectrum) state what they would demand;
 - Regulator then adjusts the price according to the balance between supply and demand, until equality between them is reached.
 - That is the price at which suppliers sell to customers. This can be seen as a synchronised version of what could otherwise be a series of bilateral trades
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Example V :an ‘incentive auction’ : a case study

- In the version under process in the USA, the two stages are separated. First, the regulator asks for broadcasters in the 600 MHz band to inform them of the price at which they are willing to relinquish their licences, and pays some of them to do so. The surviving holders of broadcast licences are then ‘repacked’ in the bottom of the band. This allows a number of MHz equal to that purchased as above, and adjacent to an existing mobile band, to be auctioned to mobile operators
- Key FCC documents establishing the rules and policies for the auction can be found on the [Incentive Auction Resources page](#). Bidding in Stage 1 of the auction began on May 31, 2016 and the first stage concluded on August 30, 2016. Stage 2 began on September 13, 2016 and concluded on October 19, 2016. The public can monitor the auction’s progress by using the [Public Reporting System dashboard](#).
- The auction does not have a set “end date.” The auction will conclude when forward auction proceeds meet the threshold established in the Commission’s rules and are sufficient to cover the prices awarded to TV stations in the reverse auction, a **\$1.75 billion** relocation fund for eligible TV stations moving to a new channel, and other administrative costs related to designing and conducting the auction.



Additional considerations for designing an auction



Spectrum caps in auctions

- **Risk:** *Loss of Competition*
 - One operator or a group of operators acting together will seek to buy up more spectrum than they need as a means of excluding or weakening competitors

- **Solution:** *Placing Spectrum caps*
 - Spectrum regulators often place a cap on the amount of spectrum an operator can either hold in aggregate or acquire at any given auction

- **Additional protection**
 - The cap, or a separate additional cap, can apply to spectrum sub 1 GHz, which is regarded as particularly necessary for a mobile operator to have

- **Criticism**
 - Caps of this kind may limit any operator to place on the bids in any auction
 - Criticised for penalising efficient and successful operators and preventing the most efficient use of available spectrum.

Good reasons for not making the caps too harsh but spite these concerns, spectrum regulators (*Europe in particular*) have made frequent use of them



Spectrum floors

➤ **Alternative way of intervention** (*Preserving competition*)

- More subtle auction is to offer assistance to an operator which might otherwise be weakened or forced to exit after an auction.
- This can be accomplished by giving preference in an auction to a bidder seeking to buy a small quantity of key bands, for example in the power ranges (sub 1 GHz).
- Case Study:
 - *This approach was used by the UK regulator Ofcom in its 2013 auction for 4G spectrum.*
 - *It requires careful calibration and should not be attempted by beginners, but in Ofcom's case it did allow the fourth and smallest operator to acquire additional spectrum at a lower than normal price.*



Summary





Summary

- **Auctions have largely taken over from ‘beauty contests’ as a means of assigning mobile licences as auctions can**
 - Divert excess profits to public ends,
 - Tend to lead to the choice of more efficient operators,
 - More transparent and less open to bias and corruption

 - **The process of running an auction is complex and specialised, and may involve specialised advice.**
 - The consequences of an unsuccessful auction are very serious, particularly with respect to delays in releasing the spectrum and negative sentiment of the market

 - **Different available and tested auction designs are appropriate for different contexts, defined mostly by**
 - Availability of spectrum band(s)
 - Current level of competition in the relevant mobile market place and degree to which that competition needs to be protected

 - **Auctions can be adapted to incorporate objectives related to enhancing mobile coverage. However, such adaptations can be complicated and they lead to higher risks of system failure.**
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References for further reading

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