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Effective Pricing in Spectrum Auction Design: Optimal Auctions out of Thin Air

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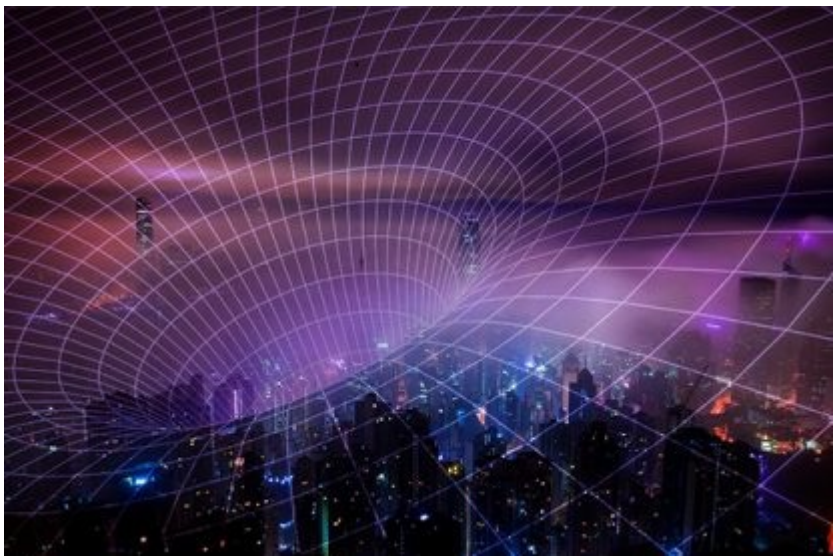

The promise of 5G

Fifth-generation wireless systems – commonly known as 5G – are a big leap forward for mobile communications. The innovations connected to 5G could be worth around $13.2 trillion over the next 15 years for the industry and public sector. By 2025, deploying the new technology could generate €213 billion in revenue in Europe, mainly in the health, energy, transport and automotive sectors, according to the European Commission's plans.

The International Telecommunication Union says 5G will mostly impact three areas: mobile broadband, where it enables emerging services like virtual or augmented reality; massive machine communications for the Internet of Things, the web of internet data exchanges among devices, with no human involvement; and ultra-reliable low-latency applications like self-driving vehicles or robotic surgery, which cannot function without large and stable data communications.

Demand for 5G networks is growing even faster in the Covid-19 world, where working remotely has become the norm and there has been a demographic shift away from city centers.

Regulators must ensure efficient spectrum use without harmful interferences. This is key to meet the booming demand for the new wireless services without endangering their essential high quality,

but, as usual, technology develops faster than regulation.

The origin of spectrum licenses

Since the first radio communications, it became clear that spectrum is a scarce resource that must not be overcrowded, but not many people remember that the proverbial Titanic shipwreck accelerated spectrum regulation.

In 1910, as the US Secretary of the Navy wrote to the US Senate, "*calls of distress from vessels in peril on the sea*" were routinely "*unheeded*", or "*drowned out in the etheric bedlam*". "*Amateurs*" clogged up the frequencies. "[*M*]*ischievous and irresponsible operators*" were taking "*great delight in* […] *sending out false calls*".

Two years later, the call for help from the sinking Titanic reached a telegraph station in Newfoundland. Amateur radio operators – flooding the airwaves to follow the unfolding situation – reportedly prevented the distress signal from travelling further. The ensuing tragedy provided impetus for the adoption of the 1912 Radio Act, which required all aspiring broadcasters to obtain licenses and only use their assigned frequencies.

Spectrum regulation advanced in large strides afterwards. Today, spectrum policies routinely include algorithm-based nationwide auction procedures. They allocate licenses for 5G spectrum usage rights on an exclusive basis.

However, the quest for the optimal auction design is still ongoing.

Market-based auctions

To accelerate the launch of 5G services, the EU has pushed strongly for the rollout of pioneer spectrum bands. A common deadline was established for EU countries to make available the 700 MHz, 3.6 GHz and 26 GHz bands, under harmonized technical conditions of use. **Italy** first assigned all of the pioneer bands, fetching a record €6.55 billion at the auction in 2018. Currently, 21 EU countries have licensed out at least some part of these spectrum bands.

Spectrum auctions must optimize the use of scarce resources to deliver maximum value. This should be done in an objective, transparent, proportionate and non-discriminatory manner. Auctions must promote – or at the very least not hinder – effective network rollout, but also service quality, innovation, and the development of competitive markets. They must also help EU countries to coordinate the use of radio spectrum and establish pan-European networks.

How can auction design help to achieve all these goals?

In the 1950s, Ronald Coase argued that competitive auctions are the best way to allocate broadcasting licenses. Auctions naturally select market players who can make the best use of scarce resources because they are willing to pay more for them. Auctions help governments maximize revenues extracted from their natural assets, without having to run businesses themselves.

Regulators in Europe widely use competitive auctions. An example among many is the emission allowance auction scheme under the EU plan to be climate-neutral by 2050. This auction scheme helps in curtailing global warming by allocating the right to pollute only to those who can offer

more.

Beauty contests, on the other hand, can provide more flexibility to select licensees according to other criteria, different from price. However, a troublesome trade-off is that government officials may enjoy too much room in picking winners, replacing market dynamics.

The winner's curse

The winner's curse is a recurring menace in competitive price auctions, which was initially identified in the awards of offshore oil-drilling leases.

Bidding choices depend only partly on a bidder's own features, like experience, available funds and technology, cost structure and synergies.

Many other strategic factors also matter, which are common to all bidders. Not least, those relating to the potential for market exploitation of the auctioned-off item. Bidders usually need expert appraisals to understand how competition will unfold, or the likely evolution of technologies and regulation.

Normally no single set of accurate information is available on these matters. As a result, each bidder will have their own views and insights. However, none of them will know exactly what the award is worth.

Winners might prevail because they are better positioned to exploit the win or because they are more insightful, or it could happen that other competitors placed lower bids because they knew something that the winner ignored, and which substantially affects the market value of the prize at stake.

This is the winner's curse. The winner realizes that it has overpaid for the award, making a loss on the transaction.

Irrational or unlucky bidders have to live with the consequences, but the mere existence of the risk of overpaying can doom auctions to failure and defeat the regulator's goals. Uncertainty may cause competitors to underbid or to not compete. Cursed winners could also try to recover losses by raising service prices to the detriment of consumers and innovation.

The impact on spectrum auctions

These dynamics, which may frustrate the regulator's purposes in launching auctions, also affect the award of spectrum licenses. Doubts over technology, over consumer demand for the new communication services, or over the outcome of future auctions for similar licenses, can have a deep impact on bidding strategies.

For instance, when frequency bands are offered on a regional rather than national basis, the value of single regional licenses for operators active nationwide will be less, if they do not manage to also get licenses for the other regions in which they operate.

The operator would not know in advance the outcomes of future auctions. Therefore it would be hard to predict how much it should pay for the license. Where a combinatorial element is central, a bidder may wind up over-investing in an incomplete collection of licenses, which lose their value if

the complementary licenses become too expensive or unavailable.

The scenario worsens when complementary spectrum auctions are infrequent. Bidders have the additional daunting task of predicting future demand trends over longer periods. This is much more complicated in emerging markets or with developing technologies, like those combining artificial intelligence and 5G.

This is why regulators have been keen to find a cure for the winner's curse. This would encourage more courageous yet balanced bids.

The Nobel-prize cure

Paul R. Milgrom and Robert B. Wilson found a solution. They dedicated much of their work to advancing the understanding of auctions and won the 2020 Economics Nobel Prize "*for improvements to auction theory and inventions of new auction formats*".

Borrowing many analytical tools from game theory, they came up with a new format in 1994. Together with Preston McAfee, they developed a simultaneous multiple-round auction ("SMRA") model for the US Federal Communications Commission. This is now standard practice in spectrum auctions around the world.

SMRA is an ascending auction for multiple lots at once. It allows bids for every available segment of the spectrum in a number of rounds. After each round, some information about prices is revealed allowing bidders to re-evaluate their strategies in light of the results. This additional certainty about the true value of the award encourages participants to not discount their offers. When there is no additional demand for any of the lots, allocation begins.

Defeating the winner's curse, the new format grants fairer and more efficient outcomes.

The trouble with record auctions

Ensuring constant improvement in the design and practice of spectrum auctions, however, remains crucial.

Modern auctions can still lead to suboptimal outcomes, for instance, when they maximize frequency price leaving participants with not enough resources to invest.

Many national regulatory authorities—in order to raise state revenues—actively try to extract rents from operators. This may be an acceptable objective, but it could conflict with other primary public goals. These include encouraging network investment and creating stable competitive markets.

Historically, telecom industry researchers considered very high spectrum license fees unrecoverable, inescapable sunk costs, with no impact on operators' investments and pricing. They basically thought that extracting maximum income from spectrum auctions was a risk-free operation without downsides for consumers.

Recent studies in financial and behavioral economics show differently. Companies do not disregard sunk costs when making decisions on investment and pricing. On the contrary, high upfront input costs can lead to a steep reduction in network investment and price competition.

This is known as the hold-up phenomenon. Above-market spectrum awards cut down winners' profits, which normally ensure return on network investments already made. In the long term, companies respond to profit-cutting by lowering their expectation of returns on future investments. This in turn reduces overall network investment, including future bids. Inability to invest might even lead companies to market exit or consolidation.

In a 2017 Study on Spectrum Assignment in the EU, the European Commission found indeed a correlation between high auction prices and poor 4G network availability, reflecting insufficient network roll-out.

Therefore, the financial upside from obtaining artificially high award prices can be evened out by risks of future auction failures. It can also generate downstream inefficiencies resulting in lower quality, more expensive, services.

The path forward

The EU lacks a widely accepted price-setting methodology that encourages efficient spectrum use. But several pro-competitive clauses in tender rules can moderate the negative effects of price auctions. Regulators should not abuse these clauses to pick winners. They should be checked against a thorough market review and introduced only if there is evidence of market dominance.

Boosting competition

Spectrum caps restrict the maximum amount of spectrum a bidder can buy. They can concern a single band or a group of bands. Or they can be symmetric for all bidders or asymmetric with a tighter or looser cap for certain bidders. These clauses prevent anticompetitive spectrum hoarding. They may also lead to more competitive markets, with a higher number of licensed players. However, setting caps too tightly can jeopardize an operator's ability to provide improved coverage.

Wholesale access obligations facilitate market entry of mobile operators or non?telecommunications niche service providers, encouraging retail competition. They involve duties imposed on licensees to offer wholesale third-party access to the awarded spectrum. However, they are not appropriate in all circumstances. There should be clear market evidence that they are needed, for instance, when the licensed spectrum is an essential facility, whose use cannot be exclusively reserved to the winner. Otherwise, parties should negotiate wholesale access with competing providers on commercial terms.

Reservation clauses reserve spectrum for certain bidders or groups of bidders, *e.g.*, new entrants or providers of niche services different from electronic communications. Lenient minimum coverage obligations or a right to national roaming are helpful measures for these special categories of market players. For example, incumbent operators that acquire spectrum may be required to offer national roaming to new entrants on FRAND terms.

Finally, the use of coverage obligations may stimulate investments. They should not lead to inefficient duplication of networks in non-profitable areas. Nor should they be so wide or unreasonable as to discourage bids from well-qualified applicants. Licensees should be allowed to meet coverage obligations using the most efficient combination of bands. Especially as 5G leverages multiple bands to provide optimal services.

Sharing the airwaves

Stakeholders are also increasingly turning to emerging spectrum sharing possibilities to meet growing demands for wireless connectivity. Sharing solutions could help unlock opportunities for new applications, including 5G networks and the Internet of Things.

Many tender rules aim to ensure efficient spectrum exploitation through sharing mechanisms. "Use-it-or-lease-it" clauses provide that operators can use the frequencies in bands that are not used by the licensees. Club use clauses allow licensees to use all the awarded spectrum, in areas where frequencies are not used by others. Spectrum sharing models allow independent users or devices to access the same range of frequencies under certain conditions.

Conclusions

Optimal auction design has come a long way since the Titanic shipwreck. Nobel prize winners have contributed to finding ingenious solutions to problems like the winner's curse. Regulators increasingly test their solutions. They try to find an optimal balance between conflicting public goals. Such as maximizing state revenues without discouraging network investment and competition.

However, there is no secret recipe for the best spectrum auction. There are a number of potential solutions, whose effectiveness should be checked on a case by case basis. In any event, it is important to ensure that procompetitive tools do not become enablers for market manipulation.

5G could have a huge social and economic impact globally, and be a core enabler for industrial transformation. It is up to the regulators to unlock this tremendous potential through careful auction design.

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