Spectrum Auctions in Developing Countries: Options for Intervention

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Table of Contents

1. Spectrum Auctions: A Brief Overview

Spectrum auctions are a means of choosing between applicants for a license to use the electromagnetic spectrum and have been in practice since the early 1990's, though they were first suggested as early as the 1950's. An auction for spectrum licenses is a market-based assignment mechanism that uses financial bids as a means of deciding between competing applications for the right to use a specific portion of the electromagnetic spectrum in a specific area in contrast with other more administrative mechanisms such as "beauty contests" or first-come first-served approaches. The goal of a spectrum auction is to let the market decide the licensee for, and in some cases the use of, a specific unit of spectrum. The auction mechanism seeks to assign the license to the bidder that values it the highest, who presumably is the one most likely to put it to its highest valued use.

A. The Nature of Spectrum

"Spectrum" does not exist in a physical sense, but rather is a conceptual tool used to organize and chart a set of physical phenomena associated with electromagnetic radiation. Moving electric and magnetic fields produce electromagnetic waves – radiation – that propagate through space at different frequencies or, equivalently, at different wavelengths. The set of all such frequencies is called "electromagnetic spectrum" and the subset of frequencies between 3,000 Hz and 300 GHz is known as the radio spectrum or for purposes of this discussion, simply spectrum. A myriad of wireless telecommunications services utilize spectrum, including radio and television broadcasting, cellular mobile radio services, military and commercial radar systems, radio astronomy, a host of communications satellite services, specialized two-way radio systems used by various public safety agencies, etc. as well as numerous consumer devices such as cordless telephones, baby monitors, and automotive keyless entry systems. In economic terms, spectrum is a critical input or factor of production in a host of services that are vital to the economic and social well-being and the safety of life and property of all nations, both developed and developing.

Generally, national governments act as the regulatory authorities for spectrum resources and manage spectrum resources at a national level (sometimes delegating management at a sub-national level) and many of them coordinate internationally through organizations such as the International Telecommunications Union (ITU).

Spectrum management has four core functional areas: spectrum allocation, service rule development, license assignment and rule enforcement. The first step, spectrum allocation, involves dividing (in the frequency dimension) the range of usable spectrum into blocks or bands of frequencies called allocations.

These frequency allocations, which are often guided by the ITU's radio regulations, determine the type of use allowed within that block or band. For example, the allocation might be for television broadcasting, land mobile radio systems, or radio navigation systems. Increasingly, regulators are being less restrictive with regard to the specific uses allowed for a given piece of spectrum. This trend toward technical neutrality with regard to spectrum is, in part, a response to the rapid development of new technology and the difficulty regulators have in keeping pace with it when allocating spectrum.

The second step is to develop and impose service rules that are associated with a particular allocation. These may include technical rules that specify, for example, how the band is to be channelized to accommodate individual transmitters and the maximum transmitter power that can be used in such a channel within the band. The rules may also include non-technical constraints such as rules that determine who or what entities are eligible to receive licenses or authorizations to operate in the allocation. Increasingly, regulators are liberalizing their approach to the allocation step of spectrum management by creating technically neutral rules[1] or promoting open access to networks[2] to increase competition and innovation. The UK regulator Ofcom has been a leader in this respect, stating that, "Spectrum liberalisation and trading will make it easier for entrepreneurs and innovators to enter the market, deploy new technologies and applications, and compete with existing players; they will make it easier for spectrum to migrate from relatively low value uses to higher value ones."[3] Service rules may also be designed to meet certain public policy objectives, including build out rules that require license holders to actually construct systems to serve the public rather than allow the spectrum to lay fallow and open access requirements that may require licensees to make services that use their spectrum open to certain classes of devices.

The third step involves assignments – granting the authority (e.g., in the form of a license) for a specific individual or entity to operate a transmitter on a specific channel at a specific location under the applicable service rules. In a first-come, first-served environment the assignment process can be very straightforward, simply grant the license to the first qualified applicant. In most cases of exclusive use, however, there are more applicants interested in the license than can be accommodated and mutually exclusive applications must be resolved so that only one is accepted. Here the assignment process can take several forms including a subjective comparative process, a random selection, or a market-based approach, each of which will be addressed in the next section.

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[1] Technically neutral rules are rules about the technical characteristics of systems that can operate under a spectrum license that do not proscribe a specific technology.

[2] As will be discussed in more detail in the section on the United States, open access provisions can be used to require network operators to allow access for devices that meet certain standards, for example, allowing consumers to buy their own mobile telephone handsets rather than having to purchase them from their wireless provider.

[3] Ofcom, "A Statement on Spectrum Liberalisation" January 26, 2005 at 1.

The fourth and final step involves enforcement of the rules and regulations established for the allocation.

Spectrum auctions, and therefore this paper, are primarily a means of implementing the third step of the spectrum management process: assignment. The other steps of the process have a significant impact on the structure and ultimately the success of any spectrum auction, and cannot be ignored when discussing spectrum auctions as an assignment mechanism, especially when you consider that many of the public policy goals set forth in the rules of the allocation step of the spectrum management process have a significant impact on the desirability and value of a spectrum license for potential licensees.[4] Auctions, while an increasingly popular means of assigning spectrum, are by no means the only means of assignment.

A. Problems in Spectrum Assignment

With the growth of mobile phone use for voice and data, licenses for the use of spectrum are extremely valuable and demand for access to spectrum is continually increasing. In the U.S. alone, 12-month service revenue for mobile telephone services was estimated at nearly $144 Billion.[5] Demand is also increasing. CTIA – the Wireless Association released a report stating that current demand for commercial mobile spectrum in the United States is four-times the current allocation and that number may grow as high as eight-times by 2020.[6]

In such a high-stakes area, if spectrum license assignment processes are unclear or opaque, unfair and even corrupt practices in spectrum assignment can emerge. In fact, allegations of unfair and corrupt practices in spectrum assignment can be found around the globe. In India, there have been allegations of corruption in the assignment of 2G mobile telephone licenses where the government is being accused of charging below-market value license fees and assigning licenses to companies that quickly sold them to foreign companies for large windfall profits.[7] In Moldova, the Broadcasting Coordinating Council has been accused of granting licenses only to media entities that are pro-

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[4] Take, for example, a regulator that specifies strict build-out requirements for providers to build and deploy service using a given piece of spectrum. In some cases, licensees may wish to provide service only to more densely populated portions of the license area, but strict build out requirements may require them to serve the sparsely populated areas as well and would have an impact on their deployment plan and its cost.

[5] CTIA's Semi-Annual Wireless Industry Survey, mid-year 2008.

[6] CTIA Wireless Demand Study, www.ctia.org.

[7] *See* http://ibnlive.in.com/news/karunanidhi-defends-raja-on-spectrum-allocation-issue/78961-3.html
http://www.zibb.com/article/4895315/CVC+seeks+clarity+on+2G+spectrum+allocation+from+DoT
http://news.webindia123.com/news/articles/India/20081215/1128713.html

government.[8] In China, weak and unclear government rules have been criticized as fostering corruption, including bribery, as a means to influence outcomes.[9]

Creating a clear, fair and transparent process for the assignments of valuable public assets such as spectrum licenses makes it more difficult for firms to apply pressure and influence the assignment process and for the regulator to engage in back-room deal making.

B. Spectrum Assignment Options

Because most regulatory authorities assign licenses for spectrum on an exclusive basis, where demand for spectrum exceeds supply, the regulator must decide to whom to grant the licenses.[10] Over the years countries have used a variety of methods to assign their spectrum licenses. The following sections briefly describe these methods.

1. First-Come First-Served

A simple alternative to deciding between applications is to simply accept the applications on a first-come first-served basis, but this approach is undesirable for a number of reasons, including the fact that it simply rewards the first to apply rather than choosing the applicant who would be most likely to provide a service of value to the public.

2. Comparative Hearings or "Beauty Contests"

In many countries comparative hearings (sometimes referred to as "beauty contests") are used to decide among competing applications for spectrum. Comparative hearings are an administrative process where the regulatory authority evaluates applicants under comparative criteria. Comparative hearings allow a regulator to consider a number of different factors when deciding between applications and require applicants to present business plans, but critics of the comparative hearing process argue that the process is time-consuming (delaying service to the public), both in terms of crafting comparative criteria, evaluating them and administering the inevitable appeals process; costly; prone to lobbying and even bribery by applicants; and often not transparent.

3. Tender Process

Some developing countries have implemented spectrum allocation procedures that include written technical and business plans along with a financial

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[8] http://www.unhcr.org/refworld/publisher,RSF,,MDA,4843fd3ac,0.html
[9] http://www3.interscience.wiley.com/journal/118649159/abstract?CRETRY=1&SRETRY=0
[10] Exclusive licensing means that the licensee is not required to share its spectrum and has exclusive rights to the spectrum bandwidth in the geographic area that is licensed. An alternative is to create non-exclusive rights, or shared access to spectrum. There are a number of practical considerations to consider, mainly revolving around preventing and coping with interference. This approach is being debated in the United States with its so-called white spaces proceeding where unlicensed use may be permitted in the unused portions of the television band. *See* Federal Communications Commission, http://www.fcc.gov/oet/projects/tvbanddevice/Welcome.html.

component. In Romania (2005), Macedonia (2007) and Riyadh (2007), bidders were required to submit the price they were willing to pay for a spectrum license along with technical proposals for their network build out plans. The regulator compares the offers based on financial and technical criteria, making this process part beauty contest, part auction. While there is a market component involved, the reliance on the comparative criteria introduces the same issues discussed above. The problems with comparative hearings are exacerbated by the degree to which the comparative criteria are weighted in comparison to the financial criteria.

4. Lotteries

Lotteries are a means of using random selection to choose between mutually exclusive applications for spectrum. The United States briefly used and then abandoned this assignment mechanism in the 1980's.

In 1982, in response to lengthy and costly comparative hearings, the FCC chose to award cellular phone licenses by lottery. What began as a means of quickly determining the winner for a license became a fiasco where speculators filed multiple applications and when they won, many of them simply sold the licenses for large windfall profits to other private entities. In one case over 320 thousand applications were received for 643 cellular licenses and one of the winners sold the license less than a year after the lottery for $41.5 million.[11] Because of these abuses the lottery process was quickly abandoned in the United States.

5. Auctions

Auctions involve the assignment of licenses through a process of competitive bidding whereby qualified applicants bid for spectrum licenses. Auctions vary widely in design and implementation from simple oral outcry auctions to complex electronic auctions.

Compared to comparative hearings and lotteries, economists widely agree that properly designed spectrum auctions produce an economically more efficient exclusive licensing mechanism that assign licenses to parties that value them most highly, minimize wasteful private expenditures to obtain spectrum, foster (economically) efficient spectrum use and increase competition with existing spectrum-based services with minimum delay and cost to the government.[12] Auctions seek to assign the license to the entity that values it the most highly and therefore the one who will have an economic incentive to put the license to a high

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[11] Spectrum Issues for the 1990s: New Challenges for Spectrum Management, Dale N. Hatfield, http://www.annenberg.northwestern.edu/pubs/spectrum/default.htm.

[12] Auctioning Spectrum Rights, Evan Kwerel, Office of Plans and Policy, Walt Strack, Wireless Telecommunications Bureau, U.S. Federal Communications Commission, February 20, 2001, http://wireless.fcc.gov/auctions/data/papersAndStudies/aucspec.pdf.

valued use. In addition, auctions are a means of generating revenue for a public resource.[13]

On the other hand, auctions have been subject to criticism because they appear to put money before public interest goals, favor well-financed incumbents, can be complex and are sometimes subject to anti-competitive behavior. These criticisms have been addressed in a number of ways in the course of spectrum auction operation over the last 20 years, and spectrum auctions have proven to be a fast, fair and efficient means of assigning licenses. The following section will discuss spectrum auctions in practice and how proper spectrum auction design can capitalize on the positive aspects and minimize the negative aspects of auctions.

2. Spectrum Auctions in Practice

A. Auction Design Elements

Much work has been done in both economic labs and the real world to study auction design for spectrum. This work has lead to the development and refinement of a number of auction methodologies. While an in depth analysis of all of these developments is outside the scope of this paper, there are some important concepts to understand before discussing spectrum auctions in practice.

Single or Multiple Bid Rounds? Auctions can consist of a single bid entry or can be divided into iterative bidding "rounds" in which bidders can submit bids. The primary benefit of a multiple round auction is that bidders receive information one round and can respond with a new bid. A clear cost of a multiple round auction comes is the time it takes to complete a series of rounds, which can vary depending on the speed with which prices increase and the rule for stopping the auction.

Simultaneous or Sequential? Most spectrum auctions involve the sale of multiple licenses, whether divided into different geographic areas or blocks of spectrum or both. These licenses can be auctioned either sequentially, one at a time, or simultaneous, all at once. In most spectrum auctions, bidders view licenses as substitutes or as complements,[14] and these preferences are unique to each

[13] In this paper we examine auctions as a means of assigning spectrum for commercial use, and do not examine auctions in the context of non-commercial assignments such as public safety and educational uses where competitive market-based assignment mechanisms may be less appropriate. For example, in the United States, the FCC's auction authority does NOT apply to spectrum that is allocated as a public safety radio service or a non-commercial educational broadcast station. 47 U.S.C. § 309(j)(2).

[14] For example, in an auction of multiple blocks of spectrum covering the same geographic area a bidder may have a desire to win any one of the blocks and see them as perfect substitutes for

bidder and their business plan. Because a simultaneous auction presents all licenses at one time, a bidder can switch between licenses or bid on multiple licenses at the same time in a single auction event rather than have to participate in several events. The simultaneous auction also reveals information about prices for all items at the same time, allowing bidders to evaluate all substitutes at once and react to them instead of having to do so in separate auctions.

Individual or Combinatorial Bids? While a simultaneous auction allows bidders to bid on complements and substitutes simultaneously, auctions can be designed to allow bidders to express their bids as a series of individual bids, that is, each bid on a license is independent of each other bid, or as all-or-nothing combinations (or "packages") of bids. The key benefit of combinatorial bidding is that bidders can avoid the so-called "exposure risk" whereby they win some, but not all of, a desired combination of licenses. Combinatorial auctions create a few problems though, including complexity and coordination issues where the overlap of packages of bids can make winning challenging for some bidders.

Transparent or Private Bidding? Auctions can be designed with varying degrees of information being made available to bidders. At one extreme is a sealed bid where bidders are not aware of the bids of other bidders, and at the other is a fully transparent auction where all information about bidders and bids is made available to everyone. There are variations in between where bidder identities are masked or individual bids are not revealed. The issue of how much information to reveal is a balancing act between giving meaningful information to bidders[15] and discouraging anti-competitive behavior such as targeting and punishing specific bidders. (cite studies from 700 MHz comments)

B. Choosing an Auction Design

The specific format for a spectrum auction is best determined after examining both what is being auctioned the potential pool of bidders and the telecommunications market they exist in.

While any assignment mechanism benefits from a clear understanding of the terms and conditions associated with the licenses being assigned,[16] clarity in the license terms is especially critical in a spectrum auction where bidders are required to assign specific values to spectrum licenses. In addition, the number and size of licenses being offered will help dictate the best type of auction to use. For example, if there are dozens (or potentially thousands) of licenses being

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each other. Another bidder may have a business plan that requires them to win several of these blocks, viewing them as complements to each other.

[15] Information about specific bidders can be useful, for example, where bidders are seeking to gain spectrum adjacent to other bidders that use similar technologies to facilitate roaming between market areas.

[16] These include but are not limited to the technical rules, such as power limits, out of band emission limits, etc.; potential services that may be deployed, such as broadcast, mobile, or even service neutral licenses; and limits on post-market transactions, such as transfers or assignments.

assigned, sequential auctions would take a significant amount of time and could produce negative results,[17] and conversely, if only one license is being assigned, a combinatorial auction is unnecessary.

License terms and conditions vary considerably from country to country. In Australia, New Zealand, the United States, and Canada for example, spectrum licenses are generally technology neutral (allowing bidders to choose among various technology options and switch technologies over the life of their license without government approval). In Europe, 3G licenses issued in the early 2000's specified GSM technology[18] as a condition of the license. Recently, the FCC introduced new rules in the 700 MHz upper C block that required licensees to provide open access as a condition of those licenses. Each of these license terms and conditions impacts the value of the license to a specific bidder, and some degree of regulatory clarity and certainty is necessary for bidders to determine the worth of the license to them.

The appropriate auction design will also depend on the degree of competition in the telecommunications market and the size and make up of the potential applicant pool. Are bidders likely to want to aggregate spectrum or see licenses as substitutes? Are there certain entities that deserve special consideration such as small businesses or new entrants? Is there a desire to prevent a single entity from acquiring the entire set of licenses? Is there sufficient competition to support an auction, or to require a multiple round auction? While answers to these questions may not be obvious, a regulator can get valuable information by engaging in a public comment process before determining the details of an auction. At the FCC in the United States, for example, a public comment process about the spectrum allocation begins well in advance of an auction and is followed by a public comment process for the specific auction rules. The comments and reply-comments of all entities are made public and the FCC responds to them publicly, making it a transparent process that benefits from the input of potential bidders and other concerned parties. The official public record for the FCC's recent auction of reclaimed analog television spectrum in the 700 MHz band contains over 26 thousand entries, all searchable on the FCC web site.

Transparency in the policy and auction design process is critical to the success of any auction. While the discussion of auction types and auction rules has been rather high level up to this point, there are countless details that must be considered in designing an auction to assign spectrum licenses, and a transparent process that involves the decision makers, the bidders and the public is critical to the success of the auction.

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[17] Auctioning substitutes or complements in sequential auctions can lead to any number of issues because bidders must guess the outcome of future auctions when deciding how to bid in the current auction. This can exacerbate the risk of exposure and can lead to overbidding to prevent it.

[18] GSM (Global System for Mobile communications) is one of the most popular technological standards for mobile phones.

C. Addressing Public Policy Goals

While auctions are a market-based approach to spectrum assignment, it doesn't mean that public policy goals, such as facilitating new entrants in the market or the supporting the participation of small businesses or disadvantaged entities, must be excised from the process. Indeed, as a market-based assignment mechanism, there are valid concerns about new entrants or smaller companies being able to participate effectively in spectrum auction with larger often well-funded incumbents. There are a number of ways in which public policy objectives have been integrated into spectrum auctions with varying degrees of success.

1. Requiring Timely Service Provision Through Build Out Requirements

A primary goal of spectrum auctions is to allocate the spectrum to the entity that values it most highly with the assumption that they will put the spectrum to its highest use. However, without regulatory requirements to build and operate a system in a timely manner, some entities could buy the spectrum with little or no intention of actually deploying a service, but rather keep the spectrum from competitors or try to sell it for a profit at a later point. While build out requirement are more a part of the allocation process than the assignment process, bidders will have to evaluate the economic impact of the requirements on the value of the license so they can reflect it in their bids.[19]

2. Ensuring the Participation by Designated Entities Through Set-asides

A set-aside involves restricting access to spectrum to a specific designated entity, such as small businesses or new entrants. For example, set asides can be used to create competition in the telecommunications market if there is a fear that well funded incumbents will shut out new entrants. Spectrum set asides have been criticized by some as inefficient ways of introducing competition in part because they are deterministic with regard to the winners rather than allowing the market to decide if a specific entity (or type of entity) should enter the market.[20]

3. Leveling the Financial Playing Field Through Bidding credits

Bidding credits are a means of leveling the financial playing field between bidders by granting some bidders a discount on their final bid. In the U.S., the level of discount is based on reported revenues and has granted qualified bidders a

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[19] Historically there has been much debate about whether and how to implement build out requirements for spectrum licenses. In the United States there has been a trend of relaxing requirements for building out spectrum licenses. In 2001, a group of prominent economists filed comments at the Federal Communications Commission stating that, "If a licensee faces the appropriate opportunity cost of not using spectrum, then there is no need to have a build out requirement." Comments of 37 Concerned Economists, WT Docket 00-230 (February 7, 2001), at 5.

[20] Crandall, Robert W. and Ingraham, Allan T, "The Adverse Economic Effects of Spectrum Set-Asides", Canadian Journal of Law & Technology, Vol. 6, pp. 131-140, November 2007

discount of as much as 40% off their final bid price. Experience in the early PCS auctions in the United States show that in some cases, small firms actually bid through their bidding credits by competing with each other, and ended up paying prices that when their bidding credit was applied were equivalent to entities who did not receive a credit.[21]

4. Leveling the Financial Playing Field Through Financing

One need only examine the disastrous C-Block PCS auction held by the FCC in 1996 to understand the danger of offering installment financing for the payment of winning auction bids for spectrum licenses. The attractive terms of the installment financing[22] contributed to wildly speculative bidding and ultimately resulted in a decade of defaults and bankruptcy litigation that kept the spectrum from being used for years after the auction.

D. Spectrum Auctions in Practice

In 1959, Nobel Award winning economist Ronald Coase's article "The Federal Communications Commission" first called for a market-based mechanism for assigning spectrum licenses.[23] Spectrum auctions came to fruition beginning in the late 1980's in Australia and New Zealand where they held oral outcry and single-round sealed bid auctions for spectrum licenses. In 1994, the Federal Communications Commission introduced a new auction design, the simultaneous multiple round auction (SMR), which combined the simultaneous aspect with a multiple round format allowing bidders to aggregate spectrum licenses and switch among substitutes over the course of the auction. The success of the FCC's early auctions, both in terms of dollars raised for the US Treasury and licenses rapidly assigned, lead a number of other countries to begin using spectrum auctions.

Since 1994, many countries have implemented spectrum auction programs to allocate PCS and 3G licenses, including but not limited to: Austria, Belgium, Canada, Czeck Republic, Denmark, Germany, Greece, Guatemala, Israel, Italy, Mexico, Netherlands, Nigeria, Slovania, Switzerland, Taiwan, and the United Kingdom. Many of these auctions followed the FCC SMR format, while others were sealed bids. There are also examples in recent history of spectrum auction failures, for example, in 2002 Brazil attempted to conduct an auction on PCS GSM licenses but the auction was aborted due to lack of carrier interest.

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[21] Ayres, Ian & Cramton, Peter, "Deficit Reduction Through Diversity: How Affirmative Action at the FCC Increased Auction Competition," (1996).

[22] The auction rules required winning bidders to make only a 5% down payment and then make quarterly installment payments with interest based on the rate for ten-year U.S. Treasury obligations applicable on the date the license is granted. Additionally, winning bidders were given interest-only payments for the first six of the ten-year repayment term.

[23] Coase, Ronald, "The Federal Communications Commission," J. Law and Econ. II (1959), 26-27.

Up to this point, spectrum auctions have been used mainly in the developed world and this may be for several reasons. First and foremost, spectrum auctions are a relatively new field with a small, but growing, body of empirical evidence and experts capable of designing and administering the auctions successfully. Spectrum auctions can also appear rather complex and costly for both regulators and bidders. Spectrum auctions also represent a shift of control in licensing from the regulator to the market, and may face resistance because of this. Developing countries may not also have much competition in the telecommunications market, so auctions may not appear to be a viable choice. However, these concerns should not lead to dismissing auctions as an assignment mechanism.

1. Complexity and Cost

While some of the aspects of the more advanced spectrum auctions discussed above may appear complicated, advancements in electronic auctions have actually made them surprisingly simple and inexpensive to implement. Software platforms exist to conduct any number of auction types appropriate for auctioning spectrum licenses, making it easy for regulators to outsource many of the steps in the auction process, including the bidding process. In addition, given the number of countries that have successfully conducted spectrum auctions, a growing body of experience exists that developing countries can draw upon and benefit from.

2. Control

An auction does not remove the regulator from the assignment process, in fact, the role of the regulator is critical to the success of an auction. Regulators must determine the qualification criteria, decide the auction format and put in place a mechanism to ensure the results are fair. In an auction the role of the regulator remains critical and the regulator has great power to shape the auction itself.

3. Competition

Certain auction formats, including the simultaneous multiple round auction, benefit from vibrant competition, but alternative auction designs can be successful even where there are few bidders. In cases with a lack of competition, single round sealed bid auctions can be a simple and effective way of assign spectrum using a market-based mechanism.

E. Spectrum Auction Cases

Several auction designs have been implemented over the past 20 years, most notably the Simultaneous Multiple Round Ascending (SMRA) Auction first introduced in the U.S., the two-step clock/proxy auction in the UK, the SRMA with switching rules in Norway and Sweden, and the hybrid SMRA/combinatorial auction used in the US 700 MHz auction last year.

Bidder qualification rules vary widely by country with sometimes bidders being limited to domestic entities, incumbent carriers (those with already existing

telecommunications networks) and in some cases certain blocks of spectrum are offered only to new entrants (those with no existing telecommunications networks). In some countries (for example, in Bahrain and South Africa, among others) bidders must pre-qualify financially and technically before being permitted to participate in the auction, but in others (the U.S.) bidders only need to make certain certifications about their suitability to be a licensee and make minimal up-front payment deposits.

Both developed and developing countries can learn much from the experience of the early auction adopters. We look briefly at the results of a developed country, the United States, and a developing country, Nigeria, and draw lessons from these auction experiences.

1. The United States

The United States developed a novel approach to allocate mutually exclusive Personal Communication Service (PCS) licenses in the early 1990's. The Simultaneous Multiple Round Ascending (SMRA) auction method was meant to address the complementary and substitution properties of spectrum, and as the first auction of its kind it revolutionized auction implementation globally for telecommunications licenses. The simultaneous aspect of the auction helped bidders to aggregate complementary licenses and bid on substitutable licenses as prices increased. The multiple rounds allowed bidders to obtain price information and shift their strategies during the auction process.

The auction mechanism was novel and was developed after a lengthy transparent process involving lawyers, economists, operations personnel and auction experts. The rulemaking process was open to the public with public releases of proposed rules, periods for comments and reply comments and a series of public forums held around the United States. Because this was the first time spectrum licenses had been auctioned in the United States, and the first time a simultaneous multiple round auction had been used for a spectrum auction anywhere in the world, the FCC made a special effort to travel around the United States to hear the comments and concerns from all interested parties as well as the public-at-large in addition to engaging in its normal public comment procedures.

To more fully understand how important these design choices are for spectrum auctions, it is necessary to describe the nature of spectrum licenses in the US and explain more fully the problems that can occur with a simpler auction design. Spectrum licenses in the US give the licensee exclusive use of a particular spectrum band or pair of bands that are partitioned geographically. License bandwidth is decided during the initial regulatory steps (allocation and service rules). Geographic areas are decided in the formation of the service rules and in the US generally favor smaller license areas to promote participation by small

business and rural telecommunications carriers.[24] For example in the PCS service, the FCC used a combination of nationwide (1 license), regional (6 licenses), metropolitan trading areas (51 licenses) and basic trading areas (493 licenses).

In a traditional sequential ascending auction (such as an oral outcry bankruptcy auction on the steps of the courthouse), where items are offered for sale one after the other, bidders are unable to aggregate complementary licenses spectrally or geographically. Spectrum licenses that cover small geographical areas can be worth more when aggregated into larger swaths of geographic coverage. Likewise a small carrier may want 20 MHz of spectrum while a larger carrier may prefer 30 MHz of spectrum. Suppose in a sequential ascending auction NY City is put up on the block first followed by complementary license in the northeast (Boston). All of the bidders that are interested in NY either as a standalone license or in combination with Boston or other complementary licenses would enter the bidding for NY. The bidders that want multiple complementary licenses might be willing to bid and pay more than their individual private value for NY in hopes that they can win NY and thereby reduce demand on other complementary licenses. Losing bidders that hoped to aggregate licenses with NY would likely drop out of the auction and not bid on Boston or other complementary licenses.

Single round sealed bid auctions are very simple to implement and partially solve the problem outlined above by keeping competition from dropping out of the auction but they introduce other problems for bidders. In a simple single round sealed bid (where bidders are asked to specify their bids on a license-by-license basis), bidders have no way of knowing whether they will win all of the licenses that they wish to aggregate. There is also the problem of the "winners curse" in a first-price single-round sealed bid auction process where, in order to ensure winning, bidders bid aggressively and end up paying more than they need to in order to win. Bidders generally prefer multiple round auctions, like eBay and oral outcry auctions, over single round sealed bids since they allow bidders to obtain price information from competing bidders and bidders may raise their bids accordingly based on that information.

When combining multiple round and simultaneous auctions together, bidders are given the ability to examine prices and the flexibility to switch to lower priced substitutable licenses during the auction, often resulting in uniform prices for identical licenses. The FCC created and implemented a novel auction design that allowed for the simultaneous auction of multiple licenses and a simultaneous auction closing rule where bidding would close on all licenses once there were no new bids for a single round on any of the licenses in the auction. This design is an extension of the oral outcry auction to a more complex model involving

[24] The Ombibus Reconciliation Act of 1993 included the requirement that the FCC provide opportunities to small business, women and minority owned business and rural telephone companies.

multiple related goods and it has the advantage of allowing bidders more flexibility to move among licenses as prices changes. The flexibility also allows bidders to aggregate packages of complementary licenses.

Because of the simultaneous closing rule, the FCC recognized that it would need to implement a bidding activity rule that would force bidders to actively participate in the auction or bidders who were holding back could cause the auction close because of a lack of activity. Consider the case of an eBay auction where bidders hold back until just before the auction close time and snipe their bids using computer programs specifically designed for this purpose. The FCC, with the help of two leading economists in game theory (Paul Milgrom and Robert Wilson) developed an activity rule that required bidders to be active in each and every round of bidding on a portion of the licenses that they ultimately hoped to win. The activity requirements increased during the auction forcing bidders to be active on an ever-greater percentage of the licenses that they hoped to win as the auction progressed. In this way, bidders could not hold back and wait for others to bid and price discovery information was provided after each round of bidding. The lower activity requirement early in the auction gives the bidder greater flexibility in shifting among licenses early on when there is the most uncertainty about what will be ultimately won while a higher requirement at the end of the auction forces bidders to make decisions and bring the auction to a timely close.

The first SMR auction took place in July 1994 and included 10 nationwide narrowband Personal Communications Service (PCS) licenses. The auction was believed to be a grand success raising over $200 million for the US Treasury and taking a few months rather than several years to assign. Since the narrowband PCS auction, the FCC has conducted over 70 auctions of tens of thousands of licenses generating tens of billions of dollars. The program has been considered highly successful in terms of revenue raised, licenses assigned and its use as a model for spectrum auctions around the globe.

Since 1994, the FCC has made various improvements in the auction design that was first implemented because of various concerns about bidding behavior in early auctions. The FCC modified their program to accommodate “click box” bidding where a bidder no longer entered a bid dollar amount but could choose among various incremental prices. This improvement was implemented to block bidders from using trailing digits as a way of signaling their strategies to other bidders.[25] They also limited the number of withdrawal rounds for all bidders to stop signaling behavior that was evident in early auctions.[26] Most recently, in the 700 MHz auction, the FCC implemented blind bidding for the first time in a high profile auction. Previously, the FCC published the bids of all bidders along with

[25] *See* wireless.fcc.gov/auctions/anticollusion/releases/da972451.pdf

[26] Withdrawals allow a high bidder to withdraw their high bids, subject to penalties if the license ultimately doesn’t sell or sells for less than the amount of the withdrawn bid.

the identities that created an opportunity for bidders to use the information for strategic purposes.[27]

Over the past ten years, the FCC has spent considerable time and resources studying the practical implications of combinatorial auctions and implemented a hybrid SMR/package bidding process for the 700 MHz auction to allow bidders to create certain all-or-nothing packages of licenses to reduce their risk of exposure. Given the relatively recent completion of the auction (March 18, 2008), little work has yet been published on the effectiveness of the hybrid design.

Early in the FCC auction program, the agency implemented an installment payment plan for Designated Entities whereby licenses could pay for licenses won at auction over time. The FCC did not fully contemplate how the licenses would be treated in a bankruptcy situation. After the .com bust, many of the PCS spectrum licensees defaulted on their licenses and filed for bankruptcy protection. During that process, the licenses remained idle and after years of litigation, Nextwave Communications sold its expansive collection of licenses to Verizon Wireless and wound up with billions in profits.

2. Nigeria

In January 2001, the Nigerian Communications Commission (NCC) awarded three GSM spectrum licenses using a hybrid auction featuring an ascending clock phase and a sealed bid phase. The auction raised $855 million. The auction was preceded by a failed attempt at the end of 1999 to award the licenses through a two-step process that involved applicants submitting technical, financial, probity and compliance checks, followed by a bidding stage. The process was cancelled after doubts were raised about the integrity of the pre-qualification process.

The 2001 GSM license assignment process was comprised of 4 stages: invitation, pre-qualification, auction and grant. The auction stage included both an ascending bid auction and a sealed-bid auction, which is known as an 'Anglo-Dutch Hybrid' approach since it combined an English ascending auction followed by a sealed bid auction. The sealed bid auction was conditioned on a sufficient number of bidders participating in the auction or if any ties existed at the end of the ascending auction phase.

The invitation process commenced on December 8, 2000 and contained details about all of the stages of the auction, application forms and pre-qualification

[27] The types of strategic behaviors that blind bidding (not revealing the identity of other bidders in the auction so you cannot tell who is placing bids on which licenses) is meant to discourage include: identifying licenses on which to place bids, or "park", that a bidder does not intend to win but that helped to fulfill their activity requirements; retaliatory bidding where a bidder purposely bids on a competitor's target license to send a message (or signal) to stay off their target license, and the purposeful reduction in demand in an effort to close particular markets or licenses or to ultimately close the auction at lower prices.

requirements. Prospective bidders were required to submit their applications along with a $20 million deposit. The amount of the deposit was set low enough to not discourage auction participation but high enough to deter frivolous and speculative bidders. In addition, by holding a deposit, regulator had a mechanism to penalize bidders if they violate the auction rules. If a bidder failed to meet the pre-qualification criteria, the deposit was returned to the applicant with interest. Applications were due on December 21, 2000 and at the deadline five consortia submitted applications to the NCC. The pre-qualification process was put in place to help establish a bidder pool of entities that were seriously interested the auction, to ensure that applicants were not engaged in money laundering or other illegal activities and to make certain that they satisfied the ownership rules that were designed to deter collusion.

On January 8, 2001 all five applicants who applied successfully satisfied the pre-qualification criteria and were announced by the NCC as Qualified Bidders. The qualified bidders were mainly African investors.

The assets being auctioned included three licenses providing licensees with 15-year exclusive access to a 40 MHz of spectrum comprised of 10 MHz (a pair of five MHz blocks) in the 900 MHz band and 30 MHz (a pair of 15 MHz blocks) in the 1800 band to be used for delivering digital mobile telephony services. After the auction, the specific frequency locations of the licenses were randomly assigned so during the auction phase the licenses were 'identical' since the frequency locations were unknown.

The auction design was chosen to satisfy the following objectives: transparency, achieving an efficient allocation and ensuring that successful bidders would commence commercial operations. Because the number of bidders applying for the auction was likely to be small, the NCC decided to design the hybrid auction to allow for flexibility in employing the best design possible given the actual number of applicants. Depending on the number of bidders that were found qualified to bid, the auction process would initiate as an ascending clock auction or a sealed bid auction. If there were four or fewer qualified bidders, a lowest-price sealed bid auction would take place;[28] an ascending clock auction would arise in the event of five or more qualified bidders. The idea behind the flexible auction format was that with only three licenses it made little sense to go through a multiple round auction with little competition. Since there were five qualified bidders after the pre-qualification stage the auction commenced using an ascending bid auction.

[28] A lowest price auction of this type is also called a Vickrey auction after its developer William Vickrey. In the auction the highest bidder wins the item but pays the price of the second highest bid. The auction is designed to give bidders an incentive to bid their true value rather than shade their bids to prevent overbidding (the "winner's curse"). In this NCC case, with three identical licenses, the highest three bidders would win but would pay a price equal to the amount of the bid of the fourth bidder.

The ascending auction was structured as follows. Before each bidding round, the NCC announced a single price for each package since the three packages were identical. The bidders were then required to accept the price in order to remain in the auction. The auction closed when the price reached a point where the number of bidders willing to accept the licenses at the current auction price was equal to the number of packages offered. If the number of bidders fell below the current supply (in this case three) from one round to the next because the current price overshot some or all of the bidder valuations, a secondary sealed bid auction would be triggered in order to allow the bidders a chance to give a best-and-final offer for the licenses.

Bidders in the Nigerian auction were given three waivers that they could use during the auction. A waiver allows a bidder to have more time to decide how to respond to rising prices.[29] As outlined earlier, bidders that choose not to bid in a round were prohibited from bidding in future rounds.[30] Granting a fixed, small number of waivers is customary in ascending auctions and allows bidders to pause and reflect on how to best proceed in the auction.

Bid increments (the amount of the price increase between rounds) in the NCC auction were set so that prices would increase by no more than 10% between rounds. The increments were at the discretion of the government and the NCC chose to apply a 10% increment in the first round of each day and reduce the increment in subsequent rounds.

The Nigerian auction was held in a single location because the regulator was concerned about potential communications problems that might prohibit a bidder from participating. The bidders were convened on January 16, 2001 and participated in a mock auction session so that they could test the robustness of the auction process and become familiar with the bidding and results forms. The actual auction began at 10:00 am on January 17, 2001. The bid teams were escorted to their bid rooms by independent observers (NCC Staff). The independent observers sat with the bidders in their bid rooms to ensure they observed the auction rules. Bidders were not allowed to communicate with people outside their bid rooms during the day.

NCC chose to make information on the progress of the auction available to a wide audience after the conclusion of each round. A press briefing was held after each round and round results were posted on the NCC website about 20 minutes after each round.

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[29] Waivers can either extend the length of a bidding round to allow a bidder more time to place a bid or can allow the bidder to violate the activity rule for a given round without penalty.

[30] This is referred to as a 100% activity rule and contrasts with the FCC's activity rules that set the activity requirement at levels lower than 100% in early stages of the auction in order to give bidders flexibility. In the NCC case where three identical items were being auctioned there is no need to have a relaxed activity rule.

The auction lasted three days and the final price for each package was $285 million. The three auction winners were: Communications Investment Ltd., Econet Wireless Nigeria Ltd, and MTN Nigeria Communications. The process was seen as a great success in Nigeria and on August 7, 2001 (seven months after the auction close) Econet launched its GSM service with MTN launching a day later.

In June 2002, Nigeria made spectrum auction history again by holding the first ever sealed bid combinatorial auction for regional fixed wireless access (FWA) licenses. These licenses allow the use of radio technology to provide the so-called “last mile” connection between the telecommunications network and the users. The licenses that were included in the auction were at 3.5 GHz and included 28 MHz (two 14 MHz paired blocks) in 37 regions. Three licenses were offered in the largest 6 regions and two licenses were offered in the other 31 regions.

The NCC stated that the primary objectives of the auction were to ensure transparency, efficiency, and regional service build out. The assignment was a four-stage process. The first stage required prospective bidders to apply for licenses and submit binding bids at the reserve price. Bidders were given the opportunity to make up to five separate, mutually exclusive, combinatorial bids. During the second stage of the process, the NCC evaluated the expressed demand from the first stage. The applications resulted in bids comprised of varied combinations of licenses and produced strong evidence of complementarities between FWA licenses that differed across bidders. Because of the strong complementarities, the NCC decided to auction the licenses in a combinatorial bidding format, allowing bidders to express bids in all-or-nothing packages. In the third stage, the demand evaluation stage, the NCC examined whether there was excess demand at the reserve price for each of the licenses. 22 of the 37 regions were contested (demand exceeded supply) so they went to auction and the remaining 15 regions were uncontested and went directly to the fourth and final stage of the process, the grant stage. After the demand evaluation stage, the NCC published a list of all applicants for FWA spectrum and details of the regions that were applied for.

Because of the relatively large number of licenses and bidders (and thus, the large number of potential different combinatorial bids), the NCC determined that it was infeasible to conduct a multiple round auction and still retain simplicity and transparency in the process, so they chose a single round format. They further simplified the auction by grouping and separating the regional licenses into 5 separate combinatorial sealed bid auctions. The first auction contained the licenses in the 4 major urban centers of Delta, Lagos, Rivers and Abuja. The other auctions contained smaller regions. The 2nd and 3rd Auctions were conducted concurrently but after the results of the 1st auction were made public and the 4th and 5th auctions were conducted concurrently after the results of the 2nd and 3rd auctions were made public.

Bidders were permitted to submit a bid amount for each combination that they were prepared to purchase limited by the licenses selected on their initial application filing. The initial bid for individual licenses was set at the same level as the reserve prices in the initial applications. The minimum bids for each combination was the sum of the reserve prices for the licenses in the combination. Winning bidders were determined by choosing the set of bids in each auction that had the highest total value. Successful bidders paid the amount that they bid for the relevant combination of licenses in each auction. 48 of the 50 auctioned licenses were assigned, with bids totaling $36 million. 19 of the 30 uncontested licenses could be assigned, each at the reserve price. Only 13 of the 80 licenses went assigned (2 auctioned and 11 uncontested) and at least one license was allocated in each region. The results were published immediately after evaluating the bids, which took approximately 1-2 hours. Full information about the bids submitted by all bidders was released, including a list of all licenses awarded by bidder; a list of all bidders awarded licenses by region; and details of all bids submitted in the auction by bidder, including both successful and unsuccessful bids. Thus, the auction process was made completely transparent through the full release of data.

Unfortunately, five of the 25 successful bidders defaulted after the auction. Most of their licenses were reallocated to other bidders on the basis of the next highest unsuccessful bid. One of the concerns with a pay-as-bid sealed bid auction is the potential for bidder's remorse since bidders might pay more than a single increment above the second highest bidder.

3. Principles for Fair and Transparent Spectrum Auctions

A. Key Principles

Given the degree of global experience in auctioning spectrum that has been gained over the last 20 years, it is possible to extract a number of key principles that help lead to fair and transparent spectrum assignment.

1. Fair and Transparent Allocation Process

A fair and transparent spectrum auction is predicated on a fair and transparent spectrum allocation process. It is important to involve potential bidders and the public in the spectrum allocation process, including the development of service rules, technical rules and the sizes of licenses. Doing so allows potential bidders to understand the extent and limits of the licenses and better prepare them to place values on the licenses, which in turn allows for more effective participation in a spectrum auction.

2. Open and Neutral Allocation Process

Increasingly, countries are implementing spectrum policies based on technical neutrality and open access as a means of liberalizing spectrum management and allowing market forces to work more freely in the telecommunications sector.

Technically neutral spectrum licenses take the regulator out of the business of proscribing specific technologies and attempting, many times in vain, to keep pace with technical innovation. Technically neutral spectrum licenses allow bidders the flexibility to deploy the technologies that make most sense based on their business plans, which may lead to more competition in an auction than if a certain technology is proscribed. Likewise, open access provisions, such as those created by the FCC in the 700 MHz band where spectrum licensees must allow any legal device or software applications on its network, can encourage technical innovation and stimulate competition.

3. Fair and Transparent Auction Policy Process

It is important to involve bidders and the public in the auction design process, including the details of the qualification procedures, the auction design and rules surrounding it and the post-auction obligations such as the application license filing, payment process and build-out requirements.

4. Verifiable Results

One of the most important aspects of a fair and transparent auction is having a set of verifiable results, either by making the raw data available to everyone or by an independent audit of the auction results by a reputable source. This is in sharp contrast to purely administrative processes that are, at their worst, back-room deals where spectrum licenses are handed out to parties for reasons that are never made public.[31]

5. Fair Auction Rules

It is important to create auction rules that discourage anti-competitive behavior and also develop clear regulations for enforcing them. Clear rules (and concomitant enforcement procedures) regarding issues such as the disclosure of ownership and the prevention of collusion will lead to a fairer auction process.

6. Appropriate Auction Design

Choose an auction design appropriate for the licenses and bidders taking into account the level of sophistication of the bidders, the likely preferences for aggregations, the possible risk of exposure and the number of possible bidders and licenses.

B. Where Do Auctions Make Sense In The Developing World?

Auctions make sense in most competitive spectrum markets, that is, where there is excess demand for spectrum licenses. While much is often made of the vast

[31] Information about closed administrative processes is difficult to come by precisely for the reason that they are deemed an undesirable process; they lack transparency. Aggrieved parties have little incentive to publicly dispute the process if they have any hope of gaining spectrum in a future allocation. While specific examples are not available to us at this time, we can be certain that a transparent process gives important information to both winners and losers and makes it much more difficult to engage in any back-room deal making when choosing a winner.

sums of money brought into the treasuries of many countries, in truth, the revenue is only one benefit of an auction. Auctions are an efficient means of letting interested parties express their preferences for spectrum assets, whether in terms of geographic aggregations or frequency aggregations or both, and get real-time feedback on the value of their desired spectrum. Auctions also replace more subjective and opaque processes such as comparative hearings with a fair, objective and open market-based process. Auctions need not be expensive to conduct or terribly complex for bidders to participate in, and can result in rapid spectrum assignment. By assigning spectrum licenses to those who value them the highest, auctions have the potential to encourage prompt provision of service for the public. Auctions also realize, for the benefit of the public, a fair market value for the use of the public spectrum resource.

4. Recommendations to OSI

Fair and transparent spectrum allocation and assignment mechanisms can facilitate competitive markets, reduce uncertainty and the associated risks and foster a market that brings the benefits of modern communications to the developing world. As developing countries prepare to allocate and assign spectrum, the Open Society Institute could be helpful in encouraging fair and transparent spectrum policies in a number of ways:

A. Supporting Additional Research and the Development of Regulatory and Operational Frameworks

The appropriate framework (or set of frameworks) for the fair and transparent allocation and assignment of spectrum will vary with each unique circumstance in which it is being implemented. Each developing country will have some degree of differing legal and regulatory structures, levels of competition in the telecommunications marketplace and goals they would like to see realized. Creating suitable legal, regulatory, engineering and operational frameworks for regulators to apply will first require a better understanding of the unique circumstances in the target developing countries so the framework can take into account as many of these circumstances as possible.

A preliminary analysis of spectrum management in developing countries shows several instances of completed or planned auctions or assignment policies that incorporate some degree of a market-based component including South Africa[32], Tanzania and Uganda. With OSI support of more in-depth research into these markets, frameworks could be developed to include details about developing fair

[32] The Independent Communications Authority of South Africa (ICASA) plans to allocate technologically neutral licenses in the 2.6 GHz band, but plans to use a two step process involving a pre-qualification "beauty contest" followed by an auction. No details have been released and depending on how involved and subjective the comparative process is, there could be negative impacts on the auction process. ICASA Gazette notice, "Assignment of the frequency bands where demand exceeds the available bandwidth," June 16, 2008.

and transparent procedures for the license allocation, pre-auction qualification, auction design, auction operations and post-auction payment and licensing processes. These frameworks would provide a direct benefit to all developing countries as they face the many challenges facing spectrum managers today.

B. Providing Technical Assistance in Auction Development and Implementation in Developing Countries

Some developing countries may not consider spectrum auctions because of the perceived complexity of both implementing and participating in them. While electronic spectrum auctions need not be complicated to develop or participate in, for countries with little or no experience in auctioning spectrum, doing so could present enough of a hurdle that they instead turn to less fair and transparent but more operationally simple administrative processes.

OSI could help developing countries to both understand and implement spectrum auctions in a number of ways.

First, OSI could support the development and implementation of educational seminars for regulators to learn from the experience of those that have designed, conducted and participated in spectrum auctions. With a wealth of legal, regulatory, engineering and economic experience exigent in the field, developing countries could hear about best practices and ask questions so they could better understand the process of designing and implementing fair and transparent spectrum allocation and assignment procedures.

Second, OSI could assist in funding the development (or licensing) of an actual internet-based auction platform that developing countries could use to conduct auctions of their spectrum licenses. While several auction software platforms already exist (including those of some spectrum regulators), an OSI-supported platform would help to reduce the costs of conducting an auction, allow developing countries to take advantage of economies of scale and ensure access to a well-tested auction software system. Given the global nature of the Internet, the system could be used by any developing country.