Spectrum Pricing

For any resource, including radio spectrum, the primary economic objective is to maximize the net benefits to society that can be generated from that resource such that there is an efficient distribution of resources resulting in maximum benefits to society. Prices are used as an important mechanism to ensure the spectrum resources are used efficiently by users.

The broad goals and objectives associated with spectrum pricing are:

- Covering the costs of spectrum management activity borne by the spectrum management authority or regulators;
- Ensuring the efficient use of the spectrum management resource by ensuring sufficient incentives are in place;
- Maximizing the economic benefits to the country obtained from use of the spectrum resource;
- Ensuring that users benefiting from the use of the spectrum resource pay for the cost of using spectrum;
- Providing revenue to the government or to the spectrum regulator.

Spectrum pricing refers to a range of spectrum management activities and tools including administrative fees, spectrum usage, and spectrum prices determined by way of market mechanisms. Developing spectrum pricing strategies invariably involves alignment with the government's and regulator's revenue goals and objectives, setting targets, and discussion with key stakeholders such as the Ministry of Finance and key sector groups – telecommunications service providers. Revenue targets and strategies relate directly back to the primary objectives; spectrum users pay for spectrum use, covering management costs, spectrum efficiency, and achieving economic and social development goals.

Practice Notes

- OFTA: Statement on Spectrum Fees

Reference Documents

- Ofcom. Spectrum pricing. A statement on proposals for setting Wireless Telegraphy Act prices, 2005.

5.5.1 INTRODUCTION TO SPECTRUM PRICING

In this section, we discuss various approaches used by spectrum managers to raise revenue and distribute the spectrum resource via spectrum pricing techniques and methods. Beginning with a discussion of important of the underlying value of and how that is important in determining spectrum prices, we then follow with a discussion of methods for determining spectrum values using an example from the Digital Dividend. Next, spectrum pricing objectives are outlined and described and market-based spectrum prices are contrasted with administratively determined spectrum prices.

Spectrum Valuation

Radio spectrum is an extremely valuable and often scarce resource which makes a major contribution to economic and social development, and is necessary to ensuring national and civil security. Maximizing and ensuring an efficient distribution of the net benefits generated by spectrum are important goals promoted by spectrum values and spectrum price mechanisms, which help to ensure that spectrum is used efficiently by users.

Spectrum values reflected in spectrum prices help to promote both economic and technical efficiency in the use of radio resources. Spectrum values can also be significant and help raise significant revenues for the government and recover the costs of managing spectrum.

Methods for Valuing Spectrum

Spectrum is either valued using prices in market transactions (auctions, spectrum trading or leasing) or by administrative means. Market based methods allow users to estimate the commercial value of spectrum based on their own and the market's expectations around what benefits that can be derived from its use. Administrative methods are also used in the

assignment of spectrum and the determination its prices. In some cases, the method employed simply results in a recovery of spectrum management costs plus targeted revenue. In other cases, analytical and modeling techniques are used develop prices which reflect the underlying spectrum value.

Administrative fees and prices

The administrative assignment of spectrum is often supplemented by imposing charges for spectrum use. These charges usually take the form of simply setting fees sufficient to recover the costs of spectrum management. Prices can also be used to guide users in making decisions to use spectrum more efficiently. One example, applicable within the framework of administrative assignment of spectrum, is to set a charge for spectrum equal to an estimate of what the spectrum might be worth in a market context. This is sometimes called 'administered incentive pricing'.

Market-based prices

Alternatively, prices can emerge through an authentic market transaction such as an auction or secondary trading. The general theory of prices involves assumptions regarding the economic behaviour of consumers when using resources while being concerned with rational preferences for certain outcomes, utility (maximizing efficiency and profit) and information availability and access. From these assumptions, economists developed a structure to help understand how the allocation of scarce resources among alternative ends occurs in markets. We employ these basic principles to begin our understanding of how market prices for spectrum are set.

Administered incentive prices

We also describe a method where the spectrum regulator attempts to approximate the prices (often flat rate charges) that might emerge in a market context. This method is referred to as 'administered incentive pricing': 'administered' because prices are set by the regulator reflecting the opportunity cost of spectrum while incorporating potential 'incentive' properties: prices are thereby set at a level to encourage efficient use reflecting spectrum scarcity.

Cost Recovery and Spectrum Usage Fees

In the section Cost Recovery and Spectrum Usage Fees, we discuss the necessary recovery of spectrum regulatory agency operations costs. A discussion on spectrum usage fees follows.

Lotteries

Next, we discuss where spectrum is assigned by means of a lottery: a winning ticket chosen at random will carry with it a spectrum award. This is a 'non-pricing' method of assignment. However we note it here (and advise against it), as the lottery winner will often wish to turn the licence into cash (if he or she is allowed to do so) by trading it on markets.

Spectrum Auctions

We then consider, in some detail, how prices for spectrum licences can emerge through an auction process, reviewing different types of auction and their likely outcome. Auctions are a well-known means of using market-generated prices to assign spectrum at the time of its first issue by the spectrum regulator. In markets where subsequent or secondary trading of licences is allowed, procedures will emerge that set the prices for such trades, and these may also include auctions.

Adjusting Spectrum Prices

Finally, we give an account of how the spectrum regulator approximates spectrum prices that might emerge in a market context by setting spectrum charges, which reflect the opportunity cost of spectrum.

An important issue can arise when the regulator uses both administrative and market-based systems for different spectrum segments, which is the issue of price adjustment and alignment. For example, a regulator needs to consider how spectrum prices should be adjusted in adjacent bands when auctions take place indicating a rise in the opportunity cost of spectrum and equally should prices fall along the lines of mark-to-market valuation adjustments.

Practice Notes

- **Canada: Spectrum Fee Regulations and Guide**

Reference Documents

- **ITU Telecommunication Development Sector, ITU-D Study Groups 1 and 2: Draft guidelines for the establishment of a system of radio-frequency usage fees**

- The Economics of Pricing Radio Spectrum
- What Price Spectrum?

5.5.2 SPECTRUM VALUATION

The reasons for valuing spectrum are abundantly clear. Radio spectrum is an extremely valuable and often scarce natural resource (especially below 1 GHz) with a multitude of uses with major contributions to economic and social development, while helping to ensure national and civil security. To suggest that modern economies depend on fully developed and robust wireless communications capability is not an exaggeration.

In general, for any resource, including radio spectrum, the primary economic objective is to maximize the net benefits generated from the resource enabling an efficient distribution with maximum benefits to society. Spectrum values and spectrum prices are mechanisms used to ensure that spectrum resources are used efficiently by users.

- Appropriate spectrum values and price promote spectrum efficiency. Spectrum is a vital natural resource and spectrum prices should be sufficient enough to ensure it is valued and used wisely.
- Using the spectrum resource drives considerable economic benefit, which should be maximized.
- Spectrum management costs money and these costs can be recovered from those who benefit from these activities through spectrum prices.
- Finally, important social and cultural objectives can be advanced by using spectrum and spectrum pricing mechanisms should facilitate the achievement of government's social and cultural objectives.

Spectrum values are therefore reflected in spectrum prices and help to promote both economic and technical efficiency in the use of radio resources. Spectrum values can also be significant and help raise significant revenues for the government, which, in turn, recovers the costs of managing spectrum.

The Digital Dividend provides an example of significant spectrum values which are presented in Table 5.2.1.

Economic Value of the Digital Dividend - An EU Example

The European Commission refers to an estimate in the value of the Digital Dividend that exceeds EUR 150 billion, which is about 2.2 per cent of the annual European GDP for the total value of electronic communications services that depend on use of radio spectrum in the EU. Radio spectrum has an essential role as an enabler for growth, as was pointed out in the i2010 initiative. Significant estimates of the economic value of the Digital Dividend in the EU have been made and are provided below.

◂ **Table 5.2.1 EU Estimates in Value for the Digital Dividend**

Source: Exploiting the Digital Dividend – a European Approach, Analysis Mason, DotEcon, Hogan & Hartson, 2009.

Use	Assumptions	Valuation
Digital Terrestrial Television	Six DTT multiplexes in each Member State requiring 48 MHz when using National SFN's (8 MHz channels per SFN) and 384 MHz when using MFN's (64 MHz spectrum channels per multiplex).	Between EUR 130 Billion and EUR 370 Billion discounted over 15 yrs.
Mobile Television	One multiplex using either 8 MHz per SFN or approximately 48 MHz for an MFN.	Between EUR 2.5 Billion and EUR 25 Billion discounted over 15 yrs.
Wireless Broadband	Use of a 72 MHz sub-band within the 470-862 MHz band for wireless broadband services.	Between EUR 50 Billion and EUR 190 Billion discounted over 15 yrs.
Total		Between EUR 182.5 Billion and EUR 585 Billion discounted over 15 yrs.

The question of how to measure spectrum values is explored in more detail in Section 5.2.1.

5.5.2.1 MEASURING SPECTRUM VALUES

Spectrum is either valued using prices in market transactions (auctions, spectrum trading or leasing) or by administrative means. Market based methods allow users to estimate the commercial value of spectrum based on their own and the market's expectations around what benefits can be derived from its use. Not all radio spectrum is assigned or re-assigned using market based methods. Administrative methods are also used in the assignment of spectrum and determination of spectrum prices. In some cases, the method employed simply results in a recovery of spectrum management costs plus targeted revenue. In other cases, analytical and modeling techniques are used develop prices which reflect the underlying spectrum value. Administered Incentive Prices (AIP) is one such technique and is used in the UK by Ofcom and by ACMA in Australia - See Section 5.9.3 AIP in Practice.

The main problems with traditional administrative spectrum price determination are:

- At best they can only reflect the scarcity of the bands to which they apply;
- They emerge from a computational process by the regulator not from the interaction of firms in a market place;
- The computational process is inevitably inaccurate and subjective. It is however better than adopting a zero price, which we know is incorrect;
- A risk assessment process (consultation or a study such as this one) is required to establish the harm imposed by making them too high and too low.
- Applying economic and business valuation modelling techniques brings much needed rigor to the exercise of valuing spectrum.

Two forms of spectrum valuation which attempt to reflect market prices but which are not derived in the market and hence may be viewed as less reliable are Economic Modelling and Business Based Valuation. These methods do have an advantage in that values will be more consistent over time which overcomes the argument that prevailing extant prices may be distorted to due transitory factors.

Economic Modelling

The objective of economic modelling is to assess spectrum value from the perspective of its contribution to the national economy. This is important because we are interested in increasing economic contribution which translates into increasing value. It also allows us to take into account changes in the raising or lowering of economic activity such as economic downturns, changes in taxation, new trade relationships.

The basic model involves examining the economy at three levels of aggregation to get a picture of the stimulus to the overall economy on the assumption there are meaningful connections between individual, households, firms, industries and the macro-economy. Economic modelling gauges the increment in economic output and its effect in terms of employment and GDP per head. The essence of modelling consists of:

- Assessing demand using various take-up scenarios;
- Constructing a quantitative model using regression analysis and carefully selecting parameters;
- Applying historical data and projecting forward across the three levels of the economy.

How can the results be used? At best we can determine general trends and make some linkages between income growth, productivity growth and increasing use of spectrum in the overall economy. A value of potential impact on the overall economy can be determined after considerable effort.

A study involving 92 countries by Waverman et al (Waverman 2004) found that on average if a country has a teledensity greater than 10%, per capita GDP growth accelerates by 0.59 per cent per annum. It is safe to conclude the use of spectrum in cellular services makes an important contribution to growing the economy. It is more difficult to attach specific valuations to specific bands. One important issue to consider is to understand at which point does the contribution from spectrum begin to tail off and what adjustments if any are necessary. The amount to be charged to individual spectrum users cannot be easily determined even when the economic contribution to the economy can be determined. Is a 10% or 25% discount rate appropriate?

Business-based Valuation Model

A business-based valuation model assesses the value of spectrum from a commercial perspective. This is highly relevant to this particular study (and to users). The objectives of both regulator and operator converge at the point when the spectrum is optimally priced. Industry Canada is interested in economic and technical efficiency while the operator is interested in exploiting the profit potential of the assigned frequencies. The principles of the business-based valuation approach involve

understanding how much profit the spectrum in question will generate.

A base model case is needed where aggregated current and future growth in demand and revenues for the sector are compared to the costs of providing and delivering service (CAPEX and OPEX). The resulting discounted cash flows do not, at this point, reflect the value of spectrum to a business since there are multiple factors affecting profitability, not just the contribution of spectrum. Measuring the value of spectrum from the operator's perspective also involves estimating the constraints on profit such as competition and regulation. The number of licensees entering the market affects the demand model and the impact of new services and technologies needs to be factored into the measurement of spectrum value.

Estimating the value of spectrum will involve analysis of the impact on profits of changes in spectrum fees over the model period. Modelling what happens to estimates of profits across the sector in the case where there are no spectrum fees is revealing and can be analyzed in comparison to current fee levels.

Some of the important issues which will affect spectrum valuation utilizing a business-based model include the following:

The level and growth in demand (subscribers and ARPU) given that certain regional markets may be considered as mature or maturing;

- The level of competition and market shares on a regional basis and the impact on spectrum valuations on a regional basis;
- Attractiveness of substitute or alternative bands such as 800 MHz and 1900 MHz band for the introduction of new services and technology;
- Strength of competition from other services including fixed line and new services such as VoIP and BWA;
- Assumptions about current and future costs of equipment and assumptions about operating costs of all operators and the timing of investments.

Determining spectrum values which relate directly to the commercial perspectives of the primary users of the spectrum in the provision of services is highly relevant to the goals of promoting efficiency and fair competition in the sector.

5.5.3 SPECTRUM PRICING OBJECTIVES

Policies are needed to govern spectrum revenues and spectrum prices which serve to ensure the efficient use of spectrum and to enable financial sustainability of the spectrum regulator. Revenue objectives and strategies relate directly back to the primary objectives; spectrum users pay for spectrum use, covering management costs, spectrum efficiency, and achieving economic and social development goals.

The total amount of revenue to be raised from some or all spectrum uses falls into three categories:

- "Partial" cost recovery – not all of the costs of regulation are obtained;
- "Full" cost recovery – all costs are covered;
- Greater than "full" cost recovery – a surplus is generated which may be related to several other objectives.

Given that the amount of revenue generated is determined and from whom, the next question to be resolved is –how should the revenue be applied:

- Cost recovery – if the amount of revenue obtained is less than or equal to the cost of spectrum management, the decision on application has already been determined. Where surplus revenues exist and are approaching revenue maximization they may be related to spectrum usage or to other benefits.
- Spectrum Usage – revenues associated with mechanisms to promote efficient
- Economic benefits for the public – revenues associated with other regulatory or government objectives: employment, technology innovation and diffusion.

Spectrum pricing refers to a range of spectrum management activities and mechanisms including administrative fees, spectrum usage, and spectrum prices determined by way of market mechanisms. Developing spectrum-pricing strategies invariably involves alignment with the government's and regulator's revenue goals and objectives, setting targets, and discussion with key stakeholders, such as the Ministry of Finance and key sector groups – i.e. telecommunications service providers

In general, for any resource, including radio spectrum, the primary economic objective is to maximize the net benefits generated from the resource initiating efficient distribution that will maximize benefits to society. Spectrum prices are used as an important mechanism to ensure that spectrum resources are used efficiently by users.

- The pre-eminent policy objective for spectrum pricing is that it should be done to promote spectrum efficiency. Spectrum is a vital natural resource and the price of spectrum is sufficient enough to ensure it is valued and used wisely.
- Use of the spectrum provides considerable benefit to the economy and the benefit derived from spectrum should be maximized.
- Managing radio frequency spectrum costs money and these costs should be recovered from those who benefit from spectrum management activities.
- In general, a user pay principle should apply which extends to all users of spectrum: public and private.

Finally, important social and cultural objectives can be realized by use of the spectrum and spectrum pricing should facilitate the achievement of government social and cultural objectives.

◂ **Box 1 Best Practice Spectrum Pricing and Fees Guidelines**

A sound legal and policy framework are the foundations upon which sound spectrum management practices are built. The authority to establish the appropriate method and means to set spectrum prices, levy and collect spectrum application fees and spectrum charges such as spectrum usage charges, assign, and licence spectrum should be established in primary legislation (the Act) and secondary (the Regulations) legislation. Establishing the authority rests with the legislature. The Government should set general spectrum policy and policy governing spectrum revenue, prices and fees.

Best practice includes such measures as communication and publication of schedules for spectrum application fees and spectrum charges. Also, legislation often provides for stakeholder input in the form of stakeholder consultation and where difficulties or infringements of rights are perceived mechanisms for raising objections, seeking redress and dispute resolution.

The approach taken by the spectrum authority should be:

- Spectrum pricing policies are efficient by being fair to all sides;
- Methods should be objective and measurable;
- Transparent decision-making and access to information;
- Practices and procedures should be simple to manage and administer.

Because one of the goals is to recover spectrum management costs there is a need to determine what costs should be included and at what (reasonable) level. In doing so there are several considerations:

- Organization strategy, structure and function and key activities;
- Initial minimal capabilities needed within the regulator;
- Strategies and costs to fill resource and capacity gaps.

5.5.4 SPECTRUM MANAGEMENT COST RECOVERY

It takes money to run a spectrum regulatory agency. The resources the spectrum management agency requires include: skilled labour, IT resources, investment in technical monitoring equipment, and expenditures to pay for participation in ITU and other international meetings. As well, the normal inputs such as office space and utility services needed to be funded. Governments can remunerate such costs directly from general revenue and in certain circumstances they should do so (for example if full cost recovering would deter spectrum use). It is usually efficient, however, for licensees or groups of licensees to be liable for the direct regulatory costs which they impose, on the ground that such costs are 'caused' by each licensee. Each user should then expect a direct cost based licence charge when it seeks access to spectrum, just as it takes account of other costs which it incurs or imposes.

5.5.4.1 THE STRUCTURE OF COSTS IN A SPECTRUM MANAGEMENT AGENCY

The activities of each licensee impose direct costs on the regulator. These include the costs of issuing, maintaining data, spectrum monitoring and enforcing its individual licenses. Some costs will be common to a band or to a radio service (such as band planning); whereas others will be common to a group of bands and some, such as management overheads, will straddle all licensees. The Australian study referenced in the following practice note suggests that indirect costs predominate.

Practice Notes

- **Cost Recovery in Australia and Cost Analysis in Canada**

5.5.4.2 SETTING FEES AND PRICES TO RECOVER COSTS IN PRACTICE

Fees are usually imposed by the regulator when administratively assigning spectrum and processing applications. The types of fees include:

- Application fees
- Type approval fees
- Radio operator examination fees
- Fees for radio operator certificates
- Interference complaint investigation fees

Setting fees schedules and prices to recover costs has been tackled by regulators in several ways. Some have used detailed costing models to establish which licenses have imposed which costs; others rules of thumb. Rules of thumb, such as setting charges on the basis of a percentage licensee's turnover, are likely to be subject to increasing criticism by those who think they are overcharged. In these circumstances, a simple model of direct costs can be developed. The model needs to be based on defined structure and business processes and associated management accounting data within the regulator – for example the amount of time spent issuing and enforcing particular licences. As well, a method of allocating indirect or common costs will be needed – for example, based on licensees in proportion to the direct costs which they impose. Or they can be allocated in accordance with the amount of spectrum (e.g., in MHz) with which a licence is associated.

The choice between these and other approaches has to be made by the regulator in the light of considerations of fairness, and the likely effect of the charges on spectrum use. If a high allocation of indirect costs makes a licence uneconomic, the matter may require reconsideration. We give two examples of alternative approaches in the following practice note and reference document.

RELATED INFORMATION

ITU-D: Study Groups: Spectrum Fees Database - Spectrum Management

Reference Documents

- **Canada: A Guide to calculating Radio Licence Fees**
- **Organization Plan Report, Telecommunication Authority Suriname**
- **Tanzania: Guideline for Fees and Application Costs for Telecommunications Equipment**

5.5.5 SPECTRUM USAGE FEES

Spectrum usage fees are charged to recover a spectrum resource rent for the government and to ensure that users of spectrum utilize the resource on an efficient basis. Under a spectrum usage pricing framework users should move to a state where only assigned and utilized spectrum is paid for. Unutilized spectrum is returned for reuse.

Specific targets for spectrum use do vary considerably across regions. There is an argument for making spectrum usage charges consistent across a region to avoid investment disincentives. However, in looking at regional best practice several important factors including scarcity, quality, congestions and value in use need to be taken into account.

It should be noted that spectrum usages charges should also apply to other main users of spectrum including microwave and satellite.

5.5.5.1 SPECTRUM USAGE FEES IN PRACTICE

There are two methods for pricing described in the articles which are commonly adopted for concession and network pricing and for spectrum usage. These two systems are briefly described below

- Spectrum Use Management Value (Nurmatov); and
- System Performance Pricing (Nozdrin)

Spectrum Use Management Value

Fees can be calculated on the base of costs on spectrum management possibly to present in the total functional form:

F = Di

F = f (Di, Li x I)

where:

F = fee, imposed on the spectrum authorisation licensee

Di = direct administrative costs on processing license applications;

Li = share of in additional administrative costs;

I = total additional costs.

System Performance Pricing

A universal approach to spectrum price determination based on system performance has been developed where the price can be built up from a number of separate elements based on any or all of various criteria such as the amount of spectrum used, number of channels or links used, degree of congestion, efficiency of radio equipment, transmitter power/coverage area, geographical location and so forth. The basic principle of this approach is to identify various technical parameters in order to measure the spectrum volume used or define the "pollution area" of a radio system as a common basis for establishing spectrum fees.

For example, the following universal formula may be considered by the box below:

◂ Box Universal Formula for System Performance Pricing

XXXXXXXX

where,

P = spectrum price;

V = volume of space or geometric area occupied;

M = useful results obtained from the radio equipment considered, for example the number of channels to be provided or users to be served;

Kf = coefficient reflecting specific characteristics of range used;

Ks = coefficient taking into account the region of the radio station installation;

Km = coefficient reflecting social benefit of radio system;

Cs = annual spectrum management costs;

Kp = coefficient reflecting the level of spectrum access demand in the band in question.

On one hand, the application of this method can stimulate more efficient spectrum utilization; on the other hand various problems with the practical use of such formulas remain to be resolved. One disadvantage of the above technique is the choice of coefficients designed to take into account specific features of service, spectrum demand, etc.

Practice Notes

- Thailand – Calculation of Spectrum Usage Fees: Generalized Formula
- Trinidad and Tobago – a simplified system performance model including license fee, spectrum usage and application fees.

Reference Documents

- Spectrum Pricing - Paper delivered at the Lusaka Spectrum Management Conference 2003
- Spectrum Pricing Methods

5.5.6 SPECTRUM ROYALTIES AND LOTTERIES

Spectrum royalties and lotteries are administrative methods for raising revenue which may bear no resemblance to either the economic value of spectrum or the cost of spectrum management. Historically, royalties and lotteries preceded what are now viewed in practice as more reliable market-based methods for setting prices – such as auctions.

Spectrum Royalties

Spectrum or licence charges can be assessed as a percentage of (or royalty on) revenues or profits, which has to be handed to the spectrum regulator under the terms of the licence received or profits earned by an operator. This can be a way to cover regulatory costs, or it can be designed to raise revenue for the government.

The amounts that royalties paid go up and down depends on the the prosperity of the firm and sector (e.g., mobile communications). This makes the regulator a kind of 'partner' of the operator, sharing a common interest in maximising revenue or profit. Because royalty payments depend upon operator's performance the income they generate is unpredictable, which may be a disadvantage. There also needs to be legislative clarity to ensure that what might be viewed as taxation is indeed legal.

Finally, the basis for calculating payments must be spelt out, to prevent an operator from using accounting devices to hide income or profit and thus reduce payment.

Lotteries

Revenues are raised by applicants paying entrance fees to gain spectrum rights. Although this procedure may seem attractive and equitable, it has many drawbacks and has fallen out of favour.

- First, if there are many applicants, the cost of administration may be large, especially if applications are reviewed and vetted for suitability.
- Second, tif applicants are not vetted the lucky winner may not have the necessary qualifications to operate the service efficiently. If they are not allowed to sell the licence, this may be a recipe for disaster.
- And if, thirdly, they are allowed to sell them to efficient operators, the winners will be appropriating auction proceeds which would otherwise go to the government.

5.5.7 SPECTRUM AUCTIONS

In recent years regulators have relied heavily upon assigning some licences via a competitive process involving (normally) a monetary payment (which we call an auction) rather than relying on alternative procedures such as comparative hearings. In which applications are judged on a range of criteria. A more complete discussion of the methods for selecting licensees can be found in **Section 3 of this Spectrum Management Module** . This present Section focuses on the pricing aspects of the selection process.

In an auction, contestants for a licence make competitive bids and the licence goes to the highest bidder. It is normal for the bids to be made in monetary term, the competitor offering the largest monetary sum getting the licence. But the competition can be in some other variable. For example, competitors can bid against are another over which of them will offer service over the largest geographical area. Or the competition can be in term of which operator will charge the lowest amount for service. Once the rules are established, however, the winner is determined by the operation of the competitive process, not by an administrative decision.

Switching from comparative hearings, followed by an administrative decision, to an auction does not in itself fundamentally change the spectrum regulatory regime. If licences specify in great detail the technological apparatus to be employed and services to be provided, the winner of an auction is as effectively tied down as a firm granted a licence by any other means. The key differences are that:

- an auction assigns the licence to the firm which bids the most, and that may in certain conditions be the most efficient firm;
- a competitive auction will, if it operates properly, cause any expected excess profits from providing the service to go to the Government, rather than the operator as would be the case if the operator were chosen via a competitive hearings.

The licence being auctioned is not always so prescriptive as assumed above, but may allow the successful licensee to choose what services to provide. We consider some of the resulting issues associated with change of use under the heading of 'secondary trading in practice'.

Although auctions have been used in many countries over the last 10-15 years, it still remains the case that most of the spectrum in use in all countries has been allocated by administrative methods. Auctions tend in practice to be confined to

cases where:

- the spectrum available is in scarce supply;
- many firms want to acquire licence;
- the service to be provided with the spectrum can be precisely defined
- the monetary value of the licence is relatively high, justifying what can be a complex assignment procedure.

It is clear, however, that auctions can be used in a wider class of cases than these. A successful auction process relies upon clarity about the rights and obligations being auctioned, and also from clear rules for the conduct of the auction. If either of these is absent, firms will face uncertainty which will make them reluctant to participate or to submit high bids.

A more extensive discussion of the methods for selecting licensees can be found in **Section 3 of this module**.

Reference Documents

- **Are Spectrum Auctions ruining our grandchildren's Future?**
- **Framework for Spectrum Auctions in Canada**
- **Using and Abusing Auction Theory**
- **What Really Matters in Auction Design**

5.5.7.1 TYPES OF SPECTRUM AUCTIONS

There are several circumstances where an auction can be considered as a means of assigning licences:

- The simplest case is one in which a single license is offered for auction in a self-standing process.
- When two or more identical or complementary licences are offered, they can be offered sequentially or simultaneously. Where each licence is local, a simultaneous auction can allow firms to piece together local licences to provide broader coverage.
- The licence(s) can be assigned on the basis of a so-called 'open bidding' or public process, with bids visible to other parties, or on a 'sealed tender' system, under which each party marks a single private offer; there are numerous alternative variants of open auctioning, one of which is the so-called clock auction.
- The auction can have a minimum acceptable bid or 'reserve price.

Some examples are given below:

- A spectrum regulator proposes to assign a single licence for the provision of a national second generation mobile telephone service. The successful applicant must commit itself to providing coverage to 50% of the land area and 80% the population. Sealed bids must be submitted by a specified date, by firms which have pre-qualified (i.e. have shown their competence to become a licensee). The winner is the firm which bids the most.
- Two or more licences to provide national 3G mobile services are auctioned.Pre-qualified applicants bid against each other in an open bidding auction. They have the opportunity to submit new bids for the licences at pre-specified intervals. The auction ends when the winning bids for each licence are the same, in terms of bidder and sum bid, as they were in the previous round. To ensure completion of such an auction, firms must be made to bid at a specified frequency.
- This example is similar to the 3G example above, except that there is restriction as to the use to which the winning competitor can put the spectrum (provided that interference conditions are met). Such auctions are said to exhibit technology- and service-neutrality. A country's territory is divided into, for instance, twenty areas, and three (identical or similar) licences are auctioned in each area (sixty in all). The procedure is an open bidding one. At each round, a firm can bid for one licence in each region. This procedure makes it possible for firms to put together a national service by bidding in all areas simultaneously. At the opposite extreme a firm can bid to provide a local service in one area only.
- An ascending clock auction is a procedure for selling multiple identical licences which requires the auctioneer to announce prices to bidders that increase over time (ascend with the clock) and bidders choose whether to accept or reject the announced prices. The auction is over when the number of bids equals the number of licences. The winning bidders all pay the required bid amount and each of them is assigned an identical licence. Variants of the clock auction can accommodate differences among licences, via a separate sequence of prices

for each one. Clock auctions can also be combined with a subsequent phases to deal with bids for packages of complementary licences.

The choice of auction mode will vary with the nature of licences made available, the number and nature of firms with an interest in theirs and the regulator's or government's objectives. There are a number of trade-offs between, for example, the advantages which an open auctioning system has in spreading knowledge among firms about other firms' valuations, hence encouraging higher bidding, and the opportunities for collusion among bidders which the communication present in open auctioning may facilitate. As a result, each set of circumstances tends to require an individual solution.

Reference Documents

- **USE OF AUCTION-BASED METHODS FOR THE ASSIGNMENT**

5.5.7.2 SPECIFYING RIGHTS AND OBLIGATIONS

A successful auction requires a clear understanding by participants of what rights and obligations are available to the winner or will be imposed upon them. If there is uncertainty about this, it will discourage competitive bidding. Auctions differ in two main ways: in the number of lots (or licences) made available and the way the auction is conducted. There has been a significant number of mobile licenses grant by auction around the world and they form a good basis for analysis and understanding. In relation to these wireless communication licences, some the the key variables in designing the auction are:

- The number of licences to be offered to the service and in which band: this decision is of fundamental importance, since it determines the structure of the services market. The objective of maximizing consumer welfare suggests the harnessing of competitive forces to the maximum – i.e., issuing, subject to spectrum availability, as many licences as the market will be able to support (plus one or two extras to permit freedom of entry into the market);
- Any commitments made at the time of the auction relating to restrictions on the award of subsequent licences;
- Whether national or local regional licences are issued; here the regulator may find it helpful to anticipate the kind of business plans (national or regional) firms are likely to have and make licences available, accordingly there is nothing to preclude a mixture of national and regional licences;
- How long the licences will last: too short a period may discourage investment in the services, while too long a period may allow the spectrum in question to stagnate if it cannot be sold on for another purpose;
- Any obligations a licensee may have to make periodic payments in the course of the licence;
- Any network roll-out obligations or 'use it or lose it' clause;
- Any foreign ownership restrictions.

All these aspects influence the expected revenues from the auction, and their expected impact on consumer welfare.

Reference Documents

- **1.8 GHz and 800 MHz Band Spectrum Licence Allocation - Area Maps and Boundary Coordinates**
- **Auction for Fixed Wireless Access Individual Licenses - Summary of Invitation to Tender**
- **AUCTION OF WIRELESS BROADBAND SPECTRUM RIGHTS**
- **How (Not) to Run Auctions: the European 3G Telecom Auctions, European Econ. Rev., November 2001**
- **Procedural Manual for Bidders, Phase 1**
- **Procedural Manual for Bidders, Phase 3**
- **Third Generation Mobile Services Licensing - Information Memorandum, OFTA, July 2001**

5.5.7.3 RULES AND PROCEDURES FOR SPECTRUM AUCTIONS

Auctions only work properly when there are clear rules attached to them which all participants understand. These should be designed both to prevent collusion and to bring the proceedings to an efficient close. Regulators have to stipulate the rules in some detail in bidding documents.

The nature of the rules required varies from the very basic to the more sophisticated, depending on the form of auction

chosen.

In the former category, basic housekeeping rules have to be established to ensure that scaled bid remain confidential until the 'official' opening date, and that competing bids in an 'open bidding' system are delivered simultaneously by all competitors.

To bring complex multiple round auctions to a close, it is necessary to force all participants to bid at regular intervals (according to so-called 'activity rules '), rather than make unexpected bids as the end of the process approaches, and to ensure that there is a minimum bid increment, to prevent bids rising endlessly by small amounts. Both the Canadian Advanced Wireless Services (AWS) and other spectrum in the 2GHz range auction and the Finnish 2500-2690 MHz spectrum auction featured activity rules, for example.

In one US PCS auction, it was discovered that participants were using the amounts they bid to signal to competitors – more precisely to 'warn them off' bidding for certain lots. As a result, a rule was introduced which required bids to be in round numbers, which could not send signals of this type.

Related Materials

Module 3, "Authorization of Telecommunication/ICT Services", Section 4.1.1, "Features of a Multiple Round Auction: The Canadian Example"

Practice Notes

- **Selection Mechanisms in Comparative Perspective**

Reference Documents

- **Auction for Fixed Wireless Access Individual Licenses - Summary of Invitation to Tender**
- **Auctioning of Spectrum for Third Generation Mobile Services (3G) -**
- **Bidders Manual**
- **Briefing to Industry and Analysts on the Hong Kong 3G Auction**
- **Canada -- Licensing Framework for the Auction for Spectrum for Advanced Wireless Services and other Spectrum in the 2GHz Range**
- **Finland -- Explanatory Memorandum regarding the Regulation on 2500 - 2690 MHz Spectrum Auction**
- **Finland -- Regulation: 2500-2690 MHZ SPECTRUM AUCTION**
- **India -- Auction of 3G and BWA Spectrum**
- **Nextwave Supreme Court Victory Ends Five-Year Struggle Over U.S. Wireless Spectrum Auction Rules, Telecomfinance (issue 99), March 2003**
- **Radiocommunications (Spectrum Licence Allocation) Determination 1998 - Setting of Entry Fee and Eligibility Payment**

5.5.7.4 SPECTRUM AUCTIONS IN PRACTICE

Literally hundreds of spectrum auctions have been conducted in the past ten years. Some have attracted great attention by generating billions of euros or dollars from bidders. Most have been on a much smaller scale. A range of methods have been employed and some have been judged successful, others found to have failed. Regulators can learn from this experience to choose a procedure which meets their circumstances.

Here we offer an account of a selection of spectrum auctions; it is not intended to be complete but to identify useful precedents.

Great experience has been accumulated in the USA, where the Federal Communication Commission (FCC) has run a series of auctions starting in July 1994, and continuing in 2007.

One commentator has drawn the following lessons from these auctions, which typically have involved the auctioning of multiple local licences which can be aggregated to provide regional or national services:

- Open bidding is better than a single sealed bid;

- Simultaneous open bidding is better than a sequential auction, in which licences are auctioned one after another;
- Allowing bidders to bid for packages (e.g. a group of local licences capable of providing wider area services) is desirable in principle but found (in 2001) to be too difficult in practice;
- Collusion in a major problem, which can be countered by concealing bidders' identities (i.e. publishing the bid, but not who made them), and setting high resume prices, amongst other ways.

The most conspicuous recent auctions have probably been those for 3G (UMTS) licences in Europe. In 2000-2001 a sequence of auctions took place, beginning with the UK, where operators bid very large amounts (USD 35 billion for five 3G licences). Although revenues from the German auction several months later were also high, thereafter they declined on a per capita basis. Many analysts of these processes have now been published – among the best that by Paul Klemperer, to be found in the references below.

Where a small number of national licences are being auctioned, for example in a developing country, a simpler approach is possible. A good example of this is provided by the auction of three identical GSM licences in Nigeria in 2002. This was done with a carefully thought-out process which involved invitation and pre-qualification stages, as well as the auction itself. Recognising the problem of collusion, the designers made alternative plans which depended on the number of qualified bidders for the three licences. If they were five or more - i.e., if bidders exceeded the number of licences by more than one, an ascending clock auction would be held. If these were only four, a sealed bid process would be implemented.

Related Materials

Module 3, "Authorization of Telecommunication/ICT Services", Section 4.1.1, "Features of a Multiple Round Auction: The Canadian Example"

Practice Notes

- **Best Practice Guidelines for Spectrum Auctions**

Reference Documents

- **Auction for Fixed Wireless Access Individual Licenses - Summary of Invitation to Tender**
- **Australia_Data on Spectrum Auction Results**
- **Comments on Auctioning of Spectrum for 3G Mobile services - Proposed Rules on Connected Bidders**
- **Framework for Spectrum Auctions in Canada**
- **High Bids and Broke winners**
- **Licence Award Process for the Provision of 3G (UMTS) and 2G (GSM/DCS) Mobile Services - Information Memorandum**
- **Solving Spectrum Gridlock: Reforms to Liberalize Radio Spectrum Management**
- **Spectrum Auctions do not Raise the Price of Wireless Services: Theory and Evidence, Federal Communications Commission**
- **Spectrum Auctions in India, Indian Institute of Management, February 2001**
- **Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism: Taking the Next Step to Open Spectrum Access**

5.5.8 SECONDARY MARKETS

When licences for spectrum are being initially offered, auctions can create competition for spectrum however it is often the case that the successful licensee is precluded from trading the licence at anytime afterward. Continuous reselling of spectrum becomes possible when a secondary market operated in respect of either spectrum that has been auctioned or of spectrum allocated initially by administrative methods but which is now been cleared for trading. When a secondary market is combined with flexibility in spectrum use, licences can be deployed by the original licensee or, after a trade, by another firm in a new innovative use. Auctions alone merely introduce an initial market-based selection by organizations that will exercise highly specified spectrum usage rights, whereas secondary trading seeks to develop a primarily market-based solution both for spectrum assignment and for spectrum allocation, on the condition that flexibility in use is permitted.

For more details on market-based sharing see sections **4.2.4 Market-based sharing** and **4.3.4 Spectrum sharing in practice** of this module.

Practice Notes

- **Spectrum Trading: Implementing Secondary Markets in the European Union**
- **What is Spectrum Trading?**

Reference Documents

- **An Essay on Airwave Allocation Policy, 2004 (Need for Reform)**
- **De-regulating the spectrum - Implications for Technology, 1999**
- **Final report for the European Commission, Study on conditions and options in introducing secondary trading of radio spectrum in the European Community, Summary of the Report, May 2004**
- **Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment**
- **Spectrum Trading: Band Managers - The Policies and Incentives Needed to Make them Succeed, 2003**
- **Study on the conditions and options in introducing secondary trading of radio spectrum in the European Community**

5.5.8.1 DEFINING PROPERTY RIGHTS FOR SPECTRUM TRADING

Where trading occurs, it is desirable or even necessary that buyer and seller – as well as the regulator and the courts where appropriate – share the same understanding of this bundle of rights and obligations which is changing hands. This is true of land, for example, and also of a spectrum licence. Clearly defined property rights are thus a precondition for efficient spectrum markets.

The dimensions of rights and obligations in a spectrum licence include:

- The band which is available for use;
- The geographical area in which it can be used;
- The period for which the licence is entitled;
- The uses to which it can be put;
- The licensee's degree of protection from other users;
- The licensee's obligation not to interfere with other spectrum user's rights.

Practice Notes

- **Designing property rights for the operation of spectrum markets**

Reference Documents

- **Sharing Spectrum**
- **USA: Assigning Property Rights to Radio Spectrum Users, 1998**

5.5.9 ADMINISTERED INCENTIVE PRICES (AIP)

Administered Incentive Prices (AIP) are used by some regulators (principally by ACMA in Australia, the Ministry of Economic Development of New Zealand, and Ofcom in the UK) as an additional tool to promote efficiency in spectrum use within a framework of administrative spectrum management.

It is called 'administered incentive pricing or AIP' since prices continue to be 'administered' or set by the regulator and include potential 'incentive' properties to promote efficient use. There is strong evidence that AIP's which are intended to be set at a level reflecting spectrum scarcity in particular bands encourage efficiency and economy in spectrum use.

In this section, AIP's are described in more detail beginning with Section 5.9.1 – Introduction to AIP followed by an outline and explanation of the opportunity cost approach commonly used to develop AIP's in Section 5.9.2 -The Opportunity Cost of Spectrum. In Sections 5.9.3 and 5.9.4 AIP in Practice and Methods to Adjust AIP are described.

- Spectrum Pricing: Administrative Incentive Prices

5.5.9.1 INTRODUCTION TO ADMINISTERED INCENTIVE PRICES

Objectives

Spectrum prices should be set with a clear view of objectives and intended results. Administratively assigned licences usually carry with them an obligation by the licensee to make a payment to the regulator or government that is designed to promote efficient spectrum use – not simply to recover spectrum management costs. The idea is that if spectrum is priced reflective of its value in a market place (for example prices set by spectrum auction) a user with unused or underutilized spectrum will choose to return it or trade spectrum rather than pay the charge. As well, if a user can pay a lower fee by using less spectrum that is by being more efficiently, that user will rationally adopt more spectrum-efficient operations.

Comparing Spectrum Pricing Approaches

Promoting efficiency is generally achieved by relating spectrum prices to key factors such as frequency band (coverage and data carrying capacity), bandwidth, extent to which the band is sterilized (exclusive licenses and guard bands), type of service, population density, location of use. In most cases, the parameters used in developing formulae bear no relationship to the spectrum demand or opportunity costs associated with the use of spectrum in an alternate higher value use. Instead of using market-based prices, values for spectrum prices and parameters are set by the spectrum manager using judgements which are heavily influenced by historical precedents and often political sensitivity and reluctance to make major changes in fees. The cost recovery price of spectrum can also cause a user to return excess spectrum or to use spectrum more efficiently, but often they are too low to impose an appropriate level of discipline on licensees.

Benchmarks using observed prices in market transactions in the same or related frequencies are often are included in the analysis of spectrum values because benchmark prices provide some reference and basis for having arrived at similar conclusions concerning price levels even though true comparisons are difficult since like for like situations are uncommon. These transaction prices will embody not only 'opportunity costs' – the cost-saving potential of the spectrum licence, but also any excess profits which the licence holder can derive through exclusivity or market power. As a result, benchmarks should be used with caution. For example, the comparison involves two mobile licences that were auctioned in another jurisdiction. Bids may well have been based on business plans which anticipated high mobile telephone charges, based on limited competition. If a new entrant in your own market is faced with administered price equal to the benchmark auction bids, it might find it uneconomic to enter the mobile market, as the profits achievable in a more competitive market might not be enough to cover so high a charge. This shows how an excessive administered price can leave spectrum underutilised.

Administrative Incentive Prices

Regulators are increasingly considering the use of market based mechanisms to determined spectrum allocations mechanisms - auctions and trading – to optimise the use of spectrum. AIP is a useful complementary tool for establishing spectrum prices using opportunity costs to promote and encourage the efficient use of the spectrum resource Ofcom, the UK regulator, has pointed out in its Administrative Incentive Price (AIP) Policy Evaluation Report (2009), that (AIP) are effective used alongside the increased use of market-based allocations. As well, AIP has improved information for all users and potential users on the value of scarce spectrum during the early transition to a market-based approach to spectrum allocation.

AIP is expected to provide long term signals of spectrum value to spectrum users. These long-term value signals are intended to help spectrum users (and their suppliers) make more efficient decisions concerning investment and the combination of inputs such as land and equipment along with how much spectrum should be and investment in radio technology. Given the significant investments made by many users which are tied up in radio equipment, land, etc., and since these, in most cases, cannot be easily and quickly reconfigured to use other frequencies and have a lifetime of many years, it should not be expected that AIP will lead to significant changes to spectrum use in the short term. Ofcom has stated in its policy it does not expect AIP to achieve any specific short term spectrum reallocation goals

AIP's are used as a surrogate for market prices reflecting opportunity cost and emphasizing productive efficiency where the demand and supply of radio spectrum is brought into equilibrium by the working of the price mechanism reflecting opportunity costs. AIP's target productive efficiency; one of three dimensions of economic efficiency:

- Productive efficiency – production of goods and services takes place at the lowest possible cost. In the case of radio spectrum users select combinations of inputs such as spectrum, equipment, land and labour to produce

services at their lowest cost;

- Allocative efficiency – an optimal mix of goods and services is produced which maximizes consumer welfare – no on benefits from the use of spectrum at some else's expense;
- Dynamic efficiency –radio spectrum should be used in a way to encourage an appropriate level of research and innovation.

Ultimately, spectrum values are determined by users using not only opportunity costs and an assessment of alternatives but also the users' view of the revenue potential associated with several possible uses and deployments. Spectrum values can be expected to be determined by users based on expected net present values of future returns where returns are determined based on calculations of all inputs (spectrum, land, equipment, maintenance) using their market prices plus a value attributable to the flexibility of options available to the user in how the frequencies can be used (positive externalities). Technology flexibility and service neutrality contribute to spectrum values. For more on opportunity costs see Section 5.9.2 – Opportunity Cost. For more on spectrum valuation See Section 5.2 – Spectrum Valuation and Section 5.2.1 – Measuring Spectrum Values.

5.5.9.2 THE OPPORTUNITY COST OF SPECTRUM

In the absence of a primary or secondary market for spectrum (or even in their presence), it may be desirable to give licensees an incentive to economise on spectrum use, in order to discourage extravagant use or hoarding. This applies both to private sector (or commercial) users and to public sector users.

There are various ways of doing this, including regular audits. By setting a charge for spectrum steady pressure is imposed on users to economise, just as appropriate electricity prices discourage waste of electricity.

To apply the right level of price pressure without forcing excessive economies which leave valuable spectrum unused, spectrum should be priced in any use at its opportunity cost. This can be found by estimating the other resources which would be saved if the same spectrum were redeployed to produce another service, or the extra costs which would be incurred if it were not available to provide the service for which it is currently employed, so service had to be produced with less spectrum.

As an example, spectrum used from mobile communications can have its opportunity cost computed in either of the above two ways. Either we can ask: "how much extra would it cost to provide mobile communications with less spectrum – i.e., with better spectrum re-use, hence lower power and use of more base stations?" Or we can ask: "if the spectrum were reallocated to another use, what costs would the new spectrum licensee save in the production of that service?" Both of these are possible measures of opportunity costs, but we should also take the higher of the two (or more) estimates provided because that measures the cost to society of keeping the spectrum in its current use.

Note that this approach only measures the potential of spectrum to reduce costs of services, not its role in generating excess profits from monopolisation of services. Hence the opportunity cost is not an estimate of the market price of leasing or buying spectrum, as this would include any 'monopoly profits'. If the regulatory body wants estimates of the market price of any spectrum, it might examine price levels in comparable commercial transactions, such as auction proceeds or secondary trading.

If AIP's are based on opportunity cost, then it follows that they should be zero (and replaced, probably, by cost recovery prices based on direct cost only) if the spectrum has no alternative use. This might arise because:

- there is no shortage of spectrum in the relevant frequency, so that all users can be accommodated;
- there is a legal impediment to using the spectrum in question for other purposes; this might apply for instance, to spectrum used for the purposes of aeronautical communication under the auspices of the International Civil Aviation Organisation (ICAO).

A criticism of AIP, is that in the real world, decisions to bid and acquire spectrum are not only based on costs, but also on the projection of future revenues, after analyzing the efficiency and capability of the technology and the marketability of the resulting applications that the spectrum will support. Some argue, the best way to capture the estimate for spectrum value is to use the *net present value* (NPV) concept, which balances the net costs against the net cash inflows over time. From the point of view of a potential operator choosing whether or not to invest in a particular Broadband Wireless Access market (for example) using NPV translates into a calculation of the total net value of a project, assessing whether positive outputs (i.e., revenues) exceed input costs including spectrum as a factor in determining net project value for the proposed project – and whether the cost for the spectrum input is justified.

Measurements of potential revenues can also be forecast with some reliability, through benchmarking similar services, or

benchmarking identical services in other markets. As well, more focused research can be done through marketing studies and demand surveys of discrete markets.

The model for spectrum pricing known as *administered incentive pricing* (AIP), is based on the economic rationale that market-based signals will generate economic responses that will lead to more efficient and productive use of spectrum resources.

In practice, *opportunity cost* calculations and spectrum management policies are used to derive market-oriented fees, even for spectrum bands that have never been auctioned. The fees may represent discounts from true market-oriented amounts, based on policy goals or to avoid "fee shock" for users in lucrative bands below 3 GHz. The fees are then imposed as economic costs upon the users of the spectrum input. If the users find that the fee costs cannot be justified economically, they can release the spectrum. The intended result is more productivity gained from the finite spectrum resource.

In its broadest sense, administered pricing has been employed in numerous countries, wherever governments have opted not to conduct auctions but rather to set up-front or recurring fees based on calculations – or often simply estimates – of what the operators would consent to pay. Contemporary AIP, however, seeks to marry auction avoidance with market-oriented fees that are based on sound economic principles. Not all governments, however, have been willing to impose AIP on all services – particularly the command-and-control public service operations that they themselves operate.

◂ **Box AIP: A Proxy for Market-Based Prices**

Source: Exploring the Value and Economic Valuation of Spectrum, GSR 2010 Discussion Paper, ITU, John Alden.

Reference Documents

- **AN ECONOMIC STUDY TO REVIEW SPECTRUM PRICING**
- **Group on Telecommunications Report - Opportunity Costs Affecting Spectrum Utilization, Group on Telecommunications – India**

5.5.9.3 ADMINISTERED INCENTIVE PRICES IN PRACTICE

Administrative Incentive Prices (AIP) based on opportunity costs are used by Ofcom in the UK and ACMA in Australia as an additional tool to promote efficiency in spectrum use within a framework of administrative spectrum management. Licences are issued administratively but carry with them an obligation to make a payment to the regulator or government which is designed to promote efficient spectrum use and not simply recover the costs of managing spectrum. Basically, if a user has unused spectrum, the user will choose to return unused spectrum rather than pay the charge. Also, if a user can pay a lower fee by using spectrum more efficiently, that user may adopt more spectrum-efficient operations.

In this section, the approaches to AIP taken by Ofcom in the UK and ACMA in Australia are briefly described. The summary conclusions drawn from Ofcom's AIP Policy Evaluation concerning the effectiveness of its AIP policy for spectrum prices are also given.

◂ Box United Kingdom - OFCOM

Smith-NERA was commissioned by Ofcom's predecessor the Radiocommunication Authority in 1996 to report on how AIP might be applied to range of licence classes given that the 1998 Wireless Telegraphy Act (the "WT Act 1998"as primary legislation, was an important cornerstone in the development of AIP. The WT Act 1998 permits the UK NRA to reflect considerations other than cost recovery when charging fees for spectrum use. Up until that point, the existing regulatory framework had not provided any means by which users could be incentivised to make efficient decisions about their spectrum requirements, based on the value of the spectrum to society at large, as the legislation in place would not permit it.). The WT Act 1998, however, did not address government users of spectrum, who could continue to use spectrum without a WT Act licence because of "Crown immunity". In the late 1990's, no spectrum auctions had been undertaken, although the principles were being discussed by the UK NRA. The results of the Smith-NERA work and initially led to proposals to phase in AIP over 3 years commencing on 1997 for Fixed Services (point-to-point links); Private Business Radio (including CBS use), and Public Mobile Communications (Cellular).

An AIP policy was subsequently continued by Ofcom given its duties and powers under the new Communications Act. Ofcom's AIP methodology uses the marginal value of spectrum to the user taking into consideration the amount of congestion in a given band and attempts to set fees at "market-clearing" rates that balance spectrum supply and demand. Ofcom has said that one way to evaluate the marginal value to the user is on the basis of the "additional costs of the least-cost practicable alternative" – another way of stating opportunity cost. For example, for a user of a point-to-point fixed service band, the most cost-effective alternative to using the band would be either deploying more spectrally efficient systems or relocating to higher frequencies. The relative costs of these alternatives reflect the marginal value.

Therefore, most valuation models involve a calculation of marginal costs associated with network infrastructure, including equipment and construction costs, as well as cost of capital or labour. Some of these costs can be known or at least well estimated, through benchmarking and survey of existing equipment markets. This is particularly helpful if the spectrum being valued is harmonized across multiple markets (or even worldwide), leading to predictable economies of scale and scope in manufacturing. It is also clear that such cost calculations are made on a forward-looking, incremental basis, because the analysis must capture ongoing costs, not a theoretical start from a baseline of zero.

Ofcom agreed with Smith-Nera that the key criteria when setting a more incentive based pricing regime should be that:

- Prices should be based on the estimated marginal value of spectrum; \
- marginal spectrum values should be calculated by costing the alternatives faced by potential users denied access to the spectrum and then taking the difference between the costs of providing the service at current levels and the minimum cost of those alternatives initially prices less than marginal values should be set, because the current allocation and assignment of spectrum was not an equilibrium position;
- initial prices should be set at a fraction of the estimated marginal values, but probably at several times the then current fee levels;
- prices should then be increased over, say, a five year timescale, depending on users' reactions.

Ofcom continued to develop AIP fees across a number of sectors beyond the initial three from a base set by a general of 50% reduction over 10 years ago. This generally reflects the assessment that the risks to optimal use posed by setting fees too high are more significant than those associated with setting them too low as setting them too high could result in the loss of existing services that are efficient in their use of spectrum, or the lack of new services that might otherwise have evolved if the spectrum was priced appropriately.

Ofcom – AIP Policy Evaluation, 2011

In 2011, Ofcom completed a review and evaluation of its AIP spectrum price policy. It concluded that:

- In the main, AIP continues to meet its primary objective in helping to incentivise spectrum users to ensure that the spectrum they have access to, is used optimally;
- Alternative use of a non-incentive pricing mechanism such as Cost Recovery would have been quite likely to allow inefficiencies to continue;
- AIP fees were set conservatively below expected opportunity costs, it is unlikely that the application of AIP-based fees, by themselves, made otherwise economic uses of spectrum uneconomic.

The case for AIP is relatively simple. Due to increasing demand for applications and the introduction of new services, spectrum is scarce or in excess demand1 in many frequencies and geographical areas – not all potential users and uses can

be accommodated in their preferred frequencies and locations, and there is a need to ration demand by means of a price.

In the absence of price signals, users will lack incentives to economise in their use of scarce spectrum, and will tend to hoard it or use it in greater quantities than if it was realistically priced. Putting a price on scarce spectrum provides the necessary incentives and allows those who value it most to gain access to it thereby providing services of a greater economic value to the benefit of citizens and consumers.

ACMA's approach to AIP is highlighted next.

◂ Box Australia - ACMA

ACMA which determines spectrum fees in Australia has operated a system of spectrum pricing which in part utilizes opportunity costs. ACMA employs the following principles in developing spectrum fees to encourage the efficient use of spectrum based on an equitable and consistent spectrum fee regime:

- Spectrum fees, however based, should cover the costs of authorizing spectrum;
- Taxes from spectrum licensees should recover the indirect costs of managing spectrum;
- Taxes should be based on the amount of spectrum denied to others;
- Spectrum fees should be based on their opportunity cost that is the best alternative use;
- If the opportunity cost is less than costs of managing spectrum, taxes should then make up the difference but not exceed these costs.
- Adjustment factors will be used by ACMA to take special situations into account.

ACMA's treatment of AIP differs from Ofcom's in that AIP's should not exceed the costs to manage spectrum somewhat restricting the incentive aspect of AIP.

The Federal Communications Commission, as directed by Congress, in 2010 developed a National Broadband Plan which includes a detailed strategy for achieving affordability and maximizing use of broadband to advance public policy goals including:

- consumer welfare;
- public safety and homeland security;
- health care delivery;
- energy independence and efficiency;
- education;
- job creation and economic growth;
- and other national purposes;

The goals identified in *Promoting Mobile Broadband Infrastructure* supports the Government's goal of making an additional 500 megahertz (MHz) of spectrum available for mobile broadband by 2020 by expanding the use of incentives mechanisms to reallocate or repurpose spectrum to higher-valued uses.

The FCC stated that it should also consider a more systematic set of incentives, (such as AIP among others) to ensure productive use of spectrum to address broadband gaps in underserved areas.

Practice Notes

- **Calculating AIP in Practice: An example for mobile spectrum**
- **Spectrum Pricing: Administrative Incentive Prices**

Reference Documents

- **Ofcom. Spectrum pricing. A statement on proposals for setting Wireless Telegraphy Act prices, 2005.**
- **Response to OFTA's Consultation Paper on 3G, Centre of Asian Studies, University of Hong Kong, 2000**
- **UK: Application of AIP in the UK_2004**

5.5.9.4 ADJUSTING AIP SPECTRUM PRICES

An important feature of the price for most objects is that it can change over time in response to scarcity, substitutes and changes in consumer tastes. To the extent prices change in well ordered markets, the prices of spectrum will change when prices are determined by market methods.

What of administered prices and AIP? Again, prices can change as allocations and availability are altered through international or national processes. If administrative scarcity is the dominant characteristic in certain bands improving availability and access should have downward pressure on spectrum prices. As regulators become more efficient in the management of radio spectrum, there is justification for a reduction in that portion of spectrum fees that are related to cost recovery.

As we have seen AIP's for a particular band or service are determined by estimating the opportunity cost of the existing service with the best alternative use. As opportunity costs change reflecting both technological improvements and changes in the service offering then we can expect AIP's to be adjusted lower. This is the case with the prices determined by Ofcom. Ofcom periodically re-calculates AIP for various services and adjusts some prices upwards and others downwards.

Should the price of spectrum in bands adjacent to bands reflecting either an opportunity cost or market-prices go up in price in some synchronous manner? The answer to this question depends on whether the bands in question are used for similar services. Market-based methods will resolve the price question quite readily whereas the spectrum manager will need to adjust the price through an administrative process and possibly run the potential for both delay and inaccuracy.

Next: 5.6 Spectrum Monitoring and Compliance ➔

The ICT Regulation Toolkit is a joint production of infoDev and the International Telecommunications Union (ITU).