Increasing mobile broadband coverage through spectrum awards

Many regulators are pursuing the goal of increasing mobile broadband coverage – the award of new spectrum offers regulators an opportunity to increase existing coverage levels. This paper explores some of the key challenges.

September 2019

coleagoconsulting

Increasing mobile broadband coverage through spectrum awards

Introduction

The limits of commercially driven coverage have been reached in many markets and further increases in coverage will require regulatory intervention

The benefits of increasing mobile broadband coverage are well established. Czernick et al (2009), for example, studied 25 OECD countries between 1996 and 2007 and found that a 10% increase in mobile broadband resulted in between a 0.9% and 1.5% increase in the rate of growth of GDP. A range of other studies have established similar results[1]. In many markets, competition between operators has resulted in reasonable levels of coverage. However, the limits of commercially viable coverage have been reached in many markets and further increases are unlikely without some form of regulatory intervention. The award of new spectrum provides regulators with an opportunity to increase coverage and in this paper, we explore some of the issues associated with this strategy.

Regulatory policy objectives

Regulators pursue a wide range of policy objectives although there are often a number of common themes. The objectives most relevant to the award of new spectrum are:

- increasing mobile broadband coverage; and
- maintaining and enhancing competition.

Pursuing increased coverage objectives often requires the regulator to make a trade-off with other goals

In addition, whilst not always publicly stated, regulators may be expected to generate (sometimes significant) revenues from the assignment of spectrum. As we will see later, pursuing increased coverage objectives often requires the regulator to make a trade-off with other goals.

The dimensions of coverage

There are a number of dimensions to coverage and regulators should define coverage obligations fully and precisely

Coverage obligations have been a common feature of spectrum awards for many years. There are a number of dimensions to a coverage obligation and regulators should ensure that there is no ambiguity regarding the coverage requirements:

- Coverage obligations are usually set in relation to the provision of outdoor coverage. This is mainly due to the difficulty in achieving (and measuring) indoor coverage due to the variety of materials used in the construction industry, some of which can be very effective in preventing the penetration of radio waves.
- Coverage obligations typically relate to a proportion of the population that must be covered. This may be expressed simply as a proportion of the population and the onus is on the operator to decide how best to meet the requirement and demonstrate that it has fulfilled its obligation. Regulators however are often becoming more prescriptive and may identify a set of towns and villages.
- Once a reasonable proportion of the population has been covered, regulators often begin to set specific geographic locations as the basis for coverage to address “not spots” where no coverage exists. For example, in the 2016 Danish auction for 1800 MHz spectrum, the regulator specified 2,143 specific addresses currently not receiving any signal, which were grouped into three, non-overlapping sets.
- Obligations may be symmetric or asymmetric. Symmetric obligations attach the same coverage obligations to all licences, whereas asymmetric obligations impose different obligations on different licences.

1 Koutumpis et al 2009 10% increase led to a 0.25% increase in growth and Waverman et al in 2009 reported that a 1% increase in broadband resulted in a 0.13% increase in economic productivity.

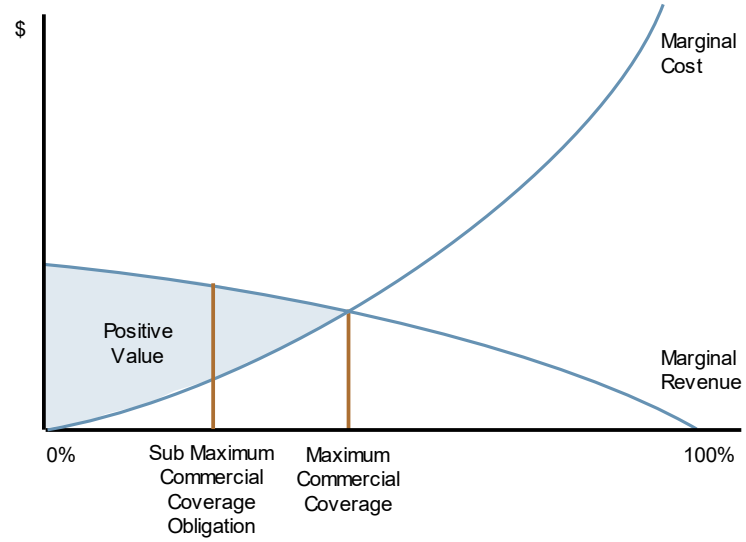
- To manage the risk of operators tacitly colluding to delay the speed of roll-out to less attractive areas, the regulator will often impose a single or series of dates by which the coverage obligations must be met. Some regulators, such as in Germany, have used “reverse roll-out requirements”. In the 2010 German 800 MHz auction, four classes of locations were identified with each assigned a different level of priority. The first priority class involved providing coverage to the smallest towns, the second priority class involved slightly larger towns and so on. Roll-out could not commence in a lower priority class until the previous priority class has been covered by 90%. The obligation could be met through jointly providing coverage with another operator based on “economic cooperation”. Five years later the obligation had to be met entirely by the individual operator.
- A further dimension is the quality of service that must be delivered. This is usually expressed as a minimum uplink and downlink speed. For example, in the Danish 1800 MHz auction the minimum was set at 30 Mbits/s for download and the uplink was set at 10% of this level, requiring an uplink of 3 Mbits/s. This level of performance is quite typical of quality of service obligations and has been adopted in a number of spectrum awards. Some regulators, however, impose more demanding coverage obligations. The German regulator, in the 2019 3.5 GHz auction, stipulated a wide range of coverage obligations which also varied by whether the operator was an established player or new entrant and the spectrum acquired. The German obligations demanded 100 Mbits/s for at least 98% of households in each federal state by the end of 2022. The obligations also stipulated coverage in terms of speed and latency for all federal roads by the end of 2022 as well. Additional obligations required the operation of 1,000 5G base stations and 500 base stations in “not spots”.
- A final dimension is whether the regulator stipulates the technology and / or the frequency band by which the obligation is met. Best practice recommends that coverage obligations are both technology and frequency neutral so that the operators can determine how the obligation can be most cost efficiently delivered.

Maximum commercially driven levels of coverage

Marginal revenue gains decline and marginal costs increase with increasing levels of coverage

In the absence of any regulatory constraints on network build, mobile operators will first cover the most commercially attractive areas, usually the wealthiest and most densely populated regions of the country. As coverage is expanded to less attractive areas, the incremental or marginal revenue from each increase in coverage diminishes. As coverage is expanded to more sparsely populated areas, the rate of decline in marginal revenues accelerates. In contrast, the incremental or marginal cost of providing increased population coverage rises as coverage is extended to ever more rural and sparsely populated areas. Indeed, depending on population densities, the cost of providing coverage can rise almost exponentially as very high population coverage levels are reached. The marginal revenue and marginal cost curves for providing population coverage are shown in Exhibit 1 below.

Exhibit 1: Maximum commercial coverage



Source: Coleago

For both developed and developing markets, the incremental revenues from expanding coverage beyond the maximum commercially justifiable levels are likely to be low

In developed markets, the marginal revenue gains from increased coverage may be limited. This is especially the case where a large proportion of customers are on contracts which include bundles of voice, messaging and data. In the case of contract customers, any additional usage generated by increased coverage is unlikely to lead to increased revenues as the additional traffic is already included within their bundle. In developing markets however, the vast majority of customers are prepaid and so any increase in traffic resulting from increased coverage will result in additional revenue. The scale of revenue growth will be tempered however as deeply rural customers tend to have lower Average Revenues per User (ARPU) compared to customer in urban areas. For both developed and developing markets, the incremental revenues from expanding coverage beyond the maximum commercially justifiable levels are likely to be low.

On the cost side, if an operator is simply deploying additional spectrum within a band they already use, on existing sites with an existing technology, say LTE, then the cost of deployment is relatively low and mainly driven by software licensing costs. If a new frequency band is to be deployed on existing sites but with existing or new technology, then the cost of deployment is higher.

As coverage is expanded to increasingly deeply rural areas the cost of providing incremental coverage can increase almost exponentially

The greatest costs of deployment, however, occur when an operator has to build additional sites in order to meet increasing coverage requirements. In rural areas the most common type of site is a macro site due to the extended coverage it provides, but these are also the most expensive. Indeed, the cost of the civil construction works often far exceed the active radio equipment deployed on the site. As coverage is expanded to increasingly deeply rural areas the cost of providing incremental coverage can increase almost exponentially.

The rapidly increasing cost of building new sites in deeply rural areas is matched by the higher levels of network operating costs. The challenges of providing power and backhaul as well as the logistical challenges of maintaining the site and ensuring security, result in rapidly accelerating costs. A number of studies have shown that as coverage is extended to the final percentages of the population or geography, the cost of coverage increases exponentially. In May 2019, Policy Tracker examined the cost of coverage using 700 MHz spectrum in the United Kingdom. They estimated that the cost of increasing population coverage from 90% to 91.5% was £160 million but the cost of increasing coverage from 97% to 98.5% was £1.3 billion.

A mobile operator will maximise its profits by continuing to expand coverage until the point where the marginal revenue from increased coverage equals the marginal cost of providing that coverage

In the absence of any imposed coverage obligations, a mobile operator will maximise its profits by continuing to expand coverage until the point where the marginal revenue from increased coverage equals the marginal cost of providing that coverage. Any increase in coverage beyond this point will result in reduced profits for the operator as the incremental costs exceed the incremental revenues. In the Exhibit, this point is highlighted as the "maximum commercial coverage". Without regulatory intervention, operators will not expand coverage beyond this point.

If the regulator is interested simply in maximising the financial proceeds from assigning spectrum then they should either, not impose any coverage obligation or set a sub-maximum commercial coverage obligation. In this way, the value of the spectrum to operators is maximised, allowing the regulator to charge the highest possible price for the spectrum.

In many markets, competition and commercially motivated coverage expansion has resulted in reasonable levels of geographic and population coverage. Even if regulatory policy objectives have been met by commercially driven coverage levels, there are a number of reasons why a regulator may still wish to set a sub-maximum commercial coverage obligation. One of the main reasons is to prevent operators from tacitly colluding to divide the market on a geographic basis in order to reduce competition in their respective regions and increase profits. Other reasons include seeking to deter operators from colluding to delay roll-out or cherry-picking only the most attractive areas in which to offer improved levels of service. An additional reason is to ensure that the spectrum is used immediately, effectively creating a "use it or lose it" condition to avoid operators "hording" spectrum. As best practice allows mobile operators to use any frequency band or technology to meet a coverage obligation, any "use it or lose it" will be difficult to implement in practice without imposing potential operational inefficiencies.

Regulators should take a very cautious and conservative approach to setting spectrum prices when demanding coverage obligations are applied

If a regulator wants to expand coverage beyond the maximum commercially viable level, then it will need to understand how the increased level of coverage impacts the price they can charge for spectrum. Accurately estimating the revenues and costs of providing deep rural coverage is a complex and challenging process for operators which is subject to a high degree of error. Not surprisingly, a regulator, who is at an informational disadvantage compared to operators, will find it extremely difficult to estimate the costs of coverage for operators. Yet, understanding the costs of providing increased coverage and hence the resulting spectrum values is vital for the regulator when setting appropriate spectrum prices and reserve prices in the case of auctions. Regulators should take a very cautious and conservative approach to setting spectrum prices when demanding coverage obligations are applied.

When there are significant differences in size between operators the spectrum pricing decision becomes even more difficult

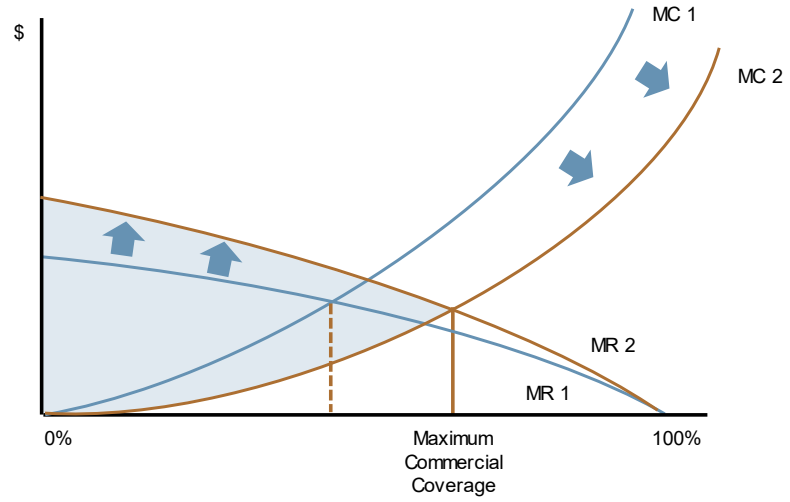
A further important point to make about the incremental revenues and costs of coverage is that they are likely to vary significantly by operator. This is most pronounced in the case of costs. The operator who already has the greatest number of existing sites and coverage will be able to meet any coverage obligation much more cost effectively than a smaller operator. In addition, a larger operator is less likely to face a budget constraint in relation to meeting a coverage obligation compared to a smaller and less profitable competitor. When there are significant differences in size between operators the spectrum pricing decision becomes even more difficult. Regulators may also have to consider imposing asymmetric coverage obligations with the larger operators expected to provide higher levels of coverage – we explore these ideas later in the paper.

Increasing coverage through demand and supply side measures

Implementing demand and supply-side measures is the first step in improving coverage

As coverage levels are determined by the marginal revenues and costs of increasing coverage, the regulator can increase coverage by implementing demand and supply-side measures to improve revenues and reduce costs. As Exhibit 2 shows, if the marginal cost curve can be shifted to the right from MC1 to MC2 and marginal revenues increased from MR1 to MR2, a potentially material increase in coverage can be obtained without the imposition of any coverage obligations.

Exhibit 2: Improving coverage through supply and demand



Source: Coleago

Introducing demand and supply side measures not only increases coverage but allows regulators to charge higher prices for spectrum

The benefit to the regulator of improving demand and supply side conditions is not only increased coverage but also an enhanced value of the spectrum for the operators, thus allowing the regulator to charge a higher price and increasing award proceeds. Typical demand-side measures include:

- reducing and eliminating taxes on the sale of SIMs, devices, etc., to reduce the cost of mobile ownership;
- reducing and eliminating taxes and import duties on the import of devices into the country; and
- eliminating any fees, for example spectrum fees, based on turnover as these directly reduce the impact of any marginal revenue gains from increased coverage.

Typical supply-side measures include:

- eliminating spectrum fees linked to the installation or the total number of sites owned or operated by an operator;
- eliminating taxes and duties on imported telecommunications equipment;
- making publicly owned buildings available for the use as sites at low cost;
- reducing the cost and time associated with planning applications for new sites;
- allowing sharing at the site, mast, RAN and spectrum level;
- reducing health and safety regulations;
- improving the national grid and access to power for sites; and
- ensuring site owners charge cost-based rents for tower access.

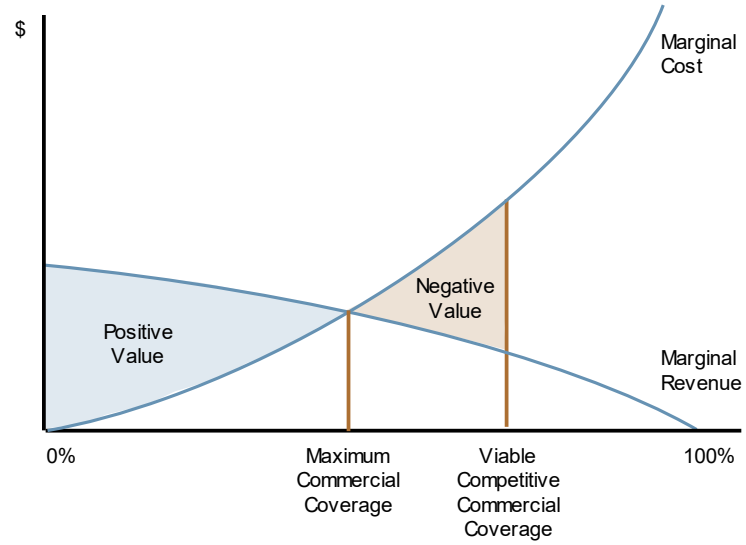
Commercially viable coverage obligations

Coverage obligations will be commercially viable if the value from covering urban areas exceeds the net costs of covering rural areas

In Exhibit 3, we have assumed that the regulator has imposed a coverage obligation which exceeds the maximum commercial coverage level. This level of imposed coverage remains commercially viable for multiple operators because, for each operator, the positive value exceeds the negative value imposed by the coverage obligation. The more attractive and densely populated areas are effectively subsidising the more rural areas. The operators still generate a net positive value, despite the coverage obligation, and so they would all be prepared to accept it. In this situation,

multiple operators would provide infrastructure-based competition in the expanded coverage area.

Exhibit 3: Viable competitive commercial coverage



Source: Coleago

Imposing an obligation above the maximum commercial level will reduce the value of spectrum and the price of spectrum will need to be reduced accordingly

The first immediate consequence of imposing a coverage obligation above the maximum commercial level of coverage is that maximum potential auction proceeds will be reduced by the amount of the negative value imposed on the operators. Regulators will need to reflect the reduced value of spectrum in their choice of reserve price (the minimum or base price in a spectrum auction). Regulators therefore face an unavoidable trade-off between the long-term socio-economic benefits of increased coverage versus short-term auction proceeds. The negative value arising from meeting the coverage obligation represents the revenue the government must forgo in order to obtain the increased coverage. This can be seen as the cost to the government of procuring the coverage. From a societal perspective, the cost of procuring coverage must be less than the socio-economic benefits that accrue from the additional coverage.

If coverage obligations are not too demanding, reserve prices are low and operators are of similar size then the use of symmetric coverage obligations and a simple auction is likely to be the best approach

Where coverage obligations are expected to be viable for multiple operators and the reserve price has been set at a reasonable and low level, a symmetric coverage obligation can be imposed on spectrum lots. This implies that each operator acquiring the spectrum faces the same obligation and promotes competition within the coverage area. The regulator should seek to estimate the value of spectrum to the weakest operator and set the reserve price accordingly. The regulator should recognise the challenges involved in estimating spectrum values and should be very conservative in their estimates. Provided that, from the perspective of the weakest potential bidder, the obligation is not too demanding, and the reserve price is reasonable, a regulator can auction spectrum with symmetric coverage obligations with a good likelihood of success. For many developing markets, this is likely to be the best approach as a simple auction design can be used. The approach becomes more challenging however when there are significant differences in size between the operators, which is also often the case, or the coverage obligation is demanding.

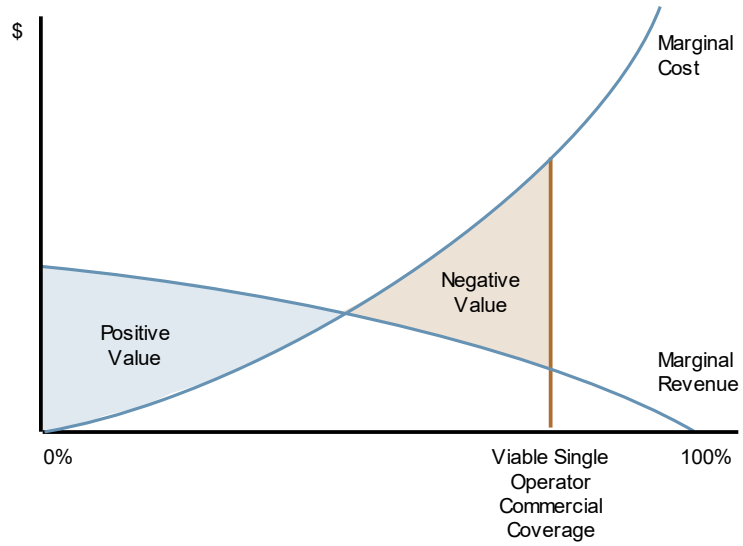
Coverage obligations and natural monopolies

More demanding coverage obligations can create an natural monopoly

As coverage obligations become more demanding, it will become increasingly difficult for smaller operators to develop a viable business case and positive spectrum values. In Exhibit 4, the coverage obligation is so demanding that it can only be fulfilled by a single operator. The absence of competition means that the sole operator generates

higher revenues than it would do in a competitive situation. This level of coverage remains commercially viable as the net value remains positive but only where a single operator provides the coverage. A coverage obligation set at this level creates a natural monopoly, a situation where only one operator can viably deliver the required level of coverage in a given area. This is likely to be the case in some rural and many deeply rural areas.

Exhibit 4: Viable single operator commercial coverage



Source: Coleago

Where there are doubts over whether all operators can meet the obligation it may be appropriate to set asymmetric coverage obligations

Demanding coverage obligations may mean that only large operators or indeed only one operator may be able to meet the obligation and place a positive value on the spectrum. Where there are doubts over whether all operators can meet the obligation it may be appropriate to set asymmetric coverage obligations. One spectrum lot may have a coverage obligation attached to it and others not. Designing spectrum lots in this way is likely to encourage auction participation and increase the competitiveness of the auction. Alternatively, different geographic coverage areas can be attached to different lots such that only one operator is required to cover a specific area to reflect the natural monopoly. When developing asymmetric coverage obligations, the regulator should take into account that there are likely to be cost efficiencies in covering geographically concentrated locations. This implies that the regulator should develop coverage obligations that contain a set of locations that can be cost effectively covered by a single operator. It is unlikely that such efficiencies will arise if the locations attached to one specific licence are widely dispersed across the country.

Asymmetric coverage obligations can have implications for auction design and post auction competitiveness

Where demanding obligations have been imposed the encumbered lot(s) is likely to sell out a discount to unencumbered lots. However, it may be necessary to attach a larger amount of spectrum to the obligation to make the obligation commercially viable. These factors can have significant consequences for auction design as well as post-auction competition.

- Coverage obligations that are too demanding may deter smaller operators and potential new entrants from participating in the auction. If participation is low the auction may lack the necessary competitive tension to ensure an efficient allocation of spectrum.
- Demanding coverage obligations may also result in spectrum lots with the coverage obligation going unsold which would represent reduced auction proceeds and a loss of socio-economic welfare as well as a failure to meet the obligation.

- If only one or a small number of operators acquire the spectrum, then this may result in excessive concentration of spectrum and further entrenching an already dominant player or players.

Imposing access obligations on the winner of a coverage lot is a potential strategy for addressing competition concerns

In markets where there is a single dominant operator and a number of smaller operators and only the dominant operator can afford the coverage obligation, the regulator may be prepared to accept that the competitive landscape is left unchanged or even worsens, in return for achieving its coverage goals. However, the regulator may not be particularly concerned about the lack of competition in remote areas if there is robust competition in other areas of the country. As tariffs tend to be set at a national level, customers in rural areas served by only one operator, will benefit from competition in other areas via lower tariffs. However, if competition is a concern, then one option to address the post-auction competition risks of asymmetric lots, dominant operators and potential natural monopolies, is to attach access obligations on the winner of the lot. Access could be based on some form of roaming, shared access of sites or some form of RAN sharing at cost-based prices.

In the German 800 MHz spectrum auction the operators were permitted to deliver the obligations with “economic cooperation” which involved site sharing and frequency leasing. Economic cooperation was permitted for a period of five years after which the obligations must be met individually.

There are limits to how demanding a coverage obligation can be before the risks and ramifications for other aspects of the market become too great

Demanding coverage obligations significantly increase the risk for the regulator and so later in this paper we explore how some of these risks can be managed through seeking to de-couple coverage obligations from specific spectrum lots. The risk of setting too high a reserve price however is difficult to avoid other than setting a very conservative price. However, setting a low reserve price can create additional problems as it increases the incentives for bidders to adopt strategic demand reduction strategies where they seek to end the auction early at, or close to the reserve price, by reducing their demand faster than they would otherwise do so. A low reserve price increases the benefits and hence the incentives for strategic demand reduction. There are, therefore, limits to how demanding a coverage obligation can be before the risks and ramifications for other aspects of the market become too great.

De-coupling coverage from spectrum

Some regulators have sought to obtain greater flexibility by de-coupling the assignment of spectrum from the procurement of coverage

When demanding coverage obligations are attached to specific spectrum lots the regulator faces the risk of not selling the spectrum and not achieving the coverage obligation. Directly linking coverage to specific spectrum lots means that the regulator loses a degree of flexibility – they do not have the option of assigning the spectrum but forgoing the desired coverage. Some regulators have sought to obtain greater flexibility by de-coupling the assignment of spectrum from the procurement of coverage.

Where the costs of coverage and spectrum being assigned are closely linked, it becomes harder to separate the assignment of spectrum from the procurement of coverage

Separating coverage from spectrum is easier to achieve when the spectrum being assigned does not have a close relationship with the costs of meeting the obligation. In developed markets where regulators have assigned a number of sub 1 GHz bands (which are ideal for providing coverage), the operator may well be able to meet the obligation through a number of different network and spectrum deployment strategies. There is therefore a weak link between the spectrum being assigned and the cost of coverage. However, in many developed markets there have been delays in the transition from analogue to digital broadcasting and so often only the 900 MHz band has been assigned and possibly only to the first or second entrants to the market. In these spectrum poor markets, the ability to meet the coverage obligations depends crucially on obtaining the new spectrum. Where the costs of coverage and spectrum being assigned are closely linked, it becomes harder to separate the assignment of spectrum from the procurement of coverage.

A number of regulators have and are developing innovative approaches to procuring coverage and assigning spectrum. The Danish regulator is at the forefront of these developments. In a recent Danish auction, the operators were able to bid for unencumbered spectrum, but they could also bid for “coverage obligations” which

specified coverage requirements and a discount on the price paid for the spectrum in return for providing the coverage. The approach was implemented using a combinatorial clock auction (CCA) format. The downside is that the use of a CCA can result in a complex auction design and challenges for bidders in formulating a robust bidding strategy. In developing markets with limited experience of the use of auctions, a CCA may be deemed too complex.

Regulators in developing markets should use the simplest possible design for awarding spectrum

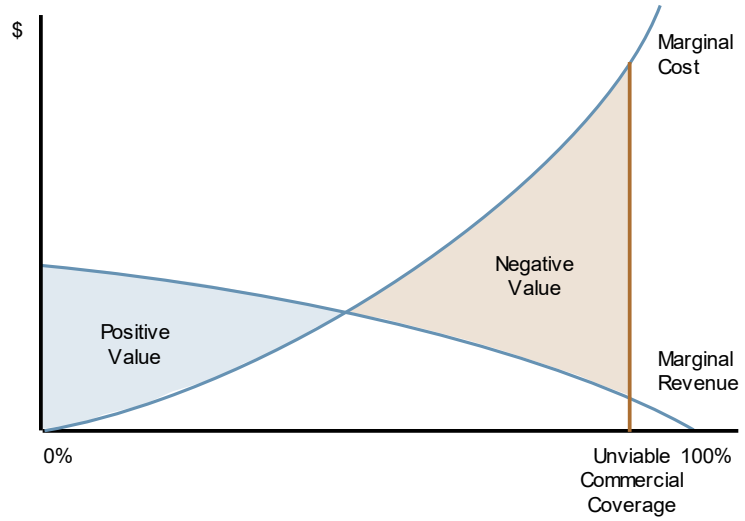
Alternative approaches have included auctioning "coverage obligations" and the winners of which received "bidder credits" which they could use to supplement their bids in the subsequent auction for spectrum. Ofcom consulted on an approach where bidders could participate in an initial "opt-in" round where they expressed their willingness to acquire spectrum with coverage obligations at the reserve price. If there was sufficient demand, then the lots would be auctioned with the coverage obligations but if demand was weak, then the coverage obligations would be dropped, and the spectrum would be auctioned unencumbered. Regulators in developing markets should seek the simplest possible approach due to the limited familiarity with auctions in some markets. An initial "opt-in" round prior to a standard auction could potentially be a viable model for developing markets.

Unviable commercial coverage obligations

Very high levels of population and geographic coverage can only be achieved through subsidy

When regulators strive to achieve close to 100% population or geographic coverage, the cost of meeting the obligation in remote areas can exceed the value created from covering the more densely populated locations. In this case, see Exhibit 5, the licence obligation is not commercially viable for even the largest operator acting in a monopoly capacity. A government can only achieve this level of coverage by subsidising the costs of expanding coverage.

Exhibit 5: Unviable commercial coverage



Source: Coleago

A number of potential models could be used to subsidise coverage. A reverse subsidy auction could be effective, where the winner is the operator or consortium of operators who accept the coverage obligation at the lowest subsidy.

Conclusions

Expanding mobile broadband coverage is an increasingly common regulatory policy objective. As coverage obligations become ever more demanding, the risks faced by the regulator increase and difficult choices between achieving competing policy goals must be addressed. Coverage obligations and the award process must be carefully

designed to maximise coverage whilst minimising the risks to other goals and avoiding undesirable unexpected consequences.

How Coleago can help

Coleago has worked extensively with mobile operators and so understands how they approach spectrum awards and coverage obligations. This understanding enables us to provide regulators with practical advice on how best to achieve their policy objectives. Coleago can support regulators throughout the assignment process including:

- interpreting policy goals and formulating appropriate licence conditions;
- estimating the value of spectrum to operators to inform spectrum pricing and reserve price decisions; and
- designing and implementing the award process or auction including managing the consultation process and drafting Information Memorandum.

About Coleago Consulting Ltd

Graham Friend, M.A., M.Phil., (Cantal), ACA, is an economist and the Managing Director and Founder of Coleago Consulting. Coleago is a specialist telecoms strategy consulting firm and advises regulators and operators on issues relating to spectrum, regulation and network strategy. If you would like to discuss any of the issues raised in this paper, then please contact Graham.

Email: graham.friend@coleago.com

Mobile: +41 798 551 354

