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By Mail

21 March 2017

Mr Ambrose Ho, SC, JP
Chairman
Communications Authority
20th Floor, Wu Chung House
213 Queens Road East
Wanchai
Hong Kong

Dear Mr Ho

Consultation on "Arrangements for the Frequency Spectrum in the 900 MHz and 1800 MHz Bands upon Expiry of the Existing Assignments for Public Mobile Telecommunications Services and the Spectrum Utilisation Fee"

We refer to the Consultation Paper dated 3 February 2016 and the Second Consultation Paper dated 14 February 2017 issued by the Communications Authority ("**CA**") and the Secretary for Commerce and Economic Development ("**SCED**").

Without prejudice to HKT's formal submissions to the Consultation Papers, we write to draw your urgent attention to highly relevant matters that the CA and SCED do not seem to have considered in the consultation process, properly or at all, in view of their notable absence in the two Consultation Papers.

The GSM Association ("**GSMA**") has recently published four reports on the subject of spectrum licensing which include detailed economic studies of the practices and experiences of mobile spectrum licensing and pricing around the globe, along with lessons and recommendations drawn from the studies:

1. "*Licensing to support the mobile broadband revolution*" issued by CEG for the GSMA, May 2012.
2. "*Best practice in spectrum licence renewals – A toolkit for licensing authorities*" issued by CEG for the GSMA, December 2014.
3. "*Best practice in mobile spectrum licensing*" issued by CEG for the GSMA, September 2016.
4. "*Effective Spectrum Pricing: Supporting better quality and more affordable mobile services*" issued by NERA Economic Consulting for the GSMA, February 2017.

It is surprising to note that the Consultation Papers make no mention of any of the GSMA reports cited above, when the GSMA represents the interests of mobile operators in over 220 countries and frequently publishes international market studies and best practices, guides and recommendations for the benefit of industry players and licensing authorities worldwide.
To highlight some of the key principles in the GSMA reports that are of particular relevance to a renewal of existing mobile spectrum licences:

(1) There is a strong case for presumption of renewal where spectrum is already in its best use, the market is effectively competitive and non-renewal would carry risks to investment and service continuity, as seen in advanced markets such as Canada and the US. Reasons for not renewing licences should be limited to spectrum replanning, where there is little risk of stranding substantial investments, or where there been a serious breach of licence conditions.

(2) Re-assigning spectrum or changing licence conditions to boost competition will only make sense where the market is not already effectively competitive. Alternatives such as releasing additional spectrum or lowering tax and other imposts on the industry may better enable all players to supply lower priced services to customers. It is expected that re-assignment of spectrum for competitive reasons would only be used in exceptional circumstances and only after a thorough assessment of the market and of potential alternative measures.

(3) Voluntary spectrum trading should be allowed to promote the efficient use of spectrum.

(4) Where the existing licence holders with established networks and customer bases would value the licence more than others, auctions can bring unnecessary costs and risk spectrum being assigned inefficiently. Licensing authorities should only decide to re-auction spectrum rights where there is a real chance that other operators could make better use of the spectrum than the current licensees.

(5) Indefinite licence terms should be introduced to provide sufficient certainty to support substantial new network investment.

(6) Charges for spectrum use should be limited to recovering the cost of spectrum management (e.g. administrative costs of the licensing process and associated regulatory costs) where a market-based licensing approach has been adopted.

(7) Licences should be technology and service neutral. Operators themselves are likely to be best placed to determine the speed of migration of services. Restrictions on use effectively create an artificial scarcity of spectrum.

(8) Licence conditions unrelated to avoiding interference should be removed or kept to a minimum.

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We enclose copies of the GSMA reports noted above for the CA and SCED's reference. To ensure that all relevant considerations are taken into account in the decision-making process of the CA and the SCED, we expect the views and recommendations of the GSMA to be properly reviewed, assessed and reflected in the ongoing consultation so that the public and local stakeholders may have an opportunity to provide their input on the same.

Yours faithfully,

Veronica Lockyer
Deputy Head of Group Regulatory Affairs

Encl.

c.c. Ms Eliza Lee – Director General, Office of the Communications Authority

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By Mail

21 March 2017

Mr Greg So, GBS, JP
Commerce and Economic Development Bureau
(Communications and Creative Industries Branch)
22/F West Wing, Central Government Offices
2 Tim Mei Avenue
Tamar
Hong Kong

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Yours faithfully,

Veronica Lockyer
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Arrangements for the Frequency Spectrum in the 900 MHz and 1800 MHz Bands upon Expiry of the Existing Assignments for Public Mobile Telecommunications Services and the Spectrum Utilisation Fee

Response to Second Consultation Paper

24 May 2017

INTRODUCTION

1. Hong Kong Telecommunications (HKT) Limited ("**HKT**") welcomes the opportunity to provide its response to the proposals put forward in the Second Consultation Paper on *Arrangements for the Frequency Spectrum in the 900 MHz and 1800 MHz Bands ("**900/1800 MHz Spectrum**") upon Expiry of the Existing Assignments for Public Mobile Telecommunications Services and the Spectrum Utilisation Fee* issued jointly by the Commerce and Economic Development Bureau and the Office of the Communications Authority on 14 February 2014 ("**Second Consultation Paper**").

2. The proposals contained in the Second Consultation Paper have been formulated by the Secretary for Commerce and Economic Development ("**SCED**") and the Communications Authority ("**CA**") after considering the comments received from the public and the industry in response to the first consultation paper issued on the subject on 3 February 2016 ("**First Consultation Paper**").

3. Before HKT addresses the specific questions raised in the Second Consultation Paper, it would like to comment on certain critical matters regarding the overall approach adopted by the SCED and the CA in this spectrum re-assignment exercise.

A Fundamental Change in Spectrum Management is Firstly Required

4. HKT is concerned with the overall approach which the SCED and CA have chosen to adopt in this spectrum re-assignment exercise. Rather than stepping back and asking themselves whether there are any major problems with regards to the underlying system for spectrum management which need to be addressed before they start dealing with the re-assignment of the 900/1800 MHz Spectrum, the SCED and CA have simply decided to blindly follow past practice and focus their attention on a very narrow set of issues pertaining to the mechanics of re-assigning spectrum.

5. In doing so, the SCED/CA have ignored the fundamental problems with regards to:

- The lack of spectrum supply in Hong Kong, and the tardiness in releasing fresh tranches of spectrum to service a rapidly growing demand for mobile data services. The CA's annual Spectrum Release Plans previously indicated that no new spectrum would be released for 2015-2017, 2016-2018 and 2017-2019. While the CA has recently indicated that it is "actively exploring" ways to make available additional spectrum in specific frequency bands, this is too little too late as compared to other countries and in view of the mobile data growth rate and scarcity of spectrum already being experienced in Hong Kong;
- The increasing number of cell sites that will be required by mobile operators to provide advanced mobile telecommunications services (5G) in the future, and the current difficulties they are facing in gaining access to such sites, including the high level of charges imposed by the site owners, which the CA has so far been unable to do anything about;
- The current charging basis for spectrum (per MHz) which is rapidly becoming costly and out-of-step with the advanced mobile telecommunications services that will be provided in the future (5G) whereby blocks of 100 MHz, rather than 20 MHz, of spectrum will be utilized;
- The problems brought about by taking back spectrum from existing spectrum holders at the end of a spectrum licence period and re-assigning the frequency bands from scratch via auction, in terms of service continuity, stranded investment costs, investment incentives and service innovation;
- The lack of a spectrum trading regime in Hong Kong which forces operators to wait (15 years) for the end of a spectrum licence period before they have an opportunity to acquire or dispose of spectrum, thereby harbouring possible inefficient use;
- The issuance of spectrum licences which are required to adopt specific technical standards. These quickly become out-of-date and result in the spectrum holder being prevented from making full use of the frequency bands as technology evolves.

6. These fundamental matters have been dealt with in more detail in HKT's paper on *Fit for the Future? Spectrum Options for Hong Kong* which is submitted concurrently with this consultation response. HKT's paper discusses aspects of the existing system of spectrum planning, allocation and charging which need to be resolved before the SCED/CA can sensibly embark on any specific exercise to deal with the re-assignment of spectrum, including the 900/1800 MHz Spectrum.

Best Practice in Spectrum Management

7. The GSM Association ("**GSMA**"), as an expert group of operators and other stakeholders[1], has published four reports on the subject of spectrum licensing which include detailed economic studies of the practices and experiences of mobile spectrum licensing and pricing around the globe, along with lessons and recommendations drawn from the studies:

- *Licensing to support the mobile broadband revolution* issued by CEG for the GSMA, May 2012.
- *Best practice in spectrum licence renewals – A toolkit for licensing authorities* issued by CEG for the GSMA, December 2014.
- *Best practice in mobile spectrum licensing* issued by CEG for the GSMA, September 2016.
- *Effective Spectrum Pricing: Supporting better quality and more affordable mobile services* issued by NERA Economic Consulting for the GSMA, February 2017.

8. It is surprising to note that neither the First Consultation Paper nor the Second Consultation Paper refer to the principles and analysis laid down in the GSMA reports cited above, when the GSMA frequently publishes international market studies and best practices, guides and

[1] To be clear, the GSMA not only represents the interests of mobile operators worldwide, but unites nearly 800 operators with almost 300 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organizations in adjacent industry sectors such as financial services, healthcare, media, transport and utilities.

recommendations for the benefit of industry players and licensing authorities worldwide.

9. The GSMA reports reference various key principles for best practice spectrum management that are of particular relevance to renewal of existing mobile spectrum licences:

- There is a strong presumption of renewal where spectrum is already being used efficiently, the market is competitive and non-renewal would carry risks to investment and service continuity. Reasons for not renewing licences should be limited to instances of clear market failure, where there is little risk of stranding substantial investments, or where there has been a serious breach of licence conditions.
- Re-assigning spectrum may make sense where the market is not already effectively competitive. It is expected that re-assignment of spectrum for competitive reasons would only be used in exceptional circumstances and only after a thorough assessment of the market and of potential alternative measures.
- Spectrum trading should be allowed to promote the efficient use of spectrum.
- Indefinite licence terms (e.g. per the UK) should be introduced to provide sufficient certainty to support and encourage substantial new network investment.
- Charges for spectrum use should be limited to recovering the cost of spectrum management (e.g. administrative costs of the licensing process and associated regulatory costs) where a market-based licensing approach has been adopted.
- Licences should be technology and service neutral. Operators themselves are likely to be best placed to determine the speed of migration of services. Restrictions on use effectively create an artificial scarcity of spectrum.
- Licence conditions generally should be kept to a minimum.

10. The above principles provide a fundamental roadmap for best practice spectrum management in developed markets. Hong Kong has

one of the most developed and competitive markets in the world. It is, therefore, surprising that there has been no reference to these principles. It is even more surprising that the CA is considering proposals that are directly at odds with these recommendations, including proposals to:

- withdraw the presumption of renewal and to auction spectrum that is already being used efficiently in a market that is extremely competitive and non-renewal would carry risks to investment, innovation and service continuity;
- attempt through an auction process to re-assign spectrum to (purportedly) boost competition despite the fact that the market is already effectively competitive and new entry is unlikely;
- impose licence conditions that prevent the withdrawal of specific technologies without prior CA approval (i.e. continued provision of 2G services), again despite the fact that the market is already effectively competitive and in disregard of the CA's hitherto technology neutral policy;
- ignore, or downplay alternatives such as releasing additional spectrum or lowering tax and other imposts on the industry to better enable all players to supply lower priced services to customers;
- use auctions to re-assign spectrum as a matter of course, despite the absence of any compelling competitive reasons, making it the norm rather than the exception, and without a thorough assessment of the market and of potential alternative measures;
- reject spectrum trading as a method to promote the efficient use of spectrum, simply on the presumed/assumed grounds that, in practice, no operator is likely to wish to dispose of spectrum when it is already in short supply;
- propose an auction which will bring unnecessary costs and risks spectrum being assigned inefficiently, without any certainty that other operators could make better use of the spectrum than the current licensees;

- reject the call for indefinite licence terms, which are necessary to provide sufficient certainty to support substantial new network investment and which, when coupled with spectrum trading, allow for a full market-based approach to spectrum management;
- introduce charges for spectrum use that are far in excess of what is necessary to recover the cost of spectrum management (e.g. administrative costs of the licensing process and associated regulatory costs) where a market-based licensing approach has purportedly been adopted in the Radio Spectrum Policy Framework[2] ("**RSPF**");
- Introduce charges for spectrum that are in reality a regressive tax on all users, reflect a desire to extract monopoly rents by the Government and enrich the Government coffers at the expense of over 17 million mobile subscribers[3]; and
- deviate from the policy of technology and service neutrality, to deliberately prolong provision of 2G services, ignoring the fact that operators themselves are likely to be best placed to determine the speed of migration of services, thereby effectively creating an artificial scarcity of spectrum (c.f. Singapore where the decision has been made to switch off 2G to allow the spectrum to be used for more valuable 4G and 5G services).

11. In short, the proposals being put forward in this consultation exercise breach almost every single best practice principle. More than that, it is becoming evident (from this and other recent spectrum renewal exercises, such as the recent **3G Spectrum Re-Assignment**[4] exercise) that the SCED and the CA prefer to adopt an outdated and inefficient command-and-control model, and do not trust market forces in spite of multiple pronouncements to the contrary.

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[2] Radio Spectrum Policy Framework issued by the (then) Commerce, Industry and Technology Bureau in April 2007.

[3] Per total Public Mobile Customers for February 2017 as reported in *Key Statistics for Telecommunications in Hong Kong – Wireless Services* issued by OFCA.

[4] Arrangements for the Frequency Spectrum in the 1.9 – 2.2 GHz Band upon Expiry of the Existing Frequency Assignments for the Provision of 3G Mobile Services and the Spectrum Utilisation Fee.

12. Rather than allowing the spectrum to be renewed and then letting licensees compete to the benefit of users, it is clear that the SCED and CA favour a model where limited licence terms are used so that, at the end of each licence term, the SCED and CA can withdraw all or part of the spectrum from the market to then sell back in at exceedingly high prices, attaching conditions that are inconsistent with market forces to compel outcomes that they, as the central planner, see as desirable.

13. Specifically, this allows the SCED and the CA to re-auction spectrum and to capture monopoly and "hold-up" rents from the industry as operators are forced to pay exceedingly high prices to try to retain their spectrum to protect investments they had made, and to keep providing services to their customers. No doubt, this is helping to line the Government's coffers (which are already over-flowing), but it is also driving up costs for consumers and depriving Hong Kong of investment in cutting edge telecommunications services and innovation that are essential to maintaining Hong Kong as a leading financial and technology centre.

14. Not only is this preference for command-and-control planning in spectrum management inconsistent with the market-based approach mandated in the RSPF, it is also in breach of Article 5 of the Basic Law. It is not permissible, as a matter of constitutional law, for policy-makers in Hong Kong to abandon market principles without clear and convincing proof that the market "does not work" and to turn to central planning. But that is entirely the direction that the SCED and the CA have followed.

Radio Spectrum Policy Framework

15. In formulating the proposals as to how the 900/1800 MHz Spectrum is to be re-assigned, the CA is guided by the principles expounded in the RSPF.

16. The RSPF stipulates that a "market-based approach" in spectrum management will be used for spectrum wherever the CA considers that there are likely to be "competing demands" from providers of non-

government services, unless there are overriding public policy reasons to do otherwise.[5]

17. The RSPF was intended to reflect best practice in spectrum management. Not surprisingly, therefore, the principles laid down in the RSPF are consistent with the GSMA recommendations on best practice in spectrum management. However, there is little in the Second Consultation Paper that is consistent with the RSPF. This is explained below.

Market-based approach

18. HKT is concerned that the CA appears to be proceeding with this consultation with misconceptions as to what is a "market-based" approach. There are two aspects to this concern. First, an apparent assumption that auctioning the relevant spectrum is the only option that is consistent with a market-based approach. Secondly, and related to the first concern, that the CA fails to distinguish between two fundamentally different scenarios: the first, when one is considering what might be the appropriate market-based approach when dealing with spectrum that has not previously been deployed into the market; and, the second, the appropriate market-based approach when one is dealing with spectrum that has already been allocated and is in use.

19. The RSPF does not define what is meant by a "market-based" approach. At its most general level, a market-based approach is one in which the market makes decisions about spectrum allocation, rather than use of a command-and-control style model that is more akin to central planning. Importantly, this means that the market, not the Government, makes the decisions.

20. A market-based approach is the opposite of a command-and-control approach. In a market-based approach, the market decides (subject to competition and consumer protection laws, interference rules, etc.). Under such an approach, licences would be of indefinite duration, or an expectation of renewal would exist. Spectrum trading and liberalization of use would also exist. Spectrum charges would be

[5] Paragraph 3.1 of the RSPF.

levied to simply cover administration costs, and licences would be technology neutral. New spectrum releases would be auctioned.

21. On the other hand, under a command-and-control approach, the Government would, as the monopoly holder of spectrum, heavily regulate the market and not allow any competing ways to access or re-allocate spectrum. Spectrum licences would be relatively short (e.g. 12 or 15 years). All spectrum, both new releases and renewal, would be subject to auction. Spectrum trading and liberalization of use would not be permitted. The Government would be the monopoly supplier of spectrum at all times. Monopoly rents would be charged for spectrum. Revenue maximization rather than consumer benefits would be a key principle.

22. The cornerstone of markets is: (i) the recognition of contractual rights, both in the capital and other resources that are necessary to deliver a particular good or service; (ii) a system of contract law that facilitates trade in that property; and (iii) certainty as to the continuity of the system that recognizes both the investments made by operators and contractual entitlements to trade. The problem when dealing with contractual rights (such as a right to use spectrum) is that there is necessarily some uncertainty as to whether the contractual entitlement or right that is created by the spectrum licence will be recognized at expiry of the current term. Where there is uncertainty about this, the incentive to invest to maximize use of the contractual right created by the licence is reduced.

23. To give a very simple example, people who lease property need to make a decision whether to invest capital to develop the leased property. If the lessee anticipates that it will be able to renew the lease at the expiry of the initial lease term, the lessee would be incentivized to invest capital to develop the leased property, whether it be to develop infrastructure or to otherwise make efficient use of the land. The certainty that comes from an expectation of renewal allows the market to operate most efficiently. Without that certainty, people would not be prepared to make the investments that they have made. There is then a secondary market for trading that allows the continued efficient allocation and use of properties, consistent with the above presumptions and expectations.

24. There is also the concern about stranded investments. Again, to give a very simple example, if someone had a lease over a commercial premises used for, for example, electricity generation and had made substantial investments that needed to be recovered over a long investment cycle (usually 50 years or more in that industry), uncertainty as to a full renewal of the lease would result in less investment which, in turn, would lead to quality and continuity issues. In addition, early termination of the licence could see a substantial proportion of the investment stranded and lost. The market can only operate efficiently to the benefit of consumers in such circumstances where people have a degree of certainty over an expectation of continuity.

25. Telecommunications is no different. Telecommunications companies obtain licences and pay fees to use spectrum. They then invest significant sums of money to build and continually update infrastructure that allows them to provide services, in this case, mobile telecommunications services for the people of Hong Kong. If there is uncertainty about the ability to continue using spectrum, this impacts on incentives to invest and innovate. Holders of the spectrum necessarily need to weigh the prospect of being able to retain the spectrum and the ability that they have to make a return on any investment that might be made to support the spectrum. It also impacts on the ability to continue providing services of an acceptable quality to consumers.

26. The CA has suggested in the Second Consultation Paper that if new parties enter the market, this will itself generate investment. However, this is misconceived. The incumbent mobile operators have invested significant sums to build out infrastructure to make use of their existing spectrum holdings. If they lose that spectrum and someone else is granted a licence, that person needs to then build new infrastructure to support the use of the spectrum, but this is not efficient investment. The old infrastructure becomes useless because the owner has been deprived of the licence to operate it. Money is then wasted building new infrastructure, where the old infrastructure was perfectly satisfactory and any new investment could have been put into further improving the existing infrastructure. Furthermore, users are potentially deprived of the current levels of service that they enjoy while they wait for the operators to adjust to the reshuffling of spectrum. Anyone in the

business of providing mobile services then realizes that there is inherent uncertainty about the use of the spectrum in the long-term. The incentive to invest in high grade infrastructure and to provide innovative services is accordingly reduced.[6]

27. It is for all of these reasons that leading regulatory bodies and the GSMA recommend that there be an expectation of renewal for spectrum licences or, as some countries have done, perpetual licences. The certainty that this provides to holders of radio spectrum encourages maximum investment and innovation while minimizing the potential for service disruption and stranded investment costs. This also maximizes benefits to users.

28. Linked to this, spectrum trading is an obvious form of market-based reallocation of spectrum, which allows market forces to flexibly determine the allocation of spectrum. With spectrum trading, operators are free to decide if and when they might seek to trade spectrum holdings. There is no need to wait three or four years until the end of the current spectrum licence period to obtain new spectrum. Spectrum can be traded immediately. Market forces, not the Government, ensure the efficient allocation of spectrum.

29. If the CA is considering release of new spectrum, different criteria may be applied. In such cases, there has been no investment to facilitate the use of the spectrum and an auction does not pose the same risks of undermining investment incentives, stranding costs or harming users.

30. The CA appears to be failing to distinguish between the scenario in which spectrum has already been deployed and is in use, and a first release of spectrum. In the scenario where spectrum is already in use, the market needs certainty that the significant investments that have been built up around the use of that spectrum will not suddenly be rendered worthless (save perhaps in the most exceptional circumstances

[6] An example of wasteful and inefficient use of spectrum is where a new entrant/licensee obtains spectrum and then does not provide any, or just a minimal level of, service. In any event, even the CA has conceded that the prospect of new facilities-based entry is minimal.

identified by other regulators and the GSMA). An auction would not, in such circumstances, be consistent with a market-based approach. In the case of a new spectrum release, an auction may be an appropriate way to determine who, at that point, values the spectrum most and could be an appropriate way to release the spectrum to the market.

Competing demand

31. The existence of competing demand is a threshold requirement of the RSPF to move from an administrative to a market-based spectrum allocation approach.

32. The CA has said in the First Consultation Paper that there are likely to be competing demands for the 900/1800 MHz Spectrum from the mobile operators and potential new entrants upon expiry of the existing assignments. This simple statement from the CA, however, is not sufficient to justify there being "competing demand". More concrete evidence and analysis should be provided by the CA that new entry will occur or that existing service providers will, in sum, want more spectrum than they currently have in these frequency bands at the proposed prices. In short, the CA needs to prove that the actual demand for this spectrum exceeds its supply.

Full cost/benefit analysis

33. For the record, and without prejudice to any of the other points made, or to be made, in HKT's consultation response, HKT wishes to note that:

- HKT and the other incumbent users of the 900/1800 MHz Spectrum have a legitimate expectation under the RSPF that there would be no re-farming or re-auctioning of the spectrum without the CA first conducting an appraisal of the various options being considered which would allow the costs and benefits of each to be weighed one against the other as a *"firm and transparent basis"* for the SCED/CA's eventual decision.
- It is clear from the terms of the Second Consultation Paper itself that such an appraisal has not yet been carried out. The Second Consultation Paper's assessment of the relative costs and benefits

of the three Options consists of little more than a recognition of uncertainty and bare assertions.

- HKT considers itself and the other incumbent spectrum holders entitled to an appraisal under the terms of the RSPF; and
- Any re-auctioning of the spectrum in the absence of such an appraisal being conducted as required by the RSPF would, in HKT's view, be unlawful.

Legitimate expectation of spectrum renewal

34. While an incumbent spectrum holder may not always have a black-and-white legal right to expect its spectrum to be renewed in all circumstances, there is a legitimate expectation that the right to use spectrum will not be terminated at the end of the licence period unless there are exceptional circumstances, e.g. it has been using the spectrum inefficiently, it has seriously infringed its licence. Indeed, this was the approach adopted when the **2G Spectrum** was renewed in 2005-06.[7] It is important to point out that the 2G Spectrum that was renewed in 2005-06 is precisely the same spectrum that is being considered under the present consultation exercise, i.e. the 900/1800 MHz Spectrum.

35. Given the large sums invested in mobile telecommunications networks, it would be wasteful if spectrum were taken away from an operator at the end of the (15 year) licence period. This creates uncertainty and is not conducive to the creation of a stable investment environment which is needed for the telecommunications industry which has long lead times to recoup investments.

36. An expectation of renewal is consistent with global best practices. Only where the spectrum relates to a fresh release of spectrum should it be subject to auction in order to determine how it is to be assigned. Re-auctioning spectrum at the end of a licence period should only be confined to exceptional circumstances where competition issues arise, where the spectrum has not been efficiently used by the operator, or

[7] See Statement of the Telecommunications Authority issued on 29 November 2004 on *Licensing of Mobile Services on Expiry of Existing Licences for Second Generation Mobile Services*.

where the operator has infringed its licence[8]. This approach is consistent with the recommendations made by the GSMA regarding the licensing framework required to support the development of mobile broadband services.

37. Renewal of the existing assignment of spectrum per Option 1, coupled with spectrum trading, would be wholly consistent with the spectrum management principles outlined in the RSPF.

Response to Second Consultation Paper

38. Without prejudice to HKT's submission that the SCED/CA should firstly address the defects regarding the existing system of spectrum planning, allocation and charging before embarking on any spectrum re-assignment exercise, including the 900/1800 MHz Spectrum, in the rest of this paper, HKT responds to the detailed questions raised in the Second Consultation Paper.

[8] Incidentally, these are also among the conditions under which the CA may withdraw the assignment of spectrum to a particular licensee before the term of the licence period has expired. See Special Condition ("**SC**") 21 in the Unified Carrier Licence ("**UCL**").

SPECTRUM RE-ASSIGNMENT OPTION THAT BEST MEETS THE MULTIPLE OBJECTIVES IN SPECTRUM ASSIGNMENT

39. *After considering the submissions received in response to the First Consultation Paper, the CA has proposed going forward with Option 3, whereby:*

- *2 x 10 MHz of spectrum in the 1800 MHz band will be offered to each incumbent spectrum holder of a Right-of-First-Refusal basis ("**RFR Spectrum**"), making a total of 2 x 40 MHz (= 80 MHz) of spectrum in the 1800 MHz band being offered on a Right-of-First-Refusal basis; and*
- *The remaining spectrum in the 1800 MHz band (i.e. 2 x 35 MHz = 70 MHz) and any spectrum not taken up by the mobile operators on a Right-of-First-Refusal basis, plus all of the 900 MHz band (i.e. 2 x 25 MHz = 50 MHz), will be put out for auction ("**Auctioned Spectrum**"), making a total of at least 2 x 60 MHz (= 120 MHz) of spectrum being available for auction.*

40. *Accordingly, the CA proposes that 80 MHz of the total amount of spectrum (200 MHz), i.e. just 40% of the available spectrum be made available on a Right-of-First-Refusal basis. Despite this spectrum being more critical to the future development of 4G and 5G mobile services, the amount of spectrum being offered to the incumbent spectrum holders on a Right-of-First-Refusal basis is significantly less than the two-thirds (67%) that was offered to the incumbent spectrum holders under the 3G Spectrum Re-Assignment exercise.*

Question 1: What are your views on the proposals of the CA to adopt the hybrid administratively-assigned cum market-based approach for the Re-assignment of the 900/1800 MHz Spectrum, by re-assigning 2 x 10 MHz of spectrum in the 1800 MHz band to each of the incumbent spectrum assignees through the offer of a right of first refusal, based on the overriding public policy reasons of safeguarding the provision of 4G services in the Remaining MTR Stations, and ensuring territory-wide continuity of 2G services if

demands exist post 2020/21, and re-assigning the rest of the 900/1800 MHz Spectrum by way of auction?

41. The analysis undertaken by the CA in reaching a conclusion to move forward with Option 3 is flawed. Upon a full and fair analysis, Option 1 (renewal to the incumbents, who are continuing to make efficient use of the spectrum) is the option[9] that best meets the multiple objectives cited in the First Consultation Paper:

- Ensuring customer service continuity;
- Efficient spectrum utilization;
- Promotion of effective competition; and
- Encouragement of investment and promotion of innovative services.

42. Re-auctioning spectrum either partially (under Option 3) or fully (under Option 2) does little to achieve the above objectives.

Ensuring Customer Service Continuity

43. It has generally been accepted by the CA, other regulators and industry observers that service continuity is an extremely important consideration. It has also been accepted by the CA, other regulators and industry observers that service continuity is best achieved by allowing the mobile operators to continue employing their assigned spectrum. Indeed, the CA recognized this in the 3G Spectrum Re-Assignment exercise:

> *From the perspective of simply maintaining service continuity, the CA accepts that Option 1, through a perpetuation of the existing 3G Spectrum*

[9] In fact, Option 1 was supported by the majority of parties who made submissions in response to the First Consultation Paper. The large number of submissions received was highlighted by OFCA following comments that the First Consultation Paper was not well publicized. Consistent with that, OFCA should take heed of the overwhelming support for Option 1

> *assignments, has the advantage of maintaining more or less a seamless transition and hence service continuity.*[10]

44. In order to assess the impact on service quality arising from the 900/1800 MHz Spectrum being re-assigned amongst the four incumbent spectrum holders, the CA engaged a consultant, Plum Consulting ("**Plum**"), to conduct a technical study.

45. According to the study conducted by Plum, there will be no service disruption to mobile services overall in the event that any of the ten selected possible spectrum re-assignment scenarios occur. For some of the scenarios modeled, Plum indicated that certain mobile operators may experience slight service degradation.

46. Critically, Plum's conclusion seems to be based on a series of assumptions as to the traffic growth, technical developments, mitigation steps that operators might deploy, and the more efficient use of other spectrum held by the operators.

47. HKT would first note that much of the report produced by Plum[11] ("**Plum Report**") has been heavily redacted before being released by OFCA for review. HKT's ensuing comments can therefore only be based on a limited review of the Plum Report. Since the SCED/CA's latest proposal to adopt Option 3 is based on the results of the Plum Report, HKT considers that it has been significantly hindered in its ability to provide comments in response to the Second Consultation Paper given that HKT does not have full visibility of all the relevant matters covered by the Second Consultation Paper. OFCA has refused HKT's request for an unredacted version of the Plum Report for review.

Traffic forecasts

48. Plum's study is based on a mobile traffic forecast which appears to be too conservative compared to worldwide projections made by Cisco,

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[10] See paragraph 28 of the Statement of the CA and the SCED on 15 November 2013 regarding the 3G Spectrum Re-Assignment exercise.

[11] *Technical Study in relation to the Re-assignment of Spectrum in the 900 MHz and 1800 MHz Bands upon Expiry of the Existing Assignments*, issued by Plum in September 2016.

who produces such forecasts on a rolling annual basis. Cisco's forecasts are generally seen to be the most reliable in the industry and are routinely referenced by operators, regulators, the ITU and other stakeholders.

49. Per the Plum Report, Plum has adopted average annual mobile data traffic growth of 26% between 2016 and 2023. This is very low compared to the growth rates forecast by Cisco (from 2016 to 2021)[12] for countries in the Asia Pacific region such as China (56%), Japan (33%) and Korea (37%). In fact, while Cisco regards growth rates of 33% (Japan) and 37% (Korea) as being on the high side for the purposes of its sensitivity analysis.[13]

50. Plum correctly points out in section 3.4.2 of the Plum Report that Cisco does not provide a dedicated forecast for Hong Kong. However, upon enquiry with Cisco, HKT has been advised that Hong Kong has been included in the "rest of Asia Pacific" which, per the Cisco VNI, shows an average annual mobile data traffic growth rate of 51%. This is essentially twice the growth rate assumed by Plum.

51. All of this suggests that Plum has substantially under-estimated the mobile data traffic growth for Hong Kong, and that it may be more appropriate to adopt Cisco's "rest of Asia Pacific" traffic growth rates as the "base case" for Hong Kong. The traffic growth rates for Japan and Korea would then be properly treated as the low end in Plum's sensitivity analysis.

52. Since the traffic forecast is key to determining whether or not mobile operators have sufficient spectrum to continue an uninterrupted supply of mobile services, any conservative traffic forecast will naturally lead to the wrong results being produced from Plum's model.

53. Plum's suppressed traffic forecast is made even more evident in the light of a recent press release issued by the CA regarding its plans to make more spectrum available in Hong Kong to "meet the demand of

[12] *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016-2021*, published on 7 February 2017 ("**Cisco VNI**").

[13] See Table A-5 in Appendix A of the Plum Report.

public mobile services towards 2020 and beyond".[14] In this press release, the CA confirms that there is continued high demand from the industry for more spectrum:

> *In face of the incessant demand for spectrum for the provision of 3G and 4G services, and to better prepare Hong Kong for the launch of 5G services in around 2020, the CA is actively exploring ways to make available additional spectrum […]*

54. Plum's view is also at odds with the ITU's assessment that, by 2020, a total of 1340-1960 MHz of spectrum will be needed by each country to provide the required mobile services.[15] The current amount of spectrum allocated to the mobile industry in Hong Kong (552 MHz) falls far short of the figure quoted by the ITU. Indeed, many countries fall short of the ITU target[16], but they recognize the need to release more spectrum to cater for the growing demand for mobile data services, e.g. The UK Government (via the spectrum Central Management Unit) announced plans in the March 2016 budget to release to the mobile industry 750 MHz of spectrum in the bands under 10 GHz by 2022, of which 500 MHz will be available by 2020.[17]

55. Such statements made by the CA, as well as pronouncements by the ITU and actions taken by overseas jurisdictions, seem to be wholly inconsistent with the picture painted by Plum that there is sufficient spectrum to satisfy the demand for mobile data services from now up to 2023:

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[14] See press release issued on the CA's website on 21 March 2017 regarding: *The Communication Authority's Work Plan for Making Available Additional Radio Spectrum to Meet the Demand of Public Mobile Services Towards 2020 and Beyond* ("**CA Press Release**")

[15] See Report ITU-R M.2290-0 issued by the Radiocommunication Sector of the ITU in December 2013 on *Future spectrum requirements estimate for terrestrial IMT*.

[16] See report issued by Analysys Mason in November 2015 regarding *Assessment of spectrum-related support for take-up and usage of mobile broadband services in GCC and other countries.*

[17] See UK Government Investments, *Enabling UK growth: Public Sector Spectrum Release Programme annual report* issued in April 2016.

For all MNOs as a whole, the Study shows that there is sufficient network capacity to accommodate all traffic demands in all scenarios, both territory wide network and in high traffic areas.[18]

56. Global best practices and common sense require that Plum allow for the very real possibility of mobile data traffic in Hong Kong reaching the levels forecast by Cisco. Accordingly, HKT would suggest that, as a minimum, Plum should adopt a traffic growth forecast for Hong Kong which is on par with that used by Cisco for "rest of Asia Pacific".

57. Unfortunately, Plum has failed to do this in its model, which is precisely why HKT finds the results of the Plum study incomplete and unscientific, and struggles to see how the outcome can be relied upon by the CA.

Technological evolution

58. One of the assumptions adopted by Plum in its model is that technological advances will enable more traffic to be accommodated using the same amount of spectrum. In section 3.5.2 of the Plum Report, Plum states:

Technology evolution is considered from two perspectives:

- *[…]*
- *The increase in average spectrum efficiency for 4G equipment over time taking into account the evolution of advanced mobile technologies such as Multi-input Multi-output (MIMO). In the period considered by the assessment model this is assumed to increase from 1.3 to 1.6 bits/sec/Hz (2016 to 2023).*

59. Here, Plum appears to be guessing as to the evolution of certain technologies and has made no real attempt to apply these crude assumptions to the unique urban and crowded environment in Hong Kong that constantly poses very unique operational challenges to mobile operators.

60. In short, there are serious limitations when applying Plum's assumptions to the Hong Kong context. Plum appears to suggest that higher 4G data rates can be achieved with the use of higher order

[18] Section S.3.1 of the Plum Report.

modulation and/or the substantial deployment of higher order MIMO (4x4 and above). However, to achieve higher modulation, the user must be close to the base station which, in Hong Kong, is fairly difficult given that many base stations are situated high up on rooftops. In addition, for indoor antenna systems such as those adopted in the MTR and shopping malls, not many of these can practically be upgraded to support MIMO. Accordingly, Plum's analysis as to the Hong Kong specific context is flawed.

Mitigation measures

61. Plum recognizes that, under certain scenarios modeled, some operators may experience service degradation, but suggests that there are mitigation measures that can be adopted to cope with this problem. These measures include: increasing the number of 4G sectors and WiFi offload. However, neither of these can practically be implemented in Hong Kong.

62. Firstly, there are physical limitations as to the number of cells that can be installed in a particular area given the dense topography of the Hong Kong urban landscape. To the extent possible and practicable, Hong Kong operators have already increased their number of cell sites and sectors. Hence, the number of 4G sectors cannot be increased without limit.

63. Secondly, WiFi also makes use of certain spectrum bands, which could be exhausted if all mobile operators elect to offload their mobile services onto WiFi and, in any case, given the lack of mobility associated with the use of WiFi services, WiFi is not really a viable alternative to mobile services. Given the very slow pick up of WiFi services (as an offload to normal mobile usage) in Hong Kong so far, and the fact that there has been no major enhancement for WiFi offload and small cells in recent 3GPP specifications, it is very difficult to see there being any possible acceleration in the deployment of WiFi offload in Hong Kong as a solution to the shortage of spectrum over the coming years.

RFR Spectrum

64. It is wrong to suggest that even if the incumbent spectrum holders are unable to retain any of their right to use spectrum through auction

they can still rely on the spectrum they hold in other bands (850/900 MHz, 1.9-2.2 GHz, 2.3 GHz and 2.5/2.6 GHz) to continue the provision of 3G and 4G services. This implies that operators have excess capacity or use their spectrum inefficiently, and is simply incorrect. Plum provides no analysis or data for such a claim. Indeed, in view of the: (a) traffic demand; (b) lack of spectrum; (c) investments made by operators; and (d) services offered, this assertion by Plum cannot be given any weight.

65. The extent to which an operator can continue to maintain the same level of service depends on the amount of spectrum held by that operator and the number of customers it is currently serving. HKT has the largest number of customers and hence requires more spectrum than the other mobile operators. Losing all of its current 900/1800 MHz spectrum holding would therefore, under any analysis, have a significant impact on HKT's service quality.

66. As the CA has stated in the Second Consultation Paper:

> *[…] the amount of the RFR Spectrum should be no more than what is required to meet the need for which a public policy reason has been identified in the particular exercise to justify deviation from the market-based approach in spectrum re-assignment as required under the Spectrum Policy Framework. Hence, the amount of RFR Spectrum, which may be offered as part of any re-assignment arrangement, will have to be justified by and be dependent on the specific facts and circumstances of each case.*
>
> *Given the analysis under the section on "Ensuring Customer Service Continuity" above, the CA's offer of the RFR Spectrum to MNOs in the current re-assignment exercise is intended primarily to safeguard the 4G service continuity for all MNOs in the Remaining MTR Stations on the one hand and to support the continue provision of 2G services on the other.*[19]

67. In other words, the whole point of granting RFR Spectrum, in this instance, is to ensure that each of the incumbent spectrum holders can continue to provide the same level of 4G mobile service in the Remaining MTR Stations and to provide 2G mobile services.

68. On this basis, should Option 3 be adopted (as proposed in the Second Consultation Paper), the amount of RFR Spectrum granted to

[19] Paragraphs 58 and 59 in the Second Consultation Paper.

HKT, as the mobile operator with the largest number of customers, needs to be more than the other incumbent spectrum holders. That is, the amount of RFR Spectrum offered to each incumbent spectrum holder should be computed according to the number of customers, including wholesale Mobile Virtual Network Operator ("**MVNO**") customers served by that operator. Only on this basis can the envisioned service quality be maintained. The proposed 2 x 10 MHz of RFR Spectrum to be offered to HKT (the same as each of the other incumbent spectrum holders) is woefully inadequate.

69. If HKT does not obtain sufficient RFR Spectrum the quality of its 4G mobile services in the Remaining MTR Stations (and to a lesser extent, its 2G services) will suffer as it needs more spectrum than the other operators to continue serving its customers. In short, retail customers will be adversely affected and MVNO services may need to be curtailed.

Efficient Spectrum Utilization

70. In the Second Consultation Paper, the CA justifies going forward with Option 3 on the basis that it permits more efficient utilization of the spectrum:

> *The CA is of the view that by adopting either the full-fledged market-based approach under Option 2 or the hybrid approach under Option 3 with all or a majority of the spectrum under re-assignment put to auction, MNOs will be given an opportunity to review their existing spectrum holdings across different frequency bands, their deployment and their network setup, and to acquire from the auction the amount of spectrum they actually need to fulfil their own business plans. A perpetual assignment of spectrum as envisaged under Option 1 does not afford MNOs any such opportunity.*[20]

71. It is wrong to characterize Option 1 as a perpetual assignment of spectrum which hinders an operator's ability to periodically review its existing spectrum holding and assess whether it needs to make adjustments, or permits an operator to hog spectrum which it is not using efficiently.

[20] Paragraph 51 of the Second Consultation Paper.

72. Firstly, under Option 1, spectrum is still being assigned for a predefined period (15 years) each time – it is not a perpetual assignment - thus operators continue to have the opportunity to assess their spectrum holding at the end of each period.

73. Secondly, the CA has the power, under SC 21 of the UCL, to take back spectrum from the licensee under limited circumstances.

74. Thirdly, spectrum trading is an actual market-based approach that continually allows mobile operators to review their holdings and react accordingly.

75. The CA is also misguided when it suggests that auctioning the spectrum, and permitting new entrants to take up spectrum, will ensure that the frequency bands are used efficiently:

> *[…] any new entrant acquiring some of the 900/1800 MHz Spectrum from the auction is likely to make efficient use of the spectrum to provide new services to consumers.*[21]

76. There is no factual basis for the above statement. Past experience does not support the CA's proposition. 21 ViaNet Group Limited's ("**21 ViaNet's**") use of the 2.3 GHz band for fixed-wireless services and focusing on serving remote villages can hardly be said to be an efficient utilization of spectrum when there is a shortage of spectrum in the mobile services industry and demand for mobile data services continues to grow in leaps and bounds.

77. In fact, it is scandalous that the CA has permitted 21 ViaNet to get off so easily; firstly, in allowing 21 ViaNet to change its use of the spectrum to provide less valuable fixed-wireless services (in the face of a dire shortage of spectrum for mobile services); secondly, in permitting 21 ViaNet to shrink its network/service coverage obligations to serve a minority sector of the population (village houses); and then thirdly, in failing to disclose its full assessment of 21 ViaNet's application which led

[21] Paragraph 81 of the Second Consultation Paper.

to the decision it made.[22] Clearly, as this example demonstrates, more efficient utilization of spectrum is not necessarily guaranteed by the entry of new players (or indeed, players with deep pockets).

78. Importantly, the CA has not conducted a detailed cost/benefit analysis in any event and so its views on the potential for new entry, and the possibility of any new entrant improving on the already highly competitive state of competition in the market at present, is just unsubstantiated speculation.

79. The CA further suggests that only Option 2 and Option 3 would enable the current problem regarding spectrum fragmentation in the 900/1800 MHz band to be resolved, and hence Option 1 must result in inefficient use of spectrum. The CA fails to understand how the problem could just as easily be fixed under Option 1:

> *The CA does not agree with HKT's argument that elimination of spectrum fragmentation could also be achieved even under Option 1, which is no more than a perpetual re-assignment of the currently fragmented 900/1800 MHz Spectrum.*[23]

80. To be clear, HKT is not advocating a simple re-assignment of the existing spectrum blocks (as is) to the incumbent spectrum holders. In order to resolve the spectrum fragmentation problem, the CA could just as easily consolidate the current fragmented frequency blocks into contiguous blocks before re-assigning back to the relevant mobile operator, with the result that each operator holds the same amount of spectrum as before, but now in contiguous consolidated blocks which are easier to manage. This would be both easy to accomplish and non-controversial. Also, HKT again notes the CA's characterization of Option 1 as a "perpetual re-assignment" of the spectrum which, as explained earlier, is not correct.

81. In any case, due to the competitive nature of the market in Hong Kong, and the growing mobile data traffic, spectrum is already efficiently

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[22] The case of *The 21 ViaNet Disgrace* and how the CA's policy has failed is discussed at length in Appendix E to the submission made by HKT in response to the First Consultation Paper.

[23] Paragraph 52 of the Second Consultation Paper.

used by the operators. However, again, the CA has not even sought to analyse this in a proper cost/benefit analysis, as is required under the RSPF.

Promotion of Effective Competition

82. The CA suggests that because Option 1 maintains the status quo, it does not permit new entrants into the market and therefore there cannot be any stimulation to competition in the local mobile telecommunications market. This is clearly wrong.

83. Firstly, as has been repeatedly recognized by the CA and other observers, the Hong Kong mobile market is hyper-competitive.

84. Secondly, spectrum trading (which is always available) is a more efficient and market-based approach to facilitate entry. Very periodic or occasional auctions by a monopoly spectrum holder (i.e. the Government) does not, in comparison, facilitate entry.

85. Thirdly, it is pure speculation to suggest that a spectrum auction would spur new entry or competition. Hong Kong's own experience contradicts the CA's linkage of spectrum auctions to new market entry and competition.

86. In this regard, let us again take the sad case of 21 ViaNet. Its entrance into the Hong Kong market has done little to stimulate competition as it is serving remote villages via the provision of a fixed-wireless service where there are few customers, low returns and competition is slim. The benefit brought about by 21 ViaNet to the Hong Kong economy is clearly minimal. If the spectrum had been acquired by an existing mobile operator it would be used more efficiently.[24]

87. On the contrary, the case of Hong Kong Broadband Network Limited ("**HKBN**") shows that successful new entry is possible without the re-auctioning of spectrum or any change in existing spectrum

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[24] In fact, if spectrum trading were already implemented in Hong Kong, the spectrum operated by 21 ViaNet could easily have been transferred to a mobile operator and put to much better use in the market. Unfortunately, this option is not yet available to 21 ViaNet.

holdings. HKBN entered the mobile market recently in the form of an MVNO, and competes aggressively with the existing mobile operators. In fact, this type of new entry was envisaged by the CA back in 2005-06 when it was dealing with the renewal of the 2G Spectrum:

> *The present regulatory framework is designed to encourage and facilitate interested parties to invest in telecommunications infrastructure and the provision of telecommunications services. There being no foreign ownership restrictions in Hong Kong, interested parties who wish to enter the market are free to invest through merger and acquisition. They may also apply for the Mobile Virtual Network Operator licence to provide their own services.*[25]

88. It has been explained above why, in Hong Kong, re-auctioning spectrum to permit new entrants into the market is inconsistent with a market-based approach except in the most exceptional circumstances. Even if there were some evidence that the spectrum was currently being used inefficiently by one or more of the incumbents (which there is not), new entry does not necessarily stimulate competition in an already competitive market.

Encouragement of Investment and Promotion of Innovative Services

89. In the Second Consultation Paper, in supporting Option 3, the CA attempts to justify the need for new entrants in order to stimulate investment and promote the development of innovative services:

> *If part of the re-assigned spectrum is taken up by new entrants, they will need to make investment to build the networks from scratch and put the spectrum to use in a timely manner. Besides, new entrants may also be potentially more innovative and act as the maverick in their business offerings in order to make early inroads into the keenly competitive mobile telecommunications market.*[26]

90. Firstly, the presumption or assumption in regards to new entry is highly speculative. Hong Kong is a small and highly competitive market, and recent attempts to enter the market by new mobile operators have failed.

[25] Paragraph 14 of *Licensing of Mobile Services on Expiry of Existing Licences for Second Generation Mobile Services – Analysis of Comments Received, Preliminary Conclusions and Further Consultation* issued on 19 March 2004.

[26] Paragraph 56 of the Second Consultation Paper.

91. Further, it is misleading to suggest that assigning a portion of the right to use the spectrum to new entrants will result in overall increased investment as new operators will be required to build networks from scratch, while existing operators will be required to pay “hold-up rents” to try to retain existing spectrum holdings and continue investing in order to stay competitive. On the contrary, if spectrum is taken up by new entrants, part of the investment which has already been made by the existing operators (especially the operator which has lost spectrum) will simply be wasted. There is therefore no overall gain in investment terms as the benefit of any new investment made by the new entrant will, at best, be neutralized by a corresponding stranded costs and reduction in investment by the existing operators. There is no overall net benefit, except to Government coffers, but certainly not to consumers.

92. Indeed, such a process simply results in wasted costs to Hong Kong as new entrants seek (perhaps successfully, perhaps not) to replicate the investment that has already been made by the hyper-competitive incumbents, while rendering the incumbents' investments useless in whole or in part depending on how much spectrum the incumbents lose.

93. Secondly, what service innovation has 21 ViaNet brought about? What “maverick” business offerings have been made by them so far? What “inroads” into the mobile telecommunications market have they made? The evidence of past experience seems quite clear that new entrants do not guarantee service innovation in Hong Kong’s already highly competitive markets. However, again, the CA has ignored this true Hong Kong example, and has made no attempt at a cost/benefit analysis to quantify its speculation about the benefits of new entry in view of the already hyper-competitive state of the Hong Kong market.

94. The uncertainty brought about by a re-auctioning of spectrum only serves to dampen investment incentives and slows down the development of innovative services.

Conclusion

95. On this basis, Option 1 is best able to satisfy all four of the CA's stated objectives and hence should be adopted, particularly in this situation involving a re-assignment of existing spectrum and not a fresh assignment of spectrum.

96. This approach would be consistent with that previously adopted by the CA when it re-assigned the 2G Spectrum bands back to the incumbent spectrum holders. This was done on the basis of ensuring continuation of existing services, efficient use of spectrum and the providing a stable investment environment for the incumbent spectrum holders – the same objectives which the CA is trying to achieve under the current spectrum re-assignment exercise:

> *The TA is prepared to consider offering the existing 2G licensees the "right of first refusal" for new licences operating on the existing 2G spectrum. […] Arguments in favour of this option include that the existing 2G licensees are likely to utilize the allocated spectrum more efficiently than new entrants, especially in the near term, given the significant sunk investments in constructing a mobile network for operation. It will also provide a stable investment environment. Besides, direct offer of new licences to the existing 2G licensees would minimize the potential disturbance to existing consumers of 2G mobile services.*[27]

> *The TA is aware of the consideration to provide a stable investment environment and to ensure continuity of customer service. At present, there are more than 7 million mobile customers in Hong Kong. Discounting the relatively small number of customers subscribing to the CDMA and TDMA services, the GSM and PCS services have become a general commodity penetrating all walks of our society and affecting every aspect of our daily life. The existing GSM and PCS licensees have been providing a satisfactory service with continuous investments and improvements. They have also been making efficient use of the scarce frequency spectrum assigned to them. If they were not allowed to continue offering their services to their customers, there would be severe service interruptions, causing confusion and inconvenience to the public. The social consequence would not be acceptable to society as a whole.*

[27] Paragraph 21 of Consultation Paper issued on 1 August 2003 on *Licensing of Mobile Services on Expiry of Existing Licences for Second Generation Mobile Services*.

> *The present regulatory framework is designed to encourage and facilitate interested parties to invest in telecommunications infrastructure and the provision of telecommunications services. There being no foreign ownership restrictions in Hong Kong, interested parties who wish to enter the market are free to invest through merger and acquisition. They may also apply for the Mobile Virtual Network Operator licence to provide their own services.*[28]
>
> *In the Consultation Papers, the TA proposed to grant the "right of first refusal" to the nine incumbent GSM and PCS licensees who had been making efficient use of the frequency spectrum assigned to them in the past years. The TA also took into account the importance of providing a stable investment environment and ensuring continuity of customer service. It was also recognized that the nine incumbent GSM and PCS licensees had been providing satisfactory service to their subscribers with continuous investments and improvements.*[29]

97. Indeed, HKT would ask, what has changed since the 2G Spectrum bands were re-assigned back to the incumbent spectrum holders in 2005-06 that would merit the CA taking a different approach this time round? Absolutely nothing! The 2G Spectrum bands in question are the exact same set of frequency blocks that are being dealt with under this consultation exercise. Logically, there should be no reason why the CA cannot adopt the same rationale as that previously taken given that, as in 2005-06:

- The current spectrum holders have been making use of the spectrum to provide a satisfactory service with continuous investment and improvements;
- The spectrum is being efficiently used;
- The existing licensees are likely to utilize the spectrum more efficiently than new entrants in view of the significant sunk investments the incumbent spectrum holders have already made;

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[28] Paragraphs 13 and 14 of *Licensing of Mobile Services on Expiry of Existing Licences for Second Generation Mobile Services – Analysis of Comments Received, Preliminary Conclusions and Further Consultation* issued on 19 March 2004.

[29] Paragraph 6 of the Statement of the Telecommunications Authority issued on 29 November 2004 on *Licensing of Mobile Services on Expiry of Existing Licences for Second Generation Mobile Services*.

- Re-assigning the spectrum back to the existing holders would provide a stable investment environment; and
- Service disruption would be eliminated by re-assigning the spectrum.

98. Fully re-assigning the spectrum back to the incumbent spectrum holders would also be in keeping with the market-based approach specified in the RSPF, the policy approaches of other Governments, and the recommendations of the GSMA whereby:[30]

- There should be a presumption in favour of licence renewal for operating and spectrum licences to encourage long-term investment and minimize the risk of service disruption to customers; and
- Re-auctioning spectrum at the end of the licence should be limited to situations where there has not been evidence of substantial investment and there is a reasonable prospect that spectrum will be re-assigned between operators (or where additional, alternative spectrum is being made available), or situations where an existing licensee decides to reject a licence renewal offer.

[30] See Recommendation 10 and Recommendation 11 in the report published by the GSMA in May 2012 entitled: *Licensing to support the mobile broadband revolution*.

THE SCED'S PROPOSAL ON SUF

99. *Given the CA's proposal to move forward with Option 3, the SCED is required to set the auction reserve price for the use of the spectrum to be auctioned (i.e. all 2 x 25 MHz in the 900 MHz band as well as 2 x 35 MHz in the 1800 MHz band) and also the SUF for the use of the RFR Spectrum (i.e. 2 x 40 MHz in the 1800 MHz band). For the purposes of this section, reference to spectrum means the use of the spectrum.*

Auction Reserve Price for Auctioned Spectrum

100. *The SCED proposes to set the same auction reserve price for both the 900 MHz band and the 1800 MHz band on the basis that, given technological advances, it is no longer appropriate to value spectrum in the 900 MHz band higher than the 1800 MHz band.*

101. *The starting prices (i.e. auction reserve prices) of the two most recent spectrum auctions in Hong Kong are intended to be used by the SCED as a basis for setting the auction reserve price for the Auctioned Spectrum. While HKT provided a list of prices fetched in overseas spectrum auctions in response to the First Consultation Paper, the SCED dismissed these as not being relevant, as only the levels of SUF as determined by past spectrum auctions in Hong Kong would have the unique benefit of factoring in local circumstances and hence must be more relevant than any other auction prices found elsewhere around the world.*

102. *The two Hong Kong spectrum auctions which the SCED has chosen as the basis for setting the auction reserve price are:*

- *Auction of 50 MHz of spectrum in the 2.5/2.6 GHz band conducted in March 2013; and*
- *Auction of 49.2 MHz of spectrum in the 1.9 – 2.2 GHz ("**3G Spectrum**") band conducted in December 2014.*

103. *The auction reserve prices for these two spectrum auctions, after adjusting for inflation (to bring the prices up to 2021 price levels[31]), are calculated by the SCED to be:*

- ***$19 million per MHz** (derived from the 2.5/2.6 GHz spectrum auction in 2013); and*
- ***$54 million per MHz** (derived from the 3G Spectrum auction in 2014).*

104. *The SCED therefore intends to set the auction reserve price for the Auctioned Spectrum between $19 million and $54 million per MHz, with an inclination to set the price closer to the higher end on the basis that: (i) the 900/1800 MHz band has been deployed in much the same territory as the 3G Spectrum band and hence shares the same characteristics; and (ii) the 3G Spectrum auction took place more recently than the 2.5/2.6 GHz spectrum auction and hence reflects more up-to-date market pricing.*

SUF for the RFR Spectrum

105. *The SCED proposes that the SUF for the RFR Spectrum be set at the average SUF of the Auctioned Spectrum in the same frequency band, subject to a minimum SUF and a cap.*

106. *The minimum SUF will be based on the SUF paid for spectrum in the aforementioned two spectrum assignment exercises (i.e. the 2.5/2.6 GHz band and the 3G Spectrum band).*

107. *The SUF paid for these two spectrum assignment exercises, after adjusting for inflation (to bring the prices up to 2021 price levels[32]), are calculated by the SCED to be:*

[31] HKT would note that if the SCED intends to adjust the prices for inflation then they should only be uplifted to 2018 (not 2021) levels, given that the auction for the 900/1800 MHz Spectrum is scheduled to take place in 2018.

[32] HKT would note that if the SCED intends to adjust the prices for inflation then they should only be uplifted to 2018 (not 2021) levels, given that the RFR Spectrum is presumably scheduled to be assigned at the same time as the Auctioned Spectrum, i.e. in 2018.

- ***$38 million per MHz*** *(derived from the 2.5/2.6 GHz spectrum auction in 2013); and*
- ***$67 million per MHz*** *(derived from the 3G Spectrum assignment exercise, which was a combination of auctioned spectrum and spectrum assigned under Right-of-First-Refusal).*

108. *The SCED therefore intends to set the minimum SUF for the RFR Spectrum between $38 million and $67 million per MHz, with an inclination to set the price closer to the higher end using the same reasoning as stated for the Auctioned Spectrum.*

109. *As for the cap, the SCED intends to set this at around 30% to 40% higher than the minimum price for the RFR Spectrum.*

Question 2: What are your views and comments on the methods of setting the SUF as proposed in paragraphs 92 - 100 above?

Auction reserve price for the Auctioned Spectrum

110. Per the Second Consultation Paper, the auction reserve price is:

> *[…] not intended to be set as a pre-estimate of an expected market price, but it should be set at a level that represents the minimum base value of the spectrum for the purpose of kick-starting the competitive bidding process.*[33]

111. In setting the reserve price, the SCED has the objective of:

> *[…] encouraging all bidders, incumbents and new entrants alike, to take active part in rounds of competitive bidding.*[34]

112. On this basis, in order to allow sufficient room for the bidders in the spectrum auction to discover the “true” price of the spectrum, it is not necessary to set the reserve price at a high level. If indeed, the SCED truly believes in the market mechanics of the spectrum auction then, through competitive bidding, the auction price will eventually rise up to the true price the participants are prepared to pay no matter how low the initial reserve price is set.

[33] Paragraph 94 of the Second Consultation Paper.

[34] Paragraph 94 of the Second Consultation Paper.

113. HKT maintains that an auction is not the appropriate route and that, because of the circumstances of this proposed auction of spectrum which is already being used by the operators, an auction will force operators to pay monopoly hold-up rents to try to retain spectrum that they have invested in and which is necessary for them to continue to provide services to their existing customers.

114. That said, in the event that the SCED/CA maintain their stance and re-auction some or all of the spectrum, setting modest auction reserve prices is consistent with the recommendations made by the GSMA in its latest report on *Effective Spectrum Pricing: Supporting better quality and more affordable mobile services* issued in February 2017 ("**GSMA Spectrum Pricing Report**"). In this report, the GSMA recommends setting reserve prices at minimum levels so that there is scope for competition and price discovery in spectrum auctions.[35]

115. The worst thing that could happen in a spectrum auction is that bidding ceases after only one or two rounds, as this would tend to indicate that the initial reserve price has already been set too high, and hence the bidders have not been given the opportunity to properly discover the real price through the auction process.[36]

116. A low auction reserve price fulfills the SCED's objective of allowing all bidders to take part, including new entrants, particularly those operators who are budget constrained. On this basis, there is no reason why an auction reserve price of "zero" cannot be set, particularly in view of the CA's contention that there is "competing demand" for the spectrum, which should drive the price up to its market value if that were really the case.

SUF for the RFR Spectrum

117. In setting the SUF for the RFR Spectrum, it is wrong to make reference to the RFR price previously paid for the spectrum in the 3G Spectrum band. This did not represent the true market price of the

[35] See Recommendation #1 in the GSMA Spectrum Pricing Report.

[36] In this regard, HKT would draw the SCED's attention to the 3G spectrum auction conducted in December 2014 in which bidding ceased after a minimal number of rounds.

spectrum, as was evident from the price that was finally determined via auction for the 3G Spectrum (which was significantly lower), and recognizing that there was also an element of monopoly hold-up pricing in that auction as incumbents sought to retain spectrum holdings they had invested substantial sums in to provide services to existing customers.

118. The rationale for setting both a minimum and maximum price for the RFR Spectrum has been explained in the Second Consultation Paper as follows:

> *[…] unless the incumbent spectrum assignees are advised of the necessary pricing information of the RFR Spectrum (including both the minimum and maximum levels as proposed by the SCED in the First Consultation Paper) at the time when they are required to take a decision on whether to take up the CA's offer of the RFR Spectrum, the incumbents would have, as they had unequivocally put forward in the context of the last spectrum re-assignment exercise, grave difficulties in making commercially sensible and rational decisions on the offer of RFR Spectrum.*[37]

119. There is no need to set a minimum SUF for the RFR Spectrum, but just a maximum SUF, as incumbent spectrum holders who elect to take up their RFR Spectrum will simply be asked to pay the average price arising from the auction of the remaining spectrum, subject to the price cap. This should provide sufficient information to the incumbent spectrum holders to allow them to decide whether or not they wish to take up the CA's offer of their RFR Spectrum.

120. By avoiding the need to set a minimum SUF for the RFR, this eliminates the difficult task of determining a sensible price. It also ensures that the price of the RFR Spectrum is on par with the prices paid for the auctioned spectrum. If the objective of granting RFR Spectrum to the incumbent spectrum holders is purely to ensure continuity of service (and not to maximize the Government coffers) then there is no need to set a minimum SUF payable for the RFR Spectrum. The outcome of the spectrum auction will simply determine the price for both the RFR Spectrum (subject to the price cap in order to give incumbent spectrum holders a degree of certainty) and the auctioned spectrum.

[37] Paragraph 69 of the Consultation Paper.

121. In any case, the SCED does not explain how it derives the 30% to 40% figure for the cap on the SUF for the RFR Spectrum. This seemingly arbitrary figure appears to have little basis and, in any case, does seem high and should be substantially lower. Besides, one of the factors which is supposedly being taken into account by the SCED in setting the cap is the "estimated market value of 1800 MHz Spectrum". But this appears to be contradictory given that the SCED is not in a position to determine the market value of the spectrum, which will be set by the market itself.

The Danger of High SUFs

122. Given the already substantial size of the Government's revenue pool, it does not need to rely on SUFs to fill its coffers. Accordingly, the SCED should not find it necessary to set high auction reserve prices or a high minimum SUF for the RFR Spectrum.

123. High SUFs impose a heavy cost burden on the mobile operators and represent a significant proportion of operating expenses. Based on the audited accounts, HKT has calculated that SUFs represented 12.2% of HKT's operating costs in 2016, which is much higher than the 3-4% estimated by OFCA. PricewaterhouseCoopers has reported that HKT's calculation was accurately and properly prepared in accordance with HKT's accounting policies, which comply with Hong Kong Financial Reporting Standards issued by the Hong Kong Institute of Certified Public Accountants.

124. High SUFs force mobile operators to slow down their investment plans (due to the substantial outlays that are required to be paid for use of the spectrum) and this correspondingly leads to a dampening of service innovation. All of this spells bad news for the consumer who, as well as being deprived of new services earlier, may very likely be forced to pay higher retail prices for their mobile services as operators seek to recover the high SUF charges from their customers.

125. On a broader context, high SUFs can damage a services-based economy like Hong Kong in which operators may be forced to cut jobs as they attempt to maintain their profitability. This could seriously affect

Hong Kong's image as a centre of telecommunications service innovation and a world class telecommunications hub.

Method of Payment

126. *In the Second Consultation Paper, the SCED proposes to give spectrum assignees a choice as to how they would like to pay the SUF:*

(i) *Lump sum upfront, which is the lump sum amount obtained in the spectrum auction and/or via RFR;*

(ii) *Annual installments, with the first installment equivalent to the lump sum amount obtained in (i) above divided by the number of years for which the spectrum is assigned. The subsequent installments will be increased each year by a pre-set fixed percentage to reflect the time value of money to the Government.*

Question 3: What are your views and comments on the method of payment of SUF?

127. HKT welcomes the CA's proposal to allow the SUF to be paid in installments over the licence period of the spectrum as this better reflects the fact that the SUF is consideration for the use of spectrum for a prescribed period (e.g. annual SUF is consideration for the right to use the spectrum for the relevant licence year). In addition, this would ease pressure on an operator's cashflow and hence leave more funds available for network investment. Should such a scheme be implemented then HKT would expect that periodic adjustments should be made to the SUF to allow for effects of inflation over the licence period.

128. In fact, given that the CA is now proposing to allow the SUF to be paid by installment, HKT does not see any necessity in also offering the option of paying the SUF in a lump sum upfront. As operators are unlikely to elect to pay the SUF in one go if they are also given the choice to pay in installments, for administrative convenience, the CA should dispense with the option of paying the SUF in a lump sum upfront.

129. HKT would, nevertheless, like to put forward a refinement to the CA's proposed payment by installment scheme. As well as making the

SUF payable on an annual basis, HKT would propose that the annual payment be in the form of SUF royalty payments linked to the mobile revenues of the operator so that the Government may share in any upside to the business generated from the use of the spectrum that has been awarded to the mobile operator. This methodology would also be helpful in ensuring that the licensees are paying for the use of spectrum based on the economic or market value of such usage. Such a scheme would correct balance the needs of all stakeholders.

130. Specifically, HKT would suggest a table of annual SUF royalty payments be established by the CA which represents the minimum annual amounts payable by the operator. These annual royalty payments could simply be the total SUF payable by the operator spread equally over the assignment term of the spectrum (15 years), including the annual interest on each payment as described above.

131. The actual amount payable by the operator each year would then be computed on the basis of the higher of:

- The amount in the table; and
- A fixed % x (the annual mobile revenues) as per the audited regulatory accounts of the licensee.

132. HKT would also note that, per Section 32I(1) of the Telecommunications Ordinance ("**Ordinance**"), SUF payments are made by the spectrum holder for the use of the spectrum (and not the "right" to use the spectrum). Further, Section 32I(3) of the Ordinance allows the SUF to be calculated on the basis of a royalty. Accordingly, these SUF royalty payments should be deductible for tax purposes.

HKT

PROPOSED FRAMEWORK FOR SPECTRUM RE-ASSIGNMENT

133. *In this section, the SCED/CA seeks views regarding their proposals on the band plan, auction design and licensing arrangements.*

Proposed Band Plans and Location of the RFR Spectrum

134. *In designing the band plan for the 900/1800 MHz Spectrum, the CA intends to eliminate the fragmented nature of the current assignments and to accommodate the carrier bandwidth requirements (i.e. size of frequency blocks) associated with each generation of mobile technology.*

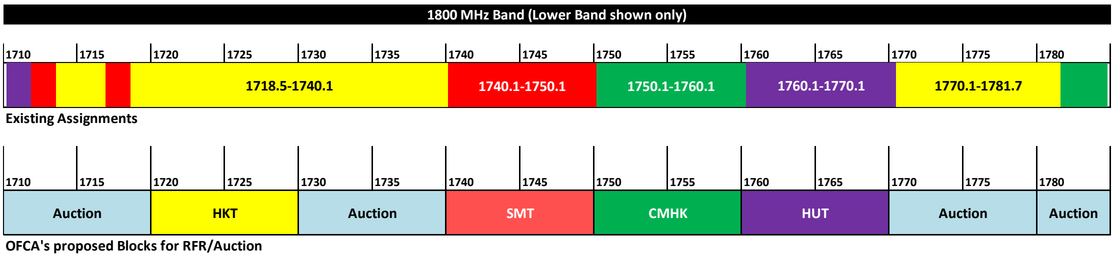
135. *HKT would like to stress that the problem regarding the fragmented nature of the current spectrum assignments could equally be resolved under Option 1 via a spectrum re-organisation exercise, as explained by HKT earlier.*[38] *Such an exercise would be easy to undertake and would not be controversial. Accordingly, this is not a distinguishing factor amongst Options 1, 2 and 3.*

1800 MHz band

136. *The CA proposes that the existing 2 x 75 MHz of spectrum in the 1800 MHz band will be structured into as many blocks of 2 x 10 MHz as possible, with the remainder grouped into 2 x 5 MHz blocks.*

137. *On this basis, the current spectrum assignments and the CA's proposed band plan, showing the specific frequency blocks to be offered to each incumbent spectrum holder under RFR and the remaining blocks to be auctioned, are illustrated as follows (lower band shown only):*

[38] Under such an exercise, the CA would consolidate the fragmented frequency blocks into contiguous blocks, and then re-assign them back to the incumbent spectrum holders so that each operator holds the same amount of spectrum as before, but now in contiguous blocks.



138. *The CA has designated the RFR frequency blocks for each incumbent to reflect the bands they are currently deploying for the provision of 4G mobile services at MTR premises in order to minimize any reconfiguration work required if they elect to take up their RFR Spectrum.*

Question 4: What are your views on the band plan proposed above for the re-assignment of the 2 x 75 MHz of spectrum in the 1800 MHz band?

Would you consider the proposed frequency slots to be re-assigned to individual incumbent spectrum assignees as the RFR Spectrum an optimal arrangement from the industry's point of view?

139. HKT considers this a reasonable band plan for the 1800 MHz band as the whole band has now been neatly organized into contiguous blocks of 2 x 10 MHz or 2 x 5 MHz, thereby ensuring spectral efficiency.

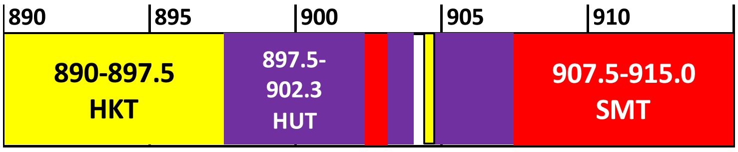
140. As for the RFR Spectrum blocks, these have been designated in such a way as to minimize the reconfiguration work required in the MTR if an operator elects to take up its RFR Spectrum and hence should be considered an optimal arrangement.

900 MHz band

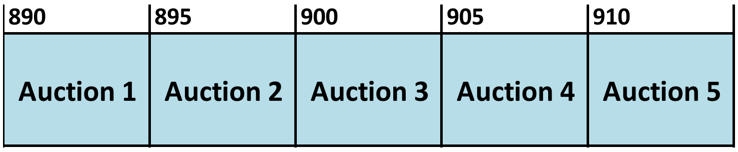
141. *The CA proposes that the existing 2 x 25 MHz of spectrum in the 900 MHz band will be structured into blocks of 2 x 5 MHz.*

142. *On this basis, the current spectrum assignments and the CA's proposed band plan, showing the specific frequency blocks to be auctioned, are illustrated as follows (lower band shown only):*

900 MHz Band (Lower Band shown only)



Existing Assignments



OFCA's proposed blocks for auction

Question 5: What are your views on the band plan proposed above for the re-assignment of the 2 x 25 MHz of spectrum in the 900 MHz band?

143. HKT considers this a reasonable band plan for the 900 MHz band as the whole band has now been neatly organized into contiguous blocks of 2 x 5 MHz each, thereby ensuring spectral efficiency.

Auction Design

144. *Per the Second Consultation Paper, the CA proposes to use a single Simultaneous Multiple Round Ascending ("**SMRA**") auction to auction off spectrum in both the 900 MHz band and 1800 MHz band in one go.*

145. *All interested parties, both existing operators and new entrants, will be eligible to participate in the spectrum auction.*

146. *The CA also proposes applying a cap of 90 MHz on the total amount of 900/1800 MHz Spectrum that may be acquired by an operator (existing or new), including any RFR Spectrum. In addition, a 20 MHz sub-cap will be imposed on the 900 MHz band given the valuable nature of band and the limited supply on offer.*

Question 6: What are your views on the use of the SMRA format that has been adopted in the spectrum auctions held by the CA in recent years to auction off the Auctioned Spectrum in the 900 MHz and 1800 MHz bands?

147. Without prejudice to HKT's overriding contention that Option 1 should be adopted, if an auction were to take place then HKT would favour the use of the SMRA format for the spectrum auction, as this is a format with which the whole mobile industry is familiar, having been adopted in past Hong Kong spectrum auctions.

148. As for the spectrum caps proposed by the CA, HKT reiterates its views that there are no real competition grounds to impose any caps on the 900/1800 MHz Spectrum given that, according to the First Consultation Paper, the amount of mobile broadband spectrum being considered forms less than one-third of the total spectrum which is currently being deployed for mobile broadband services. The market should be allowed to decide on its own how the spectrum is to be re-assigned.

Licensing Arrangements

149. *In order to facilitate a smooth handover of spectrum among the operators and to simplify future administrative arrangements, the CA proposes that the new spectrum licence periods for all spectrum in the 900 MHz band will be aligned to commence on the same date, i.e. 12 January 2021, for a term of 15 years.*

150. *The CA does not consider it necessary for the new licence period for the 900 MHz band to be aligned with the 1800 MHz band. Accordingly, the new licence period for the 1800 MHz band will commence on 30 September 2021, i.e. later than the 900 MHz band, for a term of 15 years.*

151. *In order to address concerns over re-assignment of the 900/1800 MHz Spectrum resulting in a premature termination of 2G services by the mobile operators, the CA proposes to introduce a new SC in the UCL of each of the mobile operators which requires them to seek the prior consent of the CA and to make satisfactory arrangements for the affected customers before they phase out the provision of 2G services.*

152. *The CA also proposes to go forward with the requirement for spectrum assignees to meet certain network and service rollout*

obligations[39] within 5 years from the commencement date of the spectrum licence period. To ensure compliance with these network and service rollout obligations, certain operators will be required to lodge performance bonds: (i) successful bidders who have newly acquired spectrum in the 900 MHz band and/or 1800 MHz band; (ii) existing mobile operators who are assigned Auctioned Spectrum that they do not currently hold; and (iii) incumbent spectrum holders who are re-assigned the 900/1800 MHz Spectrum currently deployed by them for service provision but their networks have not yet reached the 90% minimum population coverage requirement.

Question 7: What are your views on the proposed SC requiring all licensees to seek the prior consent of the CA and to make proper arrangements for the affected customers before phasing out their provision of 2G services and other generations of mobile services in the future?

153. It does not make sense to impose a requirement to seek approval from the CA before phasing out a service. This is micro-management and departs from the "let the market decide" approach. It should purely be a commercial (not regulatory) decision as to whether or not to end a service. It also does not make sense to introduce this for future phasing out of services, including 3G, 4G, etc. It is wrong for the CA to use this particular consultation exercise on 900/1800 MHz band to introduce a requirement which will equally apply to other generations of mobile services in the future.

154. The concern regarding 2G services is exaggerated. It has only been raised by two local tourism organizations and there are another 3-4 years to run before the 900/1800 MHz spectrum licence period ends. The amount of attention devoted to this issue is therefore unwarranted.

[39] Minimum coverage of 90% of the Hong Kong population (mobile services) or 200 commercial and/or residential buildings and to establish and maintain a minimum of 50 hubs (fixed services). Incumbent spectrum holders need only provide network coverage figures demonstrating that they have already fulfilled these requirements using the assigned spectrum.

155. In any case, there is no need to inscribe a specific condition within the current licence concerning the phasing out of services. This is already covered by more general provisions within the licence, e.g. GC5 re Provision of Service which requires the licensee to operate, maintain and provide a good, efficient and continuous service in a manner satisfactory to the Authority.

Question 8: Do you have any views on other aspects of the proposed framework for the Re-assignment of the 900/1800 MHz Spectrum not explicitly asked in the questions set out in the paragraphs above?

156. There are some fundamental issues regarding the overall approach adopted by the SCED and CA in this spectrum re-assignment exercise which are not addressed by the specific questions in this Second Consultation Paper. These matters are raised by HKT in the Introduction to this submission[40].

157. HKT also suggests that it would be beneficial for the SCED/CA to extend the expiry date for the current spectrum licence period in respect of the 900/1800 MHz Spectrum by say, 5 years. This should allow sufficient time for the SCED/CA to:

- Resolve all the problems concerning the underlying system for spectrum management outlined in the Introduction; and
- Release the spectrum bands as identified in the CA Press Release; or at least, provide for greater clarity as to the timeframe within which these bands will become available so that mobile operators can more easily plan their business in the event that there is to be a future re-auction of the 900/1800 MHz Spectrum.

[40] These matters are also discussed in greater detail in HKT's paper on *Fit for the Future? Spectrum Options for Hong Kong* which is submitted concurrently with this consultation response.

CONCLUSION

158. Before the SCED/CA embark on any specific exercise to re-assign spectrum, they should step back and critically assess whether the underlying system of spectrum planning, allocation and charging is still appropriate or if any problems need to be resolved in order to facilitate the development of future mobile services.

159. A "market-based" approach, per the RSPF and global best practices, is one in which existing spectrum assignments are re-assigned back to the incumbent spectrum holders (or assigned to operators on a perpetual basis) and spectrum trading is permitted. This is particularly the case where the spectrum has been used efficiently by the operators and there have been no serious licence infringements.

160. Any intervention by the regulator to re-assign spectrum, such as conducting a spectrum auction, would be regarded as deviating from this market-based approach and, effectively, no different to command-and-control. Auctions should only be deployed where a fresh release of spectrum is concerned, to determine how the spectrum should be assigned initially. On this basis, in this spectrum re-assignment exercise, Option 1 is the only "market-based" approach that can be considered.

161. Should the SCED/CA move forward with a spectrum auction to re-assign the 900/1800 MHz Spectrum, they will have ignored the adverse consequences such an action will have on the mobile telecommunications industry:

- The substantial network investments already made by the mobile operators will become stranded if they fail to re-acquire all of the spectrum they previously held;
- The uncertainty brought about by a spectrum auction will dampen investment incentives towards the final years of the spectrum licence period, leading to a slowing down of service innovation;
- The high fees which inevitably result from a spectrum auction will eat into the pool of funds operators have reserved for further network investment and service innovation; and

- Consumers will suffer as operators seek to impose higher retail charges in order to recoup the high fees resulting from the auction process. At the same time, customers lose out as operators are slow to bring forth service innovation due to curbed investment plans. Service quality and service continuity will also be affected.

162. All of these risk seriously damaging Hong Kong's reputation as a centre for service excellence and world class telecommunications hub, unless spectrum is fully re-assigned back to the incumbent spectrum holders. This begs the question: "If it ain't broke, why fix it?"

Submitted by
Hong Kong Telecommunications (HKT) Limited
24 May 2017

HKT®

FIT FOR THE FUTURE?

Spectrum Options for Hong Kong

May 2017

HKT

Fit for the Future? Spectrum Options for Hong Kong

What is the problem?

The world of wireless data consumption is changing. Since the advent of Smartphones and mobile broadband, demand for data and speed of data communication has exploded and it continues to grow exponentially with no sign of abatement. This exponential growth is compounded by the prospect of huge numbers of new services and applications – beyond Smartphones to devices with new, non-human demands.

In this future world millions of customers with Smartphones will become billions of connected devices (including Smartphones). Vast numbers of sensors and IoT devices will serve M2M, V2X,[1] robotics and industry 4.0, Smart Cities and Smart Home requirements. The possibilities are endless.[2] But none of this can be delivered without sufficient spectrum and the necessary network infrastructure. This presents huge challenges which cannot be properly addressed under the current system of spectrum management in Hong Kong. Nor can these challenges be resolved without the implementation of robust policies to facilitate the installation of necessary infrastructure. Vast amounts of new spectrum in different bands needs to be made available to support new and innovative services, much wider bandwidths will be needed and new infrastructure will be required. The sheer amount and range of spectrum needed will mean that the existing system of spectrum planning, allocation and charging will no longer be sustainable. A radical new approach is needed and fast.

The current consultation in relation to the Re-assignment of Spectrum in the 900 MHz and 1800 MHZ Bands upon Expiry of the Existing Assignments and the spectrum auction proposed in the Second Consultation Paper[3] cannot sensibly go ahead in the absence of a holistic review of spectrum policy implementation and the adoption of a new, forward looking system of spectrum management which can accommodate the rapidly evolving needs of industry and society for spectrum.

Standards bodies and regulators around the world are already taking steps to facilitate the emerging services and applications and operator trials are taking place all around the world. The Hong Kong Government has not been keeping up with global best practices. Without a radical overhaul of its spectrum policy implementation to ensure economically, socially and technically efficient use of spectrum for the benefit of the community and to facilitate the introduction of innovative services, Hong Kong risks losing its competitive edge and its consumers, businesses and economy will suffer irreparable damage. There is no time to waste. The Government needs to take steps now.

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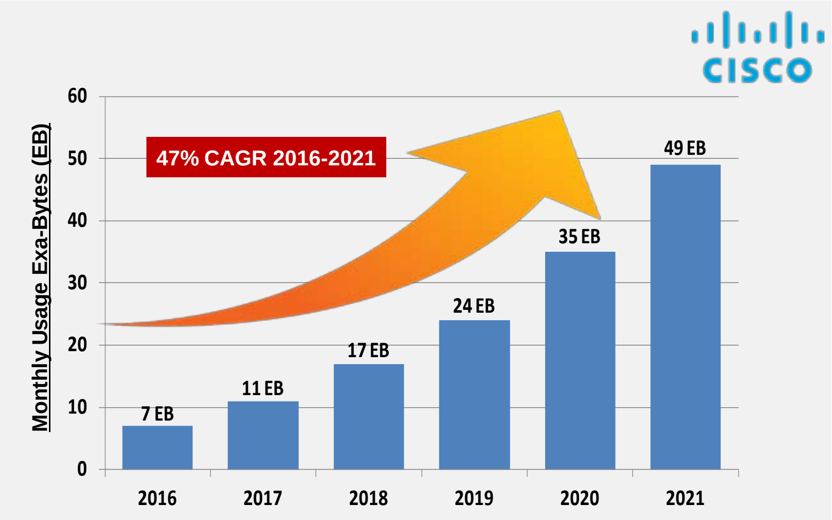
[1] Vehicle- to-everything i.e. connected cars.

[2] For a more detailed discussion of the potential of the 5G era see GSMA "The 5G era: Age of boundless connectivity and intelligent automation, 27 February 2017 https://www.gsmaintelligence.com/research/?file=0efdd9e7b6eb1c4ad9aa5d4c0c971e62&download and IHS Economics and IHS Technology "The 5G economy: How 5G technology will contribute to the global economy, January 2017 https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf

[3] http://www.coms-auth.hk/filemanager/en/content_711/cp20170213_e.pdf

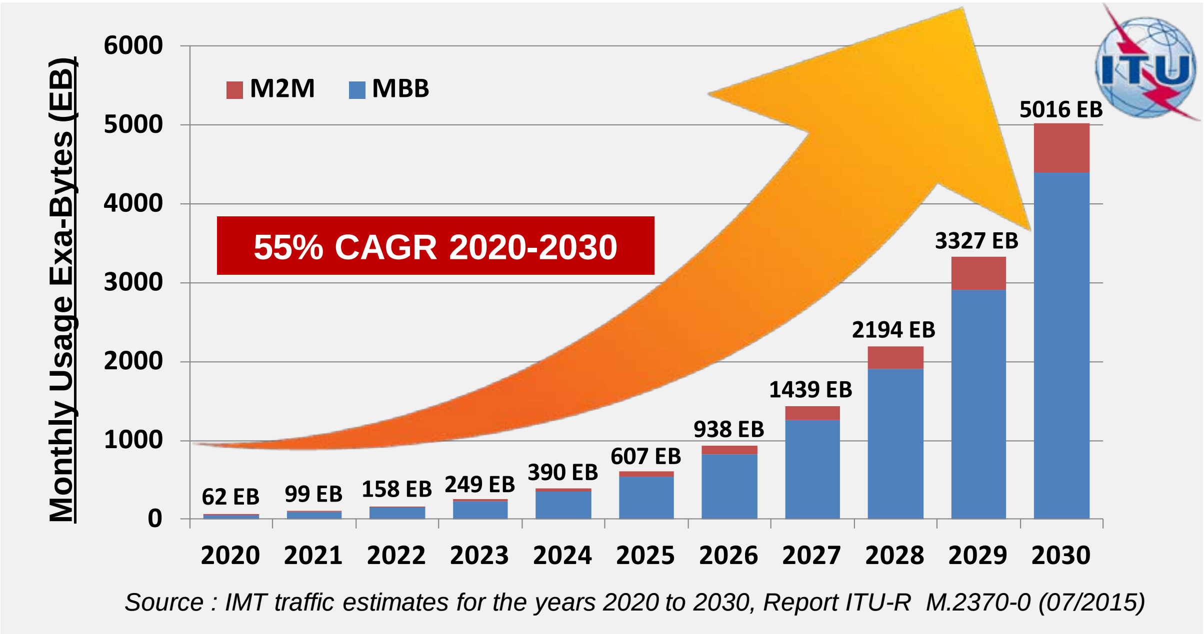
Why is more spectrum and new network infrastructure needed?

With the phenomenal growth of data usage observed since the arrival of the Smartphone era and the continued exponential growth predicted by various organizations including the International Telecommunications Union ("**ITU**") and Cisco[4] it is abundantly clear that the current available spectrum is woefully inadequate to support anticipated future demand given the constraints imposed by technology and the practical limits on implementation in the real world.



Global Mobile Data Traffic, 2016 to 2021 (Source : CISCO VNI)

[4] The ITU is a UN agency based in Geneva through which Governments work to coordinate spectrum releases. For information on growth forecasts from the ITU and Cisco see GSMA, "Future Mobile Spectrum Requirements, Creating a Sustainable Future for Mobile Broadband", 13 July 2015. https://www.itu.int/en/ITU-D/REgional-Presence/Americas/Documents/EVENTS/2015/0713-MX-Spectrum/3_3.pdf and Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016-2021, published on 7 February 2017, updated 28 March 2017 http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html



There are two key drivers behind the need for more spectrum:

1) Network capacity

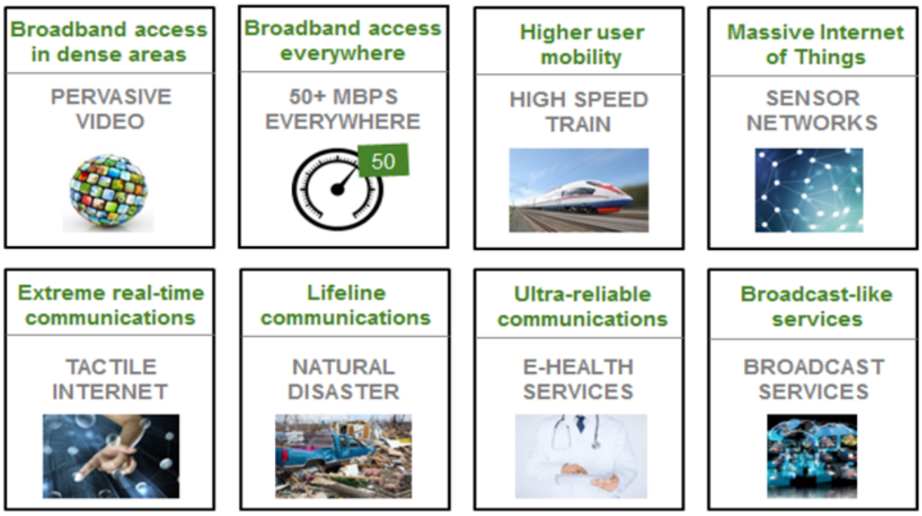
   More spectrum is needed to support:

   - Higher data usage; and
   - more connected users and many, many more connected devices, e.g. IoT, connected cars).

2) End user throughput/User data speed

   More spectrum is needed to support:

   - Ultra high speed connections for more bandwidth hungry applications (e.g. 4K Video / VR / AR); and
   - a much lower latency (delay) connection for mission critical applications (e.g. real time robotic control, connected cars).



True 5G use cases[5] requiring more spectrum

To understand the existing constraints, it is necessary to understand the basics of mobile communications. In principle, network capacity depends on three variables as follows:

Network Capacity (bit/s in Area)	=	(1) Available Spectrum (in Hz)	•	(2) Spectral Efficiency (bits/s/Hz/Cell)	•	(3) Cell Density (*) (Cell/Area)

(*) no of cell sites

It follows that with a given amount of spectrum, network capacity can only be increased by improving spectral efficiency and/or by increasing cell density.

Operators have invested very significant amounts over the past decade to improve all three variables, including:

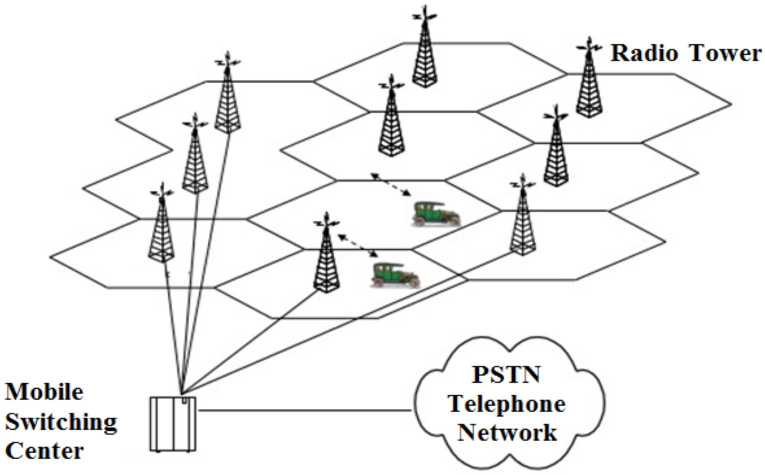
- acquiring more spectrum through auctions (where available);
- using new spectrum to build additional radio layers;
- significantly increasing the number of cells and cell sites to increase cell density;
- deploying new technologies;
- reallocating existing spectrum to new generation technology (so called refarming) in order to achieve better spectral efficiency e.g. 2G -> 3G; and,
- migrating/upgrading users from one technology generation to the next in order to maximize spectrum utilization e.g. 2G -> 3G.

However, we have now reached the point where, despite all these efforts, it is becoming more and more difficult to further increase network capacity without any new spectrum. There are a number of reasons why this is the case:

[5] NGMN, "5G White Paper", February 2015: https://www.ngmn.org/uploads/media/NGMN_5G_White_Paper_V1_0.pdf

1) Limitations on more cell sites

Mobile services are supported by a network of radio towers/cell sites which cover the surrounding area in a cellular pattern as illustrated below.



Cellular telephony – General architecture[6]

As a result of the efforts and investments of operators to increase the number of cells in order to increase network capacity, Hong Kong is already one of the world's leading cities in terms of cell site density. HKT alone has around 3,000 cell sites across the whole territory and the site density is already reaching the upper limits in urban hot spots like Causeway Bay and Mongkok. It is difficult to further increase the cell density because of problems with coverage and interference caused by the dense built environment. It is also extremely difficult, if not impossible, and in any event very expensive, to acquire new cell sites in these areas.

New spectrum is needed and easier and affordable access to new cell sites.

2) Spectral efficiency is approaching physical limits

Tremendous technology advances have been achieved in the past decades and these have continuously pushed up spectral efficiency, driving the evolution from 2G to 3G and then 4G.

However, spectral efficiency for a single channel has now been pushed to its limits. Further improvements are not possible in practice because of the power needed. For instance, a 2 fold increase in spectral efficiency from 4 bit/s/Hz to 8 bit/s/Hz will require 17 times more power. This is simply not doable.

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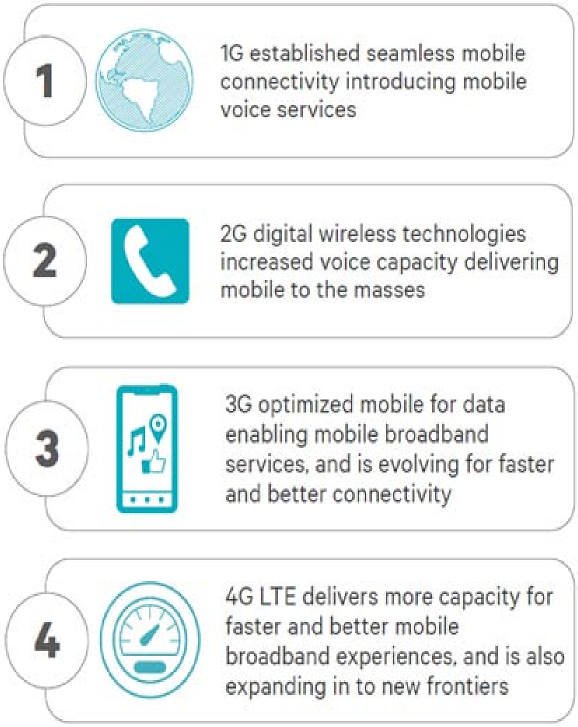
[6] Qualcomm, "The Evolution of Mobile Technologies: 1G -> 2G -> 3G -> 4G LTE", June 2014 https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf

Spatial Processing (i.e. MIMO (Multiple Input and Multiple Output) technology has been developed to tackle this problem by the use of "multi-channels."[7] However, due to the physical characteristics of the low frequency spectrum currently available for mobile use, it is not practical or realistic to increase MIMO beyond 8x8[8] . Higher Order MIMO (64 x 64) and Massive MIMO (256 x 256) are only practically deployable with higher frequency spectrum (above 3GHz and even 6GHz).



1st Generation Mobile
- Analogue systems with limited capacity
- Provide basic mobile voice communications
- Limited roaming is supported

2nd Generation Mobile
- Digital systems with higher voice capacity
- Supports two-way texting (SMS) and low speed data (CSD, GPRS, EDGE) at around 100Kbps (max)
- True international roaming is achieved

3rd Generation Mobile
- Offering even higher voice capacity
- Supports video-call
- Improve data speed, starting from 384Kbps all the way up to broadband speed at 42Mbps

4th Generation Mobile
- Data centric system, all services delivered by IP data
- Voice and Video calls carried over data (VoLTE/ViLTE)
- Boosting data speed from 150Mbps and above toward 1Gbps, comparable to fixed broadband

Capability improvement over generations[9]

Again, additional spectrum is required beyond what is available today.

3) Limits on concurrent users

Current LTE (4G) technology is only capable of handling a maximum of 1200 concurrent users per cell. Mobile users already experience congestion (no connection) in extremely crowded areas like the MTR where existing cell sites are fully utilized and operators are unable to deploy new cell sites. In future, the vast number of connected devices will necessitate up to 100,000 concurrent devices per cell. Again additional spectrum[10] is required.

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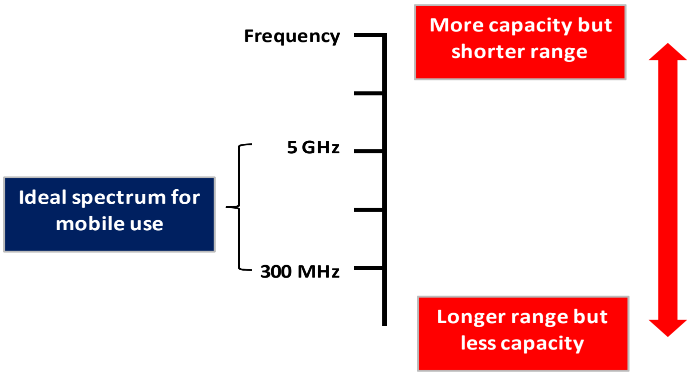
[7] MIMO uses multiple antennas to enable the sending and receiving of more than one data signal simultaneously over the same radio channel.

[8] i.e. 8 channels in 8 channels out.

[9] Qualcomm, "The Evolution of Mobile Technologies: 1G -> 2G -> 3G -> 4G LTE", June 2014 https://www.qualcomm.com/media/documents/files/the-evolution-of-mobile-technologies-1g-to-2g-to-3g-to-4g-lte.pdf

[10] Alternatively, next generation radio technology (Massive MIMO, 5G) is needed but this is also not possible without additional spectrum for the reasons explained above.

It is clear that new spectrum is needed to unblock existing technical and physical constraints on network capacity. In addition because of the different characteristics of spectrum and different frequency bands, additional spectrum in new frequency bands and with wide spectrum bandwidth is required to meet the widely varying demands of future services and applications.



Differences in capacity and range of different frequency bands

1) Studies carried out by the 3rd Generation Partnership Project (3GPP)'[11], indicate that bandwidth of 100MHz is required in order to realize the broadband of the future (so-called eMBB (Evolved Mobile Broadband)) which can support a very high peak user data speed of 20Gbps[12]. This is 5 times the bandwidth currently available for 4G.[13] Indeed the latest IMT-2020 specifications indicate that, for spectrum at higher frequencies (above 6GHz) up to 1GHz bandwidth is needed to support 5G[14].

   In addition to the eMBB requirement for wide bandwidth, IMT-2020 also envisages very diverse use scenarios which require:

   - Very Low Latency (delay): URLLC (Ultra Reliable Low Latency Connection) for mission critical application (such as public safety and C-V2X for smart mobility); and

   - Very low bit rate (only small amounts of data to be transmitted) very wide area coverage: mMTC (Massive Machine Type Connection) for IoT type of application to connect billions of devices.

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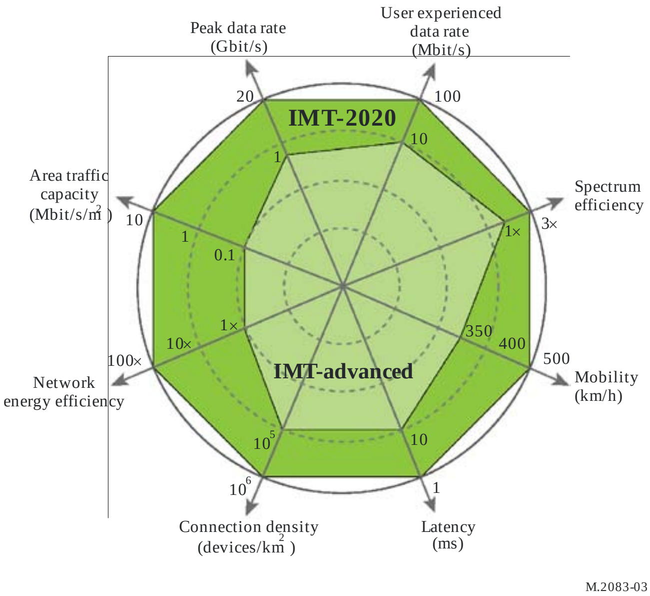
[11] 3GPP is a mobile communications industry collaboration that organizes and manages the development of mobile communications standards.

[12] As envisioned by ITU IMT 2020 More information about the ITU's work in relation to 5G and the issues that need to be addressed before it can be delivered can be found in ITU News Magazine, Issue No. 2/2017: http://www.itu.int/en/itunews/Documents/2017/2017-02/2017_ITUNews02.pdf

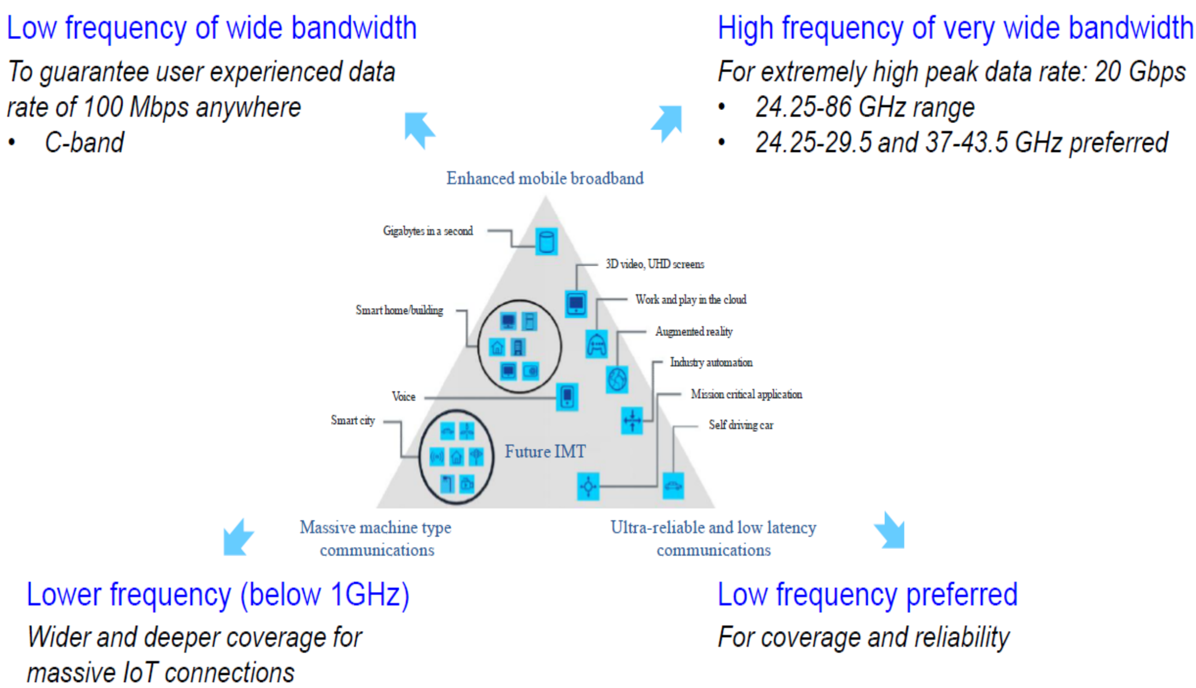
[13] Current bandwidths are as follows: 2G – 200 KHz; 3G – 5MHz; 4G – 20 MHz.

[14] Indeed operators including Telia and Verizon have already carried out trials using bandwidth of 800MHz: https://www.sdxcentral.com/articles/news/5g-trials-and-tribulations-a-guide-to-global-5g-operator-tests/2016/12/ and http://www.telecomlead.com/5g/huawei-is-making-slow-progress-in-5g-than-ericsson-and-nokia-74707

These applications call for new spectrum bands to be made available for mobile use (e.g. 700MHz, 3400 – 3800MHz) due to the different characteristics required.[15]



ITU 5G Vision[16]: Enhancement of key capabilities from IMT-Advanced to IMT-2020 (5G)



ITU - 5G Vision[17]

[15] Spectrum bands are not all equal. They differ in how well they can provide coverage and capacity (i.e. the amount of data they can carry). Lower frequency bands provide wider coverage; higher frequency bands tend to have greater capacity. Consequently different bands are required for different applications.

[16] ITU-R, "IMT Vision – Framework and Overall Objectives of the future development of IMT for 2020 and beyond", Sep 2015 https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf

[17] ITU-R, "IMT Vision – Framework and Overall Objectives of the future development of IMT for 2020 and beyond", Sep 2015 https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf

The conclusion to all this is obvious: much, much more spectrum as well as timely and affordable access to install new cell sites is required to unblock the current constraints and enable the provision of future applications and services.

The current situation is not sustainable: What is needed?

As explained above, additional capacity (more data usage and more connected users),[18] improved user experience (much higher data speeds) and extreme use cases (ultra low latency, wide area coverage) can only be realized with additional spectrum, new bands and wide spectrum bandwidth. With this understanding, it is not difficult to realize that the current situation in Hong Kong is simply NOT sustainable:

1) High Site Rental Cost => Affordable access to new cell sites

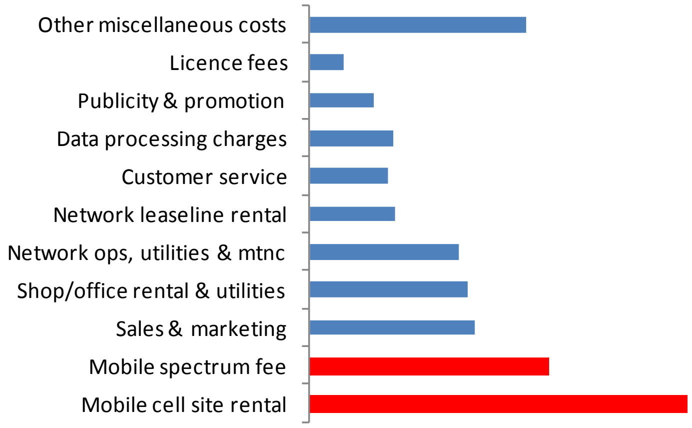
   Currently spectrum used for mobile services in Hong Kong is at lower (sub 3GHz) frequencies which provide wide coverage.

   To meet on going capacity demands and to realize the eMBB speed targets of 20Gbps it is expected that the majority of future spectrum allocated for mobile services will be at much higher frequencies [from 6GHz to 100GHz according to the World Radio-Communications Conference 2015 ("**WRC-15**")]. Spectrum at these high frequencies provides relatively poor coverage compared to the lower frequency spectrum which is currently used for mobile services. This severely limits the area which can be covered by an individual cell. Consequently the number of cells required will increase exponentially. For example, HKT currently has around 3,000 sites but estimates that it will need well over 30,000 sites in order to provide good territory coverage with higher frequency spectrum (both outdoor and indoor). This is a 10 fold increase.[19]

   Operators will therefore face the unpalatable prospect of needing to place multiple cell sites in each building or premises – for which building owners and landlords will charge a site rental. As shown below, mobile cell site rental charges already comprise the largest single item of HKT's (and presumably other network operators') costs.[20]

[18] Not just people with smart phones but a wide variety of machines from cars to electricity meters
[19] Although we do not have specific details the impact on other operators will be similarly significant.
[20] This was explained in detail in HKT's open letter to the Secretary for Commerce and Economic Development and the Chairman of the Communications Authority dated 15 December 2016 which also expressed HKT's wider concerns about radio spectrum in Hong Kong: http://www.pccw.com/staticfiles/PCCWCorpsite/Press%20Release/2016/Dec/HKT%20Open%20Letter%20%28full%20version%29.pdf

HKT



HKT's SUF payments and cell site rental relative to mobile operating expenses for the year ended 31 December 2015

If the number of sites needed increases 10-fold then operators will be at the mercy of landowners who will be able to charge whatever fees they like for rental, knowing that operators need the sites in order to provide their services. The options currently available to operators (e.g. installing cell sites on neighbouring buildings instead) will be very limited given the vastly increased number of cell sites that will be required. This will have a very significant impact on operators' costs which, unless the cost base can somehow be restructured, can only result in an increase in fees paid by Hong Kong businesses and consumers.

To address this issue, the Government must come up with a means to ensure that network operators are able to access buildings and other privately owned/controlled land without incurring excessive costs. This will enable operators to achieve more advanced mobile networks with much more capability at an affordable cost to the benefit of the general public as well as the Hong Kong economy as a whole.

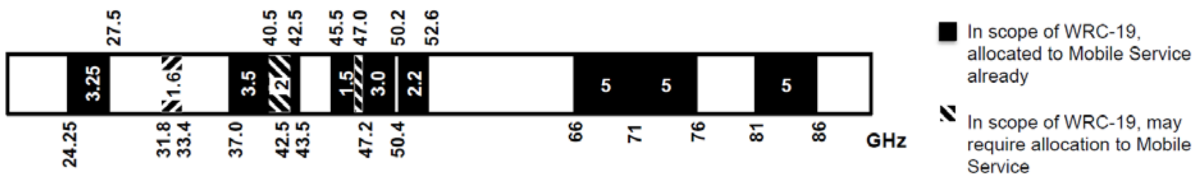
2) Spectrum allocation => much more spectrum

The IMT-2020 calls for carrier bandwidth from 100MHz to 1GHz. It is a global challenge to identify worldwide harmonized spectrum bands which can support a minimum of 100MHz bandwidth per operator. This is particularly the case at the sub-6GHz band which is extremely important for territory-wide 5G because of its wide coverage and ability to penetrate objects, including buildings.

WRC-15 identified worldwide harmonized spectrum bands below 6GHz for 5G implementation. These include spectrum bands at 700MHz, 3.5MHz and other bands. The candidate bands for 5G implementation above 6GHz were also identified. These bands will be confirmed at the upcoming World Radio-Communications Conference 2019 ("**WRC-19**").

Frequency bands	Amount of spectrum (MHz)	Remarks
470 – 694 / 698 MHz (600 MHz)	TBC	Mainly for Americas, subject to auction proceeds in the USA
694 – 790 MHz (700 MHz)	60	global band, now also in EMEA
1427 – 1518 MHz (L-band)	91	global band, in most countries
3300 – 3400 MHz	100	global band, in many countries, not in Europe / North America
3400 – 3600 MHz (C-band)	200	global band, now in most countries, already allocated in Europe
3600 – 3700 MHz (C-band)	100	global band, in many countries, not in Africa / some in APAC
4800 – 4990 MHz	190	some few countries in APAC, and one in Americas

Sub-6GHz Bands Allocated to IMT Service in WRC-15



Bands between 24.25 GHz and 86 GHz being studied for WRC-19

This is an extremely urgent issue that requires the immediate attention of OFCA. OFCA must look seriously and quickly at the sub 6GHz harmonized bands identified at WRC-15 and the candidate bands above 6GHz, explore how the needed bandwidths can be made available for multiple competitive operators in Hong Kong and take clearly identified steps to make this happen within a published timeframe. While HKT welcomes OFCA's recent announcements regarding its work plan to make more spectrum available to the industry, a much clearer and more comprehensive roadmap is needed setting out the spectrum bands that are being looked at and timeframes within which these will be released. Operators need access to a comprehensive menu of spectrum with dates when it will be made available in order to enable them to chose the spectrum they need and plan effectively to be able to provide the services which consumers and businesses demand and which maintain Hong Kong's position as a prime commercial hub and a regional leader in the mobile and IT industry.

3) Need for higher speed => wider bandwidth

Capacity should not be confused with speed.

As pointed out in earlier sections, capacity increases can be achieved by increasing the number of cells and/or increasing the number of cell sites. However, the demand for user data speed continues to rise way beyond the peak speed of existing 4G LTE / LTE-A / LTE Advanced Pro networks.

While the addition of more cell sites will provide more capacity with which to support more users with more data consumption, it is important to note that this would only give more people the same throughput speed. It will not satisfy the increasing performance demands in terms of speed or low latency (delay) required by new services like IoT and connected cars. 3,000 or 30,000 cell sites of 4G LTE with a bandwidth of 20MHz will still only give customers a peak speed of around 150Mbps regardless of number of cells. Even with the use of new technology, the peak speed achievable is only a couple of Gbps, which is far below the 20Gbps peak speed anticipated for eMBB. This is regardless of the number of cell sites.

Only increases in bandwidth from the current 20MHz to 100 MHz and more can further push up the peak speed.

4) Spectrum costs => a new charging mechanism

It is abundantly clear from the above that a new approach to spectrum planning and allocation is needed. However this alone is not enough. A new approach to spectrum charging is also required. If the current system of charging is allowed to continue, the increased spectrum costs and the cost of network expansion necessary to support the exploding demand for increased data, high speed and low latency, will result in operators being unable to offer services in Hong Kong at an affordable price.

The prices paid for 2G, 3G and even in future 4G spectrum are irrelevant when considered in light of the anticipated exponential growth in spectrum requirements. Historical spectrum charging and auctions cannot continue as this will render the costs of network capacity expansion unaffordable. Spectrum prices have traditionally been based on historical price/MHz benchmarks. This is simply no longer workable with the vastly increased amount of spectrum that will be needed. Spectrum costs already represented 12.2 % of HKT's costs in 2016.[21] Based on the Governments proposals in the Second Consultation Paper HKT could be paying $1.34 billion ($67 million per MHz) for its 1800 MHz RFR spectrum (2x10MHz). When much, much more spectrum is required in bands of 100MHz and higher charging on this basis will be unsustainable.

In short, if the current system is allowed to continue, the two largest costs borne by mobile operators – mobile cell site rental (see above) and spectrum costs – are set to explode. If customers expect the ongoing charges for data service consumption to remain stable, this requires a fundamental rethink of the way in which operators pay for spectrum and access to install cell sites. Under the current system the exponential

[21] HKT's paper "The Facts about the Admin Fee – and why Spectrum Costs drive increases in the Admin Fee" 21 December 2016 http://www.pccw.com/staticfiles/PCCWCorpsite/Press%20Release/2016/Dec/20161221e%20Admin%20Fee%20paper.pdf has already discussed the issue of spectrum fees. The figure of 12.2% for 2016 has been confirmed by HKT's auditors, PricewaterhouseCoopers.

spectrum and related network capacity expansion costs would make the current level of charges utterly unsustainable.

<u>What steps should Hong Kong be taking right now?</u>

In order for Hong Kong to remain a prime commercial hub, maintain its regional leadership position in mobile services and meet consumer demand, including for 5G and IoT, the Government must take urgent steps to facilitate the industry and address the very significant issues identified in this paper. Regulators around the world are moving forward apace and, unless the Government also takes urgent action, Hong Kong will be left languishing. In particular the Government needs to take action in the following areas:

1) Opening Up Street Furniture and Facilitation of Building Access for Mobile Cell Site Installation

As explained in earlier sections, the future spectrum for 5G is anticipated to be of a much higher frequency - above 3GHz or even beyond 6GHz. As a result the coverage provided by each cell will be greatly reduced and hence at least 10 times more cell sites are required to provide territory wide coverage.

It is increasingly difficult for operators to acquire more cell sites in private buildings and other locations where cell sites are acquired solely via commercial negotiations with landlords. There is no right of building access as there is for fixed line operators. The Government must consider establishing policies on “utility” status to facilitate equal access in a timely fashion and at reasonable cost for all operators to the MTR, road tunnels, buildings and all locations where access for the installation of cell sites and other equipment for the provision of mobile services is currently solely via commercial negotiations with owners/landlords who are in a position to charge whatever they like.

In addition to facilitating access to tunnels, buildings, the MTR etc, the Government should also take urgent steps to facilitate the opening up of street furniture (e.g. lamp posts, telephone booths) for mobile cell site installation. Street furniture is ideal for mobile cell site installation as it is widely available across the territory, and close to street level which is perfect for mobile cell sites operating at high frequencies bands.

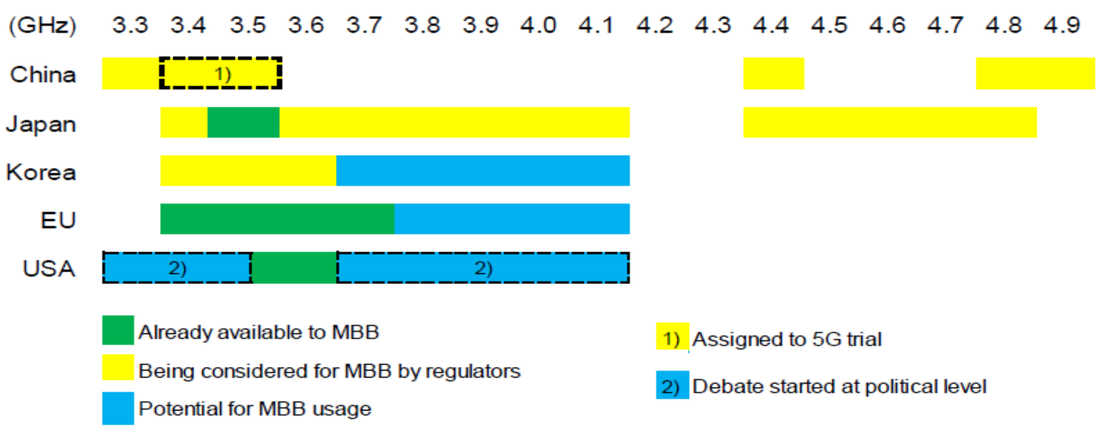
Other countries (such as Indonesia, Thailand and Mainland China) have been opening up lamp posts, electricity poles, telephone poles etc for cell site installation. The Government should establish policies on "essential facilities" (particularly the pre-provisioning or retro fitting of continuous electrical power and telecom access facilities) in all key public spaces and on public street furniture such as lamp posts, street lamps, telephone booths, and road signage. This will require not just a change of policy but also a simplified process for obtaining Government approval e.g. one point of contact for one unified Government approval.

2) Making More Spectrum and wider bandwidths available for mobile services

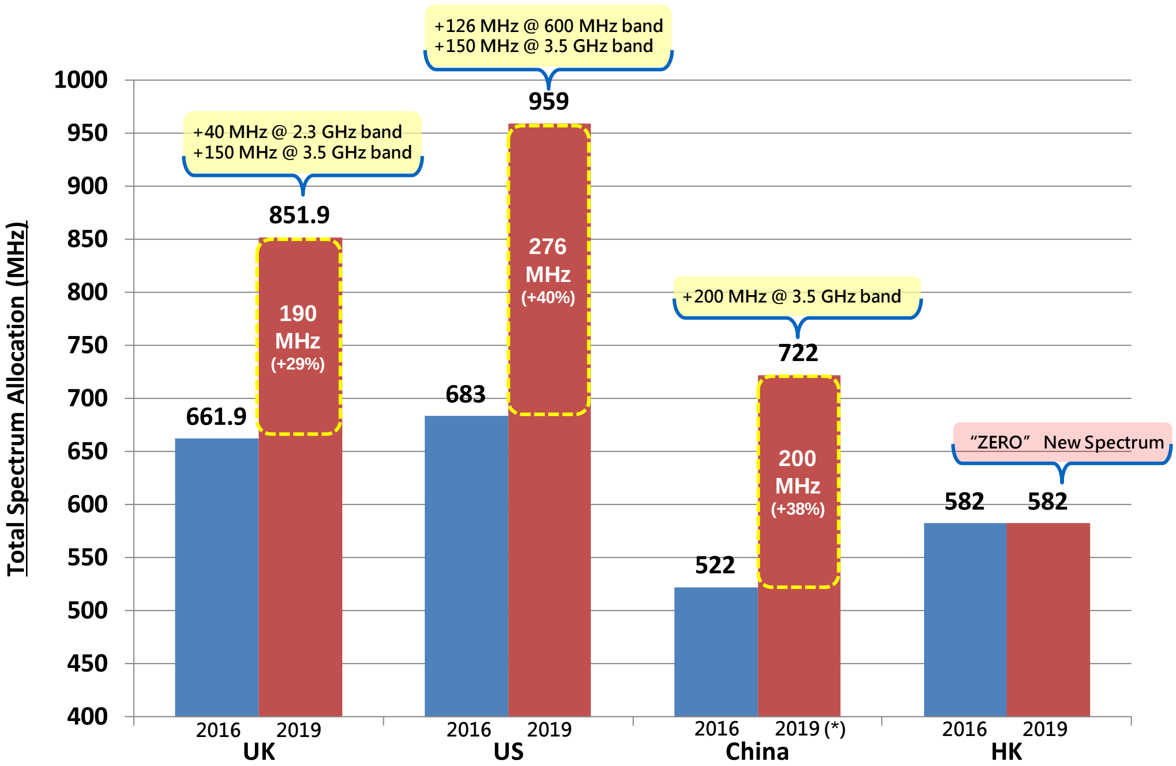
The ITU predicts that some 1340-1960 MHz of mobile spectrum will be required to provide mobiles services by 2020 but so far only 552 MHz has been released for mobile use in Hong Kong. Telecom regulators around the world realize that much, much more spectrum is needed to foster continuous advancement in mobile service development. Major markets are expediting a variety of actions and initiatives to release more spectrum and by benchmarking the spectrum plans of Hong Kong with other developed markets as shown below it is obvious that Hong Kong is already seriously lagging behind. HKT's paper on Spectrum Supply, released on 10 January 2017[22] sets out in quite some detail steps that have been and are being taken in major markets including the US, UK, EU, France, Germany and, closer to home, China, Korea, Japan, Taiwan and Singapore. Shortly after HKT's paper was published, OFCOM in the UK released a paper entitled "Update on 5G Spectrum in the U.K."[23] which sets out OFCOM's plans to make the 700 MHz band available for mobile services including 5G. OFCOM is currently undertaking work with regard to the 3.4 to 3.6 GHz and the 3.6 to 3.8 GHz bands, and examining other bands with a view to consulting the U.K. public shortly. It is clear that most countries are proposing to make available much more spectrum than that identified at WRC-15. As shown in the charts below, the leading countries have been forward looking in their approach to spectrum planning going beyond the sub-6GHz bands specifically identified for 5G spectrum at WRC 15.

[22] http://www.pccw.com/staticfiles/PCCWCorpsite/Press%20Release/2017/Jan/20170110e%20Spectrum%20Supply%20Paper.pdf

[23] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf released on 9 February 2017.



Frequency candidates considered by leading countries for WRC-19 (Sub 6GHz)[24]



New spectrum plan by country

(*) China is conducting compatibility trial on 3.5 GHz band. Upon completion of trial by end 2017, the band is expected to be ready for allocation before 5G rollout in 2020

[24] GSMA, "5G Vision, Characteristics and Requirements", June 2016 http://www.gsma.com/spectrum/wp-content/uploads/2016/08/GSA-5G-Spectrum-update.pdf

Hong Kong is falling behind other countries. The Government's Spectrum Release Plans for 2015 – 2016, 2016 – 2018 and 2017 – 2019[25] indicate no new spectrum is available. HKT welcomes the recent announcements by the Government that it is taking steps to explore ways to release or re-allocate spectrum for mobile services following repeated requests from HKT. HKT also notes OFCA's recent press releases regarding spectrum in the 3.4 – 3.6 GHz band and the 26GHz band. However, the issue is very urgent and the Government needs to be more proactive and expedite the process of identifying and freeing up inefficiently/under-utilized spectrum bands. Spectrum in the 3.5 GHz band, for example, was identified in 2015 as a harmonised band for 5G, yet OFCA has only this year begun seriously investigating making spectrum in this band available for mobile use. We are now at the point where this spectrum is entering mainstream mobile use: Samsung's new S8 phone supports the 3.5MHz band – and yet this band is still not available for mobile use in Hong Kong.[26] The goal should be a transparent menu of spectrum from which operators can select what they need with full knowledge of what is available and what is coming. Withholding spectrum only serves to create uncertainty as to future availability of spectrum and pushes up prices in any auction unnecessarily, as participants are forced to bid aggressively in order to secure spectrum just in case no further supply is imminently available. For example, the recent Thai spectrum auction for the 900 MHz and 1800 MHz bands resulted in excessive prices because bidders were not given a clear roadmap as to future spectrum releases, as explained by Plum Consulting ("**Plum**").[27] Operators should not be bounced into expensive auctions with high reserve prices, for spectrum which is already being efficiently used for mobile services, with no clear understanding of how much additional spectrum will be available at what frequencies and when in the future.

If Governments in other countries, like the UK, can issue clear guidance as to the availability of future spectrum releases, why can't the CA?[28]

3) A new way of charging for spectrum

As explained above the current system of charging for spectrum is untenable and needs to be changed. The government must move away from the historical system of charging for spectrum on a per MHz basis. As millions of connected Smartphones become billions of connected devices and demand for spectrum grows exponentially as a consequence, continuing to levy upfront Spectrum Utilization Fees for fixed assignment periods based on a per MHz basis will result in huge fees becoming payable further increasing what is already a significant financial liability for the mobile industry. Ultimately this will serve only to stifle innovation.

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[25] The 2017 – 2019 Spectrum Release Plan was published on 21 February 2017.
[26] https://www.frequencycheck.com/models/AabYB/samsung-sm-g950f-galaxy-s8-td-lte-samsung-dream#frequencies
[27] Plum Consulting, Valuing Spectrum in Thailand: What can we learn?, 25 April 2016: http://plumconsulting.co.uk/plum-insight-valuing-spectrum-thailand-can-learn/
[28] See report published in April 2016 by UK Government Investments on Enabling UK growth: Public Sector Spectrum Release Programme annual report ("UK Government Investments Spectrum Release Programme"). https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/518303/enabling_uk_growth_pssr_programme_annual_report.pdf

HKT suggests that OFCA should consider a move to a flat spectrum fee, regardless of spectrum allocated, based on a percentage of revenues. This would mirror the approach, taken by the Rating and Valuation Department in rating telecommunications infrastructure in the ground in fixed networks. The approach is not new to OFCA as it has already been used for 3G spectrum. OFCA could hold auctions in relation to the percentage of revenues to be charged. In this way, the social benefits of wireless broadband can be maintained whilst maintaining a fixed cost of spectrum relative to the operator's business and at an agreed rate of percentage of revenue or costs.

4) A new way of managing spectrum assignments

HKT is not against auctions per se. For new spectrum releases (and a key theme of this paper is that much new spectrum needs to be released), an auction may well be an appropriate way to determine who values the spectrum most. However, once spectrum has already been deployed, it must be managed in a way that incentivizes investment and is conducive to the development of mobile services. The market needs certainty that the significant investments which have been built up in order to utilize that spectrum effectively will not be wasted. Global best practices, as highlighted in several reports published by the GSMA and followed in many countries now indicate that:

a) Spectrum should be licenced on a technology neutral basis[29] i.e. its use should not be restricted to specific technical standards. Given the speed of innovation in technology and mobile services, operators should be free to decide the best use for their spectrum as technology changes. Licence conditions unrelated to avoiding interference should be removed or kept to a minimum.

b) Spectrum should be licenced on a perpetual basis or with an expectation of renewal.[30] This is would not be new in Hong Kong. In 2005/06 when the initial assignment period for 2G spectrum ended, the Government re assigned the spectrum bask to the existing holders on the basis that service continuity would be assured, the spectrum was being used efficiently and that there was a need to provide a stable investment environment for mobile operators. There is no reason why this approach to existing spectrum assignments should change. Unless the spectrum is being used inefficiently or a licensee has seriously infringed its licence, the spectrum should be re-assigned back to the incumbent holder upon expiry of the assignment period. This was and still is global best practice. Not only is Hong Kong not keeping up with best practices, it actually seems to have taken a step backwards.

c) Spectrum trading should be implemented.[31] Spectrum trading is not difficult to implement and it brings important benefits for consumers. It has been successfully

[29] GSMA "5G Spectrum, Public Policy Position", published November 2016.
https://www.gsma.com/spectrum/wp-content/uploads/2016/06/GSMA-5G-Spectrum-PPP.pdf

[30] GSMA "Best practice in spectrum licence renewals", published September 2016
http://www.gsma.com/spectrum/wp-content/uploads/2016/11/spec_best_practice_ENG.pdf

[31] See HKT's earlier paper "Spectrum Trading in Hong Kong – Why are we waiting?" published 18 January 2017
https://hkt.com/staticfiles/PCCWCorpsite/Press%20Release/2017/Jan/20170118e%20Spectrum%20Trading%20Paper.pdf

introduced in most developed markets. Spectrum trading provides flexibility to mobile operators in how they manage their supply of spectrum and makes it easier for them to ensure that they have the spectrum they need and are using is efficiently, without having to wait years for another auction. It enables changes to happen far more quickly, efficiently and consistent with technological advances. In 2007 the government agreed in principle to introduce spectrum trading, it has not so far done so and has now decided to commission a new consultancy study on spectrum trading as the previous one is out of date. There is no reason why the introduction of spectrum trading should be further delayed.

Conclusion

Hong Kong is facing a severe spectrum deficit. Compared the bench marks of international best practice from Europe, North America and neighbouring countries in Asia, Hong Kong is behind in its approach to spectrum management. The current spectrum roll out plan has failed to set the stage for early adoption of 5G. Along with the archaic principles and practice adopted by the Communications Authority for building access, spectrum charging and spectrum management this poses a clear and substantial threat to Hong Kong's services based economy, consumer satisfaction, our role as a telecommunications hub, our ability to serve as a gateway to Mainland China and our ability to be a creative centre. While other countries have already announced clear road maps for the release of specific frequency bands for the development of mobile service (indeed most are proposing to make available much more spectrum than that identified at WRC-15) and are taking steps to facilitate access to street furniture and buildings and are moving to technology neutral licences with a presumption of renewal and introducing spectrum trading, Hong Kong is way behind. This can only result in Hong Kong quickly falling behind other developed countries and losing its leadership position in mobile telecommunications services. A radical overhaul of the Government's approach in this area is needed, before any decisions are taken with respect to 900MHz and 1800 MHz spectrum.

Hong Kong Telecommunications (HKT) Limited
24 May 2017

Licensing to support the mobile broadband revolution

A report for the GSM Association

May 2012



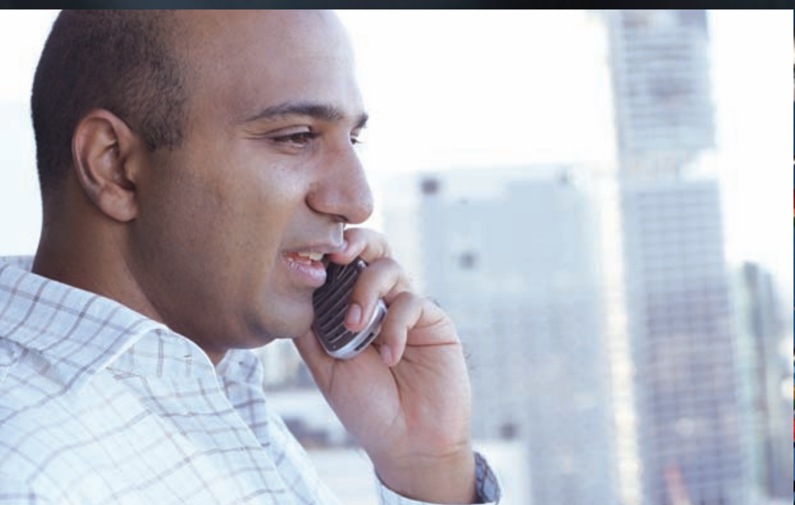




Table of Contents

Executive summary

Mobile phones have become the main means for making voice calls in the world and have brought telecommunications access to many of the world's people for the first time. Now the industry is in the middle of another major transformation with rapidly growing take-up of mobile broadband services across both developed and emerging markets. Mobile data traffic is expected to increase 18-fold between 2011 and 2016 with growth rates being highest in emerging markets, including the Middle East and Africa, Asia Pacific, Central and Eastern Europe and Latin America.

Spectrum is the lifeblood of the mobile industry. The amount of spectrum made available and the terms on which it is made available fundamentally drive the cost, range and availability of mobile services. Across the world, substantial new spectrum is needed to support ongoing growth in both traditional voice and new broadband mobile services. It is also critical that the rights to use the spectrum are provided in a way that enables the industry to deliver maximum benefits to consumers. The rapid growth in demand for spectrum increases the importance and the difficulty of efficient spectrum management. The GSMA has commissioned this report to examine the experience with mobile spectrum licensing around the globe to date and draw out the lessons for policy. A key focus is on what works well in emerging markets and how the lessons can be applied to the additional spectrum to be allocated over the new few years. Choosing the correct spectrum policy will be particularly important in emerging markets where mobile services can be expected to provide the principal access to high-speed data, as they have with voice.

The countries that get their spectrum policy right will achieve widespread access to affordable and innovative mobile broadband services. Strong communications infrastructure, in turn, brings significant wider economic benefits including in boosting productivity and living standards. Governments that currently face significant fiscal demands also stand to benefit both directly from licensing revenues as well as more generally through the higher economic growth generated by access to mobile broadband.

Achieving a flexible licensing framework to support substantial new investment

Traditionally, many governments imposed highly prescriptive operating and spectrum licences that required operators to supply only certain services and/or use specific technology (although other countries have not had separate operating and spectrum licences). Given the rapid pace of technological and market developments, restrictive licensing requirements will limit operators' ability to make the best use of their networks to supply services and risk delaying the investment required to introduce new broadband services. Detailed spectrum licences that are specific to one operator, type of service, network or technology also risk distorting competition if operators supplying competing services face different licence conditions. While, in the past, operators have been subject to extensive restrictions, many licensing authorities provide little guidance on their own approaches to forthcoming spectrum issues. This increases regulatory risk and deters operators from making the large investments required to deploy new technologies and services.

Following are our key recommendations in relation to reforming the overall licensing framework:

- *Recommendation 1* - Licensing authorities should progressively remove restrictions that unduly restrict operators from determining which services they will provide and the technology that they will use. Restrictions that do not result in clear net benefits should be relaxed. Operating licences should be expanded to cover a greater range of services or, where appropriate, replaced altogether by simpler authorisations or class licences. Where restrictive operating licences are maintained they should be separated from licences for the use of spectrum. Spectrum licences should, in general, contain spectrum management provisions only or principally. This will assist changes in business activities and spectrum holdings and support the evolution of technologies and the different needs between radio spectrum management and other aspects of the licence. Operators offering similar services should be subject to the same terms and conditions.
- *Recommendation 2* - Spectrum should be managed to ensure that a country obtains maximum benefit from the use of its spectrum resources. Spectrum rights should be assigned to the services and the operators who can generate the greatest benefits to society from the use of that spectrum, i.e. to achieve the efficient use of spectrum. Market-based approaches represent a key means to ensure that spectrum is used to supply the services most in demand and operators are able to use the best available technology to deliver those services.
- *Recommendation 3* - Licensing authorities should ensure that the overall licensing framework offers stability and transparency to reduce regulatory risk and promote investment. Key principles should include:
  - establishing and adequately resourcing an independent regulator with responsibility for operator and spectrum licensing among other matters;
  - announcing in advance a long term plan for reform of the spectrum and operating licensing framework;
  - facilitating international harmonisation so that equipment and devices use the same frequency bands to support international roaming and enable the realisation of scale economies in manufacture;
  - publicly setting out the criteria and process to be followed in licensing decisions and including public written consultation in advance of key decisions being made with both consultation responses and the assessment of input in reaching final decision being published;
  - clearly defined spectrum rights that are backed up by a robust compliance/enforcement regime;
  - taking a holistic approach to licensing that ensures that the overall package enables the ongoing development of the mobile industry (including a process for the renewal of licences at their expiry); and
  - taking into account investors' legitimate expectations and providing compensation mechanisms where decisions are made in conflict with those expectations.

Freeing up spectrum resources to meet growing demand

Licensing authorities can take a number of key steps to free up spectrum that is currently poorly utilised and use that spectrum to deliver higher valued services. In particular, authorities should both identify what spectrum rights are able to be assigned to provide additional spectrum capacity as well as enabling current spectrum assigned for mobile services to be used more effectively. Enabling flexible/technology neutral use of spectrum so that operators who currently use spectrum for 2G services have the ability to determine when the use of part or all of this spectrum should be changed for 3G and newer mobile technologies such as Long Term Evolution (LTE) services. This is an important way to expand over time the services able to be carried with existing spectrum as well as facilitating lower cost services, expanded geographic coverage and better indoor coverage, depending on the bands considered.

- *Recommendation 4* – Current rights to use spectrum should be clearly specified and spectrum bands that are currently idle or being poorly utilised (including by public sector agencies) should be considered for re-allocation to services that could use the spectrum to generate greater benefits for society.
- *Recommendation 5* – Licensing authorities should publish a road map of the planned release of additional spectrum bands to maximise overall benefits from the use of spectrum including taking into account the benefits of international harmonisation. In doing so, aligning spectrum rights with the internationally harmonised mobile spectrum bands will ensure that operators and their customers can acquire competitively provided equipment and devices and that customers can readily access international roaming services.
- *Recommendation 6* - Licensing authorities should progressively remove service and technology restrictions in existing mobile spectrum usage rights to enable operators to choose when to deploy mobile technologies that can technically co-exist so as to increase spectral capacity, reduce cost of provision, extend coverage to rural areas and improve indoor coverage. Operators themselves are likely to be best placed to determine the speed of migration particularly recognising that 2G services are likely to remain important for the next 5 to 10 years.
- *Recommendation 7* - New spectrum usage rights within the mobile bands should be issued on a service and technology neutral basis subject to the use of technologies which can technically co-exist without intolerable interference.
- *Recommendation 8* - Licensing authorities should facilitate harmonisation of spectrum through allocating radio frequency bands in accordance with international agreements and by applying spectrum management approaches aligned with international best practice.

Assignment and renewal of licenses

A major forthcoming issue for many licensing authorities is to determine what should happen to spectrum rights as licences approach the end of their initial term. Uncertainty about the future rights to spectrum can lead to operators reducing or delaying investment in upgrading their networks and deploying new services. Securing funds for investment is difficult in the current economic environment even for established players. As such, authorities should be alert to the real danger that their investment incentives can be undermined by uncertainty over future rights. The loss of rights to spectrum currently being used for the supply of services also carries risks to customers in relation to the loss of service. Reflecting these risks, many authorities have established a presumption of licence renewal with only exceptional and well specified circumstances under which licences will not be renewed. More generally, where licences are to be re-assigned or assigned for the first time, authorities will need to determine whether market-based or administrative approaches will best promote efficient allocation of spectrum in the specific market context.

- *Recommendation 9* – Licensing authorities should clearly set out their approach to licence renewal in advance (a range between 2 to 4 years as a minimum should be adequate) of the expiry of the licence so as to avoid network investment being postponed. The authorities should publish the criteria that they will use to assess renewal as well as the terms and conditions that will apply to the renewed licence.
- *Recommendation 10* - There should be a presumption in favour of licence renewal for operating and spectrum licences to encourage long-term investment and minimise the risk of service disruption to customers. Reasons for not renewing licences should be limited to spectrum replanning, where there is little risk of stranding substantial investments, or where there has been a serious breach of licence conditions which should be evident in advance of the renewal time. Exceptionally, a licence may not be renewed in relation to the whole or part of the relevant spectrum so as to promote competition through re-assignment of spectrum. However, before not renewing a licence for this reason, regulators should first (i) assess whether competition is already effective in the market; (ii) identify whether competition can be promoted by other means such as the release of alternative spectrum; and (iii) assess whether the expected competition benefits will exceed the potential costs such as in relation to spectrum replanning, customer migration and the risk of deterring investment.
- *Recommendation 11* – Re-auctioning spectrum at the end of the licence should be limited to situations where there has not been evidence of substantial investment and there is a reasonable prospect that spectrum will be re-assigned between operators (or where additional, alternative spectrum is being made available), or situations where an existing licensee decides to reject a licence renewal offer. In most cases, the existing operators would be expected to re-acquire the licence with the consequence that an auction only creates unnecessary uncertainty and costs.
- *Recommendation 12* – Where spectrum is to be re-assigned or assigned for the first time, licensing authorities should determine the approach or combination of approaches to assigning licences taking into account their particular objectives as well as the likely advantages and disadvantages of the different approaches in the particular market context drawing on both theory and practical experience. Licensing authorities should attach priority to ensuring effective competition in downstream markets for services to end-users. Whether an auction or beauty contest is adopted, the detailed design of the approach is important. Open auctions are likely to be superior to sealed bid auctions for spectrum relevant to mobile broadband services in terms of promoting efficient spectrum use.

Efficient pricing of spectrum

The overall level of licence fees (including upfront and annual charges) can significantly impact market outcomes including the number of players that enter the market and, particularly where annual charges are levied, the prices for mobile services. There is a strong economic case to avoid the level of licence fees being determined on the basis of revenue maximising objectives. Rather, licence fees can be used to help recover the administrative costs of the licensing process and of managing spectrum and, in some circumstances, to encourage efficient spectrum use.

Following is our key recommendation in relation to spectrum pricing:

- *Recommendation 13* - Licence fees, if any, should generally be limited to recovering the administrative costs of the licensing process and associated regulatory costs (including spectrum management costs). However, where there is excess demand for spectrum, then an auction or administrative assignment of spectrum with a charge set in line with the Marginal Forward Looking Opportunity Cost (MFLOC) of spectrum should be considered. Indexation or benchmarking may prove a practical means to estimate MFLOC in particular circumstances. The MFLOC should be estimated conservatively to reduce the risk that valuable spectrum will be left idle. It is also important that the estimated prices are set appropriately relative to spectrum prices in other bands. The relative merits of upfront licence fees versus annual charges should be considered with regard to the particular market circumstances.

Promoting competition

The approach to spectrum licensing can significantly impact competition in the mobile services markets. There is a case for regulators to ensure that national spectrum resources do not become excessively concentrated in the control of only one or two operators. However, there is also a danger if spectrum becomes too fragmented as mobile operators would be prevented from realising scale economies so that service costs and prices are higher than otherwise. Generally, licensing authorities should ensure that operators are able to expand their access to spectrum if they are delivering value and attracting customers.

- *Recommendation 14* - Licensing authorities should aim to ensure effective competition in the downstream markets for mobile services. Many sector regulators and competition authorities have accepted that three to four national operators are likely to be sufficient to achieve effective competition.
- *Recommendation 15* - Specific measures to promote competition should only be imposed in markets where there is market failure and competition would otherwise be ineffective and where those measures are assessed as being likely to result in greater benefits than costs. Spectrum caps, spectrum set-asides, bidding credits, competition law enforcement and open access requirements carry advantages and disadvantages and should be assessed in relation to the specific market context.

Reviewing non-price terms and conditions

Efficiency can be promoted by licences that support operators making substantial investments that reflect fundamental market conditions rather than requirements imposed by regulators. Many governments have traditionally included a range of terms and conditions in licences which go beyond those necessary for the intrinsic purpose of the licence to authorise market access and/or manage the use of spectrum. However, licence conditions tend to be relatively inflexible and can create the risk of market distortions as competition develops in telecommunications markets. Alternative, targeted regulation is likely to better achieve particular goals such as the control of market power and promoting universal access.

Following are our key recommendations in relation to non-price terms and conditions:

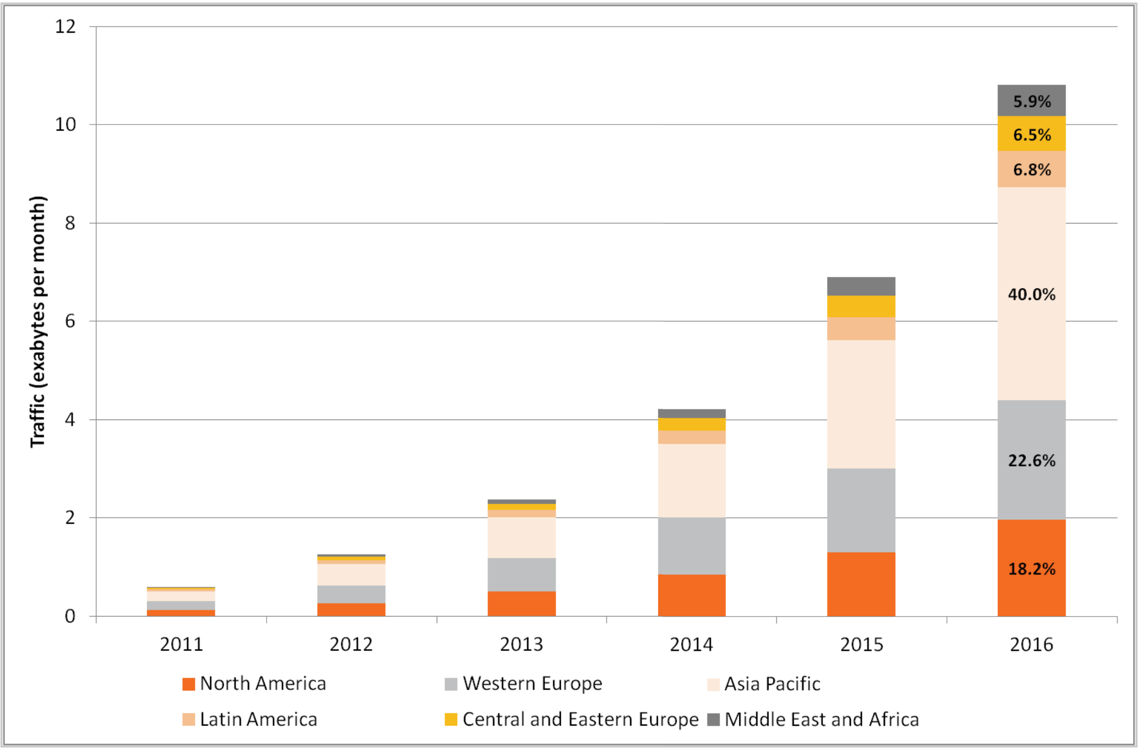
- *Recommendation 16* – Licensing authorities should introduce licence terms for mobile operators that are at least in line with the expected payback period for the investments and should consider the introduction of indefinite licence terms (with a specified minimum term, i.e. 15 years).
- *Recommendation 17* - Licensing authorities should provide for national licences where customer demand and/or scale economies are likely to support national provision as being most efficient. Where regional licences are under consideration, the auction process itself could be used to determine whether regional or national licences are valued most highly.
- *Recommendation 18* – As an alternative to licence obligations, governments should achieve universal access and competition objectives through policies that help to change the underlying economics of extending access or entering the market or through alternative targeted regulation.
- *Recommendation 19* – Licensing authorities should enable voluntary spectrum trading between operators and facilitate trading through well specified spectrum rights, long licence terms and minimizing administrative costs. Such trading helps to ensure that spectrum remains efficiently assigned over time. Competition concerns should be assessed taking into account the specific circumstances of each trade, although certain safe harbours could be established such as where the operator acquiring the spectrum has a market share below a certain threshold and/or the spectrum represents a relatively small share of the overall spectrum available for those services.

1. The mobile broadband revolution

The number of mobile subscriptions in the world reached more than 5.9 billion in 2011 and mobile penetration in the developing countries more than doubled between 2006 and 2011 to over 78%.[1] The expansion of the mobile industry has brought telecommunications access to the majority of the world's population for the first time, significantly improving the quality of life for billions of people as well as providing critical infrastructure to enable business to flourish even in remote areas. Mobile technology has proven to be a successful way to rapidly expand the reach of telecommunications at affordable prices while fixed networks remain very limited in most developing countries.

The global mobile industry is now undergoing another major transformation as mobile subscribers increasingly use mobile data services alongside traditional voice services. Cisco estimates that global mobile data traffic increased 2.3-fold in 2011, more than doubling for the fourth year in a row.[2] Cisco expects mobile data traffic to increase 18-fold between 2011 and 2016 with growth rates being highest in the Middle East and Africa (a compound annual growth rate of 104%), the Asia Pacific (84%), Central and Eastern Europe (83%) and Latin America (79%).

Figure 1: Mobile data traffic forecast by region 2011 – 2016



Source: Cisco visual networking index: Global mobile data traffic forecast update 2011-2016.

The rapid growth of mobile data volumes is being driven by the increasing variety of services being used across smartphones, laptops, netbooks, tablets and other devices. For example, mobile data services support access to the Internet and email for business and personal use, mobile video, business applications, cloud applications and services, social networking and many other online services. While in developed countries, mobile broadband's primary advantage is to have access to data

[1] International Telecommunications Union, Key Global Telecom Indicators.

[2] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2011-2016.

services anytime and anywhere, for many subscribers in developing countries mobile often provides the only means to access these services. Smartphones are expected to outnumber personal computers by the end of 2012.[3]

On-going improvements in mobile technology have been integral to the growing use of mobile data services. Many existing 3G networks have been upgraded to High Speed Packet Access standards and the first Long Term Evolution (LTE) networks have commenced supplying services. The Global Mobile Suppliers Association (GSA) reports that 57 networks in 32 countries were supplying commercial LTE services by March 2012.[4] Technologies improvements are bringing substantial increases in connection speeds that improve the usability of existing services and are enabling new bandwidth-hungry services to be introduced. The first LTE deployments provide instantaneous downlink peak data rates of at least 100 Mbps within 20 MHz spectrum allocations. Cisco estimates that average global mobile connection speeds will increase from 189 kbps in 2011 to 2,873 kbps in 2016.

The new mobile technologies also increase the overall capacity of the networks which will help meet growing demand. Research for Ofcom found that 4G technologies including LTE deliver more than 200% of the capacity of existing 3G technologies using the same amount of spectrum.[5] Ofcom also noted that "*the research revealed that the capacity gain from the increased spectral efficiency of 4G technologies will not on its own be sufficient to meet the expected growth in demand for mobile demand. As well as using spectrum more efficiently, more spectrum itself is also needed*".[6]

Increased access to mobile communications in a country has been found to significantly increase overall economic growth and productivity. Studies found that a 10% increase in mobile penetration in a developing country typically leads to a 1.2% growth in GDP[7]. The gains from mobile access will now be magnified through its impact on expanding access to broadband. The World Bank has estimated that in low and middle income countries every 10 percentage points increase in broadband penetration accelerates economic growth by 1.38 percentage points.[8] Mobile broadband will better connect customers with businesses as well as supplying the information necessary for the efficient operation of markets. Access to the Internet can help match people with job opportunities and reduce unemployment. Mobile broadband will also increasingly be used to deliver health, education and financial services and better link citizens with governments.

[3] Strategy Analytics, January 2011.

[4] GSA, Evolution to LTE report, 13 March 2012.

[5] Real Wireless, Report for Ofcom – 4G capacity gains, 27 January 2011.

[6] Ofcom news release, 12 May 2011.

[7] Deloitte for GSMA Global Mobile Tax review 2006-07, ICRIER India the Impact of Internet 2009

[8] World Bank (2009) Information and Communication for Development: Extending reach and increasing impact.

Need for more spectrum and better use of existing assignments

Access to spectrum and better use of assigned spectrum are critical to realising the full economic and social benefits of mobile services including the potential of mobile broadband to spur economic growth and improve quality of life. In particular, the availability, cost, variety and quality of mobile services depends crucially on how much spectrum is made available to operators, what frequency bands are made available and the terms and conditions on which the spectrum is made available.

- An operator with more spectrum can supply a given volume of mobile services at lower cost because it will need fewer cell sites to do so. With limited spectrum, any one cell site will be able to carry fewer calls before that cell site fully uses the spectral capacity. Where too limited spectrum is made available, operators may find that they are not able in practice to meet growing demand for services.

- Spectrum in lower bands has greater propagation properties so that a given geographic area will be able to be covered with fewer cell sites. Access to this spectrum can be critical to enable coverage to be extended to rural and remote areas in an affordable way. Spectrum in lower bands also enables services to travel better into buildings and thereby improves indoor coverage where the majority of mobile services in many countries are accessed.

- Where particular spectrum bands are restricted for use with only certain services or technologies then operators may be prevented from achieving the maximum potential capacity or from supplying the services most in demand.

- Licence fees, if any, annual spectrum charges, taxes and other obligations impact on the economics of investing in the industry of a particular country and can also raise the price of services to consumers. While some charges may be efficient, large industry-specific charges and taxes can come at the expense of economic growth and can even be self-defeating as a way to raise revenue. By raising the cost of using mobile services, mobile-specific charges and taxes can constrain the growth of the wide range of industries that rely on mobile communications and hence reduce the ability of governments to earn higher revenues across the economy.

On-going rapid growth in demand for mobile voice and data services will require not only the renewal of existing spectrum rights but also the allocation of substantial new spectrum to mobile services. For example, the US National Broadband Plan recommended that 500 MHz of additional spectrum be allocated for mobile broadband technologies within ten years for the US to achieve world-leading mobile broadband infrastructure and innovation. The US FCC also found that the amount of mobile data demanded was likely to exceed the capacity of US mobile networks in the near-term and that making an additional 275 MHz of spectrum available would save approximately $120 billion in capital expenses to accommodate mobile data demand.[9] Fully realising the potential of mobile broadband also requires that spectrum licensing is undertaken in a way that promotes efficient use of the spectrum, competition to maximise benefits to end-users and avoids unnecessary regulatory risks so as to provide the confidence for businesses to undertake substantial new investment.

In the remainder of this report, we examine how government and regulators can best carry out spectrum licensing to maximise benefits to their citizens.

[9] Federal Communications Commission Staff Technical Paper, *Mobile Broadband: The Benefits of Additional Spectrum*, Oct. 2010.

2. The general licensing framework

This section addresses how the overall licensing regime should be structured and what steps can be taken to improve the general framework. An important distinction exists between general operating licences relating to network and service provision and licences for the rights to use particular spectrum bands. Many countries have introduced greater flexibility in operating licences and this promotes competition as well as spurring the growth of the overall electronic communications sector. For spectrum licensing, on the other hand, the immediate priority in many developing countries is to clarify current spectrum usage and rights and to ensure that valuable spectrum is not being left idle or underutilised. We conclude this section by considering key principles applicable to the overall licensing framework that can support high levels of investment and ensure that the licensing framework operates well to maximise benefits for consumers.

2.1. Two main types of licences

There are two main types of licences in relation to mobile services: general operating licences and rights to use particular spectrum bands.

Operating licences

General operating licences have traditionally been used by governments to control or at least monitor which companies provide particular communication services as well as imposing a range of obligations on those companies.[10] Restrictive operating licences can, however, carry large economic costs in artificially limiting the ability of networks to provide a range of services and in preventing full competition between different types of operators. For these reasons, many countries have introduced greater flexibility in general licensing so that operators have the freedom to choose the lowest cost of way of supplying existing and new services. Greater flexibility has been achieved by:

- expanding the range of services and technologies covered by an individual licence such as in Malaysia or introducing unified operating licences covering all networks, technologies and services such as in Nigeria[11] or in India (where a unified licences for basic and cellular services were introduced in 2003 with the intention of moving towards a fully unified licensing regime); or

- introducing general authorisations which entitle a provider to commence offering services without being required to first obtain any explicit administrative approval (albeit they may still be required to notify the authorities and provide a minimal amount of information) – this has been the approach adopted by the European Union.[12]

In reviewing the framework for operating licences, important issues for authorities to consider are:

i. the ease with which providers can establish new networks and offer new services;

ii. the flexibility for a provider to choose the range/bundle of services depending on the market being served;

[10] A more detailed discussion of the issues and approaches to operating licences is contained in our 2007 report, Licensing for growth. Since 2007, the trend to more flexible operating licences and the use of authorisations has accelerated.

[11] See CIPACO, *Unified licences: what benefits for the telecoms sector*, 17 January 2007.

[12] *Directive 2002/20/EC of the European Parliament and of the Council of 7 March 2002 on the authorisation of electronic communications networks and services.*

iii. avoiding detailed obligations that carry more costs than benefits or that could be better targeted through regulation of operators with significant market power (we discuss licence conditions further in Section 7);

iv. limiting the extent to which existing operators are harmed through changes in conditions that conflict with investors' legitimate expectations (or compensating affected parties where reforms would bring significant benefits); and

v. promoting efficient competition by ensuring that operators which offer similar services are subject to the same terms and conditions.

By getting the operating licensing regime right, authorities can provide a substantial stimulus to the growth of their telecommunications sector both directly in terms of the provision of more services from existing networks as well as over time as stronger competition drives lower prices and more varied and better quality services.

Spectrum licenses

Rights to use spectrum raise a distinct set of issues. While competition between multiple providers of networks and services is generally desirable to promote better outcomes for consumers, a particular spectrum bandwidth on the other hand may need to be assigned to one user if it is to be used for certain technologies. Allowing multiple users of the same spectrum bandwidth can risk high levels of interference that would prevent some types of services from being offered at an acceptable quality of service.

For the provision of mobile services over wide areas, the risk of intolerable interference requires that the government restrict who is allowed to transmit on a particular spectrum bandwidth over a particular geographic area. Such restrictions can take several forms:

- Governments may mandate that only one specified user may transmit on a particular spectrum bandwidth using a particular technology and for the supply of a particular service (this is referred to as a Command and Control approach);

- Governments may allow some greater flexibility such as allowing users to choose from within a range of prescribed technologies or to buy and sell spectrum between each other; and

- Governments may allow anyone to use a particular spectrum band but restrict the type of use of the spectrum such as in terms of power constraints (this approach is known as licence-exempt use or a spectrum commons and is commonly used for short-range, low power services, such as Wi-Fi).[13]

In Appendix A, we have set out a sample generic licence as a guide to the terms and conditions that could form a spectrum licence along the lines of the approach proposed in this report.

[13] While a number of commentators have suggested that greater use of spectrum commons is desirable, spectrum commons can give rise to significant inefficiencies including no guaranteed quality of service (particularly in urban areas), ongoing government determined restrictions on use and acting as a deterrent to investment in the band. The problems of spectrum commons are discussed in J. Brito, "The Spectrum Commons in Theory and Practice", *2007 Stanford Technology Law Review* 1.

Separation of operating licences from spectrum licences

In most countries, operating licences and spectrum licences serve different purposes and it is desirable that they form separate licences where restrictions are being imposed unrelated to spectrum. Such a separation can help ensure that rules in relation to network or service provision are applied in a neutral manner across technologies and operators by allowing the same licence type to be issued to all network operators and service providers. Spectrum licences can then be targeted at issues of specific relevance to spectrum use, particularly interference management. Separation can also provide operators with greater flexibility to adapt their activities or spectrum holdings over time without calling into question the validity of their overall licence.

2.2. Principles to guide spectrum management

Historically, particular spectrum bands could be allocated to particular uses on a 'first-come, first-served basis' as new radiocommunications technologies were developed. This is no longer the case. The proliferation of technologies that rely on access to spectrum and the rapidly growing demand for services delivered via those technologies means that spectrum allocated to one use can come at the expense of the supply of other services. The growth of mobile broadband in particular is greatly increasing the need for spectrum to be allocated efficiently. As such, authorities are finding that in licensing rights to use spectrum they need to make choices between industries, services and operators. Establishing robust and clear principles to govern spectrum management is crucial.

Spectrum licensing is fundamentally about ensuring that a country obtains maximum benefit from the use of its radio frequency spectrum resources. This requires:

- Policies to ensure that spectrum rights are assigned to the services and the operators who can generate the greatest benefits to society from the use of that spectrum (i.e. to achieve the efficient use of spectrum). Market-based approaches represent a key means to ensure that spectrum is used to supply the services most in demand and that operators are able to use the best available technology to deliver those services.

- Mechanisms or reviews to identify where valuable spectrum is being underutilised so that it can be traded or reassigned. Mobile operators in many markets suffer from limited spectrum assignments while spectrum may be lying idle or assigned to other uses of little value.

- Clear rights governing the use of particular bands so as to avoid intolerable interference or preventing spectrum being used efficiently. These rights should be backed up by a robust compliance and enforcement regime. Users should have legitimate expectations that their rights to use will not be changed without good cause.

- Facilitating international harmonisation so that equipment and devices use the same frequency bands to support international roaming and enable the realisation of scale economies in manufacture.

- Avoiding unnecessary administrative restrictions on what services can be supplied or on the way in which they are supplied. With rapid advancements in technology and demand for services, such restrictions can prevent customers from being able to access innovative new services.

- Regulatory obligations to achieve specific policy goals or address problems of inadequate competition are best determined as part of regular market reviews with regulation being targeted in scope and duration.

- Stability and transparency in the licensing framework and with an overall spectrum plan to facilitate the large investments required in rolling out networks and introducing updated technologies and new services.

We expand on the justification for these principles in the remaining sections of this report. In the next section we consider specific measures to promote stability and transparency in the general licensing framework.

2.3. Stability and transparency in the licensing framework

Regulatory certainty can be promoted by establishing and maintaining a transparent, predictable regulatory framework. A stable regulatory framework, in turn, can encourage new entry as well as giving confidence to the existing operators to undertake substantial investment in developing their networks and deploying new services. Regulatory stability and transparency also improves the quality of licensing decisions and minimises the risk of protracted legal proceedings.

Following are key elements that can promote regulatory stability and transparency:

- Setting out the long term plan for reform of the overall licensing framework including a schedule for introducing greater flexibility in relation to operating licences as well as the future assignment of spectrum.
- Setting out publicly the criteria and process that will be used to determine how licences will be assigned and renewed at an early stage (licence renewal decisions should be taken well before the expiry of the licence[14]).
- Establishing and publishing other aspects of the licensing environment as early as possible including but not limited to the pricing approach for licence renewal, non-price terms and conditions, and longer term plans in relation to spectrum trading and liberalisation.
- Licensing decisions should be based on a detailed assessment of the costs and benefits of a range of licensing options with particular regard to longer term impacts on investment incentives and sustainable competition.
- Ensuring that regulatory action does not conflict with investors' legitimate expectations including in relation to the planned introduction of competition and rights to continue to use spectrum based on legislation and regulatory decisions, statements and past practice.
- Assigning the responsibility for licensing decisions to an independent regulator who is required to follow specific, transparent criteria in making its decision and with an independent appeals process with the power to enforce its decisions.
- Ensuring that the regulator is adequately resourced including in relation to spectrum management functions which can require specialist monitoring equipment and technical expertise to ensure the equipment can be used effectively. While regulators in developing countries may not be as well-resourced as in developed countries they can nonetheless learn from both the positive and negative experiences encountered by other regulators who have already sought to address particular licensing issues. Regulators must additionally work to maintain a clean spectrum construct by stopping the operation of unauthorised devices which create intolerable interference.

[14] A minimum period for a licence renewal decision should be determined with regard to the expected payback period for ongoing investment that relies on the affected spectrum. A minimum period of 5 years, as applied by some jurisdictions (e.g., the UK and New Zealand), is likely to be appropriate for ongoing investments in developing mobile networks.

- Prior to a licensing decision being made, consultation should be undertaken to ensure that the perspectives and information of different industry players and of customers can be taken into account and to help identify all the impacts of different options.
- Publishing the reasons for decisions to improve the transparency of the decision-making process and to provide guidance on the likely approach to other licensees.
- Where licensing decisions are made which conflict with a licensee's legitimate expectations or where licences are revoked before their expiry date, a commitment to pay compensation can be important to protect general incentives to invest in the sector.

International trade agreements act to reinforce sound licensing practices. In particular, the General Agreement on Trade in Services requires that authorisation requirements must not "constitute unnecessary barriers to trade" (GATS Article VI) and the Telecommunications Services Reference Paper sets out the following principles, among others, which have been incorporated in commitments made by a large number of countries:

- Where a licence is required, all the licensing criteria, terms and conditions of individual licences and time normally required to reach a decision concerning an application for a licence are made publicly available;
- The reasons for the denial of a licence will be made known to the applicant upon request; and
- Any procedures for the allocation and use of scarce resources, including frequencies, numbers and rights of way, will be carried out in an objective, timely, transparent and non-discriminatory manner and the current state of allocated frequency bands will be made publicly available.

Next we examine licensing approaches in practice by examining the experience in Sweden which is relatively well progressed in the allocation of spectrum for mobile broadband and India where operators have been hindered by very limited spectrum.

2.4. Licensing in practice: Sweden

The licensing framework in Sweden is managed by an independent and well-resourced Regulator, PTS. Commercial suppliers of public communications networks and publicly available electronic communication services in Sweden are required to notify the Regulator (PTS) before commencing operations. This arrangement has been in place since the European Union's Authorisation Directive (2002/20/EC) became effective in July 2003.

The PTS's policy for spectrum in Sweden (PTS-VR-2006:2) is to ensure that spectrum is managed in a way which ensures the greatest possible usage and maximum benefits to society. Key components of the spectrum policy include: technology- and service neutral spectrum licences; auction as a spectrum distribution method; and exemptions from licensing requirements if there is no risk for harmful interference.

PTS prescribes that licenses to use radio transmitters should be as neutral as possible to the technology and services used. This gives the licensee maximum flexibility to choose which services to produce and which technology to employ. In practice, technology neutral licenses mean that only obligations which are necessary to ensure co-existence with other users, and to avoid harmful interference, shall be imposed. In addition to this, PTS notes in its spectrum policy that the introduction of a greater degree of service neutrality is a logical consequence of convergence when the same network is able to distribute voice, video, data and other services.

In Sweden, auctions are used as a primary way of distributing spectrum when demand exceeds supply. The purpose of using auctions is to achieve an efficient and transparent distribution by awarding the spectrum to the party which values it the highest. A secondary market for existing spectrum licenses already exists.

The current regulations restrict to some extent the use of market mechanisms such as auctions. For example, an auction is undertaken primarily in the event of a new or significantly altered use, in combination with frequency shortages. Also, the law of electronic communications specifically regulates the transfer of licenses, not the leasing of licenses. PTS has used different types of auction forms to distribute spectrum, including single-round sealed bid, simultaneous multi round auction (SMRA), simultaneous clock auction and limited combinatorial auctions. It is the responsibility of PTS to choose the auction method which is most suitable to the situation and the spectrum that is being distributed.

PTS publishes a frequency plan online, which also includes a search function in which it is possible to determine the specific use of frequencies. This is designed to avoid uncertainty over the current use of spectrum. In addition to this, PTS has an orientation plan for how it intends to distribute spectrum over the coming years. The purpose of the plan is to increase transparency, and outline the work undertaken by PTS in relation to spectrum. The plan is updated annually, but more frequently if required.

Prior to PTS auctioning specific spectrum frequencies, a consultation process is undertaken. The purpose of the consultation is to analyse the future use of the spectrum frequency in question. Each step of the consultation and auction process is published on the PTS website.

An important consideration in the spectrum planning process applied to PTS is to ensure international harmonisation - especially in situations such as: to enable roaming and interoperability; to achieve benefits associated with scale (i.e. lower prices) in the production of radio equipment; when radio signals cross boarders; for international aviation and maritime transport; for research; and for areas with binding EU law.

Sweden's approach to licensing has been highly successful with Sweden often being among the first countries to licence additional spectrum for the ongoing development of its mobile industry. The spectrum policy and planning undertaken by the Swedish Regulator also provides a transparent and predictable regulatory framework to support ongoing large investments in the sector.

2.5. Licensing in practice: India

India has allocated relatively little spectrum for mobile services. Further, the available spectrum has been assigned to a large number of operators. In particular, in most parts of the country around 15 operators were licensed with the average Indian operator only receiving around 5.5 MHz of spectrum.[15] This contrasts with the situation in other major countries in which there are generally 3-5 operators and with each of these operators having around 22 MHz of spectrum. While competition is an important objective for regulators, it is not the case that additional entrants bring greater and greater competition. The ultimate aim should be to achieve lowest sustainable prices to consumers with the best quality services. In other large markets, three or four players have been sufficient to create vigorous competition. For example, the four Ukraine mobile operators charge similar prices (as proxied by mobile revenue per minute) as India's operators[16], despite Ukraine's much higher general

[15] Plum, An assessment of spectrum management policy in India, December 2008, p.7.

[16] Average revenue per minute data from Merrill Lynch, Global Wireless Matrix 4Q11, Table 2.

cost level. The European Commission has found that three to four operators is generally sufficient to ensure effective competition. Limiting operators so that they only have access to small blocks of spectrum increases the cost of service provision (including through more towers being required to cover a given area or provide a given level of capacity). This results in higher prices to customers than otherwise and makes it less likely that operators will find it economic to extend coverage in rural and remote areas.

A progressive feature of India's regime is that licences are awarded on a technology neutral basis and allow for the delivery of all types of mobile services. This flexibility allows operators to respond dynamically to technology developments and changing consumer demands without being delayed by the need to seek changes to licence conditions.

The award of further licences and spectrum in 2008 became the subject of a major public interest litigation before India's Supreme Court.[17] The case related to serious problems in the awarding of the spectrum including that: (i) the prices paid for the spectrum were based on 2001 prices which were substantially below current market prices; (ii) spectrum was assigned on a first come first served basis; and (iii) the date for receipt of licence applications was brought forward so that only parties with advanced warning of the change could apply (including some parties with no experience in the telecoms sector). The Supreme Court, in its judgment dated 2 February 2012, quashed the irregular grant of licenses and spectrum. While the problems possibly reflect irregularities on the part of some individuals, this case also highlights a number of general lessons:

Assigning valuable licences on the basis of a process that is neither transparent nor objectively justified, creates significant risks of misuse. With large profits available from the re-sale of licences (as took place in India), a process that can be manipulated to favour some parties over others. Regulators should instead follow a transparent, consultative process in which all parties are given equal opportunity to participate.

Assignment criteria should be designed to ensure that spectrum goes to the uses and operators that will bring most value to society. Criteria, such as first come first served, in cases where demand far outstrips supply, carry large costs including that the public fails to receive the full value of the licences/spectrum and that valuable spectrum is poorly utilised, at least until it is finally able to be acquired by operators that can make proper use of the spectrum. A well run auction is a key means of ensuring spectrum is assigned efficiently although other transparent, non-discriminatory and objectively justified processes may sometimes also be appropriate.

India did carry out an auction for 3G spectrum in 2010. The auction raised around US$15 billion for the government and was free of the irregularities that tainted the 2008 process. The auction also served to advance the rollout of mobile broadband in India, which is of particular importance given India's very limited fixed network. Bharti and Vodafone launched 3G services in the first half of 2011. In addition, the auction brought much needed additional spectrum to India's operators. However, one drawback of the auction was the very high prices for the spectrum that resulted from the scarcity of spectrum for mobile services in India as also the uncertainty regarding roadmap for 2G spectrum. High levels of debt among operators can restrict them in investing in the rollout of services and network. The Indian Government's Economic Survey 2010-12 found that Profit After Tax (PAT) in the Telecom sector is expected to fall during 2011-12 by 84.7 per cent particularly due to the heavy borrowings for acquiring 3G spectrum. As retained earnings are a key source of companies' financing for new investment, this dramatic fall in profits carries the risk of much lower investment in the sector in the period ahead. A further drawback of the auction was that due to the very high prices, no operator (except the incumbent for whom 1 block was reserved in all service areas) was able to

[17] A copy of the Supreme Court's judgment is available at :

http://www.thehindu.com/multimedia/archive/00911/Supreme_Court_verdi_911309a.pdf acquire a pan India footprint. There are significant fixed costs in supplying mobile services so that unit costs can be minimised by supplying services on a national basis. Operators have sought to achieve a national 3G services footprint through roaming agreements, which are permissible under licence. However, despite the license clearly permitting such arrangements since mid-2008 and the Licensor explicitly clarifying on the permissibility of such arrangements prior to the auctions, it was ruled against these agreements in late 2011. While the matter is presently before the Telecom Tribunal, it is important to note that changes in rules such as these after the auction can unfairly penalise operators who paid the auction price based on the rules at the time.

In response to the Supreme Court judgment, the licences assigned as part of the 2008 process have been quashed and the spectrum is now to be re-assigned through an auction. However, this remedy is creating its own problem as the spectrum is now in use by operators including by some operators who acquired the spectrum at full price from parties reselling the licences they received under the flawed 2008 process. The cancellation of licences becomes operative in September 2012. It is therefore desirable that the re-assignment process should be undertaken as expeditiously as possible to remove the substantial uncertainty hanging over the industry and enable operators to proceed with investment plans.

The Indian regulator (Telecom Regulatory Authority of India TRAI) released a consultation paper on 7 March 2012 on proposals for auctioning of spectrum assigned in the 2008 process and this paper also raises a number of issues in relation to the assignment of spectrum in the 700 MHz band.[18] For example, the regulator is seeking to determine how best to package the spectrum across the bands to avoid operators being left with fragmented spectrum holdings. The regulator also raised whether spectrum in different bands should be auctioned simultaneously, eligibility criteria and what terms and conditions should govern the spectrum licences including in relation to refarming[19] of the 2G spectrum, reserve price and ongoing spectrum charges, rollout obligations and trading. The issues raised are important to the future development of the industry and we examine the best approaches to these issues in the various sections of this report.

Following this public consultation, on 23 April 2012, the TRAI published its recommendations on the 'Auction of Spectrum'. One of the key recommendations of the Regulator is that only 5MHz be auctioned in every service area as against 413.6MHz spectrum made available through license cancellation by the Supreme Court and 211MHz already available with the Government[20]. This will make it impossible for the cancelled licensees to have a fair opportunity to bid and acquire spectrum and ensure service continuity. In addition to the very limited spectrum being put up for auction, the Regulator has also recommended a very high reserve price, which is close to the final market discovered price discovered for the 3G spectrum in 2010. Under these circumstances, it is unlikely that a fair and effective auction can take place and the spectrum will either remain unsold or be acquired at close to the reserve price, which would defeat the very purpose of an auction.

The reason given by the Regulator for releasing only 5MHz for auction is that spectrum needs to be reserved so as to allocate in lieu of 900MHz at the time of the extension of licenses coming up from 2014 onwards. The regulator has recommended extinguishing the existing rights to 900MHz at extension and auctioning the same for 3G services. Accordingly, the affected Indian operators are faced with uncertainty over the future rights to the spectrum that is critical for them to be able to supply services to their customers. In Section 4, we highlight the serious risks to investment created by uncertainty over future rights to spectrum. As pointed out above, many countries instead adopt a

18 http://www.trai.gov.in/WriteReadData/trai/upload/ConsultationPapers/285/Consultatition%20Paper%2007.03.2012%20.pdf

19 The term 'refarming' is generally used to mean a change in the technology use (such as from 2G to 3G) without a change in the holder of the licence. However, in India, 'refarming' is used to refer to the removal of spectrum from one set of users in order to release it for future assignment (to be used with a different technology).

20 TRAI recommendation on 'Auction of Spectrum' 23 April 2012

presumption of renewal so that licensees are allowed to renew their licences except under certain defined circumstances that are expected to arise relatively rarely. There does not appear to be any sound reason for the Indian regulator to depart from this international best practice. It is also the case that the licences are already technology neutral so that they already provide for the introduction of 3G services. A particular concern in the Indian market context is that the loss of access to 900 MHz spectrum could severely impact rural coverage and service for which 900 MHz spectrum is critical for the commercial viability of rural service provision. Operators with existing rights may stop investing in the roll-out of their networks until they know whether they will receive rights to the spectrum in the future. If a new entrant were to acquire the 900MHz spectrum, it is likely that they would first focus on urban provision so that it may be many years before they provide rural coverage that remotely match the levels currently being provided.

Another major challenge for the Indian industry will be to secure sufficient spectrum to improve the quality of 3G and help drive its take-up as well as to facilitate the development of LTE services. Currently, only spectrum in the 2.3 GHz band (assigned for broadband wireless access) is available for Time Division LTE services with Bharti being the first operator to offer TD LTE services in India in April 2012. Additional spectrum in lower frequency bands, particularly in the 700 MHz band, will be important to enable widespread access to mobile broadband services at least cost.

An on-going issue in India is the level and structure of annual spectrum usage charges. The Indian regulator takes a higher percentage of revenues the greater an operator's total spectrum holdings.[21] This means that an incumbent can pay substantially more than an entrant for equivalent spectrum. However, for efficiency, similar spectrum should be priced at similar levels. If a new entrant is making relatively poor use of spectrum, it is important that the operator faces incentives to return some of the spectrum. However, India's current spectrum charges instead penalise the operators that are most effectively using spectrum while setting much lower charges for operators that are making little use of their spectrum.

Although some steps have been taken for licensing and spectrum reforms in February 2012, with the Minister announcing delinking of spectrum and licence, introduction of a unified licensing regime, uniform licence fee for all services and service areas, some relaxation in the restrictions on mergers and acquisitions and permission being allowed for operators to share spectrum in the same area, there are still some areas of concerns.

[21] Somewhat inconsistently the charge rate is determined with reference to holdings of GSM and CDMA spectrum separately. This effectively penalizes operators who have all of their spectrum being GSM spectrum compared with another operators with a similar total amount of spectrum but split between GSM and CDMA spectrum.

2.6. Recommendations

Following are our key recommendations in relation to the overall licensing framework:

- *Recommendation 1* – Licensing authorities should progressively remove restrictions that unduly restrict operators from determining which services they will provide and the technology that they will use. Restrictions that do not result in clear net benefits should be relaxed. Operating licences should be expanded to cover a greater range of services or, where appropriate, replaced altogether by simpler authorisations or class licences. Where restrictive operating licences are maintained they should be separated from licences for the use of spectrum. Spectrum licences should, in general, contain spectrum management provisions only or principally. This will assist changes in business activities and spectrum holdings and support the evolution of technologies and the different needs between radio spectrum management and other aspects of the licence. Operators offering similar services should be subject to the same terms and conditions.
- *Recommendation 2* - Spectrum should be managed to ensure that a country obtains maximum benefit from the use of its spectrum resources. Spectrum rights should be assigned to the services and the operators who can generate the greatest benefits to society from the use of that spectrum, i.e. to achieve the efficient use of spectrum. Market-based approaches represent a key means to ensure that spectrum is used to supply the services most in demand and operators are able to use the best available technology to deliver those services.
- *Recommendation 3-* Licensing authorities should ensure that the overall licensing framework offers stability and transparency to reduce regulatory risk and promote investment. Key principles should include:
  - establishing and adequately resourcing an independent regulator with responsibility for operator and spectrum licensing among other matters;
  - announcing in advance a long term plan for reform of the spectrum and operating licensing framework;
  - facilitating international harmonisation so that equipment and devices use the same frequency bands to support international roaming and enable the realisation of scale economies in manufacture;
  - publicly setting out the criteria and process to be followed in licensing decisions and including public written consultation in advance of key decisions being made with both consultation responses and the assessment of input in reaching final decision being published;
  - clearly defined spectrum rights that are backed up by a robust compliance/enforcement regime;
  - taking a holistic approach to licensing that ensures that the overall package enables the ongoing development of the mobile industry (including a process for the renewal of licences at their expiry); and
  - taking into account investors' legitimate expectations and providing compensation mechanisms where decisions are made in conflict with those expectations.

3. Amount and use of spectrum to be released

Meeting the rapid growth in demand for mobile voice and data services will require significant additional spectrum being allocated to mobile services. Licensing authorities across the world are currently determining what spectrum can be made available and how it should be assigned. In this section, we first review what are the main frequency bands that are in use for mobile services or which have been identified for use by mobile services. We then examine key steps that licensing authorities can take to put that spectrum into use as early as practical to deliver services to customers.

3.1. Internationally identified mobile spectrum bands

Access to several key spectrum frequency bands have been identified internationally as fundamental to the development of the world's mobile industry. This includes securing ongoing rights to spectrum that is currently assigned to mobile operators as well as new bands that are only in the process of being assigned.

Original spectrum assignments to mobile operators

Mobile services were initially introduced into different countries using a variety of frequency bands. For example, AMPS and NMT (Nordic Mobile Telephone) analogue mobile services, which have now largely been discontinued, used the 800 MHz band and the 450 MHz band respectively. The most common mobile technology today, Global System for Mobile Communications (GSM), generally uses 900 MHz and 1800 MHz frequencies in Africa, the Asia-Pacific, Europe, Latin America and the Middle East. The GSMA supports the 880-915/925-960 MHz and the 1710-1785/1805-1880 MHz band plans with conventional duplex which gives 2x35 MHz and 2x75 MHz of bandwidth respectively for deploying mobile technologies. In the Americas and some other countries, spectrum assignments for mobile have also included the 700 MHz band (698-806 MHz), the 850 MHz band (824-894 MHz) and the 1900 MHz band (1850-1990 MHz).

In many countries with spectrum assigned for mobile services, licensing restrictions inhibit the full use of the spectrum. For example, some countries require that the spectrum only be used for 2G mobile services although a growing number of countries are removing these restrictions so that the spectrum can also be used for 3G, LTE or any technology that does not cause harmful interference to other spectrum users. As we discuss in this report, the aim should be to enable the spectrum to be used to generate the greater benefits to society. This should enable newer technologies and services to be introduced over time while still supporting ongoing use of 2G voice and data (in many emerging markets, GSM 2G voice services are likely to continue to be the predominant service for many years particularly given their role in enabling affordable access to voice connectivity).

A second issue in relation to current spectrum assignments is that many existing licences are approaching the end of their initial period. Where there is uncertainty over whether the licences will be extended, operators may decide that significant new investments in network extension and services are too risky thus inhibiting further growth and rollout of the network. Mobile customers may be disadvantaged until this uncertainty is resolved. The approach to licence renewal is a key focus of this report.

Assignments for 3G services

3G services have generally been deployed using 2100 MHz spectrum, although 3G services are increasingly also being supplied in lower frequency bands. For the 2100 MHz band, the GSMA supports the 1920-1980/ 2110-2170 MHz band plan with conventional duplex which gives 2x60 MHz of bandwidth available for deploying mobile technologies. In North America, 1710-1770/2110-2170 MHz has been made available for Advanced Wireless System services including 3G.

The issues affecting the original spectrum assignments are present (albeit to a lesser degree) with the 3G assignments. In particular, there are likely to be efficiency gains from allowing operators to use these assignments for newer technologies over time. In addition, as the 3G licences approach the end of their terms, new investment will become increasingly risky if operators are not given security over their future rights to use the spectrum.

Digital Dividend spectrum

The transition from analogue television to digital television will free up significant spectrum in the 200 MHz to 1 GHz frequency range. The excess spectrum is known as the Digital Dividend. Access to this spectrum for mobile services offers three key advantages: (i) significant new capacity to meet the needs of mobile broadband; (ii) the low frequency band enables coverage to be provided at relative low cost; and (iii) the low frequency makes it more economic to extend coverage to rural and remote areas as well as providing for much better indoor coverage. A report for the European Commission estimated that use of the Digital Dividend could generate between EUR150 billion and EUR700 billion of economic benefits to Europe (discounted value over 15 years) in addition to or instead of deploying the same services using other frequency bands or alternative delivery platforms.[22] Ofcom has estimated that the potential gains for the UK from the use of the Digital Dividend are likely to be between £5 billion and £10 billion over 20 years.

2.6GHz band

The ITU has identified the 2.6GHz band for mobile broadband use. The GSMA supports a 2500-2570/2620-2690 MHz band plan which gives 2x70 MHz of paired bandwidth with conventional duplex plus 50 MHz of unpaired bandwidth available for deploying mobile technologies. While the relatively higher frequency implies that the band is less suitable for providing widespread coverage, the significant amount of available spectrum provides substantial capacity to meet growing traffic volumes in densely populated areas. As such, the 2.6 GHz band represents a good complement to lower frequency bands. TeliaSonera who launched the world's first commercial LTE services will use 800 MHz frequency in addition to its existing use of 2.6 GHz spectrum to supply LTE services.

Future spectrum

In some countries other spectrum bands are already being considered to support mobile broadband. For example, Hong Kong auctioned spectrum in the 2.3 GHz band in February which will be used to support TDD LTE services. The International Telecommunications Union (ITU) has also started considering further spectrum allocations to mobile services. In February 2012, the World Radiocommunications Conference (WRC) adopted an agenda item for the next WRC in 2015 to secure additional spectrum for International Mobile Telecommunications (IMT) which cover a family of technology standards including EDGE, CDMA2000, UMTS, DECT, WiMAX and LTE.

[22] Analysys Mason, Exploiting the digital dividend – a European approach, 2009, p.6.

3.2. Freeing up spectrum resources to meet growing demand

Licensing authorities are at varying stages of the process of reviewing existing use of spectrum and identifying how they can best meet the increasing demands for spectrum for mobile services and for other public and private sector industries. In this section, we set out key preliminary steps that authorities are taking to determine what spectrum can be made available to meet new demand.

Spectrum inventory

In many developing countries, the major concern with current spectrum licensing is that little information is available on the current assignment of spectrum rights, particularly in regard to who has the legal rights to use particular bands and what services and technologies they are allowed to use. The lack of information on current spectrum rights can come at a substantial economic cost including in terms of:

- deterred investment, degraded quality of service and protracted disputes because of the heightened risk of interference; and
- valuable spectrum being left idle or underutilised because not even the licensing authority may have a good knowledge of the details of the spectrum rights that have been assigned in the past.

Thomas W. Hazlett, Professor of Law & Economics at George Mason University and former Chief Economist of the Federal Communications Commission, has commented that:

> "**To restrict the spectrum available to mobile networks is to reduce the value of the services they provide** (…) the restrictions that policy makers consistently impose on spectrum for mobile services most often simply freeze virtually unused bands in place. These actions do not enable alternative wireless applications of higher value, they simply squander bandwidth. This does yield regulators option values, as they can decide what to do with unused frequencies at a later date. But these options have negative value to society**. The bandwidth that lies idle is not saved but destroyed, as the opportunities not used are gone forever**."[23]

Licensing authorities should consider undertaking an inventory of existing spectrum if there is uncertainty over current ownership of spectrum rights and usage. This exercise should specify in detail which services currently use which frequency band, and by whom. This can also clarify current rights to use spectrum particularly in regard to key parameters such as frequency, users, use, geography and the levels of interference that are allowed so as to be compatible with other licensed uses. Such exercise should be focused initially on those spectrum bands and geographic areas which are most heavily used or which are likely to be most capable of supporting growing demand. This should include the spectrum bands that have been identified internationally for mobile services discussed in the previous section.

A key benefit of the spectrum inventory will be to identify where the current pattern of use gives rise to harmful interference that reduces quality of services and raises costs of operators in seeking to overcome the interference. Where incompatible uses are identified, a migration process should be introduced with compensation for legitimate users if licensed spectrum is required to be returned prior to the end of the licence period. In addition, where unlicensed users of licensed spectrum or users in breach of their licence conditions are identified, they should be subject to proportionate penalties.

The result of the spectrum inventory should be made public to facilitate network design and longer term planning by existing and potential new users of spectrum.

[23] Hazlett, T.W., "Spectrum policy and competition in mobile services", *Vodafone Policy Paper Series,* No. 12, May 2011.

Spectrum road-map

On the basis of the spectrum audit in relation to current use as well as knowledge of which particular bands are likely to be most in demand for future use, licensing authorities should develop a road-map which identifies which frequency bands will be made available and the proposed timing for those assignments. It is important that spectrum allocation decisions are made as part of a longer term plan because once spectrum has been allocated it can be difficult to re-assign. Information on future releases of spectrum is also critical for businesses to be able to prepare their investment plans including securing finance and developing arrangements for deploying particular technologies.

As well as setting out the timing of when particular frequency bands will be made available, the authority should also provide information on the approach that the licensing authority will take to spectrum management going forward. This information should aim to provide as much information as possible on the proposed approach to a range of areas including how licences will be assigned, what restrictions are likely to be apply on the use of the spectrum for particular technologies and services, what types of charges are likely to apply and the method to determine their level, whether particular measures will be adopted to protect competition, the ability of licensees to directly sell their licences or change the use of the spectrum and what other price terms and conditions will apply such as the term of the licence and whether specific policy-related obligations are likely. While it will not be possible or desirable to detail every approach in advance of analysing the expected demands for particular spectrum, where a menu of approaches will be considered investor certainty can nonetheless be promoted by the authority setting out what factors or criteria the authority will use to choose between the specific approaches.

In the next section, we examine the importance of reviewing restrictions on the rights to use spectrum that has already been assigned. In Section 4, we then turn to consider how rights to use can be renewed and new spectrum rights established.

3.3. Refarming and technology and service neutrality

Even without spectrum rights being re-assigned, authorities can achieve better use of spectrum by removing current restrictions on use that are found to be creating greater costs than benefits. Many current restrictions on use effectively create an artificial scarcity of spectrum. The aim should be to remove restrictions on the use of spectrum to deliver particular services or using particular technologies provided interference to other users remains limited so that the country can maximise the overall benefits from its spectrum resources. Thus technology and service neutrality can be seen as a precursor to further spectrum assignment.

Whether restrictions on the use of spectrum should be relaxed requires carefully weighing up the expected benefits and costs of doing so. Benefits can include enabling the supply of new or additional services or reducing the cost of supplying existing services by the deployment of more efficient technologies. For example, 3G technologies offers significant technological advantages and consumer benefits compared with 2G technology. However, in many countries, the use of 3G is limited by restrictions that still require initial spectrum assignments for mobile services to only be used for 2G. This means that 3G has often been restricted to a relatively high frequency band particularly at 2100 MHz. However, the last few years have witnessed a major trend around the world to enable 3G and more recently newer technologies such as LTE in frequency bands formally reserved for 2G services. This process is generally referred to as refarming and does not involve a change in the holder of the spectrum rights. Elisa in Finland was the first operator to commercially launch 3G services using 900 MHz in Finland in 2007. Authorities in a number of countries have also made changes/lifted technology restrictions to allow 3G networks to be used at 1800 MHZ and for newer technologies such as LTE to be introduced into the traditional 2G frequency bands (potentially leap-frogging 3G entirely). For example, the European Commission has provided for the introduction across the EU of

3G, LTE and WiMAX technologies in the 900 MHz and 1800 MHz bands. Refarming allowed by the Polish regulator has enabled a commercial LTE network to be launched in Poland in September 2010 (see case study).

The ability for operators to refarm lower frequency bands, currently used for 2G services, is estimated to generate substantial economic benefits.

- **Lower cost of provision**. For example, Elisa in Finland found that 3G at 900 MHz requires around half the number of cell sites as 3G at 2100 MHz in rural and suburban areas and this translated to a 50%-70% savings on opex and capex.[24]
- **Wider geographic coverage**. The need for fewer cell sites improves the economics of extending mobile broadband coverage further into rural and remote areas as well as enabling coverage to be extended in rural areas more quickly.
- **Better indoor coverage**. Ofcom found that a 3G network at 900 MHz delivered a minimum of 8 Mbps to 70% of indoor locations whereas 3G at 2100 MHz delivers the same data rate to only 45% of indoor locations.25

In addition, 3G and, to an even greater extent, LTE uses spectrum more efficiently enabling greater capacity (i.e. more services and better, innovative services) to be provided from a country's scarce spectrum resources.

Relaxation of spectrum usage restrictions does not mean that there will be random patterns of spectrum use across countries. Even with less technology and service neutrality, substantial international harmonisation of the use of particular spectrum bands will remain to take advantage of the realisation of scale economies to reduce equipment costs and roaming. Further, while 3G and LTE technologies bring benefits, the substantial existing base of 2G devices means that 2G services will continue to be important for the next 5 to 10 years.

Changes to the rights to use spectrum will not always be justified however. There may also be transitional issues that will need to be addressed.

Interference issues

The main rationale for restrictions on use being imposed is to minimise the risk of intolerable interference to other users of spectrum. Any decision to provide some liberalisation of the use of spectrum should ensure the careful management of interference issues. Where different technologies can technically co-exist then there is a strong case for licences to be neutral as between those technologies. In relation to refarming of spectrum from 2G to 3G use there is now significant practical experience in addition to technical studies on addressing interference issues. This experience also covers situations in which 2G services have been maintained while 3G services are introduced in neighbouring frequency as well as where countries with common borders pursue liberalisation in different time frames. More generally, the IMT technologies GSM/GPRS/EDGE, UMTS/HSPA and LTE have been standardised based on criteria for technical co-existence and are intended to be backwards compatible.

Operator issues

For operators, refarming raises a number of issues including how to free up some spectrum currently used for 2G services to use for the introduction of 3G, how to facilitate the migration of customers from 2G to 3G and how to transform the network from one supporting only 2G to one in which most traffic is carried using 3G or later technologies.

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[24] Qualcomm, HSPA and LTE can foster economic development presentation.

[25] Ofcom, Application of spectrum liberalisation and trading to the mobile sector – A further consultation, §4.34.

Competition issues

The benefit of refarming has also raised concerns that if only some operators in a market are able to use 3G and LTE at lower frequency bands then competition may be adversely affected. In many cases, it is the larger, more established operators that currently have rights to spectrum below 1 GHz. Whether or not competition will be significantly affected requires an analysis of the overall position and spectrum-holdings of operators in a market including what other spectrum bands will be made available in the foreseeable future. Generally, however, operators should be allowed to refarm their licensed spectrum as the market and technology change using whatever bands they are licensed in and all should be given a fair opportunity to obtain newly purposed spectrum

To simply prohibit refarming at all would deny customers the benefits that could be realised from greater capacity, lower costs of provision and the improved economics of extending networks further into rural and remote areas. Where relaxing restrictions on current rights is expected to harm competition, then a number of options exist that can allow for the benefits of refarming to be realised while preserving or even promoting competition:

- Some licensing authorities, such as ARCEP in France, allowed for refarming of 900 MHz spectrum for 3G use after the two major operators redistributed 2 x 5 MHz of 900 MHz spectrum to France's third operator, Bouyges. ARCEP also provided for a further re-distribution of 900 MHz spectrum upon the entry of a fourth operator and this process was activated by the award of a licence to Free in December 2009. Following these processes, the two major operators have 2 x 10 MHz of 900 MHz, Bouyges has 2 x 9.8 MHz and Free has 2 x 5 MHz.
- An alternative approach is for new spectrum releases (such as the Digital Dividend) to be licensed in a way that achieves a more uniform distribution of comparable spectrum (e.g. the sub-1 GHz spectrum) across operators. Regulators may also decide to prevent lower frequency bands being used for newer technologies until the additional spectrum is auctioned.
- Another approach is where equivalent wholesale access is provided to the services of a 3G or LTE network that uses the lower frequency bands. Such access may be provided nationally or only in rural/remote areas.
- Licence fees or annual spectrum charges can also be adjusted to take into account the different value of liberalised spectrum at different frequency bands. Where licences are auctioned, then the bids of operators for different licences can be expected to reflect the differences in the expected value of the rights to use each frequency band.

We examine measures to protect competition more fully in Section 6. These measures can carry costs as well as benefits and hence it is important to carefully assess which particular approach would be in the best interests of end-users. Consultation with all affected parties is crucial to ensure that all costs and risks are identified and that the regulator is able to choose from the full range of practical measures.

Next we examine the experience of Poland and Singapore which have successfully provided for refarming.

Refarming in practice - Poland

In September 2010, Poland's Mobyland and CenterNet deployed the first phase of their commercial LTE network in the 1800 MHz frequency band – becoming the first commercial LTE technology network in the 1800 MHz band in Poland and only the fourth in the world. Huawei, the supplier of the LTE network solutions, noted that "*Refarming Mobyland and CenterNet's existent 2G bands at 1800MHz, allowed for greater performance across bandwidth. This in turn enabled the LTE network to improve spectrum efficiency, enhance coverage quality, reduce the quantity of sites, and decrease carbon emissions*."[26]

In January 2012, the Polish regulator announced the start of consultations on assigning currently available frequencies (2 x 25 MHz) in the 1800 MHz band. The regulator noted that there will be two tender procedures: the first will be aimed at providing a licence for 2 x 10 MHz of the spectrum for an operator that does not currently have any 1800 MHz spectrum and the second will be aimed at granting three additional blocks of 2 x 5 MHz of 1800 MHz spectrum. The Polish Regulator has also dedicated the 2.6 GHz and the digital dividend bands for the deployment of LTE. The LTE spectrum auctions are expected in 2012 or later.

Refarming in practice - Singapore

Singapore's regulator, the IDA, issued an interim decision on spectrum framework 4G mobile communication systems in Singapore in January 2011. The IDA clarified the use of existing spectrum rights for wireless and mobile services, especially on the 900 MHz and 1800 MHz bands which are suitable for refarming (while noting that it was not in a position to then conduct a re-allocation of the 2.3 GHz and 2.5 GHz bands).

The 900 MHz and 1800 MHz bands have been allocated in Singapore to 2G and 3G technologies and other technologies on a similar platform with higher speed data services. The rights are due to expire in 2017. The IDA noted that should operators wish to deploy technologies other than 2G and 3G or their evolved versions, that are capable of providing public mobile services, they would need to seek the IDA's approval before doing so.

Further, the IDA noted that it will not prohibit operators from deploying LTE in the bands so long as operators meet the requirements for public mobile services. Operators that deploy LTE within the 900/1800 MHz band also need to coordinate with other operators to reduce harmful interference. Operators deploying LTE may be required to dedicate additional spectrum for larger guard bands between their LTE system and the 2G systems of other operators.

The IDA noted that operators which intend to deploy LTE using their existing mobile (or WBA) spectrum bands **need to consider the remaining duration of the spectrum rights, and consumer transition issues at the end of the spectrum rights**. The IDA also commented that **its decision to allow LTE deployment in its interim decision should not be seen as restricting its flexibility to re-allocate bands for 4G or other systems in the future**.

Singapore is thus supporting the timely introduction of LTE services and at the lower frequency bands that will maximise benefits to customers.

On 3 March 2011 IDA announced an auction for 1 x 5 MHz of 1800 MHz spectrum. The auction closed on the 28 March 2011 with the winning bid of S$21.69m from M1 Limited. After securing the rights to the 5 MHz of 1800 MHz spectrum, M1 launched a dual-band network on the 1800 MHz and 2.6 GHz bands. M1 is the first in Singapore, and South-East Asia, to launch ultra-high speed mobile services with LTE. Other operators that are already using 1800 MHz spectrum for 2G services will first need to free up some of this spectrum to support the introduction of LTE.

[26] Huawei (2011) *LTE 1800 MHz Ecosystem Drivers*, p. 14.

3.4. Recommendations

Following are our key recommendation in relation to the amount and use of spectrum to be made available.

- *Recommendation 4* – Current rights to use spectrum should be clearly specified and spectrum bands that are currently idle or being poorly utilised (including by public sector agencies) should be considered for re-allocation to services that could use the spectrum to generate greater benefits for society.
- *Recommendation 5* – Licensing authorities should publish a road map of the planned release of additional spectrum bands to maximise overall benefits from the use of spectrum including taking into account the benefits of international harmonisation. In doing so, aligning spectrum rights with the internationally harmonised mobile spectrum bands will ensure that operators and their customers can acquire competitively provided equipment and devices and that customers can readily access international roaming services.
- *Recommendation 6* - Licensing authorities should progressively remove service and technology restrictions in existing mobile spectrum usage rights to enable operators to choose when to deploy mobile technologies that can technically co-exist so as to increase spectral capacity, reduce cost of provision, extend coverage to rural areas and improve indoor coverage. Operators themselves are likely to be best placed to determine the speed of migration particularly recognising that 2G services are likely to remain important for the next 5 to 10 years.
- *Recommendation 7* - New spectrum usage rights within the mobile bands should be issued on a basis that is on a service and technology neutral basis subject to the use of technologies which can technically co-exist without intolerable interference.
- *Recommendation 8* - Licensing authorities should facilitate harmonisation of spectrum through allocating radio frequency bands in accordance with international agreements and by applying spectrum management approaches aligned with international best practice.

4. Assignment and renewal of mobile licences

Where demand for particular spectrum exceeds the amount of available spectrum, governments will need to determine which operators should obtain a licence. In this section, we evaluate the advantages and disadvantages of the main approaches to assigning licences. We first focus on what should happen to spectrum rights that have already been assigned but where those licences are approaching their date of expiry. We then consider more general approaches to assigning licences.

4.1. Approaches to licence renewal

In many countries, spectrum rights to mobile operators were licensed on terms that are due to expire over the next few years. In these countries, governments need to clearly set out their approach to licence renewal well in advance of expiry of licence. Such decisions are clearly of critical importance to operators that rely on access to the spectrum to serve their customers. These decisions, moreover, can fundamentally impact the development of a country's mobile industry including on the level and timing of investment, continuity of service provision, competition and ensuring that spectrum is available where efficient for new services and technologies. In this section, we assess the approaches that countries are undertaking to manage this process.

Presumption of licence renewal

A number of countries have established a presumption or high expectation of renewal in relation to spectrum licences (such as the Canada, Jordan and the US) – indeed this characterizes most countries that have already considered the renewal of GSM licences. For example, the World Bank states that "*While the legal regime for license renewal could embrace the process of automatic renewal, tacit renewal, or renewal at the express request of the licensee, most legal and regulatory frameworks adopted a regime based on the 'presumption of renewal' or 'renewal expectancy*'".[27] A presumption of renewal means that licensees are allowed to renew their licences except under certain defined circumstances which are expected to arise relatively rarely.

Where a country's licensing regime does not already specify a presumption of licence renewal then a key question is whether it would be desirable to establish one.

A presumption of renewal can make sense where the service, such as mobile communications, clearly represents the best use of a particular spectrum band and where the ongoing continuity of communications is important given the particular service's role as part of the economy's key infrastructure. A presumption of renewal also gives operators greater certainty and encourages them to bid for licences and invest in network development and the deployment of new services knowing that after the initial licence period it is highly likely that the licences will be renewed with little risk of losing the investment. This can be critical for investments that have long payback times such as mobile networks. A presumption of renewal can also improve operators' abilities to raise capital from financial markets.

If operators were instead given no confidence over renewal, they would be expected to undertake only shorter and shorter term investments as the year of expiry of their licences approaches and avoid undertaking any longer term investments – an operator may face large losses if sunk assets need to be written off because its licence is not renewed. This could mean that consumers in that country go without a major network upgrade for years compared with consumers in other countries. A failure to allow an operator to renew its licence can also cause harm to customers through service disruption with the potential that coverage in some areas is lost and/or handsets purchased by consumers no longer work. Service disruption may be prolonged given the timeframe for a new entrant to establish its network.

[27] World Bank, *Mobile licence renewal: What are the Issues? What is at Stake"*, June 2005, p.4.

The World Bank has noted the importance of licence renewal for investment:

> "*Providing details for license renewal or reissue is an important guarantee for regulatory certainty, which is a prerequisite for attracting potential investors entering the market of developing and emerging economies… For the sake of regulatory certainty, the discretion offered to the licensing body should be curtailed by conditions set in the regulatory framework or in the license. itself, and be subject to checks and balances. The conditions requested for renewal and the methods for specifying them become minimum guarantees to ease investors concerns over arbitrary refusal to renew. They give a positive signal for operators to continue to invest in their networks and to fulfill their obligations, at least until the end of the license term. Prospects for license renewal also offer needed assurance to operators to engage long-term financing for their network.*"[28]

Given the risks to ongoing investment in the sector, licensing authorities should determine their approach to licence renewal as early as possible. Even within 5 years of the expiry of mobile licence, an operator may not be able to recover even smaller scale network investments within the remaining licence period and hence may put off investing until receiving greater certainty over their future rights. At a minimum, a licensing authority should be able to specify the approach that they will take to assessing whether a licence will be renewed. This should cover important licence elements including:

- Whether a presumption of renewal will be applied and under what circumstances would a licence not be renewed;
- Whether there will be any changes in the bandwidth or the amount of spectrum covered by the licence;
- Whether any technology or service restrictions will be removed as part of the renewal (see Section 3) or whether other licence obligations will be changed (see Section 8);
- The cost or the method to be used to determine the cost of licence renewal as well as any ongoing spectrum charges (see Section 5); and
- What protections will be applied in the event that an authority decides not to renew a licence such as a right of appeal, a minimum period for the spectrum to be vacated (including so as to enable customers to migrate to other services) and under what circumstances would compensation be paid particularly where there was a legitimate expectation of renewal.

While recognising the major benefits of providing security of tenure for certain spectrum licensees, it is useful to examine circumstances under which particular countries provide for licensees not to be renewed. Indeed, a presumption of renewal will only provide a high degree of business certainty where the conditions under which licences will not be renewed are clear.

Spectrum replanning

Many countries provide for licences to not be renewed where continuing the current use of the spectrum would be incompatible with the planned use of spectrum. The impetus for a change in use of the spectrum may arise from international radiofrequency planning and co-ordination or from national decisions. Such a provision can be an important means to enable new technology platforms to be introduced particularly where spectrum management continues to be centrally planned. For example, the change from analogue to digital broadcasting will imply that broadcasters need much less spectrum to supply the same content and the spectrum that is freed up (i.e. the Digital Dividend) can instead be used for newer technologies and services such as LTE. Spectrum may also be replanned where the spectrum is required for national security or other purposes.

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[28] World Bank, *Mobile licence renewal: What are the Issues? What is at Stake",* June 2005, p.1-2; 5-6

While spectrum replanning may be necessary to support efficient use of the spectrum on an ongoing basis, it is important that the benefits of different uses are carefully assessed and that where a change in use is contemplated, the cost of migrating or terminating the current use is taken into account. Further, spectrum plans should be announced as early as possible to give existing users sufficient notice. Forward reviews could be linked with the ITU's World Radio communications Conferences held approximately every three years. \

Finally, the need for regulatory-imposed spectrum replanning can be reduced by providing existing licensees with greater flexibility over the services for which the spectrum is used.

Breach of licence conditions

A breach of a licence condition is also commonly included as a reason for not renewing a licence. Where the licence conditions are made clear at the time of the initial assignment of the licence, then not renewing the licence or, indeed, revoking the licence before its expiry may be seen to be a proportionate response to a breach of a condition. For instance, revocation of the licence may be necessary if the licensee continually breaches the licence's technical conditions causing intolerable interference to users of neighbouring spectrum. Given the serious consequences to consumers and to investment, denial of renewal should be considered as a last resort, after having been through a series of sanctions, fines and alternative remedial measures.

It is the case that occasionally licence conditions prove to be infeasible to meet such as where there are delays in equipment for new technology or because the economics of the business have fundamentally changed. This may call for some flexibility on the part of the regulator, albeit that too much flexibility may invite disputes where other operators who have made more progress towards meeting licence conditions or where bidders who were unsuccessful in acquiring a licence believe the later relaxation of conditions discriminate against them. In many cases, less severe measures than revoking the licence may be more proportionate. For instance, in Norway, one operator received a fine for not meeting its 3G coverage requirements based on the expected savings to the operator from not completing its coverage.[29] Many of the issues associated with failures to meet licence conditions can generally be avoided by keeping ongoing licence conditions to the minimum necessary to ensure efficient spectrum use, i.e., essentially what is necessary to manage interference (we discuss this further in Section 8).

Promoting competition

Another reason that has been used by some regulators for not renewing spectrum licences is where ending a licensee's current use of spectrum is used as a means of promoting competition. For instance, the Australian Government sought to encourage the entry of new GSM operators in the early 1990s by undertaking to close the incumbent analogue AMPS network in 2000 and thereby putting all players on an equal footing. As discussed in Section 3.3, a key issue in the consideration of whether 2G spectrum should be allowed to be refarmed for use in supplying 3G services is whether some existing licensees should be required to give up some of their spectrum so that the lower frequency spectrum is more evenly distributed among all the mobile operators in the particular market.

Given the risk of deterring investment, any provision that would result in a licence not being renewed for competition reasons needs to be carefully circumscribed. We examine approaches to protect competition in Section 7.

[29] Bird & Bird, "Crunch time in the roll-out of UMTS in Swedish electronic communications markets", 16 February 2005.

Poor use of spectrum

A licence may also not be renewed where the existing licence holder is considered not to be making the best use of the spectrum. Such a provision is often put forward as a means by which to guard against valuable spectrum being left idle or underutilised. In Hong Kong, the regulator decided to not give a right of first refusal to the CDMA and TDMA licensees at the time of renewal because it considered that they had neither actively developed their networks nor actively marketed their services. In Bangladesh, despite limited spectrum being available for mobile operators, certain spectrum that could be used for GSM was being left idle because it had been allocated to wireless local loop operators that had not established businesses. Bangladesh's regulator has subsequently cancelled some of the wireless local loop operators licences.[30] In the US, licensees are required to demonstrate that they are providing "substantial service" as a pre-condition for licence renewal.

While such provisions are reasonable in principle, there is a significant risk of error where a regulator seeks to assess whether spectrum is being poorly used. For instance, there may be sound economic reasons as to why spectrum is left idle for a period such as when new technology or equipment is expected to become available shortly. In that regard, a regulatory requirement to demonstrate substantial service may encourage operators to behave inefficiently such as by undertaking investments prematurely so as to avoid losing the spectrum.[31] There is also a more general danger arising from such provisions in that they risk greatly increasing business uncertainty and undermining the incentive to undertake long-term investments.

The FCC in the US has argued that the concept of "substantial service" provides licensees with the flexibility to determine how best to use their service rather than having the regulator mandate particular benchmarks to be met. The FCC does set out 'safe harbour' benchmarks, such as a particular level of coverage that, while not mandatory for licence renewal, would meet the "substantial service" requirement for renewal. However, given the value generally placed on licence renewal, licensees tend to focus on the 'safe harbour' benchmarks rather than risking alternative service delivery.[32] Thus, the use of specific benchmarks (which limit licensees' flexibility to use spectrum in its most valuable use) or vague concepts such as "substantial service" (which creates business uncertainty that risks deterring investment) can cause some uncertainties.

Where an authority provides for operators to change the use of spectrum (without causing intolerable interference to others) and to trade licences amongst themselves, then market forces are likely to lead to the efficient use of spectrum without any need for a regulator to assess whether or not spectrum is being poorly used. Such market-based approaches are likely to prove superior to an administrative assessment over time as they are more flexible and responsive to changes in the market and will reflect information on the value of different uses from multiple parties rather than being reliant on the regulator's information which is likely to be more limited.

[30] Wireless news, "Fixed line licences cancelled", 2 August 2007.

[31] Similar "use it or lose it" provisions are often applied to airport landing slots and have resulted in empty planes being flown simply so that the airline does not lose its landing slot (for instance, see the Times, "The plane now leaving Heathrow is…empty", 11 March 2007).

[32] Prime, J., "Finding substance in the FCC's policy of 'Substantial Service'", *Federal Communications Law Journal*, Vol.56, March 2004.

Re-auctioning of spectrum versus administrative renewal of a licence

An alternative approach to a regulator deciding to automatically renew a licence subject to the operator meeting certain criteria is for the licence to put up to auction. Re-auctioning can be viewed as ensuring all operators and potential new entrants have an equal opportunity to acquire spectrum in a fair and transparent manner. Further, assigning a spectrum licence on the basis of bids in an auction represents a more transparent allocation mechanism than regulatory judgements as to which operator is likely to better meet particular objectives.

Re-auctioning of spectrum rights does however have a number of major drawbacks. In particular, where spectrum rights are to be re-auctioned then the existing rights-holder will face uncertainty about whether or not they will retain their rights to the spectrum until the outcome of the auction is known. There could thus be a period of years in which investment in the development of the network (including extending coverage to rural areas) and the deployment of new services is delayed with the possibility of stranded investment. This delay could represent a loss in foregone consumer benefits of hundreds of millions of dollars. In addition, where licences are re-auctioned there is always a risk that a problem in the process leads to the rights going to operator that fails to make the best use of the spectrum. For example, a number of new operators that acquired 3G licences in Europe around 2000 and 2001 did not succeed in developing commercially viable networks and eventually exited the market. If spectrum rights are re-assigned to a new operator, customers could be left without service (or with fewer competitors than otherwise) for years until that new operator is able to build its network to provide coverage that is at least equivalent to that of the current rights-holder. In addition, there is also the risk that competitors may game the re-auction by bidding up the price, putting the winning bidder at a cost disadvantage. Auctions can also be administratively costly to run.

To avoid such problem, licensing authorities should only decide to re-auction spectrum rights where there is a real chance that other operators could make better use of the spectrum than the current rights-holder. For example, in 2005 the Norwegian Ministry invited parties to register their interest for an auction of 900 MHz licences that were coming up for renewal (and to supply a bank guarantee for the NOK100 million reserve price). When no other parties registered their interest, the existing operators' licences were renewed without the need for an auction. Indeed, in general, incumbent operators with networks and customer equipment already tailored for the particular spectrum band have already incurred substantial costs that are sunk in the sense that only a proportion of the total costs may be recoverable if they are unsuccessful in retaining their licence. As such, incumbent operators will bid for the spectrum on the basis of the expected profitability of the services excluding the sunk costs, i.e., the sunk costs have already been borne regardless of whether the operator retains its licence. In contrast, a new entrant would need to factor in all its costs in establishing its business were it to win the licence. Thus, in many cases incumbent operators would be expected to win an auction and thus the costs and uncertainty created by re-auctioning are unlikely to be justified in those cases.

4.2. Administrative versus market-based approaches in general

Where an authority has decided not to renew existing rights or where rights to spectrum are to be assigned for the first time, there are three main approaches to assigning the future rights to use that spectrum band.

- Administrative approaches involve the licensing authority assigning rights on the basis of a number of criteria (such approaches are sometimes called 'beauty contests').
- Market based approaches (particularly auctions) involve the licence being assigned to whichever party bids the most for the licence (with that bidder either paying the amount of its own bid or in some cases the amount of the second highest bid).

- A hybrid approach combine aspects of the two main approaches such as where the licensing authority initially selects a short-list of bidders based on administrative criteria and then holds an auction to assign the licence between the bidders.

Administrative approaches are often seen as desirable on the grounds of allowing a range of criteria to be taken into account such as where applicants present plans for coverage extensions and the introduction of new or higher quality services. Administratively set licence fees are likely to be below the fees that would be determined at auction and this can improve operators' ongoing financial viability to assist in raising capital for network investment. Administrative approaches may also be cost efficient where there is no real competition for the licence such as where sunk costs imply that only one particular operator is expected to win any competitive process. On the other hand, administrative approaches may result in licences being assigned to the operator that presents an attractive proposal rather than necessarily the operator that can use the licence to generate the greatest benefits for society. There are a number of cases in which commitments provided at the time of licence renewal are later not met. Administrative discretion is also more vulnerable to bias or even misuse, which can lead to administrative approaches ending in legal disputes. This typically occurs in instances where clear tender procedures and evaluation criteria are not applied. Finally, while there are grounds to believe that high licence fees will have a limited impact on future investment (in terms of that investment being based primarily on the expected returns on that future investment), it may be the case that high licence fees increase an operator's cost of capital and this can result in lower investment than otherwise.

Auctions have the desirable property of assigning the licence to the operator that attaches the highest value to the licence, which will generally be the operator that can generate the greatest benefits to society from the licence. While the final assignment will be determined by price, non-price objectives can be targeted through including particular conditions in the licence to be auctioned (see Section 7). Auctions can also be highly transparent and maximise revenue for the government given the number of licences being assigned. As with administrative approaches, outcomes in practice from auctions may not always be efficient, particularly where poor auction rules lead to coordination between bidders. However, the deficiencies of auctions can generally be remedied by attention to auction design whereas the problems of administrative discretion may be less easily dealt with.

Licensing authorities should determine the approach or combination of approaches to assigning licences, taking into account their particular objectives as well as the likely advantages and disadvantages of the different approaches in the particular market context, drawing on both theory and practical experience. Particular criteria to take into account are:

- how best to ensure that the licences are assigned to the most valuable use for society;
- ensuring the Government receives a fair return on spectrum without risking charges that are so high that valuable spectrum is left idle;
- the cost effectiveness and transparency of the differing assignment approaches; and
- competitive neutrality across technologies and players.

Whether an administrative or market-based approach is adopted, importance should also be attached to the detailed design of the approach. This includes: (i) ensuring a transparent process with sufficient time and information being provided to maximise participation; (ii) determining which operators should be eligible to apply/bid and whether the design should treat incumbent operators and new entrants equally; (iii) how to determine the price in a beauty contest or the reserve price for an auction; (iv) what non-price objectives should be targeted either in the beauty contest criteria or in licence conditions; and (v) what rules should govern participants particularly to prevent coordination. Public consultation on the design of the licensing approach can help in ensuring that all key issues are taken into account.

4.3. Issues in auction design particularly in relation to spectrum for mobile broadband services

There is no single auction methodology that is best in all situations. The appropriate auction design will depend on the specific objectives of the auction, any relevant legal, regulatory, and institutional constraints, the characteristics of the licence(s) being auctioned and the likely competition for the licence(s) and the likely competition in the downstream markets for services to end-users.

Objectives of the auction

Licensing authorities can in practice seek to pursue a variety of objectives including efficiency (i.e. the winning bidder is the bidder who values the opportunity the most), optimal revenue and price, and various policy goals (for example, to increase post-auction competition in the downstream markets). Sometimes these objectives can conflict in which case the authority will need to balance them in its choice of design. For example, the immediate revenues from an auction can be maximised by licensing only one mobile operator. However, to do so would come at a large cost to the overall economy through high prices for mobile services as well as the loss in the competitive discipline to provide high quality and widely available services. Creating a monopoly mobile operator would constrain the growth of all the other sectors of the economy that rely on mobile communications. The government would then have less ability to raise as much revenues from these other sectors. As such, licensing authorities should aim to ensure that the auction leads to effective competition in the downstream markets for end-user services. Such auctions can still raise substantial revenues for governments including in terms of both licence fees as well as higher general taxation revenues from the faster economic growth enabled by competitive communications markets.

A recent report has identified approaches to spectrum licensing that can boost government revenues while maintaining competition in downstream markets.[33] These include: establishing clear rights and obligations in licences; maintaining a predictable regulatory approach including in relation to future spectrum charges and taxes on the industry; promoting participation in the auction, flexibility in the auction of spectrum that bidders may bid for and setting reserve prices to ensure a floor price for spectrum in case competition is weak but to avoid setting the price too high as to risk valuable spectrum being unsold.

Sealed-bid auctions versus open auctions

Two main types of auctions are:

- Sealed bid auctions where each bidder submits one bid without knowing what others have bid and the licence is awarded to the highest bidder who pays either their bid (first price sealed bid) or the highest losing bid (second price sealed bid); and
- Open auctions in which there are multiple rounds of bidding until only one bidder remains

Sealed bid auctions can be relatively easy to run, attract entry, reduce the risk of collusion and can potentially raise more revenue than open auctions if competition for the licence turns out to be weak. However, sealed bid auctions for licences that will support mobile broadband have a major drawback in that bidders are prevented from gaining useful information on how much others are valuing the licence. Mobile broadband services are still relatively new and there is significant uncertainty over the future demand for the services and the path of technology. Open auctions in which there are multiple rounds enable bidders to gain information on how others view the development of the market. For the bidder, this helps avoids the problem of the winner's curse where they bid based on excessively optimistic assumptions about the market and then find that they are unable to earn revenues to recover the licence fees (with the risk of bankruptcy). Licensing authorities can also gain from open auctions. First, efficient use of spectrum is promoted where bids are put forward taking into account as much useful information on the market as possible. In doing so, the licence is more likely to go to the party that can generate the greatest value from the spectrum rather than a party

[33] Dotecon, *Collecting revenues from spectrum – A report for GSMA*, February 2012.

whose limited information on the market leads them to over-estimate the value of the licence to them. Second, knowledge of the risk of winner's curse will lead to parties discounting their valuations so that the uncertainty over the market's development leads to lower bids in general. An open auction can thus lead to higher licence fees being paid and with the licences more likely to go to the parties that can make best use of the spectrum.

In addition to establishing the objectives (and constraints) for the auction, the choice of auction will also depend on the characteristics of the licence(s) being auctioned. For example, how important is the common value component of the licence: the common value is the component of value derived by the bidder from the licence that is correlated across bidders. When the common value is important and there is uncertainty about the common value itself, the auction design should aim to mitigate the "winner's curse" effect in which bidders bid conservatively for fear of "outbidding the market." Finally, the best design can depend on who is likely to bid in the auction: how many bidders, the similarities and differences amongst bidders, and how strong are these asymmetries amongst bidders.

Simultaneous Multiple Round Auctions are the most well established type of open auction for mobile spectrum. Bidders bid on single licences in a series of rounds and the auction stops when no new bids are submitted on any licence. Combinatorial auctions instead allow bidding for packages of items. Combinatorial clock auctions are a particular type of auction that has been adopted by a growing number of regulators for recent licensing of spectrum relevant to mobile services. This auction format involves several stages: (i) a first clock phase in which prices for different categories of spectrum lots are increased with bidders allowed to make a bid for a package of lots across multiple categories until the price level is reached where there is no excess demand remaining for any of the lots; (ii) a supplemental sealed-bid round in which bidders make their best and final offers for all combinations of spectrum they want with their bids being required to be consistent with their bids in the first phase; (iii) the assignment phase in which the winners from the supplemental round (i.e. those who made the highest value combination of bids) can offer to pay extra to secure a specific spectrum lot from within the relevant category. However, combinatorial clock auctions are more complex and a relatively new concept for spectrum allocations. The rules to achieve optimal outcomes in a combinatorial clock auction are still evolving. These auctions have been used to assign spectrum for mobile services recently in Austria, Denmark, the Netherlands and the UK.

The following table lists a number of upcoming auctions.

Table 1 – Upcoming mobile spectrum auctions

Country	Spectrum band	Proposed auction date
Albania	2.1 GHz	Early 2012
Australia	700 MHz and 2.5 GHz	Late 2012
Austria	800, 900 and 1800 MHz	September 2012
Brazil	450 MHz and 2.6 GHz	June 2012
Canada	700 MHz, 2.5 and 2.6 GHz	Late 2012
Chile	2.6 GHz	Q2 2012
Colombia	1700 and 1900 MHz, 2.1 GHz	Under consultation
Czech Republic	800 and 1800 MHz, 2.6 GHz	Consultation Mar 12
Denmark	800 MHz	May 2012
Finland	800 MHz	By end of 2013
Hong Kong	2.5 and 2.6 GHz	Targeting Q1 2013
Hungary	900 MHz, 2.6 GHz	Early 2012
India	700 MHz	Possibly 2014
Ireland	800, 900 and 1800 MHz	During 2012
Lithuania	2.5 and 2.6 GHz	Early 2012
Netherlands	800, 900 and 1800 MHz	Planned for October 2012
New Zealand	700 MHz	November 2012
Nigeria	2.6 GHz	Under consultation
Norway	800 MHz	Under consultation
Pakistan	700, 800 MHz, 2.1 GHz	March 2012
Peru	1700 MHz and 2.1 GHz	Under consultation
Poland	1800 MHz & 800 MHz and 2.6 GHz	Mid 2012 & During 2013
Romania	800, 900, 1800 MHz and 2.6 GHz	Under consultation
Slovakia	900 and 1800 MHz	Auction proposed, no timeframe
South Africa	800 MHz and 2.6 GHz	Postponed until further notice
Sweden	2.3 GHz	During 2012
Thailand	2.1 GHz	Late 2012
United Kingdom	800 MHz and 2.6GHz	2012

Source: Various

In the following sections, we consider the experience of spectrum licensing in Bangladesh which has been carrying out a licence renewal process and South Africa where a specific proposal has been made for the licensing of digital dividend spectrum.

4.4. Spectrum licence renewal in Bangladesh

Bangladesh has allocated significant spectrum in the 800-900 MHz and 1800 MHz band, although it is still to licence spectrum in the 2.1 GHz band.

In 2011, Bangladesh's regulator determined arrangements for the renewal of the existing 2G spectrum licences. The renewal of these licences will ultimately give Bangladesh's GSM and CDMA operators security over their rights to spectrum for an initial period of 15 years which will enable them to plan for investments in the development of their networks. The regulator also included a provision for the future refarming of the spectrum to be used for 3G services. However, to date, the 2G licence renewal process is not yet finalised, creating uncertainty for the operators.

The licence renewal process in Bangladesh did indicate a number of areas where improvements to the process could have been made to better support the development of the industry in the interests of Bangladesh's consumers.

First, the rules themselves were still being decided in the months leading up to expiry of the licence and a court case relating to the payments to be made was only decided this year after the expiry date. Given that mobile services required network investments with long pay-back periods, licence renewal should be determined years in advance of the licence expiry date so as to avoid necessary network investments being postponed. Further, operators need time to arrange funding when large amounts are to be paid.

Second, there was little transparency over the basis for the determination of licence fees and the resulting structure does not appear consistent with promoting efficient use of spectrum. The general level of fees was set at the same level for 900MHz and 1800MHz spectrum and at a lower level for the 800MHz spectrum used by the CDMA operator. However, the lower the frequency band, the more valuable the spectrum because it enables coverage to be achieved at lower cost. Thus higher fees for lower band spectrum would have better reflected the opportunity cost of the spectrum. The level of fees does not appear to have been set on any objective basis. While comparisons could be made with other countries, these should take into account all significant factors impacting on the value of spectrum. For example, Bangladesh's taxes on the mobile sector are amongst the highest in the world which will significantly impair the profitability of investment in the sector even before payment of the spectrum fees. An additional issue in the fee structure is that the regulator imposed a utilization factor requiring operators with more subscribers to pay higher fees even for spectrum in the same band. This effectively punishes operators for seeking to attract new subscribers and thereby can reduce the intensity of competition. It will also undermine the efficient use of spectrum as operators who make poor use of spectrum by using the spectrum to supply relatively few subscribers pay lower fees. It should also be noted that in addition to the licence fees, Bangladesh's operators face the highest mobile-specific taxes in the region.

A third area where the licence renewal process could have been improved is by providing for the use of the spectrum for 3G services at the same time as the renewal of the licences. Mobile broadband will be a critical enabler of economic growth in Bangladesh because of the very limited fixed network and yet Bangladesh is already well behind other countries in the availability of 3G services. Further, while initial 3G services in other countries were offered at 2.1 GHz, many countries are now also supplying 3G using the 900 MHz band and the 1800 MHz band. Accordingly, there is no technical reason as to why restrictions on the use of the 900 MHz and 1800 MHz could not have been removed already to enable the rollout of 3G services in those bands.

Bangladesh's regulator and Ministry are currently defining guidelines for the 3G licensing process, expected to take place later in 2012. While the issuing of 3G licences would ideally have been made much earlier, the auctioning of this spectrum will greatly help Bangladesh's operators in meeting demand for mobile services including the take-up of mobile broadband. The choice of an auction for the assignment of the spectrum should greatly help in leading to a transparent and fair process with spectrum going to the operators that are likely to be able to generate the greatest benefits from the use of the spectrum.

The success of the auction will nonetheless depend on its detailed arrangements which are still to be determined. Of the information that has been provided by the regulator to date, two particular aspects are of concern. First, the regulator has stated that the state-owned operator will not be required to bid but will receive 3G spectrum for a payment equal to the amount of the highest bid. The state-owned operator will also be given a 6 month head-start in launching 3G services. It is not clear what the rationale is for having a state-owned mobile operator. Bangladesh's other operators show that competitively provided mobile services can be supplied by private operators without the need for a state-owned operator. If the Government were to instead sell the operator, it will gain funds that it could use to increase support to services that are reliant on government support such as health and education services to low income households. To the extent that Bangladesh's Government considers it important to retain ownership of the operator, that operator should nonetheless be treated on an equal basis with other operators. In guaranteeing spectrum for the Government-owned operator, the regulator may prevent another operator from being able to use that spectrum even when it could better use that spectrum in delivering services to consumers. If that is the case, then Bangladesh's consumers would be made worse off. A final concern is that the regulator has indicated that if a new operator wins 3G spectrum, that operator will also be given the opportunity to acquire 2G spectrum. If that situation arises, it will be important to ensure that the 3G auction is not distorted by arrangements for the 2G spectrum. For example, if the new entrant were able to acquire 2G spectrum at less than the market price then they might be prepared to pay more for the 3G spectrum to take advantage of this opportunity. In that case, the 3G spectrum would not necessarily go to the operators who could best generate value for society from the use of the 3G spectrum.

In summary, while the Bangladesh's regulator is taking decisions to support the development of its mobile industry to the benefit of consumers, there is nonetheless, in the detail of the decisions, considerable scope for the regulator to align the process more closely with international best practice and thereby generate greater value to Bangladesh's consumers from the use of the country's scarce spectrum resources.

4.5. Spectrum assignment in South Africa

Mobile spectrum licences were initially directly assigned by the South African Government. Two licences were granted in 1993 with a licence for a third operator being granted in 2001 and with Telkom establishing the fourth network following the divestment of its stake in one of the original operators, Vodacom.

The South African Government and the regulator, ICASA, have been seeking to introduce more market-based approaches to assigning and managing spectrum. The Government's Radio Frequency Spectrum Policy for South Africa, released in April 2010, sets out an overall framework for spectrum policy with the aim of promoting efficient use of spectrum resources in the national interest.

In December 2011, the South African Government published draft policy directions for the assignment of spectrum in the frequency bands 790 – 862 MHz ("800MHz") and 2500 - 2690 MHz ("2.6GHz")[34] and invited applications for the licences[35]. The 800MHz spectrum (together with 2x10MHz of the 2.6GHz spectrum) is to be licensed to one wholesale open access network as the Government considers that there is insufficient 800MHz bandwidth to support full network competition. The wholesale access conditions include "no locking" (no prohibitions against devices that may be connected to the network), "no blocking" (no restriction against legitimate content, applications, and services), and "no retail" (entity will not be allowed to compete with its customers).[36] Multiple operators can apply for licences in the 2.6GHz band (with the proposal for some spectrum to be exclusively for new entrants and for some to be available in the future for sharing by a group of operators which the Government labels a Managed Spectrum Park model).

The proposed licensing process involves a number of phases. Phase 1 involves prequalification criteria, including 30 per cent ownership by Historically Disadvantaged Individuals (HDI), holding an electronic communications network service license and financial credibility such as proof of funding. Phase 2 involves comparative selection (i.e. a 'beauty contest') which takes into account the business plan (20%), technical plan (20%), market innovation and stimulation (15%) and the network rollout plan (50%). Minimum network rollout requirements have been specified for the open access network and for the 2.6GHz only licensees. If more than one applicant meets the prequalification criteria and passes the threshold points required in Phase 2, then the applicants will move to Phase 3 in which they submit seal bids. Phase 4 involves granting the licences to the highest bidder.[37]

The duration of the radio spectrum licence would remain valid from 1 April until 31 March of the following year, and thereafter will be renewable by payment of the annual licence fee for 15 years or the duration of the ECNS licence, whichever comes first.[38]

The proposal is currently suspended to take into account a forthcoming policy announcement on high demand spectrum.

Assessment of the new South African proposals

The South African Government has recognised the importance of releasing additional spectrum to achieve widespread access to mobile broadband. The open access network proposal is a practical way forward which limits the potential harm of a single provider, although the first best approach would have been to try to make sufficient lower bandwidth spectrum available to support competing providers. This is particularly important given the substantially better propagation properties of that spectrum. A number of details of operation of the proposed open access network remain to be determined (such as to how congestion in local hotspots would be resolved), although these should not prove insurmountable.

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[34] Department of Communications (2011), *Notice 898 of 2011 Policy Directions Drafted in Terms of Section 3(2) of the Electronic Communications Act, 2005 (ACT No. 36 of 2005),* available at:

http://www.info.gov.za/view/DownloadFileAction?id=156635

[35] ICASA (2011), *Draft Invitation to Apply for Radio Frequency Spectrum License to Provide Mobile Broadband Wireless Access Service for Urban and Rural Areas Using the Complimentary Bands, 800 MHz and 2.6 GHz.*

[36] ICASA (2011) *Notice 911 of 2011,* p. 4 -5, available at:

http://greengazette.co.za/documents/national-gazette-34872-of-15-december-2011-vol-558_20111215-GGN-34872.pdf

[37] Ibid, p. 24

[38] ICASA (2011), *Draft Invitation to Apply for Radio Frequency Spectrum License to Provide Mobile Broadband Wireless Access Service for Urban and Rural Areas Using the Complimentary Bands, 800 MHz and 2.6 GHz*, p. 22, available at:

http://greengazette.co.za/documents/national-gazette-34872-of-15-december-2011-vol-558_20111215-GGN-34872.pdf

There are a number of reasons to question aspects of the qualification criteria and comparative selection round. Generally allocating licences to the highest bidders can be expected to lead to those bidders to aim to supply services in the way that generates the greatest benefits to consumers because in doing so they maximise their own returns. The main exception would be if a licence were acquired to limit competition, although such rules can be adopted to prevent this. A comparative selection leads to the licences being assigned based on the regulator's, rather than consumers', view of the value of different service features. Further, where a regulator is being called upon to assess the business plans and strategy, then there is a risk that product variety and innovation will be constrained either because the regulator might wrongly reject a very innovative plan as impractical or because bidders design their plans with the aim of appealing to the regulator's interests rather than consumers' interests.

The requirement for the bidder to have 30% HDI ownership may appear a desirable way of reducing inequality; it could reduce significantly the revenues that would otherwise be earned by the Government. The forgone Government revenues might have been able to fund expenditures that could more effectively alleviate poverty.

The choice of a sealed bid auction has the advantage of simplicity and can also encourage entry as well as limit the risk of collusion. However, it is not clear to what extent the Government has considered the relative merits of alternatives such as a multiple round ascending auctions (which can enable bidders to gain from information of earlier bids which may, for instance, encourage them to bid more highly than they otherwise would do) or a sealed bid auction in which the winner pays a fee for the licence equal to the second highest bid (such an auction can be expected to encourage bidders to bid their true valuation rather than a discount to that valuation).

4.6. Recommendations

Following are our key recommendations in relation to the assignment of licences and the approach to licence renewal.

- *Recommendation 9* – Licensing authorities should clearly set out their approach to licence renewal in advance (a range between 2 to 4 years as a minimum should be adequate) of the expiry of the licence so as to avoid network investment being postponed. The authorities should publish the criteria that they will use to assess renewal as well as the terms and conditions that will apply to the renewed licence.
- *Recommendation 10* - There should be a presumption in favour of licence renewal for operating and spectrum licences to encourage long-term investment and minimise the risk of service disruption to customers. Reasons for not renewing licences should be limited to spectrum replanning, where there is little risk of stranding substantial investments, or where there has been a serious breach of licence conditions which should be evident in advance of the renewal time. Exceptionally, a licence may not be renewed in relation to the whole or part of the relevant spectrum so as to promote competition through re-assignment of spectrum. However, before not renewing a licence for this reason, regulators should first (i) assess whether competition is already effective in the market; (ii) identify whether competition can be promoted by other means such as the release of alternative spectrum; and (iii) assess whether the expected competition benefits will exceed the potential costs such as in relation to spectrum replanning, customer migration and the risk of deterring investment.

- *Recommendation 11* – Re-auctioning spectrum at the end of the licence should be limited to situations where there has not been evidence of substantial investment and there is a reasonable prospect that spectrum will be re-assigned between operators (or where additional, alternative spectrum is being made available), or situations where an existing licensee decides to reject a licence renewal offer. In most cases, the existing operators would be expected to re-acquire the licence with the consequence that an auction only creates unnecessary uncertainty and costs.
- *Recommendation 12* – Where spectrum is to be re-assigned or assigned for the first time, licensing authorities should determine the approach or combination of approaches to assigning licences taking into account their particular objectives as well as the likely advantages and disadvantages of the different approaches in the particular market context drawing on both theory and practical experience. Licensing authorities should attach priority to ensuring effective competition in downstream markets for services to end-users. Whether an auction or beauty contest is adopted, the detailed design of the approach is important. Open auctions are likely to be superior to sealed bid auctions for spectrum relevant to mobile broadband services in terms of promoting efficient spectrum use.

5. Pricing of mobile licences

A wide variety of approaches have been adopted for determining the fees to be charged in relation to mobile licences. In this section, we first evaluate different pricing objectives and then examine the various pricing approaches against a range of criteria.

5.1. Objectives

Licence fees can be set for three main purposes:

- to recover the administrative cost of the licensing process itself, of administrative management of spectrum and associated regulatory costs;
- to encourage efficient spectrum use such as where the level of the licence fee is determined in an auction or where it is set at the level estimated to be in line with the market value of the licence; and/or
- to raise revenue for the government.

The first objective of setting the licence fee to recover the cost of the licensing process is particularly common in relation to operating licences and for spectrum licences where there is no excess demand for a particular spectrum band. We discuss this pricing approach further in the next section.

Where there is excess demand for spectrum, the level of licence fees may serve an additional purpose of helping to assign scarce spectrum resources efficiently, i.e., so that spectrum is assigned to the user that is able to generate the greatest value to society from its use. Auctions can be expected to function in this way. Alternatively, even where spectrum rights are assigned using an administrative process, setting the licence fee in line with the opportunity cost of the spectrum[39] can promote efficient spectrum use. For spectrum that has previously been assigned, charges set in line with the opportunity cost of spectrum may also facilitate efficient spectrum use if that spectrum is not already assigned to its highest value use. Where the spectrum is already in its highest value use then raising the licence fee would bring no efficiency benefit and may even harm efficiency if the level is set too high so that valuable spectrum is left idle. As we discuss in Section 7, where spectrum trading is effective then the market can be expected to result in spectrum being assigned to the user who can generate the most value from the use of the spectrum without any need for a licence fee to be set to achieve efficient spectrum use.

A third potential objective of setting a licence fee is to raise revenue for the government. It is reasonable for governments to seek to earn a fair return on selling rights to use public resources such as spectrum and such a return may be achieved either from an upfront licence payment or from ongoing taxes and charges. However, there is the need to ensure that the licence fees are not set so high as to harm investment and the efficient development of the sector. High upfront licence fees can deter new entry and lead to debt levels which increase the cost of raising funds for investment in network and service deployment. High ongoing charges flow through into high mobile prices which can retard growth in the number of subscribers and limit call volumes and ultimately high overall economic growth. A number of studies have found that reductions in mobile specific taxes can have a significant positive impact on subscriber numbers and overall economic growth.[40] The faster growth of the sector, in turn, acts to limit any loss in government revenues – indeed, in certain cases, overall

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[39] The opportunity cost of spectrum is the value of the spectrum in the best alternative use which is the highest price that would be offered by a rival bidder at auction. In this Section, we discuss a number of approaches to determining the opportunity cost of spectrum. Note that where there is no excess demand for a particular spectrum band, then the opportunity cost of that spectrum band falls to zero.

[40] For instance, see Deloitte, *Global mobile tax review 2006-2007*.

government revenues may even increase from lower rates of tax on the mobile sector. The studies' finding that lower mobile specific taxes and charges may boost overall economic growth is in line with general taxation theory that it is more efficient to raise revenue from as wide a base as possible.

In short, there is a strong economic case to avoid the level of licence fees being determined on the basis of revenue maximising objectives. Rather licence fees should be limited to recover the administrative costs of the licensing process and, in some circumstances, set higher to encourage efficient spectrum use (i.e., where efficient spectrum use would not otherwise be achieved).

5.2. Pricing approaches

We now turn to examine particular pricing approaches that have been applied in practice.

Setting fees to recover administrative costs of licensing

Licence fees in a number of countries are set to recover the administrative costs of the licensing process and regulatory costs associated with the licensed activity. This pricing approach is in line with a user-pays principle (i.e., that telecommunications users should ultimately bear the cost of licensing activity incurred to support the provision of the particular services).

The European Union's Authorisation Directive (Art. 12) provides for EU Member States to levy administrative charges but requires that the total amount of the charges should not exceed the administrative costs incurred in relation to management, control and enforcement of the licensing scheme and in relation to associated regulatory activities. The Directive also requires that the charges be imposed in an "objective, transparent and proportionate manner which minimises additional administrative costs and attendant charges".

It is important that the licensing authority faces external control to ensure that costs are kept at efficient levels and in that regard the funding arrangement should also be relatively simple and practical. Further, the licence fee should be collected across the industry in a competitively neutral manner and avoid creating incentives for firms to restructure their activities so as to reduce their liability for the charge.

The European Union's Authorisation Directive (Art. 13) also provides for fees to be levied, where objectively justified, for the rights to use radio frequencies which reflect the need to ensure the optimal use of these resources. We next consider how such charges might be determined.

Auctioning or re-auctioning of spectrum

Auctioning of spectrum provides the most transparent and direct way of determining the market or efficient price for spectrum. However, as discussed in Section 4, auctions will not always be appropriate. As such, indirect ways of estimating the market price of spectrum may be desirable in many cases. Even in these cases, licensing authorities may decide to maintain the option for existing licensees to decline to pay the regulatory-determined price and instead to re-bid for the spectrum rights at auction. This can provide a safeguard against the regulatory-determined price being set too high with the risk that valuable spectrum is left idle.

Marginal forward-looking opportunity cost (MFLOC)

The MFLOC approach is based on estimating the change in costs that would result for an operator, operating an optimal network, to maintain the same quantity and quality of services to customers if it were to gain or lose an increment of spectrum. For example, if a mobile operator were to gain a marginal unit of spectrum then it would need fewer base stations (and other inputs) to maintain the same volume of services and service quality. Those additional network costs that the operator incurs represent the opportunity cost of using that marginal unit of spectrum for another purpose rather than the operator using it. The MFLOC can thus be estimated by modelling how a network's costs would change with and without additional spectrum while maintaining the same quantity and quality of services.

The rationale of a MFLOC approach is to promote efficient spectrum use by encouraging holders of spectrum licences to return their licences (or part of their licensed spectrum) whenever the value they place on the licence (or part of the spectrum) is less than the price charged. The choice of the optimal network is akin to a forward-looking cost approach of using the costs that would be incurred by a new entrant using the least cost modern equivalent assets for supplying the services. Estimating the MFLOC can be useful for spectrum that is not sold at auction or that is not tradable. Charges based on MFLOC may be particularly relevant to public sector users of spectrum who may not face incentives to maximise the value from their use of spectrum with the risk that spectrum assigned to them is poorly utilised.

The Australian Communications and Media Authority (ACMA) has decided to use opportunity cost pricing to improve incentives for the efficiency allocation and use of spectrum in cases where it sets prices for administratively allocated spectrum. In particular, the ACMA has decided to prioritise the introduction of opportunity cost pricing for spectrum bands where an auction is not considered optimal but where: (i) there is evidence of congestion; (ii) there is evidence of inefficient pricing; (iii) new high value uses become apparent; (iv) there are expected net benefits to opportunity cost pricing; or (v) opportunity cost pricing is expected to contribute to its statutory objectives.[41] The ACMA also noted that opportunity cost pricing will not always be justified as the expected benefits may not outweigh the costs.

Calculating the MFLOC directly can rely on assumptions with consequent uncertainty over the actual level. A risk of an MFLOC charge being calculated incorrectly too high is that efficient spectrum use may be undermined. As such, choosing a conservative value from within the estimated range for MFLOC will be appropriate. Further, if the charges are imposed where they do not affect the use of spectrum (i.e., where spectrum is already in its best use), the charges will simply represent a transfer of income from customers of the services using the spectrum to the Government rather than promoting efficiency. We turn next to consider indexation and benchmarking which may be more practical means to estimate the opportunity cost in particular circumstances.

Indexation of historical fees

An alternative way of arriving at an estimate of the current market price for spectrum is to take the original price (particularly if it has been determined at an auction) and adjust this price by an estimate of how much the forward-looking value of the spectrum has changed over time. For instance, the New Zealand Government has applied this approach to the renewal of AM and FM radio licences based on adjusting the original auction prices for the spectrum by a growth factor estimated to reflect the change in value of the spectrum up to the time of reallocation (in practice, the value may have increased or fallen over time). The change in value was estimated based on comparing net cash flows from the current period with expected net cash flows over the period of the renewed licences taking into account revenue drivers. The Government's own advisors rejected the use of an indexation approach for mobile services in New Zealand given the significant technological and commercial

[41] ACMA, The ACMA response to public submissions: opportunity cost pricing of spectrum, January 2010, p.4.

changes impacting the mobile market since the time that the initial licences were issued. However, this approach could be considered for licences where historical prices have been more recently determined and where the development of market values over time is less uncertain.

Benchmarking

Another way to estimate the market price for a particular band of spectrum is to use benchmarks based on recent prices determined in auctions or in secondary trading of spectrum either for similar spectrum in the same country or in other countries. A benchmark will provide a reasonable estimate provided that:

- the chosen benchmark is for spectrum that can be expected to have a similar market value to the particular band given the demand and cost factors impacting on the use of the spectrum; or
- robust adjustments can be made to the chosen benchmark to account for any differences in demand and cost factors.

Relevant demand and cost factors that would need to be controlled for include population and population density, GDP per capita, the type of spectrum, license duration, license conditions and expected future releases of spectrum in the market.

In Pakistan, prices for the renewal of licenses for the existing mobile operators were determined on the basis of prices paid at auction for licenses provided to 2 new entrants. Pakistan's Government was able to draw on the results of a recent auction for similar spectrum. Where a comparable price exists then benchmarking may be a practical means to estimate the fee for a new license. Benchmarking may also be useful as a cross-check on the reasonableness of other approaches.

Discounted Cash Flow (DCF) modelling

DCF modeling seeks to value spectrum on the basis of the present value of the future cash flows that the use of the spectrum is expected to generate. In particular, the modelling estimates the discounted present value of expected future revenues from the output produced by the asset, less the present value of associated future operating costs and taking into account any potential future re-sale value for the spectrum rights. An investor would be expected to be prepared to pay a price for the spectrum up to the value at which it can no longer make a commercial return on the investment given the expected future cash flows.

DCF modeling would be problematic if it were used to seek to capture all the economic profits of an operator that has already incurred significant sunk costs in building its network.[42] This is because it is the opportunity to earn such profits that provides the incentive for such investment. DCF modelling can also be highly complex and contentious, particularly as uncertain forecasts of future demand can have a significant impact on the valuation. Accordingly, there may be a large margin for error in relation to DCF modelling, particularly given the information available to the regulator.

An alternative approach of establishing the value of spectrum would be to seek to disaggregate the market capitalisation of a listed operator so as to identify the value attributed to the spectrum rights. However, it is unlikely that this approach can be applied robustly in most cases because of uncertainty over the value of non-spectrum assets as well as volatility in share prices. Sales of wholesale capacity are also unlikely to provide a reliable approach because of uncertainty of the value of the non-spectrum assets.

42 DCF modelling could instead be used to estimate the MFLOC of spectrum by valuing the spectrum to an operator at the margin. As such, it would have the efficiency properties in principle described above under the MFLOC section as well as the difficulties of estimation in practice.

Annual versus upfront licence fees

In addition to determining the amount of licence fees to be recovered, there is also a question of the structure of the fees, particularly in relation to whether the full amount should be recovered upfront, by annual charges or by a combination of the two.

As a matter of principle, licence fee payments should be aligned with the timing of rights for a licensee to access and earn a return from the spectrum asset.

Recovering licence fees through an upfront payment may help ensure that spectrum is allocated to only serious operators. Upfront fees also imply that, once the fees have been paid, they will not affect the pricing of services as operators will set their prices to maximise their profits given the competition in the market regardless of what they have paid previously.

Annual charges, on the other hand, may encourage new entry. Particularly where entrants would have difficulty raising a large upfront payment and where the risk of entry is reduced by being able to return the licence if their business does not succeed. Royalties, i.e., annual charges levied as a percentage of revenues, can further reduce the risk to new entrants as their payment to the Government will be relatively small while their revenues are small. However, precisely because royalties imply a relatively small payment for operators that are making little use of its spectrum, royalties may undermine efficient spectrum use - indeed some licensees may choose to hold off making any network investment. Further, the actual royalty rate in practice tends to be highly political and contentious.

Annual charges carry a further problem in that they will tend to be factored into service prices. This is particularly the case where the level of charges varies with service volumes as occurs with royalties, i.e., where a charge is set as a percentage of revenues. As discussed above, earlier reports for the GSMA have found that mobile revenue taxes in some countries are so high that they are significantly inhibiting the growth of the mobile sector. Further, in markets in which competition is limited, royalties can also exacerbate the welfare loss arising from any excess pricing.

5.3. Comparative summary

Table 2 summarises the advantages and disadvantages of the different pricing options.

Table 2: Assessment of pricing options

Approach	Advantages	Disadvantages
Pricing to recover administrative costs of licensing process	Appropriate for operating licences and where spectrum is already in its best use or where there is no excess demand for spectrum	May not lead to efficient spectrum use where there is excess demand for spectrum
Re-auctioning	Accurate market value (subject to auction design and competition among bidders in the auction)	In the context of licence renewal, can create substantial uncertainty and significant administration costs
MFLOC	Can promote efficient spectrum use (subject to accuracy of estimate)	Difficult and contentious to model
Indexation of historical prices	Simple and transparent where changes in market values from historical prices can be estimated	Accuracy depends on the extent to which the change in market values over time can be estimated
Benchmarking	Simple and transparent where close benchmarks exist	Can be misleading if no close benchmarks exist because of differences in the nature of spectrum bands or differences between markets
DCF modelling	Can be accurate in principle	Requires detailed modelling and may be highly inaccurate given uncertainty over forecasts. Assumptions may prove contentious. DCF modelling would carry a large risk of deterring investment if it were used to seek to capture all the economic profit from acquiring a licence
Royalties	Reduces risk for licensees compared with upfront charges and encourages new entry	Royalties act to increase service prices. Royalties can also undermine efficient spectrum use as operators with low revenues make only small payments

In the case of several bands being renewed or auctioned simultaneously, it is important to ensure that appropriate consideration is given to pricing relativities between the bands in order to avoid distorting investment decisions toward inefficient deployments.

5.4. Reserve prices

A separate pricing issue to the level of licence fees is what approach licensing authorities should take to setting reserve prices in auctions. Reserve prices help discourage non-serious bidders and they can also ensure a floor price for spectrum in case competition for the licences are weak. However, reserve prices should be set conservatively rather than to try to match the expected market price. This reflects the danger that even a reserve price that is set a little too high may lead to the auction failing to assign the licence. If a licence fails to sell, there can be unnecessary administration costs in needing to hold another auction and consumers can also be harmed by the delay in the spectrum being able to be used. Where competition is expected to be strong, reserve prices can be set as minimum safety net as competition in the auction will ensure a fair price for the spectrum.

3G licensing experience shows the problem that can be caused by inappropriately set reserve prices. High prices for 3G licences auctioned in 2000 in Germany and the UK led to a number of countries setting high reserve prices in 2001. However, these countries failed to recognise that the UK and German experience was not directly applicable to countries with smaller populations and that in any event market expectations changed fundamentally with the end of the dotcom boom. As a consequence, licences failed to sell in Belgium, Singapore, Greece, the Czech Republic and Israel in 2001. In later auctions, authorities applied more appropriate reserve prices and in most subsequent 3G auctions all licences were sold. The experience of 3G licensing shows the need for caution in using benchmarking for setting reserve prices and, in particular, to take into account local market conditions expected to prevail at the time of the auction.

5.5. Recommendations

Following is our key recommendation in relation to licence fees:

- *Recommendation 13* - Licence fees, if any, should generally be limited to recovering the administrative costs of the licensing process and associated regulatory costs (including spectrum management costs). However, where there is excess demand for spectrum, then an auction or administrative assignment of spectrum with a charge set in line with the Marginal Forward Looking Opportunity Cost (MFLOC) of spectrum should be considered. Indexation or benchmarking may prove a practical means to estimate MFLOC in particular circumstances. The MFLOC should be estimated conservatively to reduce the risk that valuable spectrum will be left idle. It is also important that the estimated prices are set appropriately relative to spectrum prices in other bands. The relative merits of upfront licence fees versus annual charges should be considered with regard to the particular market circumstances.

6. Promoting competition through licensing

As access to spectrum is essential for the supply of mobile services, the way that spectrum is assigned and how it is managed on an ongoing basis can impact on the level of competition in the downstream markets for mobile services. As such, it is important for licensing authorities to consider how their decisions may impact on competition for services.

6.1. Promoting competition is a means to an end

Competition is a process of rivalry between firms in a market as they seek to win customers from each other. Competition is important because it helps constrain price levels to efficient cost levels as well as strengthening the incentive for operators to maintain high quality of service and introduce innovative new services so as to avoid losing customers to competitors.

It should be noted that competition is not an end in itself. It is valuable to the extent that it leads to higher social welfare, particularly in terms of lower sustainable prices and better quality services for customers. Achieving the lowest sustainable level of prices will also depend on the costs of operators supplying the services. In markets such as the mobile industry where there are significant economies of scale, it is likely to be efficient for there to be only a relatively small number of operators. In particular, market volumes may only enable a few operators to reach the minimum efficient scale. If a regulator were to try to achieve a greater number of operators, customers could be made worse off because these operators would need to set higher prices to recover their higher unit cost levels. Customers could also be harmed if a regulator prevented an operator that was better at delivering services from being able to expand to meet customer demand. Thus, while having many small competitors may give the appearance of greater competition compared with a market with fewer operators, in terms of what should ultimately matter – outcomes for consumers – a market with fewer but more efficient operators may be better.

A further consideration is that, depending on the market context, rivalry between a few large operators can be intense with additional operators making little difference to the level of competition. Features of the mobile market contribute to greater competitive rivalry including the rapid pace of technological and commercial developments (that imply that it would be hard for operators to reach or maintain coordination between themselves) and there have been generally low barriers to expansion (although regulators could perversely harm competition if operators reach the practical capacity of their spectrum assignments). Longer term evidence of rapid falls in prices also indicates that competition in mobile markets is generally effective.

Competition authorities have recognised that effective competition in mobile markets is consistent with a few, large competitors. For example, the European Commission has allowed in a number of merger regulation decisions for the consolidation of European mobile markets to generally 3 to 4 operators, together with a number of retail services providers.[43] Under the European regulatory framework for electronic communications, market reviews also found that markets with at least 3 mobile operators were generally effectively competitive. Bank of America Merrill Lynch data shows that across developed markets the average number of mobile operators is 3.5 and across emerging

[43] For example, *Case No COMP/M.5650 – T-Mobile/Orange, Case No COMP/M.4748 – T-Mobile/Orange Netherlands* and *Case COMP/ M.3530 - TeliaSonera/Orange.*

markets the average number of mobile operators is 3.9. Of all the countries in the Bank of America Merrill Lynch data set, only three markets have more than 5 significant operators: Bangladesh, India and Nigeria. The US Department of Justice did block the proposed acquisition of T-Mobile by AT&T and expressed the concern that the merger would combine two of the four national mobile providers in the US that between the four of them account for more than 90 per cent of US mobile subscriptions.[44]

6.2. How should licensing authorities assess whether measures to promote competition are warranted?

Competition works by firms expanding or contracting based on their relative success in providing services at prices and quality levels that are attractive to customers. Thus, spectrum policy should aim to support downstream competition by enabling operators to gain the spectrum required to expand. Specific policy measures to promote competition are only likely to be needed where spectrum resources would otherwise become excessively concentrated in the hands of one or two operators and without sufficient spectrum available to support the growth of other operators. In the previous section, we noted that around 3 to 4 national operators is likely to be sufficient to ensure effective competition in most mobile markets. Were a licensing authority to impose measures with the aim of creating more operators, particularly more than 4 or 5 national operators, there would be a significant risk of customers being harmed particularly in terms of facing higher prices than would otherwise be the case.

In assessing whether to impose particular measures to promote competition, licensing authorities should:

- Assess what would be the level of competition in the absence of the measures. Where competition is already expected to be effective then imposing additional obligations may bring little additional benefit while carrying costs such as in terms of spectrum not being assigned to its most valuable use or where the market becomes excessively fragmented resulting in higher costs and prices than otherwise.
- Identify whether there are ways to achieve effective competition that do not constrain the ability of any operator to grow by attracting more customers. For example, it may be possible to free up additional spectrum resources so that all operators can acquire sufficient spectrum for their needs.
- Whether particular measures are introduced to protect or promote competition, it is important to evaluate the costs and benefits of each measure to ensure that benefits do exceed costs and that the particular measure is chosen that is expected to achieve the policy aim at least cost.[45]
- Even where obligations are imposed initially, regulators should undertake periodic reviews of the competitiveness of the market to determine whether such obligations continue to be required.

[44] US Department of Justice press release, 31 August 2011.

[45] For example, the New Zealand Government decided to renew the mobile licences of the major NZ operators except for a part of the spectrum which was made available by the major operators to a new entrant.

6.3. Measures to promote competition

Licensing authorities have imposed a variety of specific measures to promote competition in the downstream services markets. In this section, we assess the experience with a number of these measures.

Spectrum caps and set-asides

Many licensing authorities have adopted spectrum caps and set-asides in licensing mobile spectrum, particularly in the early stages of market development. Spectrum caps limit the quantity of spectrum that can be held by an operator in a particular geographic area. For example, in an auction, bidders may be limited to acquiring only one block of spectrum. Spectrum set-asides reserve a particular block of spectrum for a particular bidder, such as a new entrant.

Spectrum caps and set-asides have the ability to promote competition in markets where competition is limited or would become limited (such as if only one firm were to acquire most of the available spectrum). This in turn can have benefits such as lowering the price and expanding the choice available to consumers. Spectrum caps can increase participation in (and potentially revenue derived from) an auction. Incumbent bidders often have an advantage over non-incumbents; in for example lower incremental cost of network build, so without a spectrum cap non-incumbents may be reluctant to participate in an auction. With a spectrum cap, non-incumbents know that some licenses will be awarded to non-incumbents, encouraging them to secure financing to participate in the auction. This in turn can have the effect of increasing not only competition but also auction revenues.

Spectrum caps can also potentially encourage more efficient use of spectrum, as carriers could have more incentive to invest in capacity enhancing technologies earlier on than they would have done if there was no spectrum cap.

Despite the potential benefits, a spectrum cap does not necessarily lead to a socially efficient outcome. An incumbent provider may be able to integrate any additional spectrum won in an auction into an existing network. That is, the incumbent may be able to provide additional capacity at a lower cost that a new entrant. Alternatively, the incumbent operator may be able to use additional spectrum won in an auction to offer a new service which requires more capacity, but which it could not have offered without the additional capacity. For example, tight restrictions on LTE spectrum can impede both the speed and the services offered, noting that LTE can use contiguous spectrum for carrier sizes up to 20 MHz.[46] If a new entrant into the market did not result in increased competition or lower prices, but rather if the new entrant incurred additional network and operating costs relative to the incumbent, or failed to establish itself, then it would not be socially efficient to promote new entry (by way of spectrum caps, set-asides or otherwise).

Given the risks associated with spectrum caps and set-asides, they are only warranted in cases where competition would not otherwise be effective. In light of this, it is necessary for a regulator to conduct a detailed market analysis to ensure that there are in fact other operators in the market whose access to spectrum would deliver more socially efficient outcomes than could be achieved in the absence of spectrum caps. Importantly, what matters is the overall level of competition in the mobile market and hence the case for any spectrum cap should take into account the distribution of all spectrum available for mobile services (including both the amount and type of spectrum held by different operators).

46 Future LTE-A systems will support the aggregation of non-contiguous spectrum and the ability to create effective bandwidths in excess of 20 MHz.

Spectrum caps and the Colombian licensing experience

Colombia offers a useful example of the experience of spectrum caps in practice.

Colombia has currently allocated an amount of spectrum to mobile services which is around the average for Latin America but well short of the top five globally. Nonetheless, the Government's ambitious Vive Digital Plan to quadruple access to the Internet in four years includes plans for the release of substantial additional spectrum for mobile services. The Colombian Ministry of Information Technology and Telecommunications has announced plans for the release of additional spectrum in the frequency range of 1850 MHz to 1990 MHz ('the 1900 MHz band") as well as indicating other spectrum to be released in the future in the bands 1710 to 1755 MHz, 2010 to 2155 MHz and 2500 to 2690 MHz. The 1900 MHz band spectrum will be assigned on a technology neutral basis and for a period of 10 years. While the technology neutral basis will enable the spectrum to be used with the best and latest technology, the period of 10 years is relatively short and creates risks for investments in extending networks into rural areas where payback periods are likely to be long.

The Ministry sought expressions of interest to acquire the 1900 MHz band spectrum on 29 December 2011. The Ministry plans for the new spectrum to be assigned on the basis of a first-price sealed bid auction if demand for the spectrum exceeds the amount of available spectrum. A reserve price of $15,860,850 per 5 MHz has been set for the spectrum based on spectrum prices determined in other countries. Sealed bid auctions tend to be better suited to relatively simple situations such as where only 1 licence or uniform frequency licences are to be assigned. While more complicated forms of sealed bid auctions can be used, they tend to make it more difficult for bidders. A second price sealed bid auction is easier for bidders to participate in than a first price auction as under a second price auction, bidders should optimally bid their actual valuation of the spectrum. Open auctions with multiple rounds have tended to be used more frequently in recent spectrum auctions. A key reason for this is that open auctions enable bidders to gain information from the bids of others that helps them to more accurately value the spectrum. This reduces the risk that bidders may overestimate the value which is a significant risk where spectrum is being sold for new services or in a market that is still developing rapidly. With less risk, bidders may be prepared to offer higher bids than otherwise so that the licensing authority can also gain more revenue from an open auction. The reduction in uncertainty over the valuation of the spectrum can also improve the likelihood that the spectrum will go to the bidders who can actually generate the greatest value from it, rather than to bidders who incorrectly estimate the value. This improves the efficiency of spectrum use.

Since 2009, Colombia has maintained a cap of 55 MHz of spectrum for any one mobile operator. This cap applies both to spectrum that has already been assigned as well as to new spectrum assignments. This cap will greatly constrain the ability of the existing operators to gain sufficient spectrum to support their ongoing service growth, particularly as their subscribers use data services more intensely. For example, the spectrum holdings of the major Colombian operators are close to or already at the cap. The impact of preventing operators who are already at the cap from being able to acquire new spectrum is that they will not be able to utilise their existing infrastructure to relatively cheaply rollout new services that require more spectrum. Any new entrant who acquires spectrum would have to first rollout a brand new network and with a small customer base they are unlikely to find it commercially viable to roll out the network to rural areas.

The ability of all operators to bid for additional spectrum will be particularly important in relation to the digital dividend spectrum which Colombia's plans to assign in late 2012 or early 2013. Access to a sufficient amount of this spectrum will provide greater capacity, the ability to supply higher speed mobile services and reduce the cost of providing widespread coverage.

Bidding credits and auction design

Bidding credits provide for a particular type of operator, such as a new entrant, to receive a discount on any winning bid. For example, a new entrant may only have to pay 80% of their bid if they win an auction. Bidding credits can thus increase the likelihood of an entrant acquiring spectrum compared with an incumbent with the potential for competition in the downstream market to be greater than otherwise. Ideally, bidding credits should reflect the additional value to society of new entry. However, this can be difficult to measure in practice. If a bidding credit is set too high then it may lead to the licence being acquired by an entrant even when the overall benefits to society would have been greater had an incumbent operator been able to acquire more spectrum. Bidding credits may also be open to exploitation if an entrant is able to acquire the licence cheaply and then re-sell the licence after the auction. As discussed in Section 4, different auction designs may also be relatively attractive or unattractive to entrants.

Competition law enforcement

Competition law is generally an effective means to protect competition and enables particular transactions to be assessed on a case-by-case basis with regard to the specific market circumstances. In a number of mergers involving mobile operators, regulators have required that the parties divest some of their spectrum resources to smaller rivals.

A competition law approach is less useful in the case of spectrum auctions. In particular, it may only be after the outcome of an auction is known that a competition regulator is able to assess whether an acquisition of spectrum rights by an operator would harm competition. If so, then forced divestment or a second auction may be required with the risk of significant delay before consumers can benefit from the use of the spectrum.

Open access requirements and Kenya

Another measure to promote competition that is being considered for auctions for LTE spectrum is a requirement that the winner of a particular licence should provide wholesale access to its services to other operators. We examine the use of such measure in the context of Kenya’s mobile industry.

Kenya’s mobile industry has been growing strongly with mobile penetration reaching over 67% in September 2011 (20% more subscriptions from a year earlier). Four mobile operators compete vigorously offering a range of services including traditional mobile voice services, SMS, mobile money transfer and mobile data/internet services growing by 68% in the year to September 2011.

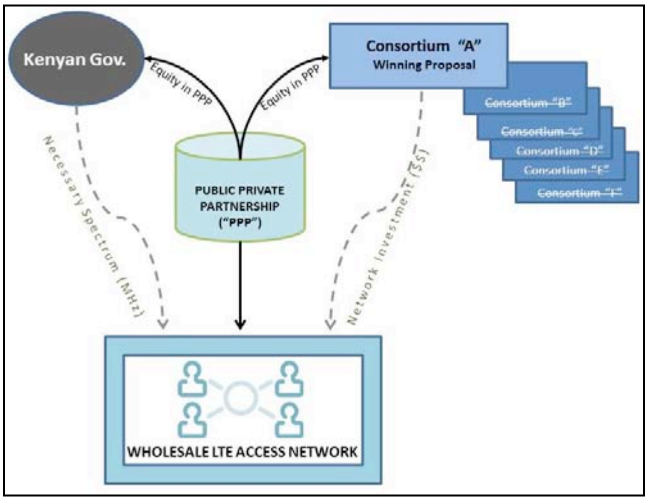
Additional spectrum allocation is critical to support the continuing rapid growth of mobile services. The Communications Commission of Kenya (CCK) has traditionally allocated spectrum under administrative approaches, although it has set out a policy framework to expand the role for market based mechanisms in the future to help ensure the efficient allocation of spectrum. Currently, spectrum for public cellular mobile services has been allocated around the 900 MHz and the 1800 MHz bands. Annual spectrum licence fees are charged which comprise a fee for the exclusive use of particular bandwidth and a spectrum usage fee based on the number of TRXs in the network.

Key priorities for the Kenyan authorities are to free up and re-assign spectrum currently used by the Government in the 400MHz, 800MHz and 2.3-2.6GHz bands as well as the re-assignment of television broadcasting spectrum with the transition from analogue to digitial television (i.e. Digital Dividend spectrum).

Proposed new models for LTE

Kenya's Ministry of Information and Communication (MoIC) proposed on 30 August 2011 that LTE services be introduced in Kenya through open access models. In particular, the MoIC has issued a tender for a Private Public Partnership (PPP) model in which the Government will provide access to the necessary spectrum to support LTE (which is likely to be in the Digital Dividend spectrum and in the 2.5GHz band) while the private sector party will undertake to meet all other costs related to the deployment and operations. The use of an open access model is intended to ensure equal access for all operators and avoid problems encountered with 3G licensing where operators acquiring licences at different dates paid differing amounts.

Figure 1: Kenyan PPP Open Access LTE Model



Source: Kenyan MoIC (Tender No MIC/9/2011-2012)

The MoIC has also raised a variation on this model, which they call a Special Purpose Vehicle (SPV), in which all local operators participate in the development of the national open access LTE network with the Government again providing the necessary spectrum.

Assessment of proposed LTE models

The Kenyan Government has recognized the importance of releasing new spectrum so that the mobile industry can meet rising demand for mobile data services. The consideration of open access models also takes into account the risk that if only one player were able to access LTE spectrum then this might damage competition in the market. The specific proposals of the MoIC raise a number of issues however.

First, competition will generally deliver better outcomes to consumers than a single provider model, even an open access model. In particular, where two or more players compete to supply services, they will face stronger incentives than a single provider to minimise costs, keep prices in line with costs and to develop innovative new services to win and retain customers. Thus, governments should seek to ensure that sufficient spectrum is made available to support competing LTE providers. The MoIC may wish to first review what spectrum it can make available including in light of other countries' abilities to free up sufficient spectrum for multiple LTE providers.

Where it is not possible to enable competing providers, then an open access model could be considered. While the MoIC contemplates the model being applied on a national basis, it might be that there is sufficient spectrum available but that in more rural and remote regions it would not be economically viable to have multiple providers. Accordingly, the MoIC could aim for competing providers in urban areas and a single wholesale provider in rural/remote areas that supplies national roaming services to the other providers.

Whether an open access network would be best operated by one winning party or all parties will depend on a number of factors. Clearly a potential risk of allowing for only one winning party is that this party might give preferential access to the LTE services to its business over other parties. Preventing opportunities for discrimination may require a ban on the winning party also having a retail business or more extensive regulation than might be needed where all parties effectively controlled the open access network. If the winner is required to only operate at the wholesale level this can lead to coordination problems such as underinvestment if one party is unable to capture the full returns to its investment.

A network controlled by all parties (and the Government), on the other hand, may have difficulties reaching decisions as parties will differ in terms of the priorities and financial resources. Allowing for individual parties to compete to provide the open access network could also enable the right to build the network to go to the party offering to supply the services at the best price/quality combination.

The proposed model also envisages that the Government would take an equity stake in the open access network in return for the provision of spectrum rights. The rationale for the Government's equity involvement is unclear. Generally, PPP models are applied where a government does not have sufficient revenue itself to fund infrastructure or where it believes that the private sector will better provide a service traditionally delivered by the public sector. However, in this case, the Kenyan Government would be giving up revenues that it would otherwise obtain from selling the spectrum rights – these revenues could be used to help fund other important demands on the Government. The Government may be concerned that a high price for spectrum licences may reduce operators' abilities to fund network rollout. However, if the price for the licences was determined at auction (or set in line with auction prices determined in comparable countries), then that price is likely to be at a level that operators expect to be able to afford while also rolling out infrastructure to supply the services. Further, if operators were expected to have trouble financing the licence fees upfront, then the Government could provide for the licence fees to be paid in instalments over time.

Another alternative would be for the Government to instead collect a tax on the services supplied. While a tax would reduce the upfront funding needs and risks of the business, it would represent a cost of supplying the services and be expected to result in higher service prices.

If the Government is uncertain as to whether operators could afford an upfront licence fee, then the Government could hold a first round in which it seeks bidders for the licence to operate the open access network without any Government equity ownership. Only if this round failed to attract a bidder at a reasonable price should the Government then consider another round in which bids are sought to operate the network with the Government taking a specified share of equity. It will also be important that the terms and quality of service on which the wholesale services are to be provided are also specified in advance. By doing so, bidders could determine an appropriate bid level taking into account the future requirements on the business. The specified share of equity could be determined after consultation with operators to identify a share that they would be prepared to accept before bidding for the right to operate the network.

A Government equity stake may also give rise to some ongoing risks. For example, if the Government were involved in decisions on the strategy and operations of the business then it might come under pressure to pursue political objectives that come at the expense of the legitimate interests of other equity-holders. Second, the Government's involvement may lead it to favour the business over other existing or potential new rivals. For instance, other spectrum that could enable rival LTE networks to enter might not be made available so as to protect the value of the Government's equity holding. The experience more generally with PPP-type arrangements is that they are complex to get right, require transparent and well-specified rights and obligations and do not always deliver value for money over more traditional approaches.[47]

Network sharing

Over the last decade, there has been a significant increase in the use of network sharing between operators. This can take a number of different forms from the relatively limited sharing of sites to sharing of the Radio Access Network to sharing of all network services. Such sharing might be seen as undermining full network competition between operators. However, where the alternative to two operators undertaking sharing to some extent is that only one of the operators is viable then sharing may achieve a degree of competition that would otherwise not occur. Further, forms of sharing can bring lower network costs while still enabling operators to compete with differentiated services. Lower network costs not only bring cheaper services to consumers but can also support more extensive rollouts than otherwise. Accordingly, the case for network sharing should be assessed by regulators relative to what level of efficiency, competition and consumer benefits would be likely in the absence of sharing.

6.4. Recommendation

Following is our key recommendations in relation to competition measures:

- *Recommendation 14* - Licensing authorities should aim to ensure effective competition in the downstream markets for mobile services. Many sector regulators and competition authorities have accepted that three to four national operators are likely to be sufficient to achieve effective competition.
- *Recommendation 15* - Specific measures to promote competition should only be imposed in markets where there is market failure and competition would otherwise be ineffective and where those measures are assessed as being likely to result in greater benefits than costs. Spectrum caps, spectrum set-asides, bidding credits, competition law enforcement and open access requirements carry advantages and disadvantages and should be assessed in relation to the specific market context.

[47] For example, see the South African Institute of International Affairs, *Working together – Assessing Public-private partnerships in Africa*, 2005.

7. Reviewing non-price terms and conditions

Licences can contain a range of obligations and conditions which go beyond authorising access to the market and/or the use of spectrum for a period of time upon the payment of a licence fee. The purpose of the section is to assist licensing authorities in reviewing particular non-price terms and conditions at the time of the initial licensing of operators and when licences are being considered for renewal.

7.1. Licence duration

An integral part of a licence is its duration. In many countries, licences of as short as one year are issued with operators forced to make investment decisions based on assumptions as to how long their licence will continued to be renewed. The uncertainty created can be a significant deterrent to investment, distort investment decisions and increase operators' cost of funds.

The longer the duration of a licence, the more attractive it will be for the licensee to undertake long-term investments in developing and upgrading its network. Investors will be reluctant to undertake investments if the licence runs for a shorter period, than the expected payback period and if there is uncertainty over whether the licence will be renewed again in the future. Depending on the type of investment and the nature of the market, some communications industry investments may take over 15 years to recover the cost of that investment, such as where operators are expected to re-use a current "2G band" for 3G or other advanced services. A shorter timeframe may be more relevant upon the renewal of a licence for other spectrum if there is expected to be less significant ongoing investment. A further consideration is to set the timeframe so as to align the expiry dates for licences for similar spectrum. This can help ensure that similar licences are subject to the same terms and conditions going forward.

Industry Canada considered the issue of licence duration in relation to the renewal of mobile and PCS licences which are expiring between 2011 and 2013. Industry Canada noted that the international trend to a less interventionist approach and decided that at the end of the current licence terms, the current licence-holders would be eligible (subject to having met the licence conditions) for a new licence for a 20-year term and that these new licences will have a high expectation of renewal for another licence term unless a breach of licence condition has occurred or there is a fundamental reallocation of spectrum to a new service or other overriding policy need.[48]

As licences become more service and technology neutral and where trading in spectrum rights is permitted, longer duration licences are likely to make more sense as the greater flexibility can help ensure spectrum is used efficiently on an ongoing basis while the longer duration provides for greater investment certainty. Thus licensing authorities which are more advanced in introducing trading and spectrum liberalisation have moved to generally auctioning licences with a minimum term, no defined expiry date and with a minimum period of notice required were the authority to seek to recover the spectrum after the minimum term. For example, Ofcom is proposing that the licences for the 800 MHz and 2.6 GHz spectrum be of indefinite duration (with a minimum term of 20 years) continuing in force until relinquished or revoked.[49]

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48 Industry Canada, Renewal process for cellular and personal communications services (PCS) spectrum licences, March 2011.

49 Ofcom, Second consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues, January 2012.

7.2. Geographic dimension

Many mobile licences are issued on a national basis while some, particularly in larger countries, have been issued on a regional basis. Issuing licences on a regional basis may appear attractive to authorities as a means of facilitating the entry of small players. However, even in the USA with relatively large regional markets for mobile services, there has been a trend towards consolidation of regional licences to enable operators to offer services nationally. There are two key drivers of this trend. First, customers attach importance to the ability to be able to use their mobile services nationally (and without incurring unexpectedly higher call charges if they happen to go outside their network's coverage area and roam onto another's operator's network). Second, there are significant fixed costs in supplying mobile services including head office costs and potentially national marketing that if spread over national service volumes lead to lower unit costs than if they are only able to be spread over small service volumes. If licences are issued on a regional basis, customers may end up paying higher prices for services or regional operators may incur significant debts in acquiring other regional operators to be able to achieve national presence. One approach is for the auction itself to offer the ability to either acquire rights to use particular frequency on a national or regional basis. The rights could then be awarded on either a national or regional basis depending on which was found to be valued most highly.

7.3. Obligations in relation to specific policy objectives

Regulators often impose additional obligations on licensees which are aimed at achieving particular policy objectives and that are not integral to the purpose of the licence. These can include obligations relating to universal access, such as coverage and service commitments as well as obligations relating to the promotion of competition. Where a licence is assigned using a beauty contest, rather than an auction, commitments to meet non-price criteria can come to dominate the assignment process.

By way of general comment, we note that when only one incumbent operator was being licensed, then imposing a series of obligations as part of that operator's licence represented a relatively straight-forward way to achieve particular objectives. However, the development of competition in telecommunications markets raises the need to review relatively regularly which policy objectives remain relevant and whether obligations should be imposed on all operators or only on particular operators. In this context, more flexible and targeted regulatory measures may prove to be more effective and efficient than seeking to achieve the objectives through licence conditions.

Reflecting such considerations, there is a regulatory trend against seeking to achieve universal access and competition objectives through licence obligations. The UK Government's independent review of spectrum management recommended that:

> *The RA [Radio Communications Authority] should aim to minimise the licence conditions to those necessary for efficient spectrum use. Existing licences should be amended to remove restrictions which are not needed for reasons of international co-ordination or interference management, and new licences should be issued with the minimum number of restrictions possible.*[50]

We explore these issues further in relation to the specific areas of coverage and service obligations as well as obligations to promote competition.

[50] Review of Radio Spectrum Management, March 2002, para. 7.2.

Coverage and service obligations

Many regulators have imposed licence obligations on mobile operators to provide a particular level of service coverage within a specified timeframe. A number of regulators have also included additional requirements to offer particular services or a particular quality of service as well as measures relating to universal access and consumer protection goals.

In deciding whether to impose such obligations, licensing authorities should consider:

i. the benefits and costs of such obligations; and
ii. whether there are less costly means to achieve the objectives.

Achieving high levels of access to telecommunications services is a common objective of many governments. Whether a particular regulatory obligation is required to support universal access goals will, however, depend on the particular market circumstances. In many cases, competition in the mobile industry has resulted in the widespread availability of affordable mobile services with levels of coverage being a key means by which operators seek a competitive advantage over their rivals.

Licensing authorities should also be aware of the potential risks of imposing stringent coverage or service requirements. In particular, obligations may sometimes force operators to deploy networks and/or services faster than it is economically or commercially sensible to do so. For instance, this could arise where technology is still at an early stage with a number of technical flaws remaining or where equipment prices are relatively high before more widespread take-up of the equipment internationally.

Obligations may also force operators to incur losses (e.g., by deploying networks in advance of sufficient demand for the services) which can create particular difficulties for new entrants without established cash flows. Where operators fail to meet their licence conditions (as was the case with 3G licence conditions in a number of European countries including France, Spain and Sweden), regulators are confronted with the dilemma of whether to take the drastic step to revoke the licence with potential harm to competition or postpone or abandon the licence condition. Relaxation of licence conditions can lead to legal challenges by other operators who have met the conditions or by potential new entrants who may have bid for the licence if they had known the licence conditions would not be enforced.

As an alternative to imposing rigid coverage and service obligations, governments could also consider other measures to improve access to mobile phones including ensuring that spectrum is released to the market to the greatest extent possible, allowing for refarming and liberalisation so that the spectrum can be used efficiently and facilitating greater voluntary network sharing particularly in relation to parts of the network that do not constrain service differentiation and in rural areas. These measures help to change the underlying economics of extending coverage and thus may be more likely to be achieved, and achieved at lower cost, than seeking to enforce licence obligations.

If the aim is to achieve mobile coverage in some remote areas, then government funding for the provision of one network in those areas may be sufficient to achieve that aim without needing obligations to be imposed on all operators. In the first instance, it is likely to be desirable to consider steps to remove barriers to the commercial provision of services in rural and remote areas (such as releasing additional spectrum in lower frequency bands or permitting greater network sharing), although public procurement such as tenders for operators to apply for government funding to extend network coverage to areas where commercial provision is uneconomic may also be useful. In this regard, the Nigerian Communications Commission (NCC) has noted that:

> *It is no longer fashionable to give rollout obligations to licensees. To spur the growth of rural service provision, regulators are rethinking their strategies and it has been found that reduced entry barriers, lower entry fees, infrastructure sharing and unhindered use of new wireless broadband technologies are more effective measures to promote cost-effective and rapid deployment of last-mile network technologies in rural and unserved areas…The Commission will not impose separate rollout obligations on unified licensees, but rather deal with universal access issues in a separate universal access regulation, in which universal access targets and respective designation mechanisms are defined.*[51]

The potential of mobile broadband services to help achieve universal broadband coverage has been recognised by a number of regulators. However, if extensive coverage obligations are imposed on all licences for spectrum for 3G and LTE, there may be costly and wasteful duplication of expensive network infrastructure. The German regulator instead imposed a 'shared' obligation on all operators who acquired 800 MHz to ensure coverage in rural areas before rolling out to urban areas. An alternative approach applied in Sweden was for one of the 800 MHz licences to have an obligation to provide mobile broadband to locations currently lacking access to other forms of broadband. These more limited forms of coverage obligations avoid duplication of network infrastructure in areas where such duplication would not be economically efficient. In addition, by setting the obligation prior to the auction, the cost of the obligation will be reflected in the licence fees determined in the auction. Accordingly, the obligations are thus equivalent to the Governments subsidising the fulfilment of that obligation. The Governments should thus have assessed whether the use of those funds (i.e. the amount by which the licence fees were reduced because of the obligations) to extend mobile broadband coverage represents the best use of those funds.

Finally, where obligations are imposed, then it is important that regulators recognise the significant cost that can be incurred by operators in meeting those obligations. In particular, the cost of extending coverage to more and more remote areas can increase substantially while there may be relatively few customers in those areas from which to help recover the cost. In France, the cost of meeting the licence obligations was explicitly taken into account in the setting of the licence fee.

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[51] NCC website, "Licensing Framework for Unified Access Service in Nigeria".

7.4. Trading

Secondary trading of spectrum rights is the ability of a current licence holder of spectrum bandwidth to re-sell its rights to use all or part of its allocated spectrum at commercially negotiated terms. In this section, we first outline the benefits of spectrum trading before briefly reviewing the experience of countries in which trading has been introduced. Finally, we turn to consider specific implementation issues and identify regulatory best practice.

Economic theory identifies a number of significant benefits from the introduction of spectrum trading including that trading:

- promotes efficient spectrum use by enabling spectrum to be acquired by the operators who can generate the greatest value from the use of that spectrum. At the same time, the ability to trade spectrum provides the incentive for licensees who have unused or underutilised spectrum to on-sell their spectrum to those who can make better use of it. As such, trading is likely to result in more efficient use of spectrum. In particular, by helping to reduce spectrum shortages faced by operators facing high demand, trading can support expansion in service volumes, increase quality of service and reduce service prices.
- enables those parties who have the best information, the individual users of spectrum, to make the decisions that determine the allocation of a resource among competing uses and users. Secondary trading in spectrum can also overcome inefficiencies in the initial allocation of spectrum.
- allows flexibility and speed in re-assignments between users helping to facilitate the introduction of new services.
- reduces operators' sunk costs and risks, i.e., operators will be more willing to invest in spectrum for innovative services with the knowledge that they have the ability to sell the spectrum rights should the services not be successful.

Spectrum trading has been introduced in Australia, Canada, Guatemala, New Zealand, Norway, the USA and the UK and on a more limited basis in Austria, France, Germany, the Netherlands and Sweden. Guatemala's experience is set out in Box 6. In other countries, individual spectrum trades have sometimes been allowed after regulatory review. The degree to which spectrum trading has been undertaken in the countries that allow trading is mixed[52] and this is likely to reflect the extent to which spectrum rights are currently assigned to the operator than can make best use of it as well as factors potentially inhibiting trades such as spectrum licences being of limited duration.

Spectrum trading is not a panacea. For instance, it would not deal with restrictions on the total amount of bandwidth available to mobile services, which would continue to require governments to allocate more bandwidth or enable spectrum currently being used for other services to be used for mobile. However, trading can reduce the cost of spectrum shortages by allowing some re-allocation between users.

Even for one country, there are substantial differences in relation to estimates of the magnitude of the benefits from spectrum trading. Ofcom estimated that the introduction of spectrum trading in the UK would generate overall benefits in the range of a net present value of £142 million over 20 years, up to several billions of pounds a year.[53] The benefits will depend on the extent to which current spectrum allocations in a particular country are constraining existing operators from expanding their services or constraining new operators from entering.

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[52] For example, the ACMA found that in most years between 1998 and 2008, less than 10% of Australian spectrum licences were traded (ACMA, *Spectrum trading*, November 2008).

[53] Ofcom, *Spectrum trading – Regulatory Impact Assessment*.

Spectrum trading in Guatemala

In 1996, the Guatemalan National Assembly enacted a new telecommunications law,[54] which, among other policies, introduced secondary trading of spectrum for some frequency bands. Guatemala thus became one of the first countries to allow for spectrum trading.

Rights to use regulated frequency bands (TUFs) are granted in fully transferable and fragmentable usage titles, i.e., they can be totally or partially rented and/or transferred. TUFs have no service limitation, and existing users are granted flexibility in the utilisation of spectrum as long as emissions are confined to the original bandwidth assigned. TUFs are subject to two interference limits: a "maximum effective radiation power" and a "maximum potency admissible in the coverage area". The regulator can impose fines for cases of repeated abuses (i.e., where interference exceeds allowed levels). If the abuse is established, the harmed user can also file a claim for damages or other remedies in the courts.

Spectrum trading in Guatemala appears to have been a significant success. Over 41 per cent of TUFs had been traded by 2004.[55] Liberalisation in Guatemala has resulting in more spectrum becoming available for key services such as mobile services and has reduced entry barriers. Competition has been strong in Guatemala's relatively unconcentrated mobile market, resulting in among the lowest mobile prices in Latin America and continuing high rates of subscriber growth (despite its relatively low GDP per capita and law and order problems).[56] Interference issues are mostly minor with tight deadlines for their resolution, although an issue has been irregular enforcement of restrictions such as in relation to pirate radio. Other practical problems have included spectrum hoarding and difficulties in retrieving spectrum for licence exempt use.[57]

Implementation issues

Markets work best when they are based on well-specified, enforceable, property rights, low transactions costs, and competition. If these features are not present, secondary trading may be inefficient or distorted. In this section, we explore the steps that can be implemented to facilitate spectrum trading in the longer run.

In principle, spectrum trading (with no change in the technology and services being provided using the spectrum) should not lead to greater interference problems. However, the prospect of spectrum rights being re-assigned between users does increase the risk of inadvertent interference as well as raising a range of other implementation issues. While the general introduction of spectrum trading at this stage is unlikely to be a high priority for many developing countries, licensing authorities should be prepared to assess proposals for particular trades subject to consultation and detailed examination of any risk of heightened interference.

Well-specified spectrum rights

Markets are based on a private property rights system. Trading bandwidth requires a clear and commercially sensible and defensible definition of initial property rights or entitlements. A spectrum licence may specify the right to exclusive usage in terms of frequency and geography (and potentially in relation to a time dimension) as well as reasonable interference levels both in terms of allowable levels of interference caused by the licensee to other spectrum users and the maximum levels of interference which the licensee must accept experience from others. As experience of spectrum

54 *Ley General de Telecomunicaciones*, D.C.A. 14 November 1996.

55 Ovum et al, *Spectrum policy review – final* report, 2006, p.145.

56 Leighton, W., "Telecom reform in Guatemala: A case study in spectrum liberalisation", Presentation to National Academy of Science Workshop, 1 March 2006.

57 Wellenius, B. and I. Neto, *Managing the Radio Spectrum: Framework for Reform in Developing Countries*,19 June 2007, p.9.

trading in developed countries grows, developing countries will be well-positioned to learn from their experience enabling trading to be introduced in the longer term at lower risk.

However the definition of well defined, technology neutral, property rights has proved to be very complex, and there is no universally agreed right adopted by the ITU or CEPT. In general, the more flexible the property right that is used, the more problematic interference control becomes. Regulators should do a careful cost benefit analysis about what level of flexibility is appropriate for their market. This is important in the absence of an internationally agreed definition of such a well defined and enforceable spectrum property right.

Licence renewal

Uncertainty over future rights to use the spectrum can act as a major barrier to spectrum trading. There may be few buyers of spectrum rights if there is only a short tenure left and significant uncertainty over whether a right will be renewed. The lack of a commitment to renewal has been identified as a key factor holding back trading in Australia.

Transactions costs

Transactions costs will also affect market efficiency. These will in part be a function of the frequency and ease of spectrum trades. In the absence of the ability to re-sell spectrum licences, the only way spectrum can be traded may be by acquiring a firm which holds a licence. Apart from the costs of doing this, and the subsequent costs and losses of disposing of other assets owned by the acquired company, the licence is for a large amount of bandwidth. Secondary markets should allow parties to divide or aggregate spectrum.

Transaction costs can also be reduced by ensuring that detailed information on current spectrum holdings is reasonably available as well as plans for future spectrum releases. Allowing the development of specialist spectrum trading brokers can also help reduce transaction costs.

Competition issues

Governments may be concerned that spectrum trading would lead to the largest operators buying up spectrum rights so as to gain or consolidate market power in the downstream markets for the services supplied using the spectrum. One response to this concern has been the imposition of caps on the amount of spectrum able to be acquired by any one operator. However, while such caps are relatively simple to apply, they are an imperfect way of protecting competition because they are not based on an assessment of the particular competition implications of the specific transactions

Whether spectrum trading would actually lead to a loss in competition would depend on: (i) the amount of spectrum available to competitors; and (ii) the degree of competition in the downstream markets. Accordingly, whether a particular transaction should be prohibited on competition grounds is likely to require a case-by-case review which could potentially be under general competition law (as, for instance, occurs in New Zealand). Safe harbours could be determined, for example, and spectrum acquisitions could be permitted, without further investigation being conducted by the competition authority, if the operator has a current market share below a particular level and if the spectrum being acquired represents only a small share of the total spectrum suitable for supplying that service.

Concerns about windfall gains

Another concern about the introduction of spectrum trading is that it may result in existing licensees earning significant financial gains over the price that they originally paid for their licences. It may be argued that such gains should belong to the government. However, the gains provide the incentive for spectrum trades to take place and the more the government confiscates these gains, the more likely it will be that a trade does not occur even when it would have generated overall benefits to society. Further, the experience with some 3G licences in Europe shows that operators may experience significant losses acquiring licences so the opportunity to earn some gains may be seen as the counterpart to the risk of significant losses if market conditions do not turn out as expected.

Governments will need to determine how best to meet their revenues requirements, taking into account principles of efficiency, equity and simplicity. A large tax on gains from spectrum sales would be likely to come at a substantial cost to efficiency. There would appear to be no reason to tax gains from spectrum sales any more than gains on the sale of other business assets.

7.5. Recommendations

Following are our key recommendations in relation to non-price terms and conditions:

- *Recommendation 16* – Licensing authorities should introduce licence terms for mobile operators that are at least in line with the expected payback period for the investments and should consider the introduction of indefinite licence terms (with a specified minimum term, i.e. 15 years).
- *Recommendation 17* - Licensing authorities should provide for national licences where customer demand and/or scale economies are likely to support national provision as the most efficient. Where regional licences are under consideration, the auction process itself could be used to determine whether regional or national licences are valued most highly.
- *Recommendation 18* – As an alternative to licence obligations, governments should achieve universal access and competition objectives through policies that help to change the underlying economics of extending access or entering the market or through alternative targeted regulation.
- *Recommendation 19* – Licensing authorities should enable voluntary spectrum trading between operators and facilitate trading through well specified spectrum rights, long licence terms and minimizing administrative costs. Such trading helps to ensure that spectrum remains efficiently assigned over time. Competition concerns should be assessed taking into account the specific circumstances of each trade, although certain safe habours could be established such as where the operator acquiring the spectrum has a market share below a certain threshold and/or the spectrum represents a relatively small share of the overall spectrum available for those services.

8. Regional overview of spectrum licensing

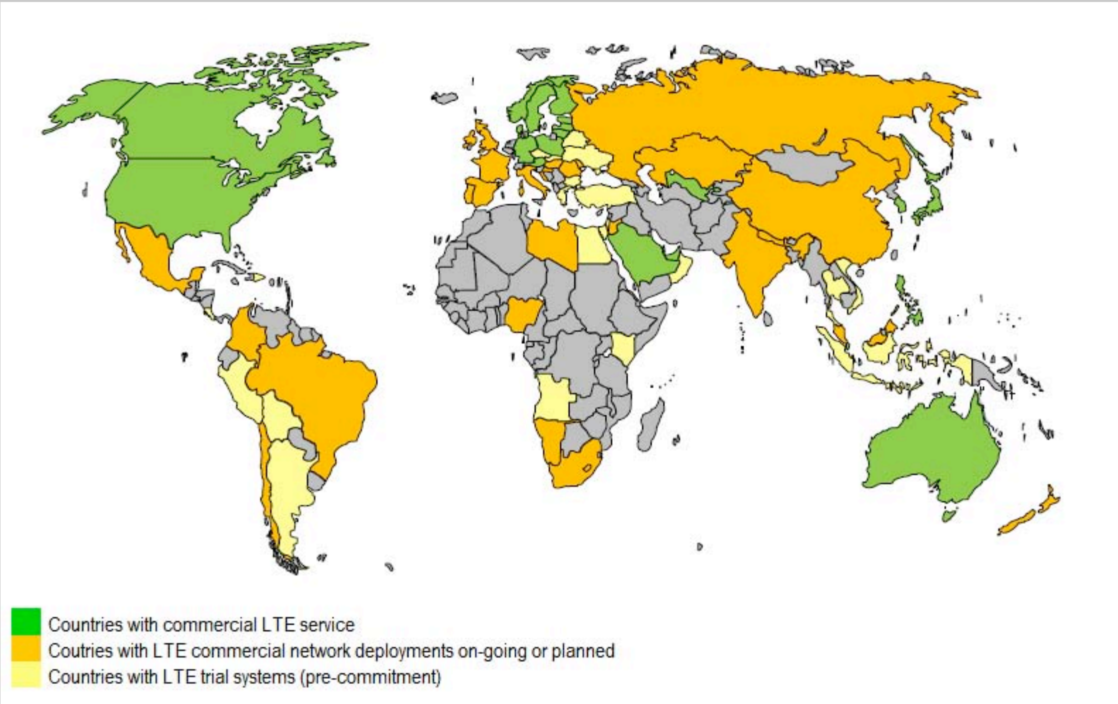
In this section, we review the status of spectrum licensing around the world. We first provide a global overview of the status of LTE and the digital dividend spectrum and then consider in more detail the status of mobile spectrum licensing in six broad regions of the world:

- Africa;
- Asia Pacific;
- Europe;
- Latin America;
- Middle East and Central Asia; and
- North America.

8.1. Regional status of LTE and the digital dividend spectrum

Figure 2 below shows the countries in which commercial LTE network launches have taken place (as at 12 October 2011). In total, there have been 35 commercial network launches in 21 countries. In addition to this there are also 185 operator commitments to commercial LTE networks in 66 countries and 63 pre-commitment trials in an additional 21 countries.[58]

Figure 2: Regional status of LTE

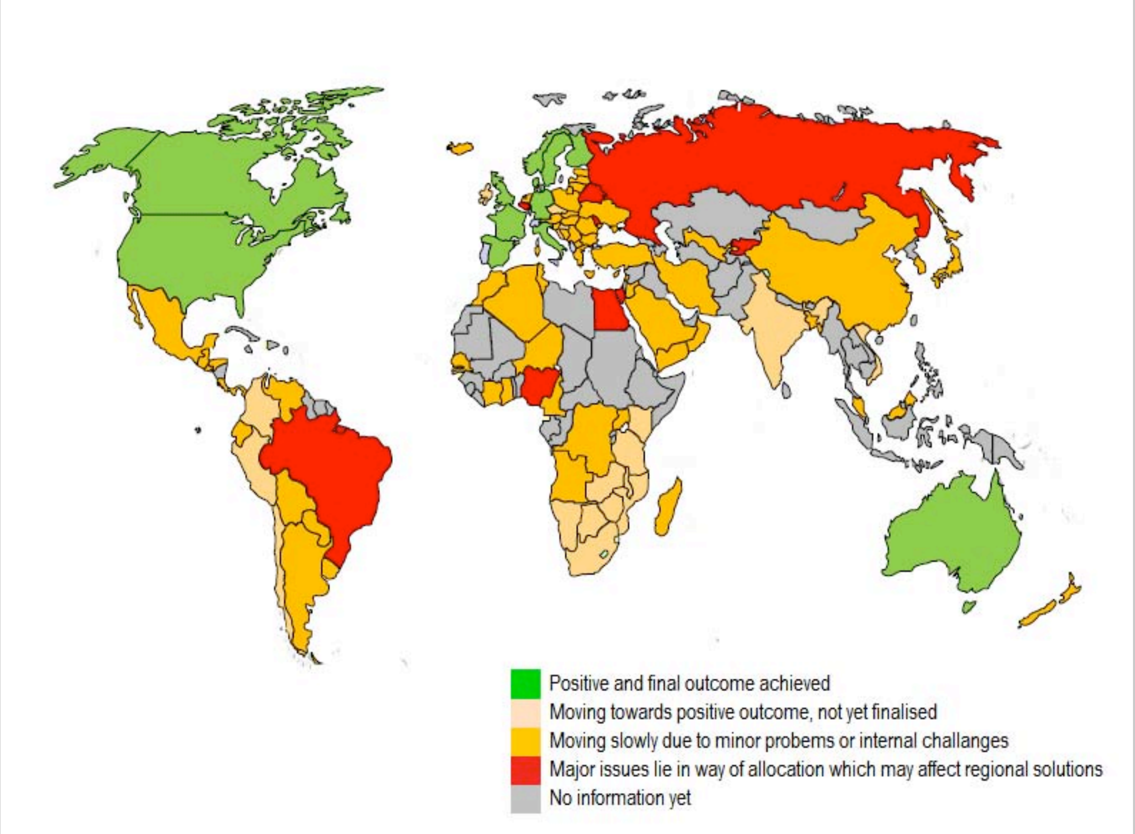


Source: GSA (2011)

The digital dividend is the prime spectrum for mobile broadband. The relatively lower frequency than the current mobile spectrum means that fewer base stations are necessary to cover the same geographic area. This lowers the cost of deployment, which in turn means that operators can provide more affordable rural coverage and capacity for broadband services. The regional status of the digital dividend spectrum is illustrated in Figure 3 below.

[58] GSA (2011) *Evolution to LTE report*

Figure 3: Regional status of the digital dividend



Source: GSMA (2011)

8.2. Africa

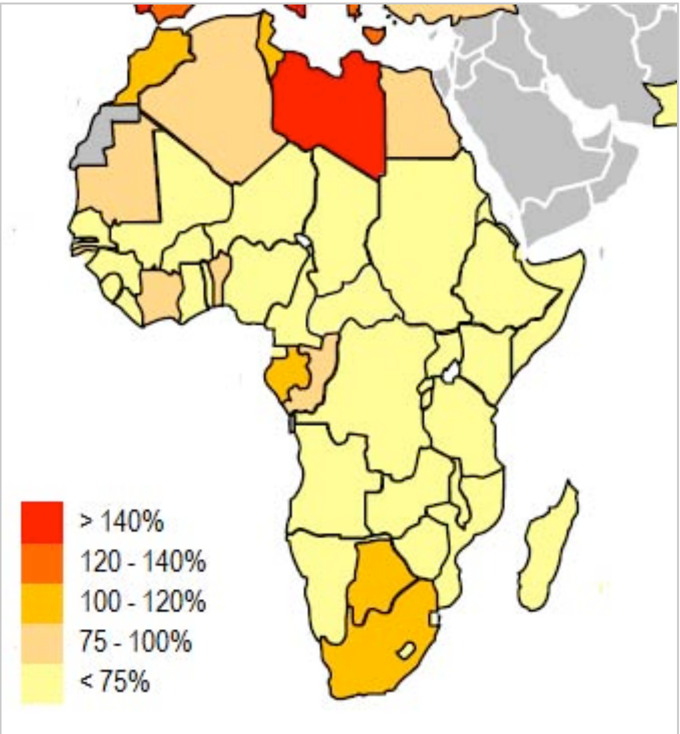
Africa is the fastest growing mobile market in the world: Over the past 10 years, the number of mobile connections has increased by an average of 30 per cent annually, and is forecast to reach 735 million by the end of 2012. Over 95 per cent of the subscriptions are pre-paid, and most of the revenues are derived from voice rather than data (although revenues from data are also increasing steadily).[59]

Despite the rapid growth of the mobile market, Africa still has a relatively low mobile penetration rate relative to other parts of the world. This is illustrated in Figure 4 below. Most countries in the African region have a mobile penetration rate of less than 75 per cent, with only a few exceptions. Libya has a very high penetration rate, which is associated with a high prevalence of multiple SIMs/handsets[60]. Mobile penetration rates of selected countries in the African region are summarised in the regulatory scorecard (Table 4) at the end of section 8.2.

59 GSMA (2011) *African Mobile Observatory,* p. 6

60 Ibid, p. 13

Figure 4: Mobile penetration in Africa



Sources: Merrill Lynch (2011) and ITU (2010)

Spectrum awarded to mobile services in Africa

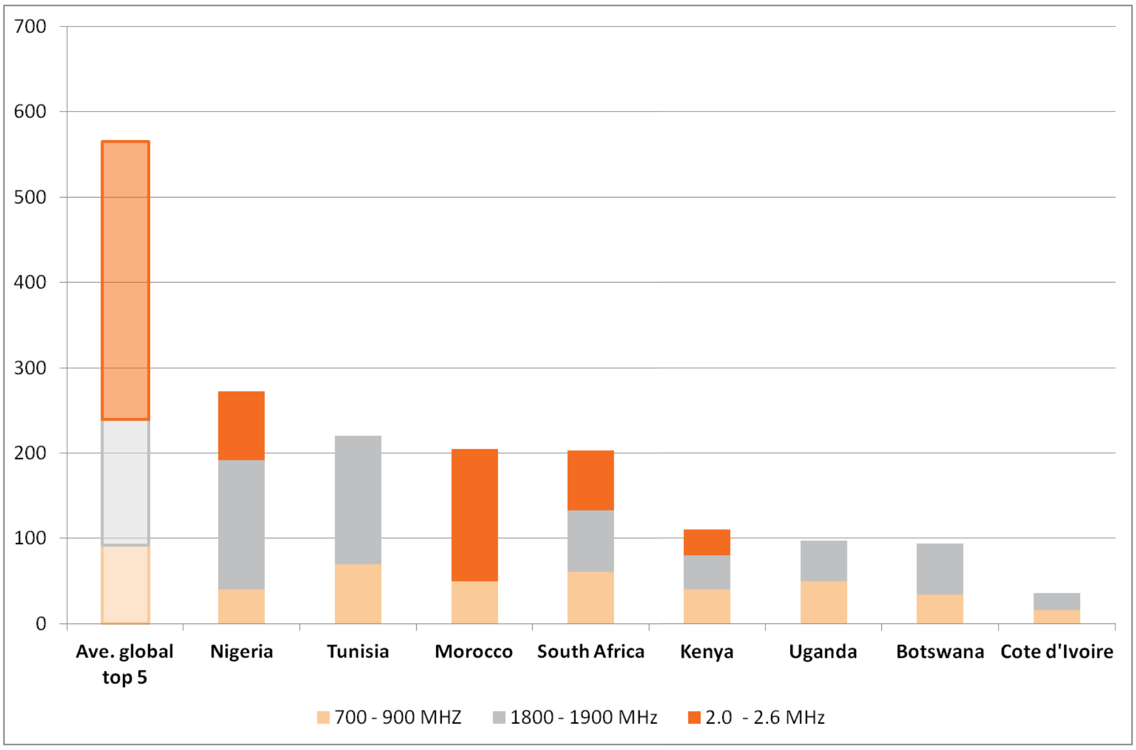
Figure 5 below illustrates the relatively limited amount of spectrum which has been allocated to mobile services in African countries in the categories 700-900 MHz, 1800-1900 MHz and 2.0-2.6 MHz[61]. Only in Nigeria has more than 250 MHz been allocated to mobile in total in these categories. The figure visually compares the spectrum released in seven African countries with the average of the five countries which have released the most spectrum[62].

For the mobile industry to continue to drive growth in Africa, it is necessary for governments in the region to allocate sufficient amounts of spectrum to the provision of 3G and 4G technology mobile services. To enable this process, it is important for governments to have clear guidelines in regards to spectrum planning, licensing, pricing and re-farming.

[61] It should be noted that it is possible that some countries have allocated spectrum in alternative frequencies to mobile, and that they would not be included in the figure. This applies equally to the following sub sections in this chapter on spectrum allocated to mobile services.

[62] The top 5 average consists of Germany (total of 594 MHz), Sweden (total of 585 MHz), Denmark (total of 552 MHz), Finland (total of 550 MHz) and Austria (total of 547 MHz).

Figure 5: Spectrum released to mobile in selected African countries



Source: GSMA (2011)

Mobile services play a large part in total broadband provision in Africa, as the fixed access networks are relatively underdeveloped. In light of this, African regulators have been licensing 3G spectrum to mobile operators over the last few years. Since 2006, 3G licenses have been released in at least 29 countries in Africa.[63]

LTE trials are happening in several countries in Africa, including for example Angola, Egypt, Kenya and Nigeria. Vodacom in South Africa reportedly has 1,000 LTE ready sites, and are planning a launch as handsets become available. Also MTN South Africa is deploying LTE in the 1800 MHz spectrum, as 2.6 GHz is not yet available.[64]

Digital switchover programmes started to take shape throughout the African continent in 2009. For example Kenya and Nigeria have scheduled to complete digital switchovers by mid-2012. South Africa is scheduled to complete the switchover by the end of 2013, and Egypt by the end of 2015.65 Table 3 below outlines possible award dates for the digital dividend spectrum for several African countries.

Allocating the digital dividend spectrum to mobile services will bring connectivity to greater parts of Africa and increase the level of mobile penetration. This, in turn, will act as a catalyst for economic growth in the region.

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[63] GSMA (2011), *African Mobile Observatory,* p. 43

[64] GSMA (2011) *Evolution to LTE report*

[65] GSMA (2011), *African Mobile Observatory,* p. 44

Table 3: Bands to be allocated in the digital dividend spectrum

Country	Band to be allocated	Possible award date
Cameroon	790 – 862 MHz	2015
Ghana	790 – 862 MHz	2014
Kenya	790 – 862 MHz	2012/13
Lesotho	790 – 862 MHz	2013
Nigeria	698 – 806 MHz	2013
Senegal	790 – 862 MHz	2015
South Africa	790 – 862 MHz	2013
Tanzania	790 – 862 MHz	2012/13
Uganda	790 – 862 MHz	2012/13
Zambia	790 – 862 MHz	2013

Source: GSMA (2011)

Spectrum licensing in Africa

Spectrum allocation has previously taken place behind closed doors and through more ad hoc processes in many African countries. In recent years however, allocation processes in many African countries have become more transparent.[66]

Local ownership pre-qualification criteria in African auctions

In two recent announcements of auctions, in Kenya and South Africa, pre-qualifying criteria has been imposed relating to local ownership. In September 2011, pre-qualifying criteria for the Kenyan 4G licenses were announced, including the requirement of at least 20 per cent national ownership. Similarly, in 2011 pre-qualifying criteria for the South African 2.6 GHz were announced, including the requirement of 30 per cent equity ownership by "Historically Disadvantaged Individuals". Concerns raised by the operators about this particular pre-qualification criterion resulted in delays in the South African auction.[67] The proposal in South Africa has now been suspended.

It is important that any procedures for the allocation and use of scarce resources such as spectrum are carried out in an objective, timely, transparent and also non-discriminatory manner.

Regulatory scorecard

Table 4 below is a regulatory scorecard, summarising the level of paired spectrum which has been awarded to mobile services in selected countries in the African region. It also summarises the mobile penetration, the percentage of revenue derived from data, the taxation of mobile services and LTE launches or launch commitments in the same selection of countries.

66 Computer World Uganda (2010) *Race issues arise in South Africa spectrum auction*

67 GSMA (2011) *African Mobile Observatory,* p. 46

Table 4: Regulatory scorecard, selected countries in Africa

Country	Spectrum to mobile[1]	Mobile penetration[2, 3]	Revenue from data[2]	Mobile taxation[4]	Expected LTE launch[5]
Nigeria	Medium	58%	6%	5.4%	Launch date TBC
Tunisia	Medium	106%		18.0%	Launch date TBC
Morocco	Medium	113%		20.0%	No plan / info
South Africa	Medium	118%	22%	14.0%	2011
Kenya	Low	62%		20.5%	Pre-commit trial
Uganda	Low	38%		28.2%	No plan / info
Botswana	Low	118%		10.0%	No plan / info
Cote d'Ivoire	Low	76%		18.9%	No plan / info

Sources: [1] GSMA (2011) and regulators' website, [2] Merrill Lynch (2011), [3] ITU (2010), [4] Deloitte (2011), [5] GSA (2011). For the allocation of spectrum to mobile services in the regulatory scorecards, we assumed that less than 200MHz was low, between 200 and 300MHz was medium and over 300MHz was high - this breakdown roughly corresponds to the bottom third, middle third and top third of countries around the world.

8.3. Asia Pacific

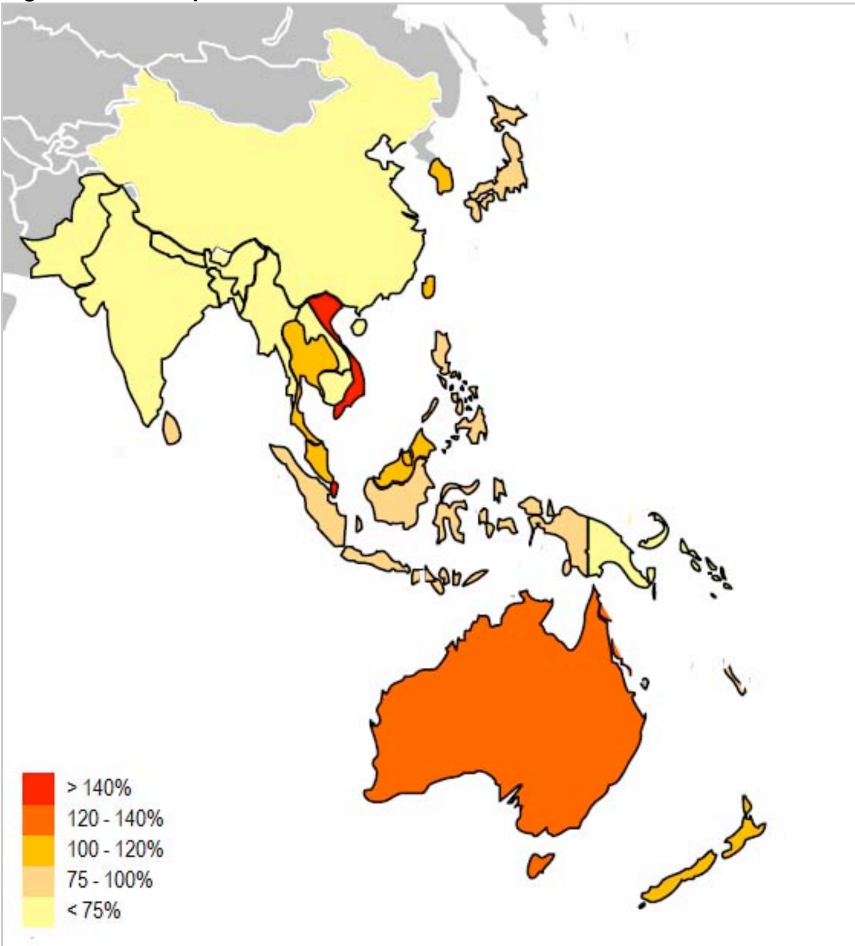
Asia Pacific is the largest mobile market in the world – accounting for half of the total mobile connections. Almost all of these connections are contributed by the largest 17 economies in the Asia Pacific region.[68]

Asia Pacific has a relatively high, but varied, mobile penetration rate, as is illustrated in Figure 6 below. Some countries, like Vietnam and Singapore, have a mobile penetration rate of over 140 per cent, whereas for example Bangladesh and Cambodia have a mobile penetration rate of below 75 per cent. Some countries in the Asia Pacific region have mobile penetration rates far below 75 per cent. One billion people remain unconnected across China and India.[69] Mobile penetration rates of selected countries in the Asia Pacific region are summarised in the regulatory scorecard (Table 6) at the end of section 8.3..

[68] GSMA (2011), *Asia Pacific Mobile Observatory,* p. 3, 7

[69] GSMA (2011), *Asia Pacific Mobile Observatory,* p. 7

Figure 6: Mobile penetration in Asia Pacific



Sources: Merrill Lynch (2011) and ITU (2010)

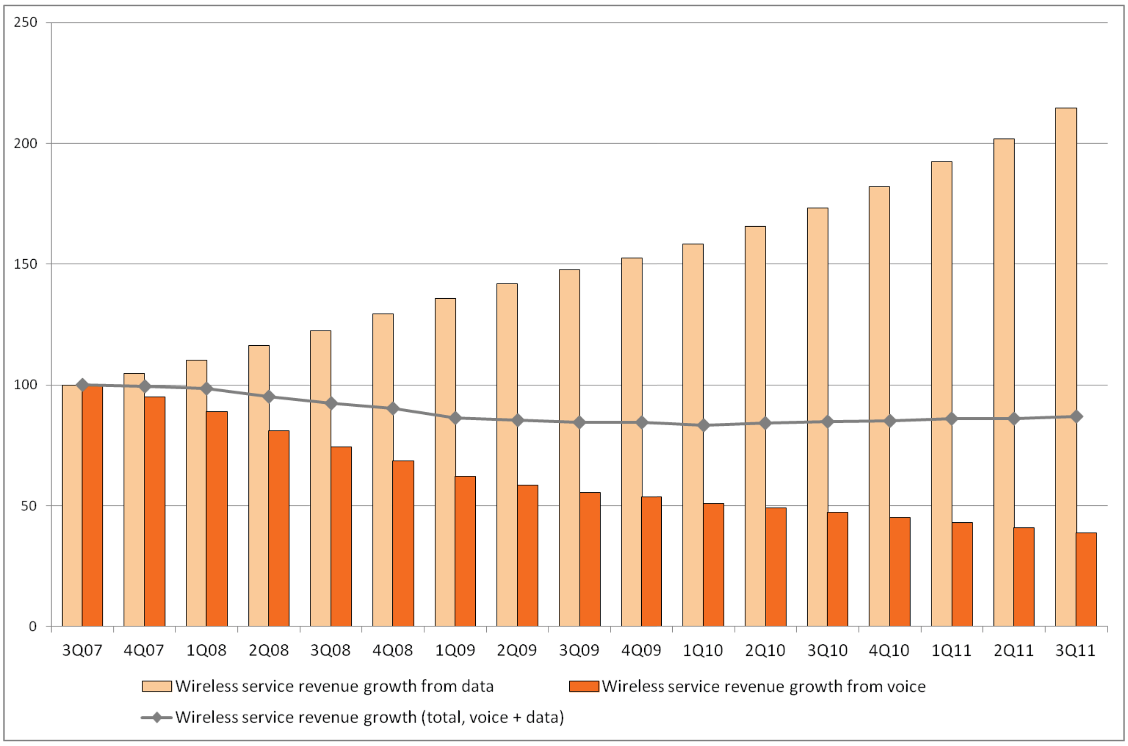
Wireless service revenue growth in the Asia Pacific region has been relatively stable over the last four years, with the wireless service revenue growth from data steadily increasing, and the wireless revenue growth from voice declining. The trend towards stronger growth in revenue from data than voice is also apparent in Europe and North America (see Figure and Figure 15 respectively).[70] Nonetheless, the large existing share of revenue from voice means that even high growth in data in percentage terms is often inadequate to offset the decline in voice revenue growth in absolute terms.

Cisco forecasts that the mobile data traffic in Asia Pacific will grow at a CAGR of 84 per cent between 2011 and 2016 (see Figure 1)[71]. This indicates that the trend towards strong growth in revenues derived from data will continue.

[70] Merrill Lynch (2011) *Global wireless matrix 4Q2011,* p. 42

[71] Cisco (2012) *Visual Networking Index: Global mobile data traffic forecast update, 2011 – 2016*, p. 24

Figure 7: Wireless service revenue growth Asia Pacific



Source: Merrill Lynch (2011)

Spectrum awarded to mobile services in Asia Pacific

The amount and types of spectrum released to mobile in Asia Pacific varies across the region. Some countries have released in excess of 350 MHz to mobile services, whereas some countries have released 200 MHz or less. The allocation of spectrum in the 700-900 MHz bands, the 1800-1900 MHz bands and the 2.0-2.6 GHz bands to mobile services in countries the Asia Pacific is illustrated in

Figure 8 below. The figure also illustrates the average amount of spectrum released in the five countries which have released the most spectrum worldwide in these frequency bands.

For the mobile industry to be able to deliver high quality and affordable access, it is important that governments' make available not only sufficient amounts of spectrum, but also that it is the 'right' spectrum (i.e. most suitable for mobile services) allocated using efficient, fair and transparent spectrum allocation processes.

As is evident in the figure below, Asia Pacific countries have awarded a varying amount of spectrum to mobile. Several countries including China, Australia, New Zealand, Indonesia and Thailand have awarded over 300 MHz to mobile in the categories outlined above, whereas Micronesia has awarded less than 25 MHz to mobile.[72] .

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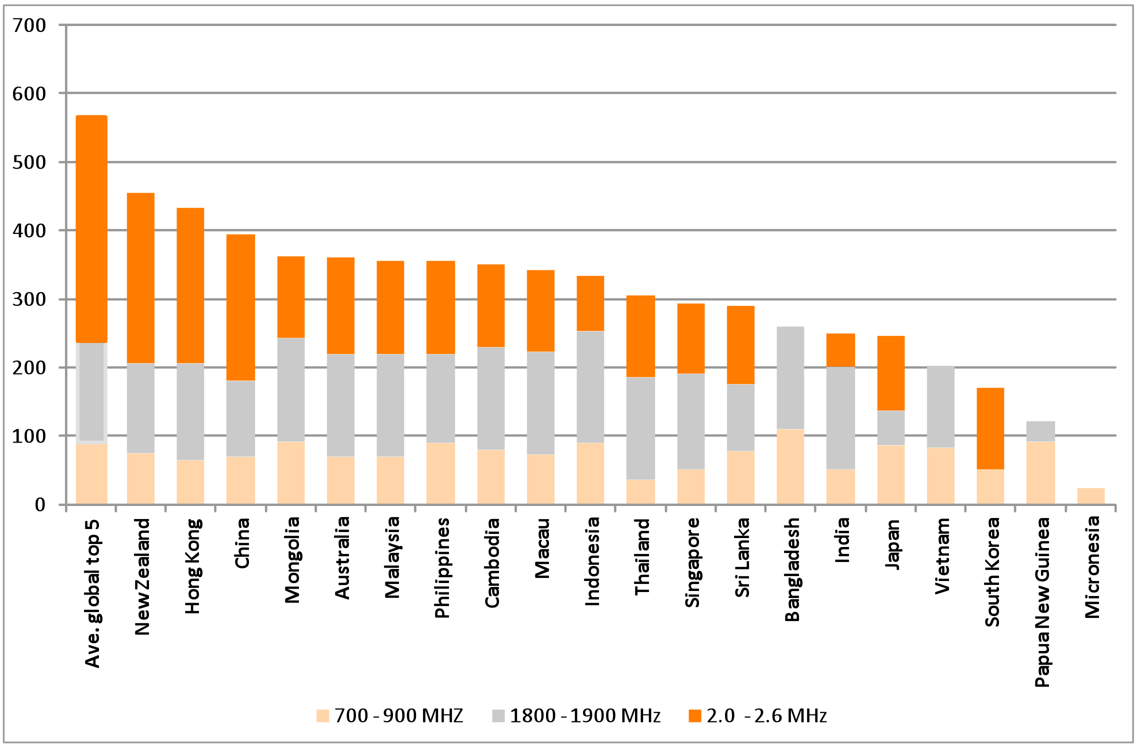
[72] Note that some countries have allocated spectrum to mobile in alternative frequency bands (e.g. 1500 and 1700 MHz bands), and that these allocations would not be included in

Figure 8.

Figure 8: Spectrum released to mobile in selected Asia Pacific countries



Source: GSMA (2011)

Commercial LTE networks has been launched in several countries in the Asia Pacific region, including by CSL Limited in Hong Kong in November 2010, by NTT DOCOMO in Japan in December 2010, by Smart Communications in the Philippines in April 2011 and by M1 in Singapore in June 2011. The launch of several more commercial LTE networks are planned for 2012 by operators in for example China and India. Some countries, like Thailand and Indonesia, are in a pre-commitment trial phase.[73]

In some developed countries in the Asia Pacific region, such as Australia and Singapore, the transition from terrestrial to digital TV is an approaching reality, whereby a significant amount of spectrum is expected to become available through the digital dividend. This is the case also in some emerging markets such as Indonesia. Other countries in Asia, such as India, Bangladesh and Pakistan, are looking into allocating the UHF band, previously used for other purposes, to mobile.[74]

Japan was the first Asian nation to complete the transition to digital transmission in July 2011. This freed up spectrum which may later be allocated to mobile operators wanting to improve service.[75]

Thailand's National Broadcasting and Telecommunications Commission (NBTC) announced in early 2012 that it hopes to begin digital TV trials this year. This would be the beginning of a switchover process which will take around four years. The digital dividend switchover will free up 'digital dividend' spectrum for reallocation to the 4G mobile sector.[76]

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[73] GSA (2011) *Evolution to LTE report*

[74] GSMA (2011) *The Digital Dividend in Asia Pacific,* p. 1

[75] Bloomberg (2011) *Japan ends all analog TV broadcasts in Asia's first transition to digital*

[76] TeleGeography (2012) *Digital TV migration to take four years*

Bands to be allocated in the digital dividend spectrum, and possible award dates, for selected countries in Asia Pacific are summarised below:

Table 5: Bands to be allocated in the digital dividend spectrum

Country	Band to be allocated	Possible award date
Australia	698 – 806 MHz	2013
Bangladesh	698 – 806 MHz	2015
China	698 – 806 MHz	2012
India	698 – 806 MHz	2014
Indonesia	698 – 806 MHz	2012
Japan	710 – 806 MHz	2012
New Zealand	698 – 806 MHz	2013
Philippines	698 – 806 MHz	2013/14
Singapore	698 – 806 MHz	2015
South Korea	698 – 806 MHz	2012/13
Vietnam	698 – 806 MHz	2015

Source: GSMA (2011)

Spectrum licensing in Asia Pacific

It is important that governments design and implement spectrum allocation procedures which are efficient, technology-neutral, fair and transparent. This ensures that participant costs remain low and that usage benefits are delivered to customers in a timely manner.

Spectrum allocation procedures have at times been unclear and resulted in inefficient outcomes. For example, 3G awards have been postponed in Bangladesh until 2012, and have not yet taken place in Thailand (but are also expected for 2012).

There have been examples in the region of both unfair spectrum allocation and over-licensing. In India and Thailand 3G licences were awarded to stated-owned operators before other market players were given an opportunity to compete for spectrum. In India, the government over-licensed to maximize revenue and stimulate competition. In Malaysia, the government issued plans to award 2.6 GHz spectrum for LTE to 9 operators despite the fact that there are only four mobile operators. The Government is also indicating that it does not expect to see all of these operating viable networks of their own but instead expects to see industry collaboration on RAN sharing.

Good practice examples in relation to spectrum allocation have come out of the Asia Pacific region, both from developed and emerging economies, including public consultations of the distribution of the digital dividend in Australia, New Zealand and India.[77]

[77] GSMA (2011) *Asia Pacific Mobile Observatory*, p. 69-71

Regulatory scorecard

The table below is a regulatory scorecard, summarising the level of paired spectrum which has been awarded to mobile services in selected countries in the Asia Pacific region. It also summarises the mobile penetration, the percentage of revenue derived from data, the taxation of mobile services and LTE launches or launch commitments in the same selection of countries.

Table 6: Regulatory scorecard, selected countries in Asia Pacific

Country	Spectrum to mobile[1]	Mobile penetration[2, 3]	Revenue from data[2]	Mobile taxation[4]	Expected LTE launch[5]
New Zealand	High	118%	40%	15.0%	Launch date TBC
Hong Kong	High	196%			Launched 2010
China	High	69%	37%	3.3%	2012
Mongolia	High	91%			No plan / info
Australia	High	128%	44%	10.0%	Launched 2011
Malaysia	High	117%	36%	16.0%	2013
Philippines	High	97%	51%	12.4%	Launched 2011
Cambodia	High	58%		10.3%	No plan / info
Macau	High	206%			No plan / info
Indonesia	High	90%	42%	10.2%	Pre-commit trial
Thailand	High	117%	16%	7.1%	Pre-commit trial
Singapore	Medium	146%	38%		Launched 2011
Sri Lanka	Medium	83%		12.3%	Launch date TBC
Bangladesh	Medium	49%		20.2%	No plan / info
India	Medium	72%	14%	10.4%	2011
Japan	Medium	97%	55%		Launched 2010
Vietnam	Medium	175%		10.0%	Pre-commit trial
South Korea	Low	105%	30%		Launched 2011
Papua New Guinea	Low	28%		10.0%	No plan / info
Micronesia	Low	25%			No plan / info

Sources: [1] GSMA (2011) and regulators' website, [2] Merrill Lynch (2011), [3] ITU (2010), [4] Deloitte (2011), [5] GSA (2011). For the allocation of spectrum to mobile services in the regulatory scorecards, we assumed that less than 200MHz was low, between 200 and 300MHz was medium and over 300MHz was high - this breakdown roughly corresponds to the bottom third, middle third and top third of countries around the world.

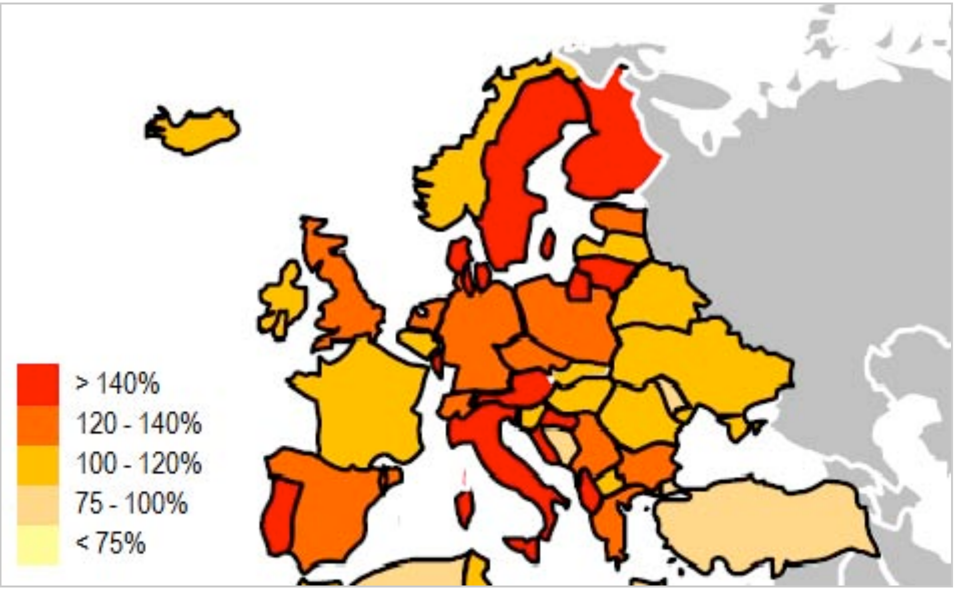
8.4. Europe

Mobile communication is a relatively large industry in Europe. Mobile coverage is nearing 100 per cent, and mobile penetration is 128 per cent. In many socio-economic groups it is the only regular communication services.[78]

As mentioned above, Europe has a very high mobile penetration rate, also relative to other parts of the world. This is illustrated in

Figure below. Several countries in Europe, including Sweden, Finland, Denmark, Italy and Portugal have a mobile penetration rate of over 140 per cent. Mobile penetration rates of selected countries in the Europe region are summarised in the regulatory scorecard (Table 8).

Figure 9: Mobile penetration in Europe



Sources: Merrill Lynch (2011) and ITU (2010)

Wireless service revenue growth in the Europe region has been declining slightly since early 2009, with the wireless service revenue growth from data steadily increasing, but the wireless revenue growth from voice steadily declining.[79]

Cisco forecasts that the mobile data traffic will grow at a CAGR of 68 per cent between 2011 and 2016 in Western Europe, and 83 per cent in Central and Eastern Europe (see Figure 1)[80]. This indicates that the trend towards strong growth in revenues derived from data will continue.

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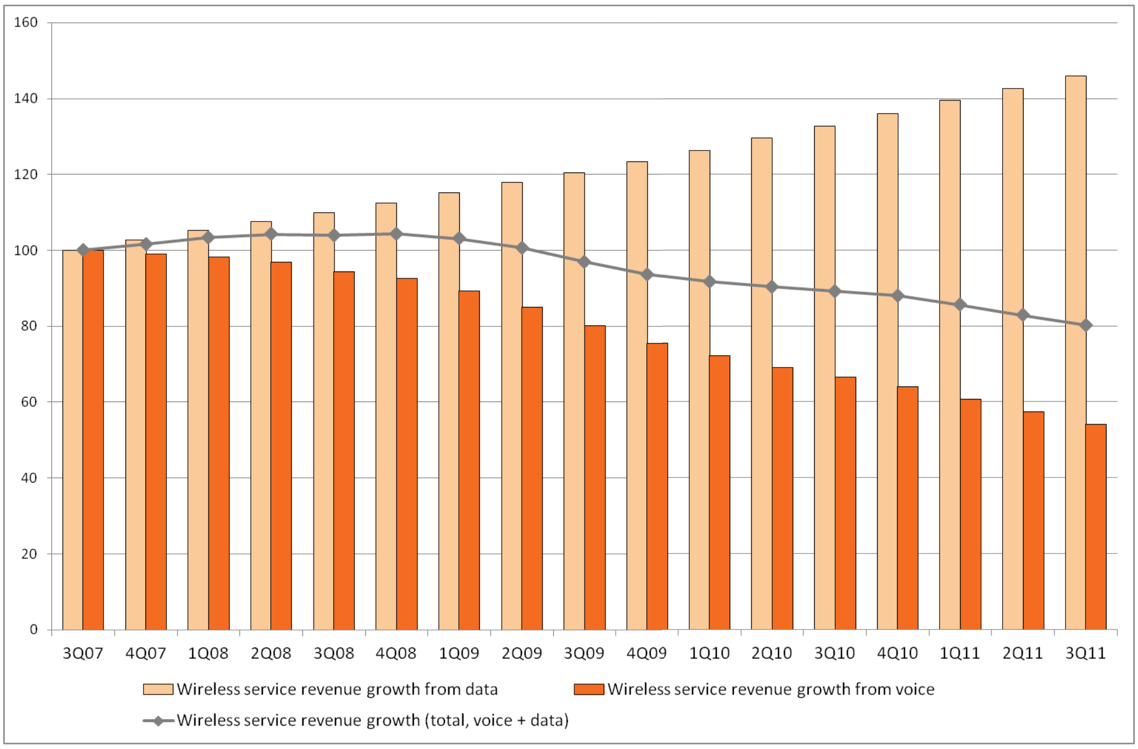
[78] GSMA (2011) *European Mobile Industry Observatory,* p. 3

[79] Merrill Lynch (2011) *Global Wireless Matrix 4Q2011,* p. 43

[80] Cisco (2012) *Visual Networking Index: Global mobile data traffic forecast update, 2011 – 2016*, p. 24

Figure 10: Wireless service revenue growth in the Europe region



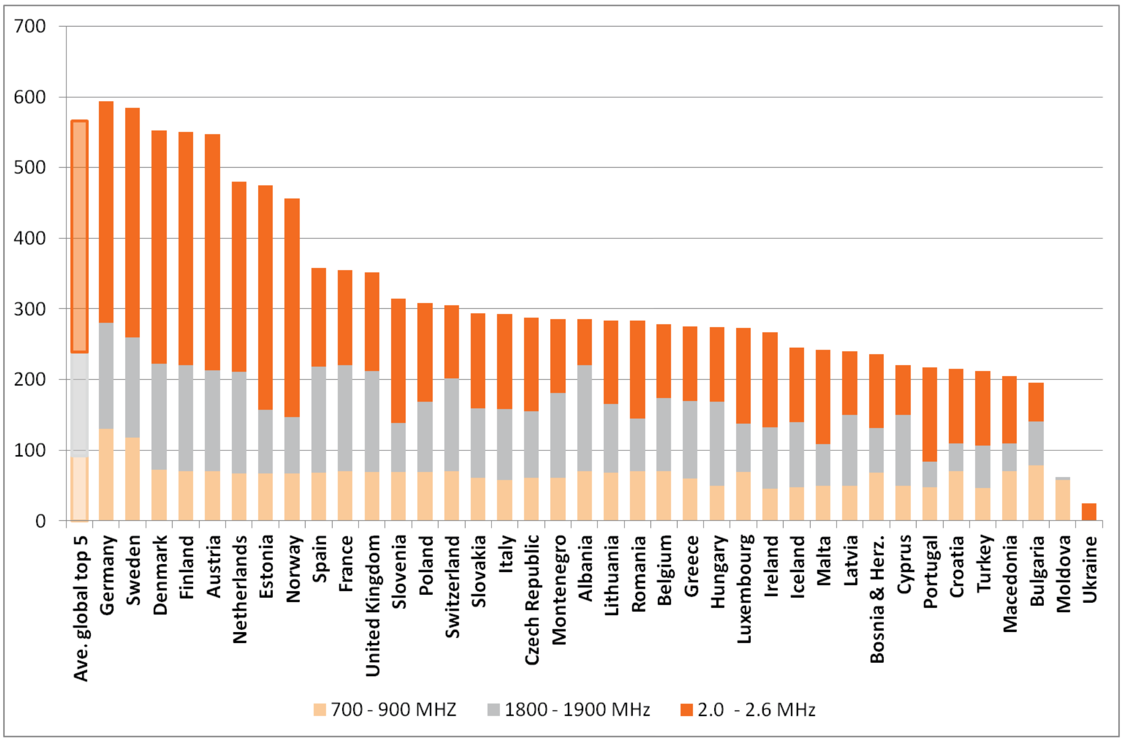
Source: Merrill Lynch (2011)

Spectrum awarded to mobile services in Europe

Most European countries have awarded significant amounts of spectrum to mobile services. The most spectrum has been awarded to mobile services in the frequency bands 700-900 Hz, 1800-1900 MHz and 2.0-2.6 GHz by national authorities in Germany, Austria and the Scandinavian countries, all of which have awarded over 540 MHz to mobile services in these frequency bands. National authorities in Moldova and Ukraine have awarded the least spectrum to mobile services out of any European country in the same bands. The spectrum awarded to mobile services in selected European countries is illustrated in

Figure 9. The top 5 average is an average based on the five countries which have released the most spectrum worldwide – all of which are located in Europe.

Figure 9: Spectrum released to mobile in selected European countries



Source: GSMA (2011)

In December 2009, TeliaSonera launched the first commercial LTE network in the world in Sweden and Norway. Since then commercial LTE networks have been launched in several European countries including Austria, Finland, Germany, Poland, Denmark, Estonia, Lithuania and Latvia[81]. Several more commercial LTE network launches are planned for 2012.[82]

In Europe, several countries such as Norway, Denmark, Finland, Germany, the Netherlands, Sweden and Spain have already completed the analogue switch off, and are now in the process of allocating of the digital dividend to mobile broadband services. Germany was the first country to award spectrum in the 800 MHz band in an auction which was completed in May 2010.[83]

In May 2010, the European Commission adopted a decision which established measures for technical harmonisation for Member States opening up the 800 MHz band for networks other than terrestrial broadcasting. The digital dividend resulting from an analogue switchover should, according to the European Commission decision, be made available to wireless broadband applications such as LTE.[84]

[81] In several countries commercial LTE networks have been launched in the 1800 frequency band, including in Poland, Lithuania, Germany, Latvia, Finland and Denmark.

[82] GSA (2011) *Evolution to LTE report 2011*

[83] GSMA (2011) *The digital dividend in Europe,* p. 1

[84] European Commission (2010) *Radio Spectrum: harmonised EU rules to foster high-speed wireless internet services and avoid harmful interference*

Bands to be allocated in the digital dividend spectrum, and possible award dates, for selected countries in Europe are summarised below:

Table 7: Bands (to be) allocated in the digital dividend spectrum

Country	Band to be allocated	Possible award date
Austria	790 – 862 MHz	2012 auction
Bulgaria	790 – 862 MHz	2015
Czech Republic	790 – 862 MHz	2015
Denmark	790 – 862 MHz	2012 auction
France	790 – 862 MHz	2011 auction
Finland	790 – 862 MHz	2013 auction
Germany	790 – 862 MHz	2010
Hungary	790 – 862 MHz	2012 auction
Italy	790 – 862 MHz	2011 auction
Ireland	790 – 862 MHz	auction
Netherlands	790 – 862 MHz	2011 auction
Poland	790 – 862 MHz	2013
Portugal	790 – 862 MHz	2011
Romania	790 – 862 MHz	2013
Slovenia	790 – 862 MHz	2012
Spain	790 – 862 MHz	2011 auction
Sweden	790 – 862 MHz	2011 auction
Switzerland	790 – 862 MHz	2011 auction
United Kingdom	790 – 862 MHz	2012 auction

Source: GSMA (2011)

Spectrum licensing in Europe

Allocating and assigning spectrum in Europe is the responsibility of national authorities, also with the EU Member States. However, in the case of EU Member States, the processes are also subject to the constraints of EU laws on the single market and international radio spectrum agreements.[85]

Alternative methods of spectrum allocation include auctions and beauty parades. Auctions can take many different formats, which are more or less relevant depending on the circumstances of the auction. Beauty contests have generally been used by national authorities when objectives such as competition; quality of service obligations; speed of roll-out; and technical innovation are more important than revenue generation. Licenses can also come with a variety of different licensing conditions, which can include deployment conditions such as legal coverage requirements and network-sharing conditions.

[85] European Commission (2011) *Managing and monitoring the radio spectrum*

3G auctions in Europe

In Europe, different countries took very different approaches to the awarding of 3G licenses in the early 2000s. Some national authorities raised exceptional amounts through rents in auctions for 3G licenses, but some others raised effectively no revenue. At the extreme, the United Kingdom raised £22.5 billion through an auction, and Finland took only an administration fee from the operators through a comparative bidding process. The licensing conditions varied greatly between different countries, including the deployment conditions.[86]

The awards of 3G licenses demonstrated that 'one size does not fit all'. Auction formats that were successful for some countries were not successful for others. Also the sequencing of the European 3G auctions had an impact on the outcome, as bidders for later auctions could learn from earlier auctions in other countries and adjust their strategies accordingly.[87]

Coverage obligations in digital dividend auctions in Europe

As at mid 2011, two auctions had been completed in the digital dividend (the 800 MHz band) in Europe. These auctions took place in Germany and Sweden respectively. Both of these auctions included specific coverage obligations. In Germany, licensees were obliged to roll out to rural areas before urban areas. The coverage obligations were shared between the licensees , however it was up to individual operators to co-ordinate with regard to rolling out to particular areas (and thereby avoiding costly duplication of infrastructure).[88]

The German 800 MHz auction was concluded in May 2010. In December 2011, the German regulator, the Bundesnetzagentur, reported that mobile companies had met the coverage obligation in the 800 MHz band in seven federal states (North Rhine Westphalia, Schleswig Holstein, Hessen, Bavaria, Baden-Württemberg, Rhineland Pfalz and Saarland). The regulator noted that the network operators were obligated to provide broadband connections progressively to towns and cities in line with individual priority stages. Only when the licensee has provided 90 per cent of the population with coverage in the previous stage, can it move on to the next level.89

Sweden was the second country in Europe, after Germany, to auction the digital dividend spectrum. The Swedish regulator PTS announced in March 2011 that the auction raised SEK 2.05 billion (€233 million), and that three operators had won 2 x 10 MHz of paired spectrum each. One operator in particular, Net4Mobility, was subject to significant coverage obligations in order to promote mobile broadband development in rural areas. Specifically, Net4Mobility was required to cover all permanent homes and fixed places of business that do not have data services with a bit rate of 1Mbps by the end of 2013.[90]

In deciding whether to impose specific license obligations on mobile operators it is important for regulators or national authorities to consider both: (i) the benefits of such obligations and (ii) if there are less costly ways to achieve the objectives of coverage.

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86 European Commission (2001) *The introduction of third generation mobile communications in the European Union: State of play and the way forward*

87 Klemperer, P (2002) *How (Not) to Run Auctions: the European 3G Telecom Auctions*

88 Analysys Mason (2011) *Mobile broadband coverage – Balancing costs and obligations*

89 BNetzA press release 28.12.2011

90 Ovum (2011) *Swedish regulator promotes rural mobile broadband in the digital dividend auction*

There are potential risks with coverage obligations, for example if they force operators to deploy networks and/or services faster than is economically or commercially sensible. Obligations could also force operators to incur losses, or, if operators fail to meet their obligations, result in a dilemma for the regulator on how to impose penalties. Relaxing coverage obligations retrospectively can also lead to legal challenges from operators who did not bid initially on account of the coverage licensing conditions. Alternatives to coverage obligations include allowing for refarming and facilitating greater network sharing.

Regulatory scorecard

Table 8 below is a regulatory scorecard, summarising the level of paired spectrum which has been awarded to mobile services in selected countries in the European region. It also summarises the mobile penetration, the percentage of revenue derived from data, the taxation of mobile services and LTE launches or launch commitments in the same selection of countries.

Table 8: Regulatory scorecard, selected countries in Europe

Country	Spectrum to mobile[1]	Mobile penetration[2, 3]	Revenue from data[2]	Mobile taxation[4]	Expected LTE launch[5]
Germany	High	137%	38%	19.0%	Launched 2010
Sweden	High	145%	32%	25.0%	Launched 2010
Denmark	High	144%	20%	25.0%	Launched 2010
Finland	High	168%	30%	23.0%	Launched 2010
Austria	High	153%	41%	20.0%	Launched 2010
Netherlands	High	121%	36%	19.0%	Launch date TBC
Estonia	High	123%		20.0%	Launched 2010
Norway	High	117%	29%	25.0%	Launched 2009
Spain	High	125%	22%	18.0%	2011
France	High	100%	28%	19.6%	2012
United Kingdom	High	122%	37%	20.0%	2012
Slovenia	High	105%		20.0%	2012
Poland	High	127%	26%	22.0%	Launched 2010
Switzerland	High	131%	30%	8.0%	2011
Slovakia	Medium	108%		19.0%	Pre-commit trial
Italy	Medium	151%	31%	24.4%	Launch date TBC
Czech Republic	Medium	130%	28%	20.0%	Pre-commit trial
Montenegro	Medium	185%		17.0%	2012
Albania	Medium	142%		20.0%	No plan / info
Lithuania	Medium	147%		21.0%	Launched 2011
Romania	Medium	115%		19.0%	Launch date TBC
Belgium	Medium	114%	31%	21.0%	Launch date TBC
Greece	Medium	138%	16%	30.4%	Pre-commit trial
Hungary	Medium	112%	24%	25.0%	2012
Luxembourg	Medium	143%		15.0%	Launch date TBC
Ireland	Medium	105%		21.0%	2011
Iceland	Medium	107%			No plan / info
Malta	Medium	109%		18.0%	No plan / info

Latvia	Medium	102%		21.0%	Launched 2011
Bosnia & Herzegovina	Medium	83%			No plan / info
Cyprus	Medium	94%		15.0%	No plan / info
Portugal	Medium	161%	27%	21.0%	2011
Croatia	Medium	144%		27.9%	2012
Turkey	Medium	90%	24%	48.2%	Pre-commit trial
Macedonia	Medium	105%			No plan / info
Bulgaria	Low	136%		20.0%	Pre-commit trial
Moldova	Low	89%			Launch date TBC
Ukraine	Low	117%	33%	20.0%	Pre-commit trial

Sources: [1] GSMA (2011) and regulators' website, [2] Merrill Lynch (2011), [3] ITU (2010), [4] Deloitte (2011), [5] GSA (2011). For the allocation of spectrum to mobile services in the regulatory scorecards, we assumed that less than 200MHz was low, between 200 and 300MHz was medium and over 300MHz was high - this breakdown roughly corresponds to the bottom third, middle third and top third of countries around the world.

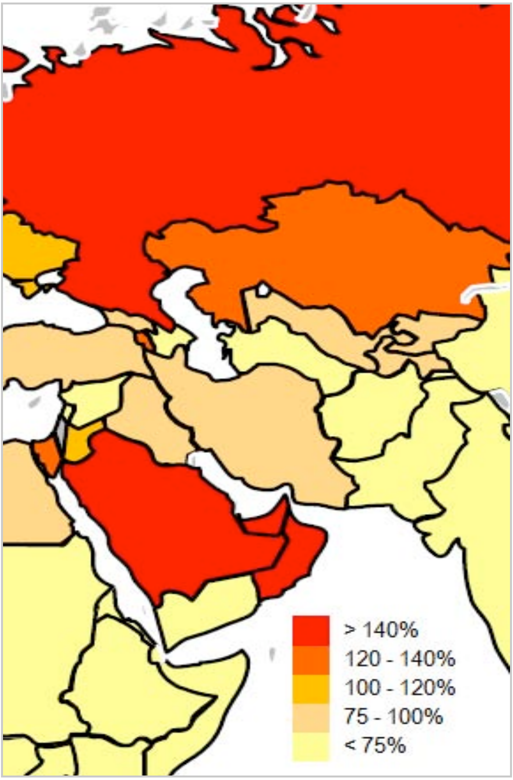
8.5. Middle East & Central Asia

During 2012, the number of mobile subscriptions in the Middle East will cross the 250 million mark, and rise to over 350 million by 2016. The biggest mobile market in the Middle East by subscriptions is Iran, followed by Saudi Arabia. The market is growing on account of increasing competition, availability of new data-based services, increasing affordability and population growth.[91]

The mobile penetration in the Middle East and Central Asia varies significantly throughout the region. Some countries, such as the United Arab Emirates, Saudi Arabia and Russia have a very high mobile penetration rate (over 140 per cent). However many countries in the region have a much lower mobile penetration rate. This is illustrated in Figure 10 below.

[91] ITU (2011) *Middle East's mobile-subscription count will cross 250 million mark in 2012*

Figure 10: Mobile penetration in the Middle East & Central Asia



Sources: Merrill Lynch (2011) and ITU (2010)

Data services only make up a relatively small proportion of mobile revenues in the Middle East region. In 2Q2011, data accounted for 13 per cent of mobile revenues. This is the lowest percentage for any region in the world except Africa. However, there are still substantial markets, such as Iran and Iraq, which have yet to introduce 3G networks, so the potential for growth in data services is significant.[92]

Cisco forecasts that the mobile data traffic will grow at a CAGR of 104 per cent between 2011 and 2016 in the Middle East and Africa (grouped as one) (see Figure 1)[93]. This indicates that the worldwide trend towards revenues being derived from data as opposed to voice services is likely to continue in the Middle East and Central Asia region[94].

Spectrum awarded to mobile services in the Middle East and Central Asia

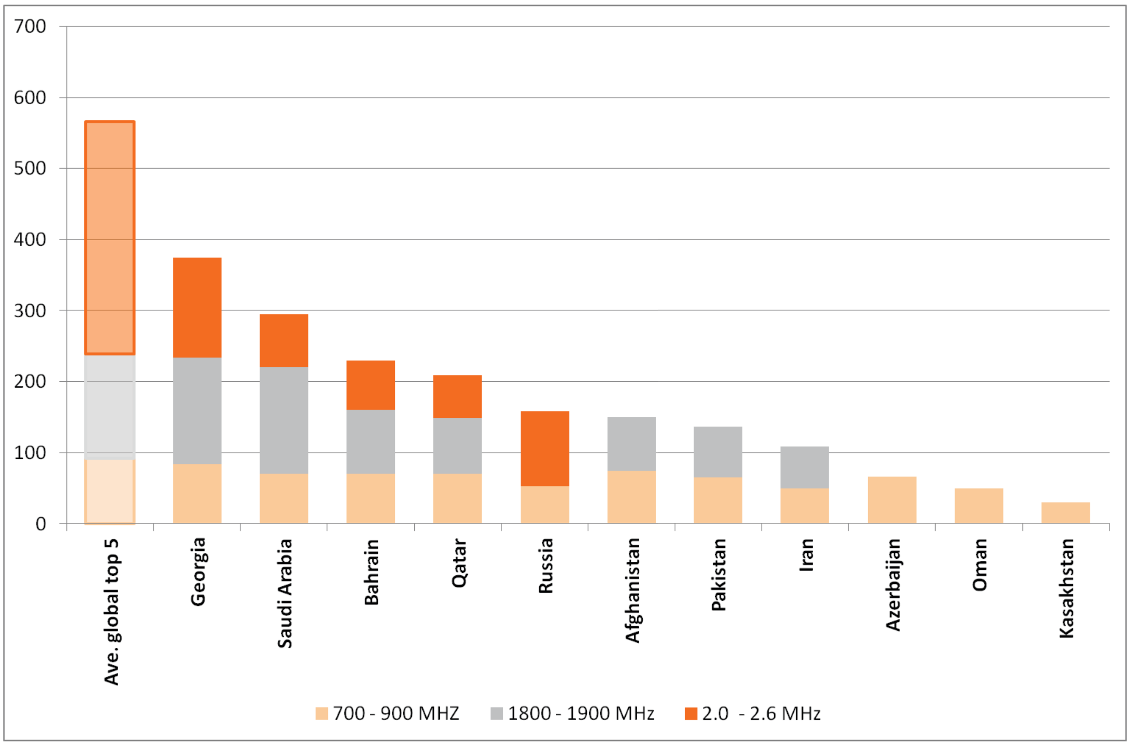
Countries in the Middle East and Central Asia have in general awarded less spectrum to mobile services than countries in other regions of the world in the frequency bands 700-900 MHz, 1800-1900 MHz and 2.0-2.6 GHz. Only one of the countries in the Figure below has awarded more than 300 MHz to spectrum in these frequency bands. Three countries; Azerbaijan, Oman and Kazakhstan, have all awarded less than 100 MHz to mobile services in the same frequency bands.

[92] ITU (2011) *Middle East's mobile-subscription count will cross 250 million mark in 2012*

[93] Cisco (2012) *Visual Networking Index: Global mobile data traffic forecast update, 2011 – 2016,* p. 24

[94] The corresponding number of the Asia Pacific number is a CAGR of 84 per cent.

Figure 11: Spectrum released to mobile in selected countries in the Middle East and Central Asia



Source: GSMA (2011)

A commercial LTE network was first launched in the Middle East and Central Asia region in Uzbekistan. In July 2010, MTS launched a commercial LTE network, followed by UCell in August 2010. Commercial LTE networks were also launched in Saudi Arabia, by three separate operators in September 2011, and in the United Arab Emirates by Etisalat in September 2011.[95]

However, it might take some time before the commercial LTE networks take off in the Middle East. Informa forecasts that LTE subscriptions in the Middle East will amount to only 1.94 million at the end of 2013, but will grow to 15 million by the end of 2016.[96]

[95] GSA (2011) *Evolution to LTE report*, p. 1

[96] ITU (2011) *Middle East's mobile-subscription count will cross 250 million mark in 2012*

Bands to be allocated in the digital dividend spectrum, and possible award dates, for selected countries in the Middle East and Central Asia are summarised below:

Table 9: Bands to be allocated in the digital dividend spectrum

Country	Band to be allocated	Possible award date
Bahrain	790 – 862 MHz	2012/12
Egypt	698 – 806 MHz	2015
Jordan	790 – 862 MHz	2015
Lebanon	698 – 806 MHz	2015
Saudi Arabia	790 – 862 MHz	2015
UAE	790 – 862 MHz	2013

Source: GSMA (2011)

Regulatory scorecard

Table 10 below is a regulatory scorecard, summarising the level of paired spectrum which has been awarded to mobile services in selected countries in the Middle East and Central Asian region. It also summarises the mobile penetration, the percentage of revenue derived from data, the taxation of mobile services and LTE launches or launch commitments in the same selection of countries.

Table 10: Regulatory scorecard, selected countries in Middle East and Central Asia

Country	Spectrum to mobile[1]	Mobile penetration[2, 3]	Revenue from data[2]	Mobile taxation[4]	Expected LTE launch[5]
Georgia	High	91%		18.8%	Pre-commit trial
Saudi Arabia	Medium	188%			Launched 2011
Bahrain	Medium	124%			Launch date TBC
Qatar	Medium	132%			Launch date TBC
Russia	Low	158%	23.5%		2011
Afghanistan	Low	41%			No plan / info
Pakistan	Low	63%		31.6%	No plan / info
Iran	Low	91%		6.2%	No plan / info
Azerbaijan	Low	99%		18.9%	No plan / info
Oman	Low	166%			Pre-commit trial
Kazakhstan	Low				Launch date TBC

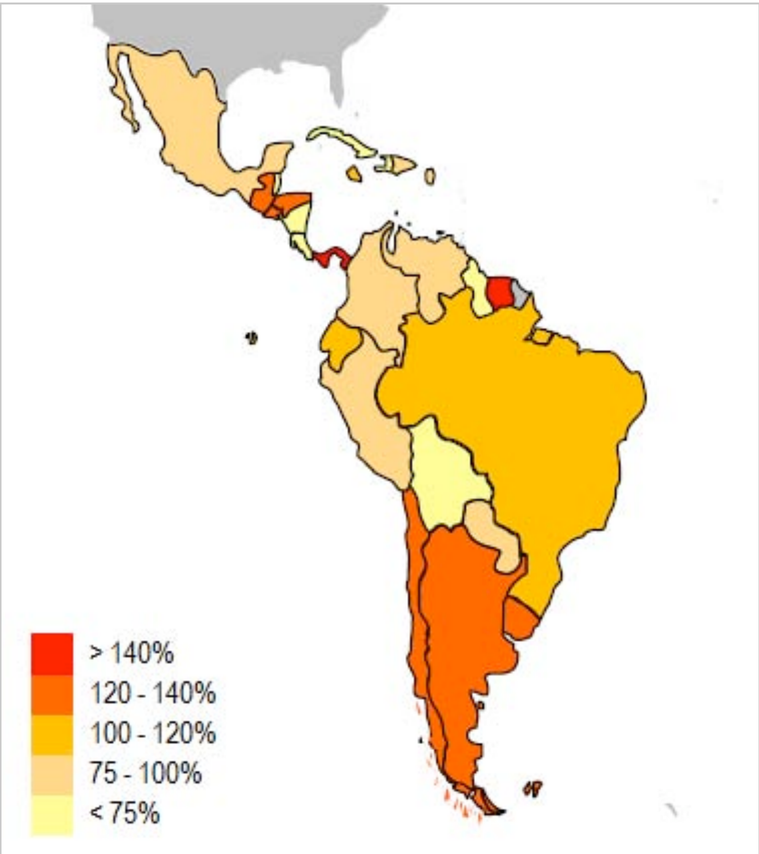
Sources: [1] GSMA (2011) and regulators' website, [2] Merrill Lynch (2011), [3] ITU (2010), [4] Deloitte (2011), [5] GSA (2011). For the allocation of spectrum to mobile services in the regulatory scorecards, we assumed that less than 200MHz was low, between 200 and 300MHz was medium and over 300MHz was high - this breakdown roughly corresponds to the bottom third, middle third and top third of countries around the world.

8.6. Latin America

Latin America is the third largest mobile market after Africa and Asia Pacific. The market has been growing rapidly, and there are over 630 million connections as at 3Q2011.[97]

Latin America has a varied mobile penetration rate, as is illustrated in Figure 12 below. For example Chile and Argentina have a mobile penetration rate of over 120 per cent, whereas Bolivia has a mobile penetration rate of less than 75 per cent. Mobile penetration rates of selected countries in the Latin America region are summarised in the regulatory scorecard (Table 12) at the end of section 0.

Figure 12: Mobile penetration in the Latin America region



Sources: Merrill Lynch (2011) and ITU (2010)

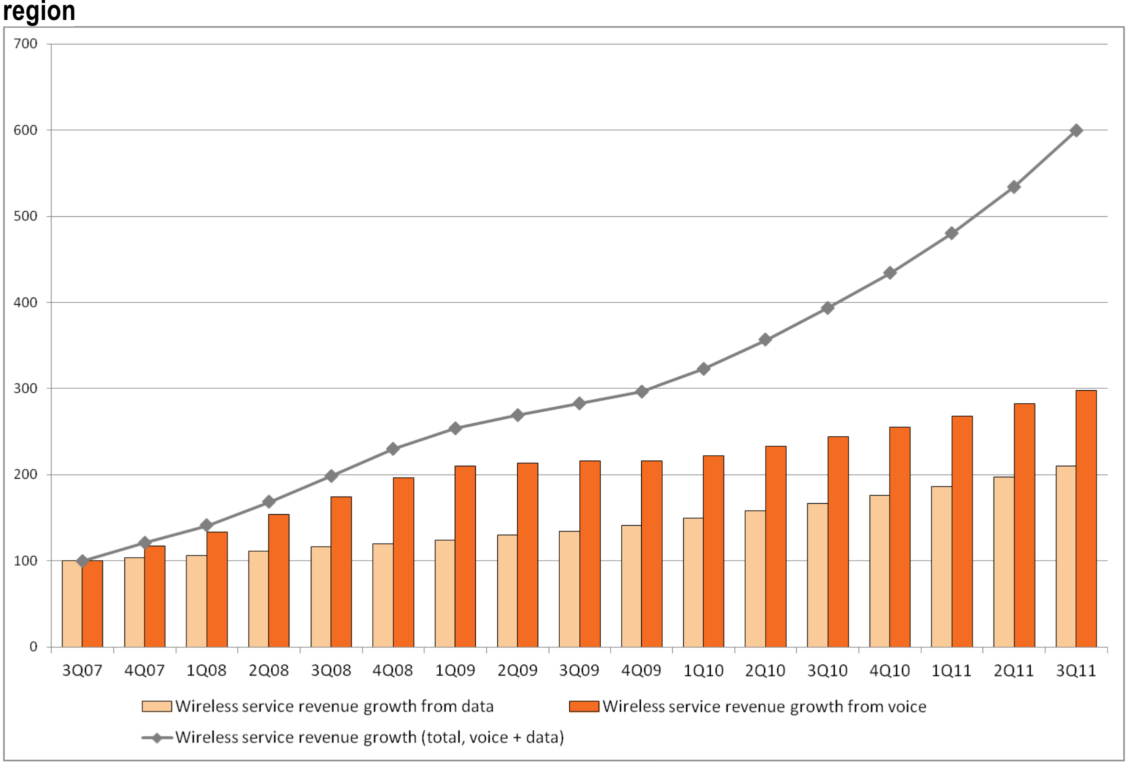
Wireless service revenue growth in the Latin America region has been increasing steadily over the last few years. This can be attributable to strong growth in service revenue from both voice and data.

Cisco forecasts that the mobile data traffic in Latin America will grow at a CAGR of 79 per cent between 2011 and 2016 (see Figure 1)[98]. This indicates that the trend towards strong growth in revenues derived from data will continue.

97 GSMA (2011) *Latin American Mobile Observatory 2011,* p. 5

98 Cisco (2012) *Visual Networking Index: Global mobile data traffic forecast update, 2011 – 2016,* p. 24

Figure 13: Wireless service revenue growth in the Latin America region



Source: Merrill Lynch (2011)

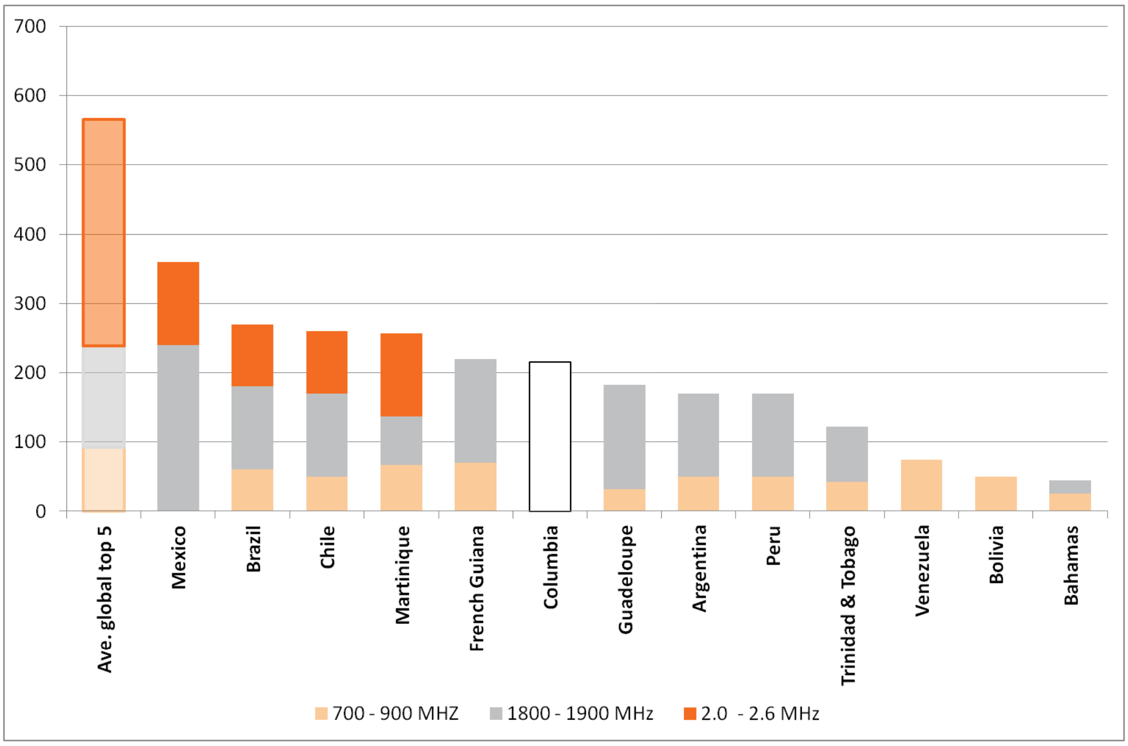
Spectrum awarded to mobile services in Latin America

The amount of spectrum allocated to mobile services is more limited in Latin America than in Europe and North America.

Figure 14 below shows the spectrum allocated to mobile services in the frequency bands 700-900 MHz, 1800-1900 Mhz and 2.0-2.6 GHz in several countries in Latin America, as well as an average of the top 5 countries in the world (i.e. the countries that have released the most spectrum in total). It shows that most countries in Latin America have released less than 250 MHz of spectrum to mobile services. The most spectrum has been released to mobile operators in Mexico in these frequency bands – 360 MHz in total. In other countries much less spectrum has been released to mobile services in the same frequency bands. However, regulators in Latin America are continuously allocating more spectrum to mobile broadband.[99]

99 GSMA (2011), *Latin American Mobile Observatory*, p. 62

Figure 14: Spectrum released to mobile in selected Latin American countries



Source: GSMA (2011)

The first live trial for LTE was held in January 2010 with Entel PCS in Chile. A trial was also held in June 2010 with Telecom Personal in Argentina, followed by a trial with Orange Dominicana in the Dominican Republic in April 2011.[100] Commercial LTE networks are expected to be launched in Colombia, Mexico, Puerto Rico and Uruguay in 2012.[101]

Many Latin American governments remain undecided on the allocation of the digital dividend spectrum to broadband. Analogue switchover is scheduled for 2016 in Brazil and not until 2021 in Mexico. However, the upper part of the UHF band is relatively clear in many countries in Latin America, so therefore there should be no major obstacles in allocating the spectrum to mobile broadband before the switchover. Chile and Argentina are expected to be the first to assign digital dividend spectrum to mobile. Mexico and Colombia have already begun clearing the UHF band.[102]

[100] GSMA (2011) *LTE in Latin America and the Caribbean*

[101] GSA (2011) *Evolution to LTE report 2011*

[102] GSMA, The Digital Dividend in Latin America, p. 1

Bands to be allocated in the digital dividend spectrum, and possible award dates, for selected countries in Latin America are summarised below:

Table 11: Bands to be allocated in the digital dividend spectrum

Country	Band to be allocated	Possible award date
Argentina	790 – 862 MHz	2012/13
Brazil	790 – 862 MHz	2016
Chile	790 – 862 MHz	2013
Colombia	790 – 862 MHz	2012/13
Mexico	790 – 862 MHz	2012/2013 auction
Peru	790 – 862 MHz	2012
Uruguay	790 – 862 MHz	2012

Source: GSMA (2011)

A study commissioned by the GSMA and AHCIET, conducted by Telecom Advisory Services LLC (TAS) in the economic impact of the digital dividend in Latin America suggested that allocating the digital dividend spectrum in the 700 MHz band for the deployment of mobile services could contribute near US$15 billion to the economies of Latin America. Additionally, it would increase the mobile broadband coverage to near 93 per cent of the population[103].

Spectrum licensing in Latin America

The preferred method of spectrum allocation in many Latin American countries is through auctions. Recently, auctions have taken place in for example Mexico and Colombia. In Mexico, an auction of 40 MHz in the 1800/1900 MHz band took place in June 2010, followed by an auction of 50 MHz in the 1.7 GHz and 2.1 GHz band in July 2011.[104]

In Colombia, an auction took place in May 2010 in the 2500 MHz band. The auction was won by Une-EPM Telecomunicaciones, who said they would use the spectrum to deploy LTE[105]. In August 2011, an auction took place for 25 MHz in the 1900 MHz band[106]. The allocation was part of a strategy by the government to increase the spectrum resources available for telecoms companies, in order for them to improve services[107].

Spectrum caps in Latin America

In Latin America, many regulators have advocated spectrum caps to increase competition in mobile markets. The use of such spectrum caps is not uncontroversial, as they involve a balancing act between competition between operators and enabling larger operators to improve speed and capacity within their network.

It is important that caps, if enforced, are set in relation to the total spectrum which is on offer, taking into account technology availability now and in the future as well as expected user demand. Sufficient continuous bandwidth is required to achieve higher speeds and exploit efficiencies made possible by new technologies.

[103] GSMA (2011) *Allocating digital dividend spectrum for mobile broadband could contribute up to $15 billion to the Latin American Economy*

[104] KB Spectrum (no date) *Spectrum auction results*

[105] TeleGeography (2010) *Une-EPM bags 2.6 GHz concessions*

[106] KB Spectrum (no date) *Spectrum auction results*

[107] TeleGeography (2011) *Spectrum auction funds expansion*

In a 2009 beauty contest in Chile of the 1.7 / 2.1 GHz AWS band, the regulator imposed a 60 MHz cap. The contest included three blocks of 30 MHz each, which the incumbent operators were unable to bid for because of the spectrum caps. This resulted in the entire spectrum in question being allocated to new entrants.[108]

Regulatory scorecard

Table 12 below is a regulatory scorecard, summarising the level of paired spectrum which has been awarded to mobile services in selected countries in the Latin American region. It also summarises the mobile penetration, the percentage of revenue derived from data, the taxation of mobile services and LTE launches or launch commitments in the same selection of countries.

Table 12: Regulatory scorecard, selected countries in Latin America

Country	Spectrum to mobile[1]	Mobile penetration[2, 3]	Revenue from data[2]	Mobile taxation[4]	Expected LTE launch[5]
Mexico	High	88%	32%	16.0%	2012
Brazil	Medium	119%	19%	25.2%	Launch date TBC
Chile	Medium	133%	24%	19.1%	Launch date TBC
Martinique	Medium				No plan / info
French Guiana	Medium				No plan / info
Colombia	Medium	96%		16.2%	2012
Guadeloupe	Low				No plan / info
Argentina	Low	132%		22.5%	Pre-commit trial
Peru	Low	85%		19.2%	Pre-commit trial
Trinidad & Tobago	Low	141%			No plan / info
Venezuela	Low	96%		12.4%	No plan / info
Bolivia	Low	72%		13.4%	Pre-commit trial
Bahamas	Low	125%			No plan / info

Sources: [1] GSMA (2011) and regulators' website, [2] Merrill Lynch (2011), [3] ITU (2010), [4] Deloitte (2011), [5] GSA (2011). For the allocation of spectrum to mobile services in the regulatory scorecards, we assumed that less than 200MHz was low, between 200 and 300MHz was medium and over 300MHz was high - this breakdown roughly corresponds to the bottom third, middle third and top third of countries around the world.

8.7. North America

The mobile penetration in North America is relatively high, albeit not as high as in parts of Europe and Asia Pacific. In the United States, mobile penetration is about 103 per cent, and in Canada mobile penetration is about 76 per cent.[109]

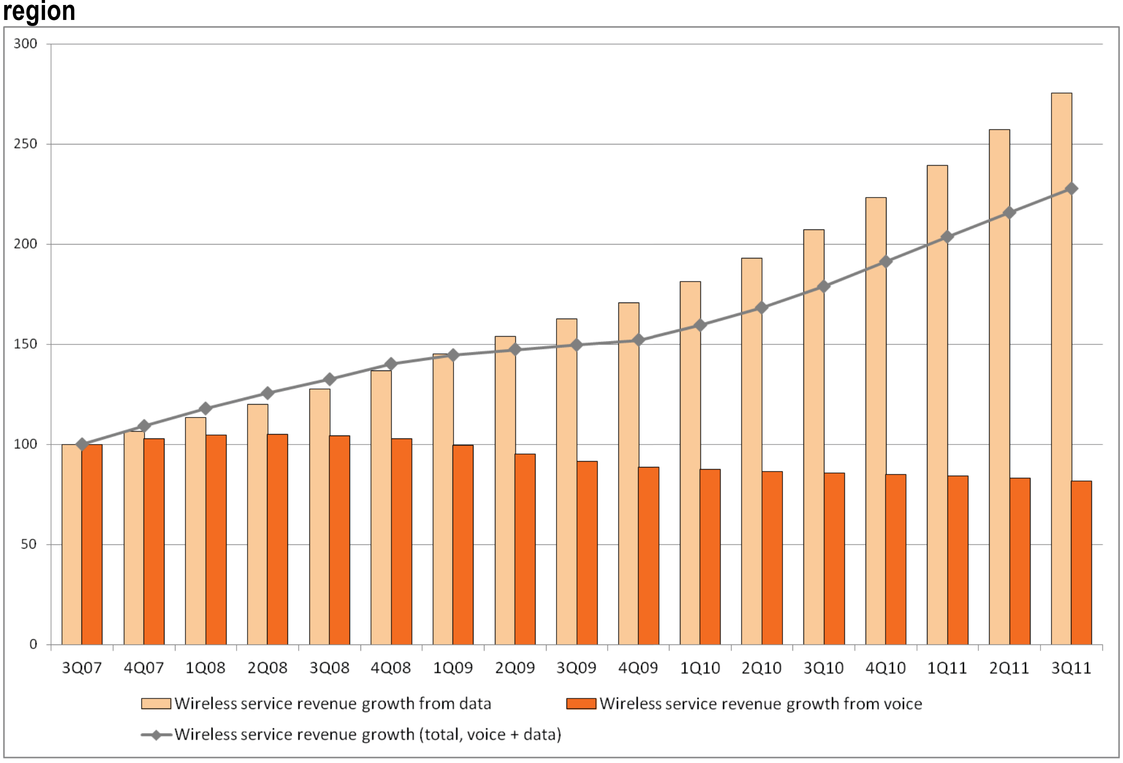
Wireless service revenue growth in the North America region has been declining slightly over the last four years, with the wireless service revenue growth from data steadily increasing, and the wireless revenue growth from voice steadily declining. This is illustrated in Figure 15 below.

[108] GSMA (2011) *Latin America Mobile Observatory 2011*, p. 67

[109] Merrill Lynch (2011) *Global wireless matrix 4Q2011*, p. 2

Cisco forecasts that the mobile data traffic in North America will grow at a CAGR of 75 per cent between 2011 and 2016 (see Figure 1)[110]. This indicates that the trend towards strong growth in revenues derived from data will continue.

Figure 15: Wireless service revenue growth in the North America region



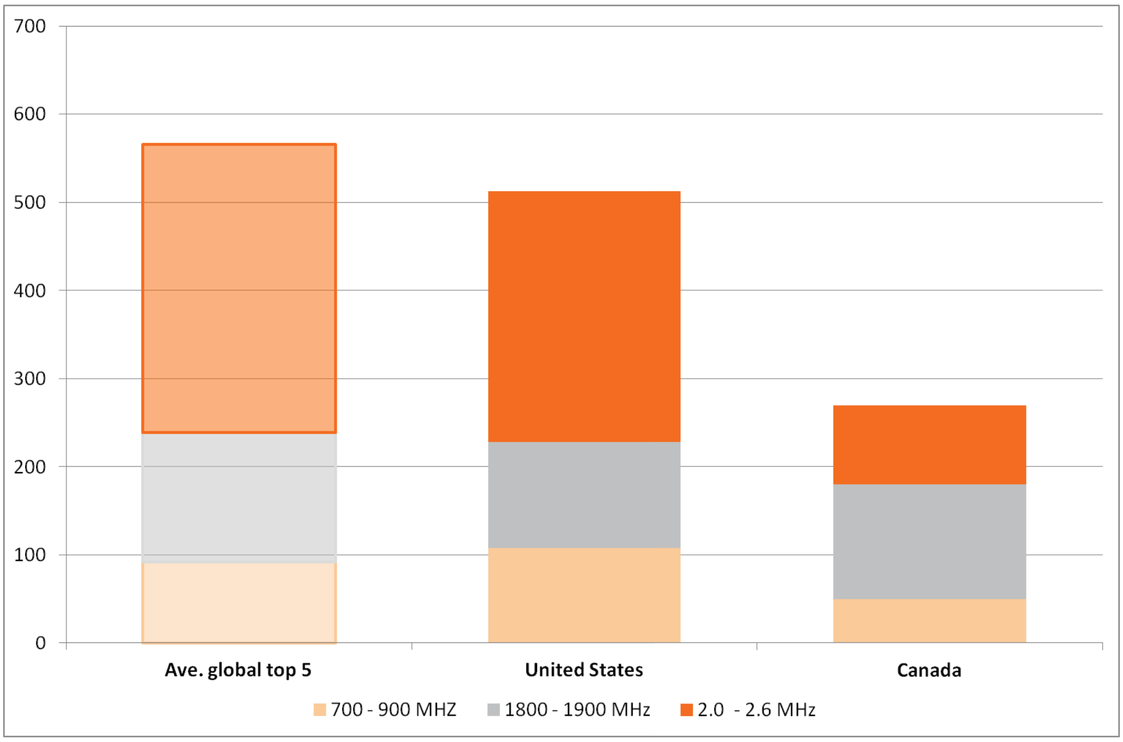
Source: Merrill Lynch (2011)

Spectrum awarded to mobile services in North America

Just over 500 MHz of spectrum has been allocated to mobile services in the United States in the frequency bands 700-900 MHz, 1800-1900 MHz and 2.0-2.6 GHz. This is a relatively large amount, and only a handful of countries in Europe have allocated more spectrum to mobile services (see Figure 18). In Canada, less than 300 MHz of spectrum has been released to mobile services in these frequency bands. This is significantly less than that released by the top 5 average and the United States. The amount of spectrum allocated to mobile services in the relevant frequency bands is illustrated in Figure below.

110 Cisco (2012) *Visual Networking Index: Global mobile data traffic forecast update, 2011 - 2016*

Figure 18: Spectrum released to mobile in selected North American countries



Source: GSMA (2011)

In the US, three operators, MetroPCS, Verizon Wireless and AT&T, have launched commercial LTE networks. A further three operators, Sprint, US Cellular and Leap Wireless are expected to launch commercial networks in 2012. Research indicates that the US will have two thirds of total global LTE subscriptions by the end of 2011.[111]

In Canada Rogers Wireless announced the launch of the first commercial LTE service in July 2011 in Ottowa, to be followed by a further 20+ markets in 2011 and 2012. Also other operators are expected to launch LTE networks in 2012.[112]

The United States completed its analogue switchover in 2009, and auctioned the associated 700 MHz spectrum in 2008. The US 'Auction 73' involved two months of multi-round bidding, and the principal winners were Verizon and AT&T. The auction raised a total of $18,957,582,150 in net winning bids.[113]

[111] GSMA (2011) *European Mobile Industry Observatory 2011,* p. 26

[112] GSA (2011) *Evolution to LTE report 2011*

[113] GSMA (2011) *Making sense of the digital dividend spectrum, auctions summary*

In Canada, the regulator set 31 August 2011 as the deadline for broadcasters to complete the transition from analogue to digital television. However in early August 2011, the regulator gave the Canadian Broadcasting Corporation (CBC) permission to continue broadcasting analogue television in 22 markets until 31 August 2012, to give CBC an additional year to find solutions to viewers who may lose access after the transition. CBC, as the national broadcaster, has a mandate to serve the entire Canadian population. The transition however went ahead in 28 Canadian markets, and the government has reserved channels for public safety and advanced wireless services.[114]

Spectrum licensing in North America

In the US, the Federal Communications Commission (FCC) conducts auctions of licenses for spectrum. The FCC generally relies on simultaneous multiple-round (SMR) auctions. These auctions have discrete, successive rounds, and the FCC announces the length of each round in advance. Bidding continues, round after round, until all bidder activity ceases. The auction design can also be modified by the FCC to allow combinatorial or "package" bidding.[115]

In Canada, the regulator relies on a first come, first-served licensing process when the demand for spectrum is not expected to exceed supply. In the cases when demand is expected to exceed supply, a competitive allocation process such as an auction is generally relied upon. An auction may also be preferably if government policy objectives can be fully met through this process. The regulator also has measures available to it to promote a competitive post-auction market-place, including the options to restricting the participation of certain entities and/or limiting the amount of spectrum allocated to any one entity (i.e. spectrum caps).[116]

The US 'Auction 73' of the 700 MHz spectrum

The US auction of the 700 MHz spectrum was the first spectrum of the digital dividend spectrum in the world. The auction started on the 24 January 2008 and finished two months later on the 18 March 2008. The auction took the form of multi-round bidding.

The auction offered 62 MHz of spectrum. Five blocks were sold: two blocks of 2 x 6MHz dividend into 176 and 734 geographic areas respectively, one block of 6 MHz unpaired divided into 176 geographical areas, one block of 2 x 11 MHz divided into 12 geographical areas and one block of 2 x 5 MHz as nationwide. The provisionally winning bid for the D block did not meet the applicable reserve price and therefore did not become a winning bid. As such, only 52 MHz of spectrum were auctioned. The auction concluded with 1090 provisional winning bids across 1091 licenses, and raised $18,957,582,150 in net winning bids.

The licenses involved specific coverage roll out obligations which were specifically designed for different licenses sold. The licenses were of the duration of 10 years and could be used for flexible fixed, mobile and broadcast uses. They may also include two-way interactive, cellular and mobile television broadcasting services. Further to this the licenses were tradable.[117]

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[114] Canadian Radio-television and Telecommunications Commission (CRTC) (2011), *CRTC allows CBC to continue broadcasting analog television signals in 22 markets until August 2012*

[115] Federal Communications Commission (FCC) (2006) *About auctions*

[116] Industry Canada (IC) (2011) *Framework for Spectrum Auctions in Canada*

[117] GSMA (2011) *Making sense of the digital dividend, auctions summary*

Regulatory scorecard

Table 13 below is a regulatory scorecard, summarising the level of paired spectrum which has been awarded to mobile services in selected countries in the North American region. It also summarises the mobile penetration, the percentage of revenue derived from data, the taxation of mobile services and LTE launches or launch commitments in the same selection of countries.

Table 13: Regulatory scorecard, selected countries in North America

Country	Spectrum to mobile[1]	Mobile penetration[2, 3]	Revenue from data[2]	Mobile taxation[4]	Expected LTE launch[5]
United States	High	103%	38.6%		Launched 2010
Canada	Medium	76%	33.5%		Launched 2011

Sources: [1] GSMA (2011) and regulators' website, [2] Merrill Lynch (2011), [3] ITU (2010), [4] Deloitte (2011), [5] GSA (2011). For the allocation of spectrum to mobile services in the regulatory scorecards, we assumed that less than 200MHz was low, between 200 and 300MHz was medium and over 300MHz was high - this breakdown roughly corresponds to the bottom third, middle third and top third of countries around the world.

Appendix A. Sample licence to use radio frequencies

This appendix sets out a sample spectrum licence and the conditions that could be attached to the licence in line with the proposed approach discussed in the report.

Sample licence for the [enter relevant frequency] band

This licence is issued under **[**the relevant Act**]** to the licensee named at Item 1 of Licence Schedule 1 of this licence.

1. The licensee is authorised to operate radiocommunications devices in accordance with:

   (a) the Act; and

   (b) the core conditions set out in Licence Schedule 2; and

   (d) the other conditions set out in Licence Schedule 3.

2. This licence shall be in force from the dates of licence effect shown at Part 1 of Licence Schedule 1 and shall continue in force until revoked by **[**the Regulator**]** ("the Regulator") or surrendered by the Licensee.

Licence Schedule 1 - Licence details, bands and areas

Part 1: Licence Details

1. Licensee Details

Name of licensee	[xxx]
Address of licensee	[xxx]

2. Licence Details

Band release	[relevant frequency band]
Date of licence effect	[dd/mm/yyyy]
Licence number	[xxx]
Date of licence issue	[dd/mm/yyyy]
Date of licence renewal	[dd/mm/yyyy]

Part 2: Frequency bands

For core condition 1, this licence authorises the operation of radiocommunications devices in the frequency bands that consist of the frequencies between the lower and upper limits subject to adjacent frequencies unwanted emission limits as described in Schedule 2 below.

Upper band	
Lower frequency limit	[xxx MHz]
Upper frequency limit	[xxx MHz]
Lower band	
Lower frequency limit	[xxx MHz]
Upper frequency limit	[xxx MHz]

Part 3: Geographic Area

The operation of radiocommunications devices is authorised by this licence in the [specified geographic area].

Licence Schedule 2 - Core Conditions

Frequency band

1. This licence authorises the operation of radiocommunications devices in the frequency bands set out at Part 2 of Licence Schedule 1.

Emission limits outside the frequency band

2. Core conditions 3 to 11 apply in relation to those frequencies that are outside the frequency bands set out in Part 2 of Licence Schedule 1.

3. Where a written agreement exists between:

   (a) the licensee; and

   (b) the affected licensees of frequency-adjacent and area-adjacent spectrum licences;

   specifying the maximum permitted level of radio emission for frequencies described in core condition 2, the licensee must comply with that specified maximum permitted level of radio emission.

4. Where there is no written agreement for the purposes of core condition 3 in force, core conditions 5 to 11 apply.

Non spurious emission limits

5. The licensee must ensure that radiocommunications devices operated under the licence do not exceed the non-spurious emission limits in core conditions 6.

6. The non-spurious emission limits in Table 1 apply at frequencies outside **[**the frequency bands of the licence**]**.

Table 1: Non spurious emission limits

Frequency offset range	**Radiated maximum true mean power (dBm EIRP)**	**Specified Bandwidth**
[xxx**]**	**[**xxx**]**	**[**xxx**]**

Spurious emission limits

7. The licensee must ensure that radiocommunications devices operated under the licence do not exceed the spurious emission limits in core conditions 8.

8. For radiocommunications transmitters operated under the licence, the spurious emission limits in Table 2 apply at frequencies outside **[**the frequency bands of the licence**]**.

Table 2: Radiocommunications transmitter spurious emission limits

Frequency offset range	Radiated maximum true mean power (dBm EIRP)	Specified Bandwidth
[xxx**]**	**[**xxx**]**	**[**xxx**]**

Emission limits outside the geographic area

9. Core conditions 10 applies in relation to those areas that are outside the geographic areas set out at Part 3 of Licence Schedule 1.

10. The maximum permitted level of radio emission for an area described in core condition 10 caused by operation of radiocommunications devices under the licence must not exceed a radiated maximum true mean power of **[xxx]** dBm EIRP per 1 MHz. The licensee complies with this sub-condition by ensuring that no radiocommunications device is operated under the licence in excess of a radiated maximum true mean power of **[xxx]** dBm EIRP per 1 MHz.

Licence Schedule 3 - Other Conditions

Liability to pay charges

1. The Licensee shall pay the Regulator the relevant fee on or before such date as shall be notified in writing to the Licensee. In case of failure to pay the fee on the due date, interest shall accrue from the due date until the date on which payment is effected. If the Licensee fails to pay the relevant fee and accrued interest after three months from the due date, the Regulator may revoke this Licence.

Radiocommunications transmitter registration requirements

2. The licensee must not operate a radiocommunications transmitter under this licence unless:
   - (a) the radiocommunications transmitter has been exempted from the registration requirements under condition 3 below, or:
   - (b) both:
     - (i) the requirements of the Regulator under the Act relating to registration of the radiocommunications transmitter have been met; and
     - (ii) the radiocommunications transmitter complies with the details about it that have been entered in the register.

3. The following kinds of radiocommunications transmitters are exempt from the registration requirement in statutory condition 3: a radiocommunications transmitter that operates in the **[**relevant frequency band**]** with a horizontally radiated power of less than or equal to **[xxx]** dBm EIRP per 1MHz.

Responsibility to manage interference

4. The licensee must manage interference between radiocommunications devices operated under this licence including by:
   - (a) investigating the possible causes of the interference;
   - (b) taking all steps reasonably necessary to resolve disputes about interference;
   - (c) taking steps (or requiring persons authorised to operate devices under this licence to take steps) reasonably likely to reduce interference to acceptable levels; and
   - (d) negotiating with other persons to reduce interference to acceptable levels.

Licence Schedule 3 - Other conditions

International coordination

5. A licensee must ensure that operation of a radiocommunications transmitter under this licence does not cause harmful interference to a receiver that operates in accordance with International Telecommunication Union Radio Regulations and is located in a country other than **[**the country issuing the licence**]**.
6. The Licensee shall comply with international agreements on frequency coordination for the bands **[**the relevant frequency bands**].**
7. The Licensee shall comply with relevant international agreements on telecommunications as advised by the Regulator.

License Variation and Revocation

8. The Regulator may not revoke or vary this Licence save at the request or with the consent of the Licensee except:
   (a) in accordance with clause 1 of this Licence Schedule;
   (b) for reasons related to the management of the radio spectrum provided that in such case the power to revoke may only be exercised after five years notice is given in writing and after the Regulator has consisted any pertinent factors; and
   (c) if there has been a breach of any of the terms of this Licence.

Trading

9. A licensee may assign or otherwise deal with the whole or any part of a spectrum licence provided that this is done in accordance with any rules determined by the Act.
10. The Licensee must give prior or immediate notice to the Regulator in writing of any change in details of the name and/or address recorded in paragraph 1 of the Licence.

Access and Inspection

11. The Licensee shall permit a person authorised by the Regulator:
    (a) to have access to the Radio Equipment; and
    (b) to inspect this Licence and the Radio Equipment,

    at any and all reasonable times or, when in the opinion of that person an urgent situation exists, at any time to ensure the Radio Equipment is being used in accordance with the terms of the Licence.

Appeals

12. An application may be made to the Regulator for reconsideration of the Regulator's decisions. A person affected by and dissatisfied with the Regulator's decision may seek a reconsideration of the decision by the Regulator. This decision can be subject to further reconsideration by [an authorised appeals body].

GSMA contacts:
Seventh Floor
5 New Street Square
New Fetter Lane
London, EC4A 3BF

CEG contacts:
Paul Reynolds, Partner, Competition Economists Group
Johanna Hansson
Camilo Corredor Miranda

Best practice in spectrum licence renewals

A toolkit for licensing authorities

The GSMA represents the interests of mobile operators worldwide. Spanning more than 220 countries, the GSMA unites nearly 800 of the world's mobile operators with 250 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and Internet companies, as well as organisations in industry sectors such as financial services, healthcare, media, transport and utilities. The GSMA also produces industry-leading events such as Mobile World Congress and Mobile Asia Expo.

For more information, please visit the GSMA corporate website at **www.gsma.com** or Mobile World Live, the online portal for the mobile communications industry, at **www.mobileworldlive com**

COMPETITION
DISPUTES
REGULATION

CEG applies expertise in economics and finance to address competition, regulation, disputes and transaction issues

The shift towards an effects-based approach in competition policy and the need for quantitative evidence in damages proceedings has led to a growing interplay between law and economics. Empirical analysis reinforces legal arguments by putting documentary evidence into context. Regulatory and transaction matters continue to require the support of rigorous evidence underpinned by expert economic and finance techniques.

CEG brings together senior professionals with experience in industry, consultancy and academia and the leading competition and regulatory agencies, to offer insightful and dependable advice.

Using up-to-date economic and finance theory and quantitative techniques, CEG personnel prepare expert reports, provide input into client submissions, advise on case strategy, and provide testimony and presentations before government agencies, courts and arbitral tribunals across the globe. Using our industry knowledge we have provided advice on strategic projects and investments in many sectors.

CEG's competition practice is amongst the top 20 competition economics consultancies according to Global Competition Review and our partners are consistently included in the GCR's list of recommended competition economists.

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Table of contents

1 Summary

Mobile broadband has grown to 2.3 billion subscriptions globally in just over a decade. On current rates more than half the world's population will have a mobile broadband subscription by 2018. The increasing demand for mobile services raises the importance of effective spectrum management and of a regulatory framework that supports ongoing high levels of network investment.

In the next few years, however, many existing mobile spectrum licences will come to the end of their term. In particular, a large number of operators that are supplying mobile services in Africa, Asia, Europe and Latin America have little certainty over whether they will continue to have access to the spectrum that is essential to the services they supply. Unless addressed by licensing authorities, this uncertainty risks deterring investments in extending networks and in deploying new services as well as reducing the incentive for operators to compete more aggressively to grow their customer bases. Consumers may not only be harmed directly but may also miss out on the wider economic benefits of ongoing strong growth in the communications industry.

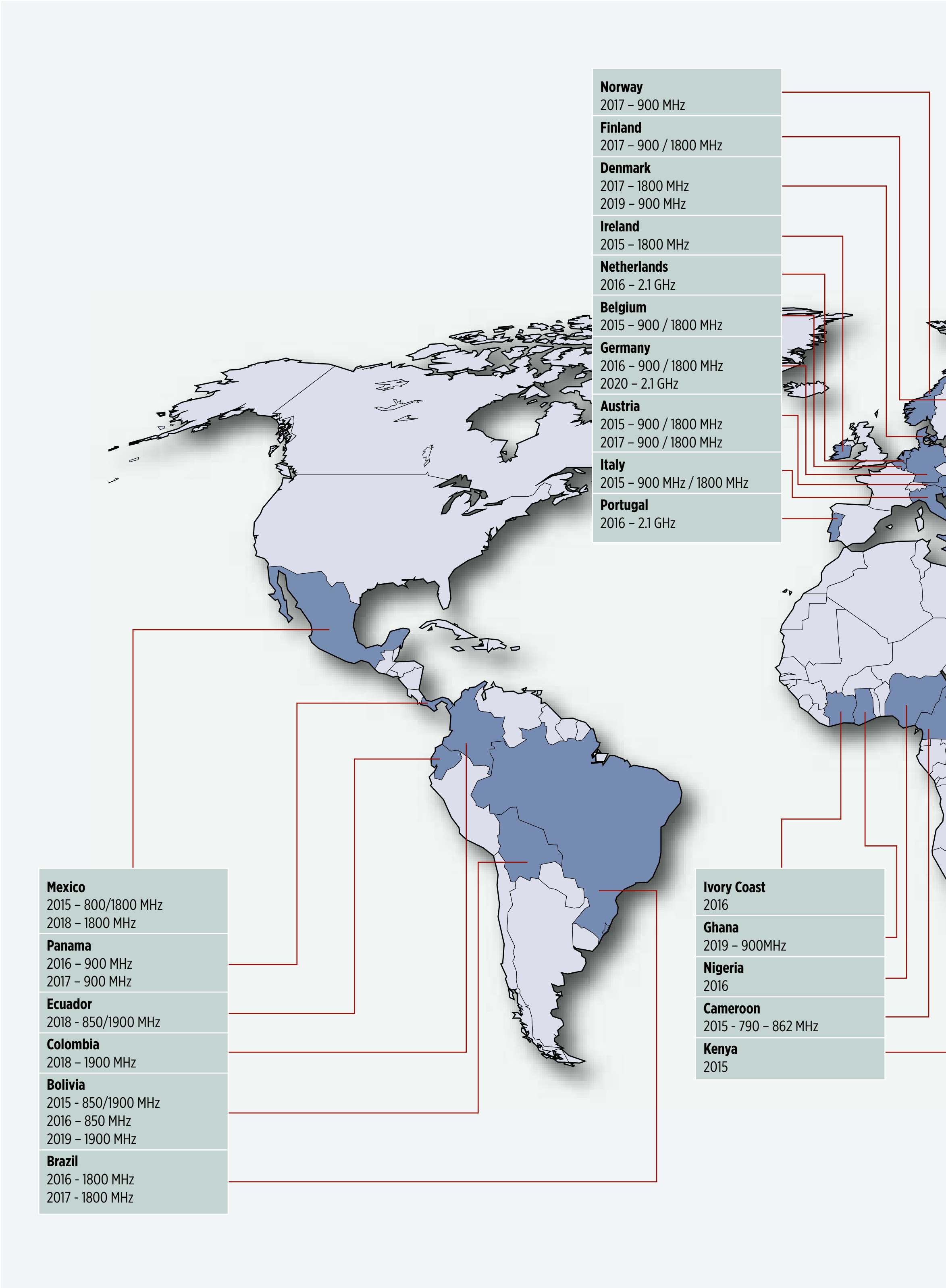
In this report, we set out international best practice in relation to the renewal of mobile spectrum licences. In particular, we identify the range of issues raised by licence renewal, assess the advantages and disadvantages of particular approaches by reference to relevant policy objectives and market factors and put forward a framework for choosing the best approach. While a poor approach to licence renewal can be costly, the renewal of licences also provides an opportunity for the terms and conditions attached to licences to be reviewed. By providing for greater certainty going forward and for the more flexible, market-driven use of spectrum, reforms to the licensing framework can build the foundation for a productive and innovative communications sector into the future.

How should authorities approach licence renewal?

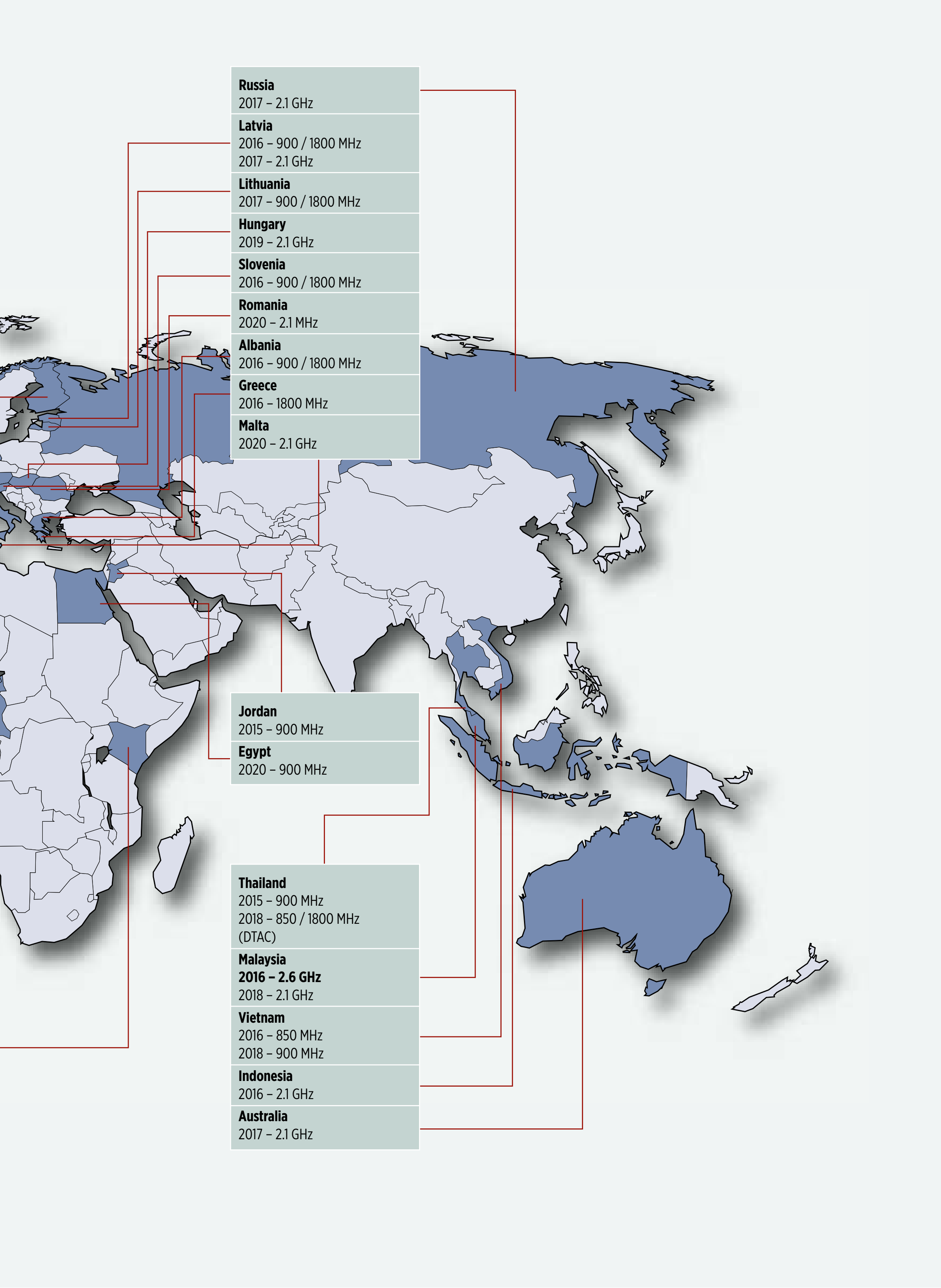
1. **The best approach to licence renewal will depend on the licensing authority's policy objectives and the specific market circumstances.** There are three fundamental approaches to licence renewal: a presumption of renewal, auctioning and administrative re-assignment. Some regulators have also followed hybrid approaches which combine elements of the other approaches. There will be a strong case for presumption of renewal where spectrum is already likely to be in its best use, the market is effectively competitive and non-renewal would carry risks to investment and service continuity.
2. **Auctions can be useful where there is uncertainty over the best use of the spectrum.** However, they may bring unnecessary costs where it is clear that the existing licence holder with an established network and customer base will value the licence more than others. Auctions also need to be designed carefully to avoid spectrum being assigned inefficiently or competition in the mobile market being reduced.
3. **Authorities should follow a predictable, timely and open licence renewal process.** A decision to renew the licence should be made at least four to five years before the current licence expires so as to reduce the risk of investment being reduced or postponed.

4. **Charges for spectrum use should be limited to recovering the cost of spectrum management where a market-based licensing approach has been adopted.** If spectrum has not been auctioned nor spectrum trading allowed, there may be a case for authorities to also set charges to reflect the opportunity cost of spectrum. There is substantial scope for error in estimating the opportunity cost of spectrum including the risk that benchmarks will not be comparable because of differences in supply and demand conditions. Charges that are designed to reflect opportunity cost should be determined conservatively to avoid valuable spectrum being left idle.
5. **Licences should be technology and service neutral.** Restrictive licensing requirements exacerbate spectrum scarcity increasing the cost of service provision and delaying the introduction of new, more efficient technology and services. International experience with refarming provides a guide as to how liberalisation can be carried out in a way that avoids harmful interference.
6. **Mobile licences should have a minimum 20 year term to provide sufficient certainty to support substantial new network investment.** Predictability can be further enhanced by introducing indefinite licence terms which combine a minimum initial term with ongoing rights to continue to use the spectrum beyond the initial term unless the authority decides to revoke the rights after giving sufficient notice.
7. **Licence conditions unrelated to avoiding interference should be removed or kept to a minimum.** Competition together with targeted policies can better support coverage and universal access without putting at risk an operator's licence.
8. **Measures to increase competition should be introduced only after assessing the benefits and costs of alternative options.** Re-assigning spectrum or changing licence conditions to boost competition will only make sense where the market is not already effectively competitive and there is a real prospect of better consumer outcomes. Even then, these measures may create larger costs than benefits such as in removing spectrum from the operators that have the greatest need for the spectrum or an ongoing need for regulation of access arrangements. Alternatives such as releasing additional spectrum or lowering tax and other imposts on the industry may better enable all players to supply lower priced services to customers. Accordingly, we would expect the re-assignment of spectrum for competition reasons to only be used in exceptional circumstances and only after a thorough assessment of the market and of potential alternative measures.
9. **Voluntary spectrum trading should be allowed so as to promote the efficient use of spectrum over time.** By doing so, trading can support higher service volumes, lower cost and better quality services. Efficient trading should also be supported by a stable and predictable licensing and regulatory framework, long licence terms, licence renewal decisions being made well in advance and a notification process to maintain transparency over spectrum usage rights. Spectrum trades should also be subject to competition law and/or ex ante competition assessments.

EXAMPLES OF FORTHCOMING EXPIRY OF LICENCES



Note: These examples are not exhaustive. The licence expiry dates do not necessarily apply to all operators within the given country and spectrum frequency.



Russia
2017 – 2.1 GHz
Latvia
2016 – 900 / 1800 MHz
2017 – 2.1 GHz
Lithuania
2017 – 900 / 1800 MHz
Hungary
2019 – 2.1 GHz
Slovenia
2016 – 900 / 1800 MHz
Romania
2020 – 2.1 MHz
Albania
2016 – 900 / 1800 MHz
Greece
2016 – 1800 MHz
Malta
2020 – 2.1 GHz
Jordan
2015 – 900 MHz
Egypt
2020 – 900 MHz
Thailand
2015 – 900 MHz
2018 – 850 / 1800 MHz
(DTAC)
Malaysia
2016 – 2.6 GHz
2018 – 2.1 GHz
Vietnam
2016 – 850 MHz
2018 – 900 MHz
Indonesia
2016 – 2.1 GHz
Australia
2017 – 2.1 GHz

2 Importance of licence renewal

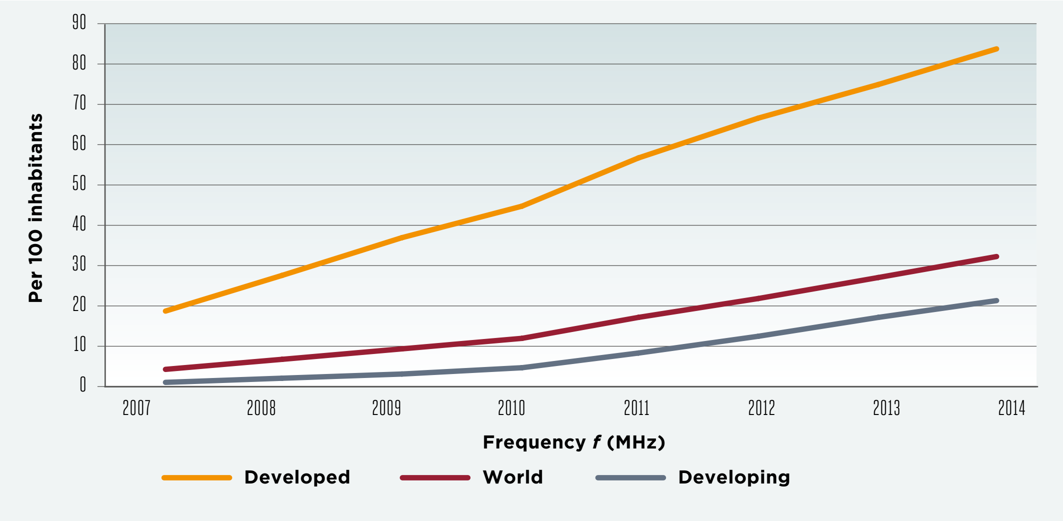
The mobile industry differs from most other industries in that the ongoing right to a critical input is often not guaranteed but subject to periodic reviews by authorities. In particular, many countries continue to license for finite periods the use of the spectrum that operators rely on to provide services. Depending on the approach taken to licence renewal, the consequence may be substantial uncertainty for operators and customers with harmful effects on investment, innovation, competition and efficiency.

Uncertainty over the future right to an important input would be damaging for any industry. The potential impact of uncertainty on the mobile industry is amplified by:

- **The high level of investment required over forthcoming years including for the capacity required by growing mobile broadband customer numbers, increasing data usage per customer, ongoing investment in extending coverage and upgrading networks for new technologies and services; and**
- **The long payback periods required to recoup substantial mobile network investments.**

The number of mobile broadband subscriptions is expected to reach 2.3 billion in 2014 with annual growth in developing countries of 26%, now more than twice the 11.5% rate in developed countries.

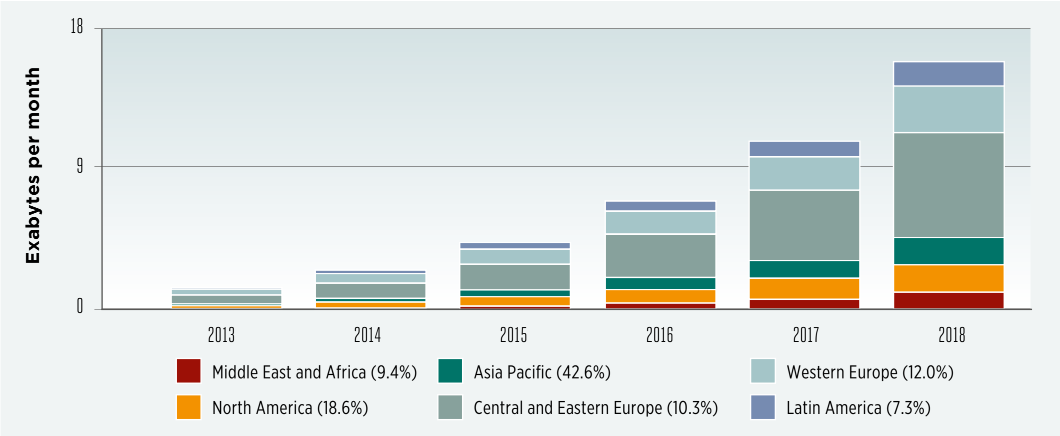
FIGURE 1 – GROWING MOBILE BROADBAND SUBSCRIPTIONS



Source: ITU World Telecommunication/ICT Indicators database (*2014 estimate)

Mobile subscribers are also using mobile data services more intensely and global data traffic is forecast to grow by more than 10-fold between 2013 and 2018 with large increases in all regions.

FIGURE 2 – RAPIDLY GROWING DATA TRAFFIC VOLUMES



Figures in parenthesis refer to regional share in 2018.
Source: Cisco VNI Mobile, 2014

Mobile operators are preparing to make the large investments required to provide the needed capacity and to extend coverage. The GSMA expects total global investment by mobile operators of US$1.7 trillion between 2014 and 2020. Ericsson forecasts that LTE coverage will grow from 10% of the world's population in 2012 to over 65% by 2019.[1]

Mobile telecommunications is a capital intensive business and requires certainty on the future environment in order for long term investment decisions to be made. Spectrum licences are one of the biggest financial commitments made by operators. Certainty on the continued renewal of these licences is a key prerequisite for operators to make the necessary investments to deliver the networks of the future.

Uncertainty of renewal in Colombia

The experience of licence renewal in Colombia highlights the extreme uncertainty that renewal processes can generate. The 850MHz and 1900MHz licences of Claro and Movistar, which had been renewed in 2004, were due to expire on 28 March 2014. In addition, a court ruling in 2013 provided for the Government to take control of network assets of the operators upon the expiry of their licences. The Government did issue a resolution providing for the licences to be renewed but only on 27 March 2014, i.e. one day before their expiry. The failure of the renewal decision to be made well in advance meant that the operators had to make business decisions without knowing whether they would soon lose access to their main spectrum assets and even their networks.

The lack of advanced notification of renewal also prevented the operators from being able to engage with the Government on the terms and conditions to be applied to the renewed licences. The new licences include significant new obligations and the possibility of restrictions on the marketing of services that apply only to Claro and Movistar and not their competitors. The licences also include a provision for economic consideration which introduces ongoing uncertainty. Consultation on the proposed conditions prior to renewal would have enabled the Government to take into account the operators' concerns over the risk posed by the conditions for competition and the development of the sector.

1 Ericsson Mobility Report, November 2013.

The forthcoming expiry of a spectrum licence can give rise to three key risks, each of which could lead to a range of negative effects on the sector and on consumers.

Risk from licence expiry	**Potential effects**
An operator loses access to all its spectrum rights	The complete loss of access to spectrum would leave an operator unable to supply its existing customers or recover the costs of its investments. Even the risk of losing its spectrum rights in the years leading up to expiry would reduce the expected returns of investment (i.e. returns discounted for the probability of non-renewal) and lead to some investments no longer taking place because their expected return is below the cost of capital. Investments to launch new services may be delayed. Operators will also be less likely to cut prices to grow market share if they are uncertain over whether they will be able to serve new customers for a long enough period to recover their acquisition costs. The time taken to re-assign the licence may lead to valuable spectrum being left idle.
An operator loses access to part of its spectrum rights	To manage the risk of losing part of their spectrum rights, operators may redirect investment to providing additional capacity rather than extending coverage, improving quality or deploying new services. If an operator is allowed to retain all its spectrum then this precautionary investment may prove wasteful. The risk of losing some spectrum may also deter an operator from competing more aggressively for customers or from launching new services so as to limit its future need for capacity.
Uncertainty over future terms and conditions	Expected returns to investment depend not only on whether a licence will be renewed but the terms and conditions of the new licence. Economic theory of the 'hold-up' problem shows that the risk that a party may decide to capture a greater share of the return on an investment once it has been made can lead to under-investment. Accordingly, expectations and uncertainty in relation to future licence fees carry significant risks of deterring new investment with consequences for service quality and the timing of access to new services.

In the next two sections, we discuss how licensing authorities can greatly reduce risks by their choice of renewal approach and by following a timely and open renewal process. In section 4, we focus on how authorities should set licence fees. Licence renewal not only carries risks but also creates the opportunity to move towards a more flexible, market-driven licensing approach. In section 5, we examine the case for relaxing restrictions in the use of spectrum. In section 6, we ask under what circumstances would it be sensible for authorities to use the expiry of a licence to seek to inject further competition into the mobile market. Finally, in section 7, we examine how the introduction of spectrum trading together with indefinite or long-duration licences can help maintain the efficient spectrum use over time while avoiding or minimising the risks of licence renewal.

3 General approaches to licence renewal

As an existing spectrum licence approaches the end of its term, should a licensing authority simply renew the licence or, if not, how should they go about determining how to assign the future rights to use the spectrum and on what terms?

The choice of renewal approach can impact multiple objectives

- **Ensuring service continuity for customers**
- **Encouraging ongoing investment and innovation in the industry**
- **Obtaining maximum benefits for society from the use of the spectrum**
- **Promoting effective competition in communication markets and ensuring competitive neutrality between spectrum users**
- **Providing revenues to government**
- **Consistency with the legitimate expectations of affected parties**
- **Achieving a timely, practical and cost effective renewal process**

The extent to which different objectives are affected will depend on the particular market context. In some cases, an authority may be forced to balance competing objectives. Often, however, unnecessary costs are imposed on the industry and consumers by authorities failing to establish a sound, overall framework by which to consider renewal decisions.

What approaches can be applied to licence renewal?

Three fundamental approaches have been applied by authorities to determine future rights to spectrum where existing licences are due to expire. These are:

- **A presumption of renewal** – current licence holders are allowed to renew their licences except under certain defined circumstances which are expected to arise relatively rarely;
- **Auctioning the future rights to the spectrum** – current holders and other potential users are invited to bid for the future rights to use the spectrum; and
- **Administrative re-assignment** – the licensing authority decides to reassign the rights to use the spectrum to another user.

A World Bank report noted in 2006 that presumption of renewal was the most common approach to renewal and it continues to be the approach of many countries. For example, spectrum licences in Canada have a high expectation of renewal, unless a breach of licence condition has occurred, a fundamental reallocation of spectrum to a new service is required or an overriding policy need arises. The US also provides a strong presumption of renewal, but subject to a requirement for the licensee to be providing 'substantial service' to the licence service area. A presumption of renewal can be considered equivalent to the use of indefinite licence terms, such as in the UK for spectrum used for mobile purposes, where the licences can only be revoked after a minimum period on spectrum management grounds and subject to a specified minimum notice period.

Balancing predictability and spectrum management in the UK

As part of its overall review of spectrum management in the UK, Ofcom decided that new licences awarded by auction should generally have an indefinite term and with an initial term in which licensees would have high security of tenure. The initial term would be set taking into account the expected period required for a reasonable return on the investment and was set at 20 years for the 4G licences auctioned in 2013. During the initial term, licences would only be able to be revoked for a narrow range of reasons including breach of licence conditions and non-payment of the licence fee. Beyond the initial term, licensees would continue to have the rights to use the spectrum unless Ofcom decides to revoke the licence on spectrum management grounds after giving 5 years notice.

Ofcom noted that the combination of indefinite licence terms together with the introduction of spectrum trading would best promote investment to enable the efficient use of spectrum and do so in a relatively simple and low cost way. While Ofcom considered that tradability and liberalisation should generally ensure spectrum was being used optimally, the right to revoke licences on spectrum management grounds was retained because of the risk of specific market failures such as coordination problems caused by high transaction costs where a new service requires gaining spectrum rights from multiple current licensees.

Even were licensing authorities to move towards the use of indefinite or long duration licences over time, they would still need to determine what approach to take to existing licences approaching the end of their terms. Auctions and administrative re-assignment are also used frequently and hence it is important to understand what benefits and costs they carry. In examining their relative merits, we also assess the use of hybrid approaches. For example, the Hong Kong Communications Authority decided to renew rights to a part of an operator's spectrum holdings while the other part of the spectrum is put up for auction or re-assignment. Other authorities, such as Singapore's IDA, have offered existing licensees a right of first refusal by which spectrum rights are only auctioned or re-assigned if the existing licensees decide not to renew the rights on the terms offered.

1 Ericsson Mobility Report, November 2013.

In deciding on the optimal approach, a licensing authority should be careful to identify the different effects that may result from alternative approaches and make an assessment of their likely magnitude in the particular market context. The approach that is best for one set of licences at one time may not be appropriate in a different context.

Approach	Advantages	Disadvantages
Presumption of renewal	■ High predictability supporting investment and the deployment of new services (including business planning and raising capital) ■ Ensures service continuity and minimises disruption to customers and operators ■ Supports ongoing competition ■ Can be used with spectrum trading to maintain efficient use of spectrum over time	■ In some cases, spectrum may be better re-assigned (eg spectrum replanning, serious breach of licence conditions, or spectrum being left idle or poorly utilized especially if trading is not allowed, or where there is the potential for significant gains in competition) ■ Switching to a presumption of renewal for already auctioned licences may raise concerns of unfair treatment of unsuccessful bidders ■ Regulator will need to determine the level of any spectrum fees
Re-auctioning	■ Transparent and efficient way to assign spectrum to highest value use particularly where there are competing demands for the use of the spectrum ■ A robust auction process enables fees to reflect the market value of spectrum ■ Ensures all operators and potential new entrants an equal opportunity to acquire the spectrum	■ Introduces uncertainty that can chill investment (risking congestion and delayed access to new services) and deter competition for customers until future rights are decided ■ Authorities need to ensure a robust auction design to avoid spectrum being assigned to parties (including speculators) that are unable to make best use of the spectrum ■ Uncertainty and cost of the auction may be imposed unnecessarily if spectrum always likely to go to licensees with existing networks ■ Auctions that result in high fees may come at the expense of competition in the mobile market either directly in auction design or later if market conditions leave players unviable ■ Customers may lose their existing service
Administrative re-assignment	■ Can be a practical way to re-allocate spectrum between uses ■ Can achieve a particular re-assignment of spectrum for competition reasons ■ Can avoid high spectrum fees of auctions and thereby better support operators' viability	■ Introduces uncertainty impacting investment and competition and can impose additional costs on customers losing existing service ■ Can be cumbersome, arbitrary, vulnerable to corruption and lead to long disputes ■ Licences may be assigned to the operator that presents an attractive proposal rather than the operator that generate the greatest benefits for society from the spectrum
Hybrid (part-automatic renewal and part re-assignment)	■ Attempts to balance achieving some predictability and some flexibility	■ Risk of same type of problems as auctioning/re-assignment although potentially moderated to some extent (eg service may continue but with degraded quality) ■ Potential costs in reconfiguring networks ■ Trading off predictability for flexibility would only be beneficial in some circumstances

Assessing renewal approaches in Hong Kong

Hong Kong's Communications Authority (CA) decided in November 2013 to adopt a hybrid approach under which a right of first refusal to existing licensees was offered for two thirds of the spectrum (19.8 MHz each) with the remaining spectrum to be re-auctioned.

After establishing that there was competing demand for the 3G spectrum, the CA assessed whether to re-auction some or all of the spectrum against four criteria.

- **Customer service continuity – modelling was undertaken for the CA and for operators including of potential impacts from loss of existing usage rights on voice call congestion, data download speeds and indoor coverage as well as the practicality and cost of mitigation measures.**
- **Efficient spectrum utilisation – the CA considered that auctioning at least some of the spectrum would promote efficient spectrum use by enabling spectrum to be re-assigned to a higher value use, encouraging existing licensees to review their spectrum use and by enabling an operator to gain a sufficiently large holding to optimise the use of LTE technology.**
- **Effective competition – the CA particularly noted that an auction would provide an opportunity for new entry.**
- **Encouraging investment and innovative services – a number of effects were raised including potential investment of new entrants, incumbents upgrading their networks, realising the full potential of LTE to offer innovative services and, on the other hand, investment being deterred by the uncertainty of the process.**

The CA concluded that a hybrid approach was best overall because it would provide benefits to efficient spectrum utilisation, competition, investment and innovation while the risks in terms of existing services could be managed. The operators believed that the CA had overstated the potential benefits, particularly given the high levels of utilisation of the spectrum and competition in Hong Kong, while it had underestimated the likely harm to service continuity.
While the optimal approach in other markets will depend on the magnitude of the different effects in those markets, the analysis undertaken for the process in Hong Kong shows the range of issues that may need to be considered in deciding future rights to spectrum.

When should a licence not be renewed?

While a decision to not renew some or all of an operator's spectrum rights can give rise to significant costs and risks, in some circumstances reallocating spectrum may result in overall net benefits. There are four type of circumstances where reallocation or reassignment has the potential to lead to net benefits although whether it would be likely to and whether there might be better alternatives would need to be assessed in the specific market context.

Spectrum replanning

Many countries provide for licences to not be renewed where continuing the current use of the spectrum would be incompatible with the planned use of spectrum. The impetus for a change in use of the spectrum may arise from international radiofrequency planning and coordination or from national decisions. Such a provision can be an important means to enable new

1 Ericsson Mobility Report, November 2013.

technology platforms to be introduced particularly where spectrum management continues to be centrally planned. For example, the change from analogue to digital broadcasting greatly reduces the amount of spectrum needed to supply broadcast content which can free up spectrum for use for other services. The relatively low frequency band of this Digitial Dividend spectrum makes it a key means by which societies can achieve widespread coverage for LTE services.

While spectrum replanning may be necessary to support efficient use of the spectrum on an ongoing basis, it is important that the benefits of different uses are carefully assessed and that where a change in use is contemplated, the cost of migrating or terminating the current use is taken into account. Further, spectrum plans should be announced as early as possible to give existing users sufficient notice. Finally, the need for regulatory-imposed spectrum replanning can be reduced by providing existing licensees with greater flexibility over the services for which the spectrum is used.

Poor use of spectrum

A licence may not be renewed where the existing licence holder is considered not to be making the best use of spectrum. Such a provision is often put forward as a means by which to guard against valuable spectrum being left idle or underutilised. While such provisions are reasonable in principle, there is a risk of error where a regulator seeks to assess whether spectrum is being poorly used. For instance, there may be sound economic reasons as to why spectrum is left idle for a period such as when new technology or equipment is expected to become available shortly. In that regard, a regulatory requirement to demonstrate substantial service may encourage operators to behave inefficiently such as by undertaking investments prematurely so as to avoid losing the spectrum.

Breach of licence conditions

Where the licence conditions are made clear at the time of the initial assignment of the licence, then not renewing the licence has been used in response to a breach of a condition. In some cases, a current licence may be revoked before the end of its term such as where the licensee continually breaches the licence's technical conditions causing intolerable interference to other uses.

Given the serious disruption to consumers and risks to investment, non-renewal or revocation of a licence should be used as a last resort. Determining proportionate responses to breaches of licence conditions can raise difficulties for regulators including the importance of fairness to other operators and to bidders who were unsuccessful in acquiring the original licence. Keeping licence conditions to the minimum necessary to manage interference can help avoid these issues arising in the first place.

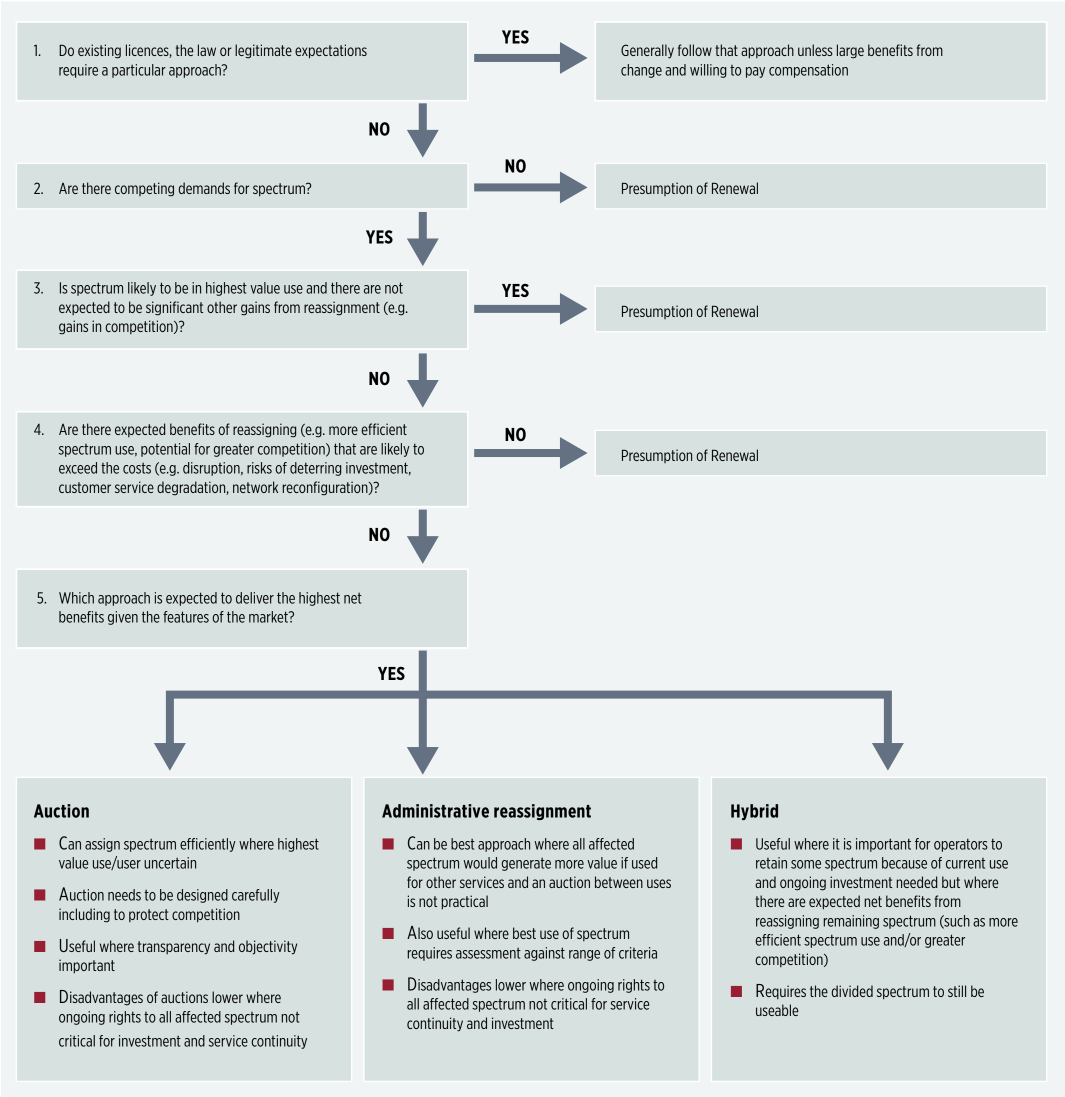
Risk of non-renewal of a licence in Kenya

Kenya's Ministry of ICT had to reassure consumers in May 2014 that Safaricom's licence would be renewed after concerns arose that the renewal might not take place because certain quality of service targets had been missed. There appears to have been issues with both the reliability of the quality of service measures and to the extent the operator was constrained by factors outside its control including limited access to spectrum and whether the high level of licence fees had diverted funds from network investment. Safaricom's licence was successfully renewed in June 2014.

Promoting competition

Another reason that has been used by some regulators for not renewing spectrum licences is where reassigning spectrum is used as a means of promoting competition. We assess the case for doing so in Section 6.

RECOMMENDED FRAMEWORK FOR CHOOSING THE RENEWAL APPROACH



The best renewal approach will depend on both the particular features of the market as well as the weight the authority attaches to competing policy objectives. There is a strong case for providing a presumption of renewal where spectrum is already likely to be in its highest value use, where there is effective competition in the mobile market, where high levels of ongoing investment are needed and where the removal of some spectrum would result in costly disruption and/or harm service quality.

At the other extreme, where spectrum is currently idle or poorly utilised or has been freed up by technological change and there are alternative valuable uses for the spectrum, then the authority may want to consider auctioning the spectrum or reassigning it. Auctions can be efficient and transparent means of assigning the spectrum to the highest value use although they do carry some costs and risks particularly where poorly designed. Administrative re-assignment may be more cost effective where there is a clear, highest value use for the spectrum but this approach is vulnerable to bias or misuse and can lead to protracted disputes.

Hybrid approaches may appear attractive where there is a clear ongoing need for spectrum by the existing licensees but where the regulator believes that there is the potential for substantial gains from re-assigning some spectrum. However, even the risk of re-assignment of some spectrum can create significant costs including in terms of distortions to investment and competition. Accordingly, whether a hybrid approach should be adopted will require a careful assessment of the likely benefits and costs.

Whichever the ultimate choice of approach, there are elements of good practice that can help ensure the decision is soundly based.

- **It is particularly important for authorities to ensure that all available spectrum is released. The release of spectrum help reduce costs and consumer prices, supports competition and minimises any need to take spectrum rights off existing operators.**
- **Choosing between approaches requires identifying the relevant trade-offs specific to that market context. An open, transparent process provides for all affected parties to present evidence on the likely effects and their magnitude. We return to this point in the next section.**
- **The detailed design of the approach matters. The conceptual advantages of any of the approaches can be lost or unnecessarily costs imposed if there are flaws in the process. For example, coordination during auctions may lead to spectrum being assigned on the basis of the ability to gain market power rather than by which operator can best deliver value to consumers. The apparent simplicity of administrative reassignment may not be realised if it results in drawn out litigation. Again, consultation over the design of the approach can help minimise these risks.**

4 A predictable, timely and open relicensing process

While the forthcoming expiry of a licence carries significant risks, the risks can be minimised by authorities adopting a process that follows a number of key principles of best practice. These principles help to avoid unnecessary costs and support more robust decision-making.

Predictability

Minimising uncertainty helps promote investment and efficient business decisions. There is no reason for authorities to delay setting out the overall framework that will applied to licence renewal, even if the implementation of that framework occurs later. In particular, authorities should specify the approach that will be applied to renewal such as whether there will be a presumption of renewal or, under what circumstances, a licence will not be renewed. The framework should also provide information on the terms and conditions that will apply to renewed licences including how licence fees will be determined and whether any existing restrictions or obligations will be removed. In the event that a licence is not renewed, a minimum period should also be provided for the spectrum to be vacated and what compensation would be paid in the event that of a conflict with operators' legitimate expectations.

Operators can also make better decisions as to whether to renew their rights to spectrum if they have good information on the country's overall spectrum plan, including the current assignment of spectrum rights, and a roadmap of planned future releases of spectrum and the introduction of spectrum trading and liberalisation.

A timely decision

The earlier renewal takes place before the date of licence expiry, the lower the risk of investment being reduced or postponed because of uncertainty over the period over which the operator will be able to recover the costs of the investment. A decision to renew the licence should be made at least four to five years before the current licence expires.

Consultation

Determining the best approach is likely to require identifying and weighing up benefits and costs to different industry players and customers for which their input is essential. In Singapore, the Info-communications Development Authority decided to switch from a proposed auction to grant incumbent mobile operators "first rights of refusal" after taking into account information provided during the consultation process on the risks of an auction in disrupting services to customers and increased costs to operators. Setting out the reasons for decisions and providing a right of appeal can also improve the quality of decisions by protecting the rights of affected parties and ensuring decisions are reasonably based.

5 Charges for spectrum licences

What factors should licensing authorities take into account in setting fees for spectrum licences and what approaches exist to determining the appropriate level of fees?

Key considerations in setting licence fees

Efficiency is promoted by prices reflecting costs including the opportunity cost of a resource being used for one purpose rather than in a different use.

Spectrum management does create administrative costs while benefitting spectrum users and it is reasonable that spectrum fees contribute to the recovery of an efficient level of these costs. Where there is excess demand for a particular spectrum band, spectrum prices above administrative costs and reflecting opportunity costs can help ensure that spectrum is assigned to the user that is able to generate the most value to society from its use. For example, in an auction the user with the highest valuation could win the licence by bidding slightly above what the user with the second highest valuation would be prepared to bid for the licence. Thus an auction can lead to the efficient allocation of spectrum with a price being paid for the licence based on the value of the licence in the second best use (which is the opportunity cost of the spectrum being assigned to the highest value use rather than the next best use). Similarly, spectrum trading can promote the efficient allocation of spectrum as the user who can generate the highest value from the spectrum can be expected to buy spectrum from other users by paying them a price at least as high as the value of the spectrum to them. Thus, market-based prices for spectrum will reflect the opportunity cost created by spectrum being assigned to one use.

Where a spectrum licence is to be renewed administratively (rather than by an auction) then the authority may seek to match the efficiency of market-based prices by setting a fee for the spectrum that reflects the opportunity cost of the use of the spectrum. Where there is not excess demand for the spectrum band, then the opportunity cost of the spectrum will be zero. Later in this section, we discuss how an authority can estimate the opportunity cost of spectrum where there is excess demand for the band.

Governments may, however, seek to go beyond an efficient level of charges by using licence fees to raise revenues. If a Government set charges at a very high level, then valuable spectrum may be left idle. For example, in the Digital Dividend auction in Australia in 2013 the level of reserve prices set by the Government led to one of the three Australian mobile operators withdrawing before the auction and 30 MHz of spectrum in the 700 MHz band being left unsold. The consequence is that this spectrum is not being used to supply services to consumers (potentially leading to higher priced and less competitively offered 4G services) and the Government failed to obtain revenues from the spectrum that may have been able to be sold if available at a lower price.

Even where operators are prepared to pay the licence fee, a high fee level can have harmful effects. High spectrum charges may mean that fewer operators are viable so that competition is lessened and prices to customers higher. A concentrated market may be the immediate result of the high spectrum charges or it may come about in time as operators with high debt levels will be more vulnerable to adverse changes in market conditions. High debt levels may also impair operators' abilities to raise capital at reasonable rates and hold back the level of investment in network rollout and service deployment. This would limit the contribution of the sector in boosting overall economic growth. High spectrum fees may even be counter-productive as a source of government revenue if lower economic growth leads to less general government revenue.

A government may be tempted to set higher renewal fees where it believes operators are currently profitable. However, it is important to recognise that where investments are risky, operators must have the opportunity to earn a particular level of returns if the investment succeeds to compensate for the risk of not receiving back their cost of capital if the investment does not succeed. Specifically, firms will only undertake risky investments if their expected return taking into account the probability of the investment not succeeding is greater than the cost of capital.[2]

Many entrants to mobile markets have not succeeded at a significant cost to their investors. If a government seeks to expropriate a significant share of the returns on the investments that have succeeded, then operators will be less likely to undertake risky investments in the future. There is a substantial economic literature on the hold-up problem in which one party is able to intervene after an investment has taken place to capture the return of the investment of another party where their investment requires significant sunk costs so that it cannot simply be recovered by redeploying the assets elsewhere. This literature shows that unless the parties can commit in advance as to how the future prices will be determined (such as a licence renewal fee that does not expropriate the return required to cover the cost of capital and compensate for risk) then the efficient level of investment will not take place.

Regulators concerned about maintaining investment incentives might still end up harming investment simply because of the inherent difficulty in accurately estimating efficient spectrum charges. The value of a band of spectrum is highly sensitive to market conditions that can change over time and vary significantly between countries. Given the risks of investment being deterred or even valuable spectrum being left idle, regulators should set spectrum charges conservatively. Over the time, the establishment of effective spectrum trading can ensure the efficient use of spectrum without the need for spectrum charges beyond the recovery of administrative costs. Indeed, as we discuss in Section 7, the continuation of significant administratively-determined spectrum charges would create a barrier to efficiency-enhancing spectrum trading because of the uncertainty introduced for potential buyers of spectrum.

Approaches to determining the level of spectrum charges

As discussed above, efficient spectrum charges will recover the administrative cost of spectrum management and, where there is excess demand for spectrum, reflect the opportunity cost of spectrum. There are a number of approaches by which authorities can estimate the efficient level of charges.

Re-auctioning

Auctioning of spectrum provides the most transparent and direct way of determining the market or efficient price for spectrum. As explained in Section 2, auctions can be particularly useful if there are a number of competing demands for the spectrum and it is unclear to which use and user the spectrum should be assigned so as to generate the highest value. However, in many cases there will be a clear best use of the spectrum and auctioning it may simply incur unnecessary costs. Flaws in the auction design may also lead to prices sometimes not supporting the efficient allocation and use of spectrum. In March 2013, the Czech regulator intervened to cancel the 4G auction taking place because of the level of bids being made. The CTU Chairman stated: *"Such high prices of the auctioned frequencies would have had a negative impact in the form of exorbitant rates for mobile broadband. We therefore consider it necessary to step in and prevent future negative consequences for consumers."*

2 For example, consider an operator that is considering making an investment of $500m, with a cost of capital of 10% and a 20% risk of the investment failing with the consequence that they lose their full investment. The operator will need to earn back $687.5m on the investment if it succeeds for this investment to have an expected return of 10% (i.e. 0.8*$687.5m + 0.2*$0m = $550m). However, if an operator expects the government to effectively expropriate any earnings above $550m in the successful case then the expected earnings will fall to $440m (i.e. 0.8*$550m), i.e. the operator would expect to lose money on the investment and not undertake it.

Even where spectrum is to be auctioned, licensing authorities may wish to estimate the value of the spectrum to help in determining what reserve price to set. Reserve prices in auctions help discourage non-serious bidders and can provide a floor price for spectrum in case competition for the licences is weak. However, reserve prices should be set conservatively rather than to try to match the expected market price. An auction will fail if the reserve price is set even slightly above the market value, which would lead to unnecessary administration costs and may harm consumers by creating a delay before the spectrum can be re-assigned for use at some later date.

Share of revenue

Annual charges levied on the basis of revenues or profits can be a way for the government to share risks with operators. This can support new entry and promote greater competition. However, it can lead to inefficient spectrum use as smaller players will not necessarily bear the actual opportunity cost of the spectrum. Royalties that vary with service volumes or revenues may also increase service prices and distort business decisions and investment. Higher fees for a more successful or more efficient operator effectively penalises success and can discourage efforts to improve efficiency or compete more aggressively. Where annual charges are to be imposed in addition to the spectrum being auctioned then for both efficiency and fairness, the charges or at least the methodology to be applied in determining the charges, should be established prior to the auction.

Modelling the marginal opportunity cost of the spectrum

A number of regulators have sought to estimate the opportunity cost of a spectrum band directly. More spectrum assigned to one operator leads to less spectrum for other operators. One approach to estimate the opportunity cost of spectrum is based on the premise that if a mobile operator loses access to a marginal increment of spectrum then it would need more base stations (and other inputs) to maintain the same volume of services and service quality. The operator should value that increment of spectrum (i.e. be prepared to pay for it) an amount equal to the additional network costs the operator incurs from being deprived of it. Thus the marginal opportunity cost of spectrum can be estimated by modelling how a network's costs would change with and without additional spectrum while maintaining the same quantity and quality of services. Where a change in an increment of spectrum would affect both revenues and costs then it may be necessary to model how the present value of cash flows would be affected by access to that spectrum.

Spectrum charges based on the estimated opportunity cost of spectrum can promote efficient spectrum use as an operator should only hold the amount of spectrum for which they are able to generate a greater value than that spectrum would provide to another operator, i.e. in terms of savings on network costs. However, the actual modelling of the opportunity cost is dependent on a host of assumptions with consequent uncertainty over the actual level. Choosing a conservative value from within the estimated range can reduce the risk of some spectrum being returned and left idle.

Benchmarking

Benchmarking can be used to estimate the market value of spectrum on the basis of prices determined in recent auctions and spectrum trades or by indexing forward past auction prices. The accuracy of benchmarking will depend on whether there exist efficient market prices for spectrum that would be expected to have a comparable value to the band being benchmarked or if robust adjustments can be made to account for differences in demand and supply factors impacting on the spectrum value. Later in this section, we identify the range of factors that can cause differences in the value of spectrum bands. Changes in these factors should also be taken into account if current market values are to be estimated on the basis of indexing forward past prices.

Pricing Approaches	Advantages	Disadvantages
Prices set to recover administrative costs of spectrum management	Appropriate where there is no excess demand for spectrum	May not lead to efficient spectrum use where there is excess demand for the spectrum and where spectrum assignment is not market based
Auction	Can provide a transparent and objective way to set prices that support efficient spectrum use	Auction prices may not be efficient if there are flaws in the design (such as excessive prices if auction does not lead to effective downstream competition or prices too low if there is coordination between bidders). Changes in market conditions may mean that auction prices turn out to have been too high with the risk that existing operators prove unviable and exit
Share of revenue	Shares risk between government and operator and can promote new entry	Can lead to inefficient spectrum use and increase service prices
Estimate incremental value of spectrum	Provides a direct estimate of the value of an increment of spectrum	Requires modelling based on assumptions with significant risk of error and danger of some spectrum being left idle - this risk can be reduced by setting prices conservatively
Benchmarking	Simple and transparent where close benchmarks exist	Will be inaccurate if the analysis does not fully account for differences in factors impacting on market value

Factors affecting spectrum value

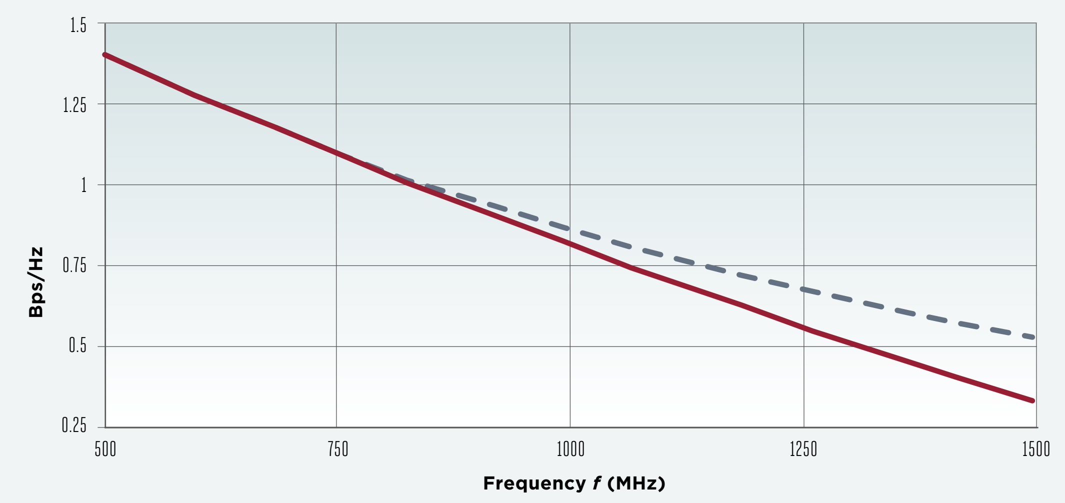
In setting spectrum fees and in setting reserve prices in auctions, licensing authorities often have regard to prices for spectrum set in auctions that have been achieved historically or in other countries. As noted above, it is important for a regulator to set prices conservatively (i.e. at a discount to their best estimate of the market value) because the uncertainty over actual market value implies a significant risk of error with the danger that valuable spectrum may not be put into use in delivering services for a protracted period.

The value of spectrum can differ significantly between countries or even over time in the same country because of a host of factors. In any benchmarking exercise, it is important that authorities consider whether a proposed benchmark is actually comparable or whether it is possible to make adjustments for the relevant differences. Such benchmarking exercises need to be carried out carefully and often prove highly contentious.

1. Characteristics of the spectrum

Lower spectrum bands have better signal propagation allowing for fewer sites to be needed to cover a given area and can provide for better in-building coverage. The need for fewer sites (and hence lower network costs) together with better service quality tends to make spectrum at a lower frequency bands more valuable than at a higher bands. The extent to which lower frequency bands provide benefits over higher frequency band will vary with the characteristics of the market to be served as well as being impacted by the other factors identified in this section. For example, the network cost disadvantage of higher frequencies is a greater issue in rural areas where sites are built predominantly for coverage reasons.

FIGURE 3 - VALUE OF SPECTRUM AS A FUNCTION OF FREQUENCY COMPARING MODELLED VALUATION FOR RURAL DEPLOYMENT WITH AUCTION PRICES FOR AREAS WITH A RANGE OF POPULATION DENSITIES



Source: Peha, J.M., "Updating the spectrum screen", Comment provided to FCC in Policies Regarding Mobile Spectrum Holdings The State of Mobile Wireless Competition, 2012.

When a particular band is harmonised internationally for use for a specific service, equipment suppliers are able to achieve much greater scale economies in producing network equipment and devices for use with that band. This can also lead to significant savings in network costs and in the value of the band to operators compared with other bands that are not harmonised internationally.

The amount of spectrum available that is suitable for particular services can also lead to differences between countries and over time. The greater the availability of substitutable spectrum, the less critical it will be for an operator to acquire a particular band of spectrum.

Operators with relatively small spectrum holdings will need to incur much higher network costs (such as by splitting cells) to provide the same capacity as an operator with larger spectrum holdings. Countries that have released more spectrum can reduce the cost of service provision and support a larger number of competitors. Small spectrum holdings can also impair the quality of the service, such as slower speeds for LTE. The services that can be supported by a particular spectrum assignment will depend on technology and hence the value of that spectrum can change over time as technology changes.

2. Cash flows of the downstream services

Operators acquire spectrum as an input to the supply of downstream services such as mobile voice and data services. The more profitable the supply of the downstream services, the higher the value that will be attached to acquiring a licence to be able to supply those services. The acquisition of spectrum can affect both future revenues and costs.

The size of the population in the coverage area will determine the potential customer base and auction prices are often compared on a per MHz per head of population basis to account for differences in population between licence areas. National income levels will influence the percentage of the population that takes up the service and the extent to which they use those services. The expected level of competition in the downstream market will also affect expected Average Revenue per User and thereby lead to differences between markets in the value of spectrum.

The higher the cost of supplying services in a country, the less valuable will be the licences (holding other factors constant). Costs will be higher the more that the population is spread out over a larger coverage area. Geographic terrain and planning regulations can also lead to differences in network costs. The profitability of the downstream services will also depend on the cost of other inputs. While some inputs will be sourced internationally, others will depend on local conditions. High taxes and any annual licence fees will also raise costs and reduce how much operators are prepared to bid for licences.

3. Terms and conditions of the licence and the award process

The value of the licence to an operator will be affected by its specific terms and conditions including its duration, upfront or instalment payments, any restrictions on the use of the spectrum and any obligations attached to it such as coverage obligations or providing access to other operators or MVNOs.

The auction design itself can also affect the auction prices. For example, spectrum caps or the reservation of some spectrum for new entrants may prevent an existing operator from being able to bid for some of the spectrum being offered. Reserved prices may lead to spectrum being sold at above its opportunity cost (i.e. where its value in the next highest use is below the reserve price). Sealed bid and multiple round ascending price auctions can also lead to different prices even when the underlying market factors are similar.

4. Summary on benchmarking factors

While benchmarking can provide useful information, it is important to identify the range of factors that may cause differences in value and consider their significance in relation to the specific data. It is also important to take into account the interrelationships between the factors as an adjustment that is appropriate in one context may be inaccurate in another because of such interrelationships. Econometric analysis enables the impact of multiple factors to be considered simultaneously and thus can help support more accurate benchmarking where there is a sufficient data set.

6 Enabling flexible spectrum use

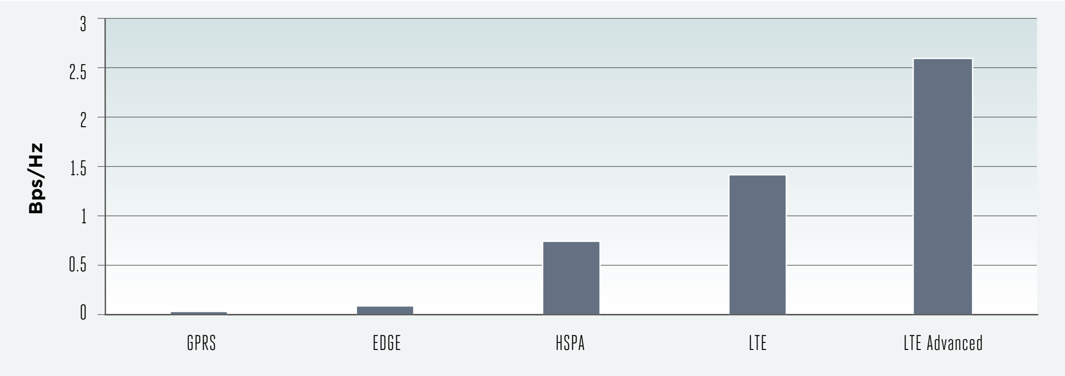
For society to gain the maximum value from its spectrum resources, licence holders need to have the incentive and opportunity to put spectrum to its most productive use. Licensing authorities play an important role in supporting efficient spectrum use through managing potential interference between competing users as well as facilitating international harmonisation of the use of specific spectrum bands. However, many authorities have gone further by imposing restrictions on the use of spectrum beyond those necessary for interference management. In markets as dynamic as modern communications markets with new technologies becoming available and shifting consumer preferences, restrictions on the use of spectrum can prevent the best use of scarce spectrum and delay investment in new services. Licensing authorities should support greater flexibility for spectrum users by relaxing restrictions on existing licences and limiting conditions imposed on renewed licences.

Technology neutrality and change of use

The traditional command-and-control approach to spectrum management tightly restricts the use of specific spectrum bands to particular services and particular technologies. This worked reasonably well where there was a clear best use for the spectrum band and sufficient spectrum available to meet demand. However, usage restrictions have not kept pace with changes in technology and demand. Such restrictions can exacerbate spectrum scarcity by restricting what spectrum is available for the most valuable uses and by preventing the introduction of new technologies that utilise spectrum more efficiently to provide greater capacity to meet rapidly growing demand.

An increasing number of countries have moved towards allowing more flexible use of spectrum. Technology neutrality allows for the use of any compatible, non-interfering technology in any frequency band. Technology neutrality has been used to enable mobile operators to refarm their existing spectrum assignments for use with newer technologies. In particular, operators have been permitted to replace 2G GSM technology with third-generation (UMTS) technology and fourth generation (LTE) technology. By allowing spectrum to be refarmed for use with newer mobile technologies, authorities can support increased throughput, higher download and upload speeds, lower service costs and better coverage compared with limiting new technology deployment to higher frequency bands.

FIGURE 4 - NEW TECHNOLOGY BRINGS LARGE GAINS IN SPECTRAL EFFICIENCY (DOWNLINK CAPACITY FOR 2X10MHZ)



Source: FCC, National Broadband Plan, 2009 and LTE Advanced projected capacity from Rysavy Research, The 3GPP wireless evolution, August 2013.

While the benefits of refarming and more generally of liberalisation can be substantial, authorities do need to consider a number of implementation issues.

- **Interference issues will continue to require careful management. There is now significant practical experience in addition to technical studies as to the implementation of refarming and liberalisation without causing harmful interference. More generally, the IMT technologies (GSM/GPRS/EDGE/UMTS/HSPA/LTE) have been standardised based on criteria for technical co-existence and backward compatibility.**
- **Operators will need to maintain continuity for current services while freeing up spectrum for the introduction of new technologies. The more spectrum available for operators, the lower the costs and the faster the likely transition period.**
- **There may be a need to manage liberalisation in a way that protects current competition such as by releasing additional spectrum or redistributing existing spectrum if effective competition would otherwise be undermined and the measures can be implemented in a cost effective way.**

Minimum 20-year terms for new licences

The longer the duration of renewed licences, the greater certainty provided to support new investment in rolling out networks and deploying new technologies and services. On the basis of the expected payback period for substantial new network investments, many countries including Canada, New Zealand and the UK have decided to provide for a minimum term of 20 years for new mobile licences and the European Parliament has proposed 25-year terms. In other countries, such as the US, investment is supported by a strong presumption of renewal.

Longer licence terms both support and are supported by a move towards a more market-based approach to spectrum management. With longer licence terms, operators will have the certainty to take advantage of increased flexibility to introduce new technologies and be more willing to trade spectrum with the consequence of promoting efficient spectrum use over time. The risk that a long licence term may lead to spectrum being locked into an inefficient use is much less likely where licensees are allowed to change the use of the spectrum themselves or to sell the rights of use to a party that could make better use of the spectrum.

Consider alternative approaches to achieve other policy objectives

Obligations are often attached to spectrum licences with the aim of achieving particular policy objectives such as widespread coverage, universal access to services or to ensure the spectrum is actually put to use.[3] However, such obligations can often result in greater costs than benefits. For example, in competitive markets, operators themselves will face incentives to secure early and widespread access to their services to make a commercial return. In some cases, however, there will be sound reasons for delaying rollout such as if an improved technology is about to become available or where an entrant is experiencing short-term cashflow problems. An obligation to continue with the rollout may lead to inefficient outcomes or exacerbate financial difficulties for the entrant.

The release of additional spectrum and allowing for new technologies to be used at lower frequency bands may be able to achieve coverage objectives at lower costs and without the need for a restrictive licence obligation. Government funding can also be used to target the extension of coverage to specific areas without putting at risk an operator's continuing licence. The higher licence fees that would be achieved by auctioning a less restrictive licence can provide the revenues to cover such funding. If, after reviewing alternative options, a licensing authority believes that a coverage obligation would still be required, the authority should consider the most efficient way to implement such an obligation. For example, coverage objectives could be achieved at lower cost by attaching the obligation to one licence rather than all licences and thereby avoiding the need for multiple networks to be built in uneconomic areas. Any coverage obligation should also be limited to lower frequency bands which are better suited to providing wide area coverage.

4 This latter reason of ensuring the spectrum is used rather than hoarded would not be relevant in most renewal cases as operators will already be able to demonstrate their use of the spectrum.

7 Licence renewal and competition

The upcoming expiry of a licence may be taken by the licensing authority as an opportunity to consider whether measures should be taken to boost competition in the market.

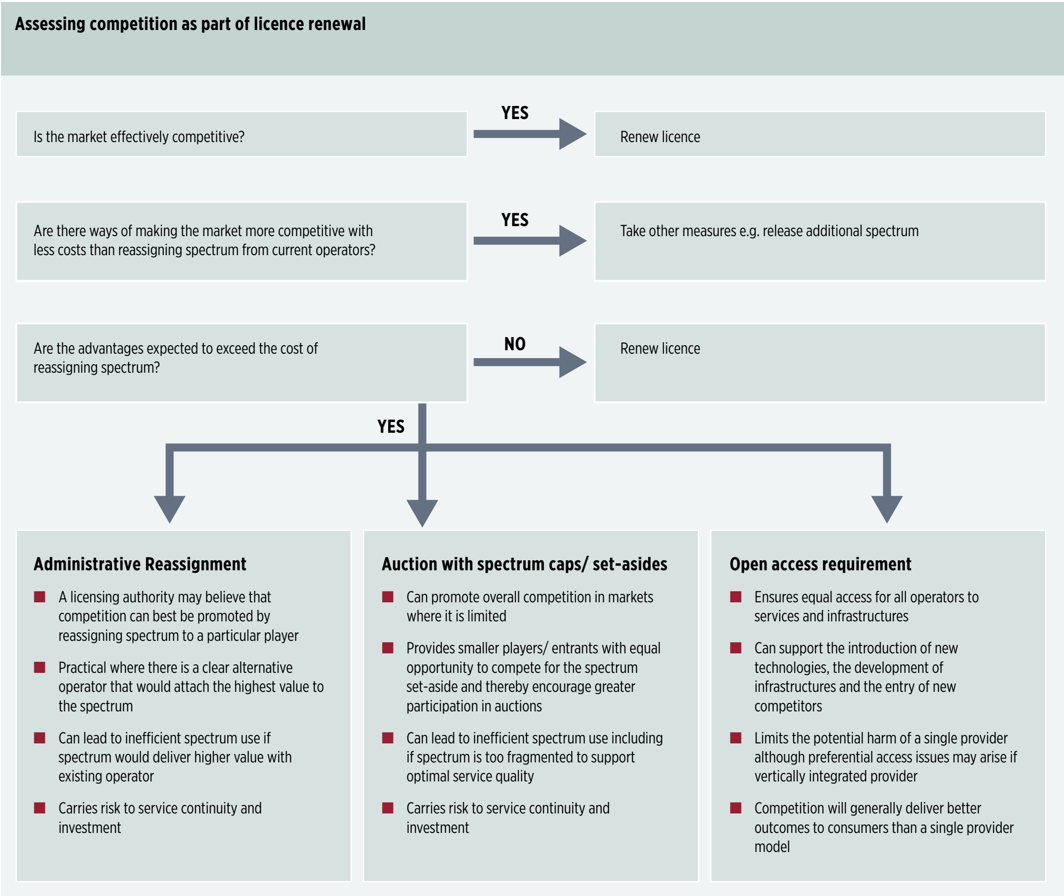
Measures to increase competition only make sense where competition is not already effective in a market and where additional players would be viable or where a smaller player could make efficient use of additional spectrum. Competition authorities such as the European Commission in a number of merger decisions have found that effective competition in mobile markets is consistent with 3 to 4 network operators together with a number of service providers. Re-assigning spectrum to additional players in such markets may lead to operators being unable to fully realise scale economies and consequent higher prices for consumers.

Consideration should also be given to whether there are alternative ways to promote competition that do not carry the risks to service continuity and investment of re-assigning spectrum. For example, reducing mobile-specific taxes and licence fees may improve the viability of all players in the market while there could be the potential for additional spectrum to be made available for mobile services. Such measures would also protect the incentive for operators to compete which may be weakened if successful operators are expected to be penalised by having their spectrum rights re-assigned to players that have failed to attract as many customers.

Where an authority does decide to re-assign spectrum either administratively or through an auction, the authority should assess the expected benefits and costs of reassigning different amounts of spectrum. The more spectrum that an existing operator is required to release, the more likely it is that the operator will need to turn to costlier solutions to try to retain sufficient capacity to serve existing customers and the greater the risk that service quality will suffer. On the other hand, an entrant with a relatively small customer base would not be expected to need the same capacity as a larger player. Spectrum caps and the amount of any spectrum set aside for new entrants should be carefully determined so that all operators can deploy networks in a technically and economically efficient manner. Further, before such caps and set-asides are applied, authorities should undertake a rigorous market analysis to ensure that there are in fact players or potential new entrants who can make efficient use of the spectrum.

An alternative means of promoting competition is to require or allow the spectrum licence holder to provide wholesale access to its services to other operators and service providers. Shared use of a network can avoid costly duplication, make it economic to extend coverage in rural areas and provide additional capacity in congested areas where space for sites and towers is limited. Depending on the form of sharing and the market circumstances, sharing can lower the cost of service provision while maintaining the ability for operators to compete with differentiated services. However, where competition is viable, consumer outcomes are likely to be better where there are competing networks rather than a single provider. Further, where an authority requires a provider to provide access to other operators and service providers it may be called upon to determine issues that it is not well placed to address such as over the pace and direction of technology upgrades, how scarce capacity is to be allocated between access seekers and the reasonable level of charges for access. Thus, regulatory imposed sharing requirements carry significant risks of errors and of investment being deterred or mis-directed.

ASSESSING COMPETITION AS PART OF LICENCE RENEWAL



8 Spectrum trading

Allowing the spectrum rights provided in new and renewed licences to be sold between operators is an important way by which to maintain the efficient use of spectrum over time. In particular, trading allows for spectrum rights to be exchanged between an operator that is under-utilising the spectrum and an operator that can generate greater value from the use of those rights. In being voluntary, spectrum trading enables the parties that have the best information as to the value that they can generate from the spectrum to determine whether a specific trade would be value enhancing (i.e. a buyer will only acquire the rights if they are prepared to pay a price at least equal to the seller's valuation of the spectrum).

In helping to reduce spectrum shortages faced by some operators while ensuring valuable spectrum does not lie fallow, trading can allow for a country's spectrum resources to be used more intensely supporting higher volumes of services, increased service quality and lower costs of service provision. Voluntary trading also reduces risks for operators as players will be able to sell rights that they turn out not to need while having the potential to acquire new rights as they grow.

There is growing experience with spectrum trading globally including in Australia, Canada, Europe, Guatemala, New Zealand and the USA. This experience highlights that certain measures can help facilitate trading in the interests of consumers.

- **Trading is more likely to take place where there is substantial available spectrum and where there is high degree of predictability including in relation to future spectrum availability, the regulatory and policy framework that will apply to licensees and where licences have sufficiently long terms for the buyer of the rights to undertake investments to make use of the spectrum. Spectrum trading is made difficult where decisions about whether licences are to be renewed and the conditions that will be attached to the new licences are made close to the expiry date of the existing licences.**
- **Authorities should be notified of the trades taking place so that it is transparent which entities hold spectrum usage rights. Information on current spectrum holdings can also facilitate future spectrum trades.**
- **Notification also enables authorities to assess whether a proposed trade would create any risks to competition. Spectrum trading could be subject to competition law or to specific ex ante competition assessments.**
- **While some authorities have been concerned that spectrum trading may lead to windfall gains, it should be recognised that it is the potential for gains that creates the incentive for efficient spectrum trades to take place. Further, while some operators may make gains, there are other operators that have incurred significant losses in acquiring spectrum. Accordingly, a gain may actually be a return on the risks incurred. There is no reason to tax gains from spectrum sales any more than gains from the sales of other business assets.**

Given the opportunity for significant gains to the development and flexibility of the industry, there is a strong case for countries to establish a regulatory framework that supports voluntary spectrum trading.

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Spectrum

Best practice in mobile spectrum licensing

September 2016

The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with more than 250 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and Internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces industry-leading events such as Mobile World Congress, Mobile World Congress Shanghai and the Mobile 360 Series conferences.

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Contents

Summary

Mobile services are the main means of communications for the majority of the world's population, supporting economic growth and connecting communities. Effective spectrum licensing is critical to support the investment required to further expand mobile access, meet the rapid increase in demand particularly for data services and enhance the quality and range of services offered.

Realising the consumer and business benefits of mobile services will require licensing frameworks which:

- **ensure operators have access to sufficient spectrum;**
- **provide predictability to support the new network investment needed; and**
- **avoid costly restrictions on the use of spectrum beyond those needed to manage interference.**

The World Bank has noted that around 2 GHz of total spectrum will be needed in major markets for mobile services by 2020, whereas most developing countries have only around 500 MHz allocated to mobile services today and some have less than 300 MHz.[1]

Spectrum licensing is also gaining increased urgency as a result of the wave of licences that are approaching the end of their initial term over the next 5 years. Uncertainty over the future rights to use this spectrum deters operators from making substantial new investments to further develop their networks and services.

This report updates earlier work for the GSMA to assess how authorities can make the required spectrum available in a way that will deliver widespread and affordable access to mobile broadband. In particular, the report considers major policy issues arising from spectrum management and the advantages and disadvantages of the different approaches available to address these issues.

Our key finding is that there is no single best approach to assigning spectrum, but a need to develop approaches taking into account the specific market circumstances. The best approach will depend on the licensing authority's policy objectives as well as market conditions such as how spectrum is currently used, the competitiveness of the market and the risks to investment and service quality over the forthcoming period. The following key principles can help guide licensing authorities:

1. **Auctions can deliver strong social benefits as long as they are properly designed.** There is no one-size fits all approach to spectrum awards. Auctions are a proven means of awarding spectrum to those who are most likely to put it to the best use. However, poor auction design can lead to spectrum being assigned inefficiently or in a way that undermines competition. Administrative assignment can offer advantages over auctions in some circumstances, such as where authorities wish to assign licences with regard to a range of criteria. Whether an auction or administrative assignment is adopted, the implementation of the approach is important.

2. **A presumption of licence renewal encourages long-term network investment.** This helps avoid investment being delayed because of uncertainty over future rights. A decision not to automatically renew a licence should only be made where there is a reasonable prospect that the benefits from reassigning spectrum would exceed the costs. Given the large number of licences approaching the end of their current term, timely renewal decisions (ideally 5 years in advance of licence expiry) can facilitate ongoing network investment and enable planning so as to provide for service continuity to end-users.

1 World Bank, Digital Dividends, 2016, p. 214.

3. **High spectrum prices jeopardise the effective delivery of wireless services.** Seeking to maximise state revenues from spectrum can have negative socioeconomic costs. Competition in communications markets can be undermined and there is a risk of higher retail prices and lower network investment. Licensing authorities should set reserve prices conservatively to allow the market to determine a fair price and to reduce the risk of leaving spectrum unassigned. Where spectrum is auctioned, ongoing charges should be limited to recovering the cost of spectrum management. Any subsequent fees associated with licence renewal should not prevent reasonable returns being earned on risky investments as this discourages technological innovation.

4. **Predictable and timely spectrum licensing encourages long-term network investment.** Predictability can be supported when governments publish (i) national broadband plans setting out how targets for widespread broadband will be achieved and (ii) a spectrum roadmap providing a schedule for forthcoming spectrum releases to meet the government's broadband plan as well as other demands on spectrum.

5. **Spectrum licences should be technology and service neutral.** This enables spectrum to be used efficiently by mobile operators rather than being tied to declining technologies and services. High charges for change of use risk delaying the benefits of new technologies.

6. **Licence conditions should be used with caution.** Generally, conditions that are unrelated to avoiding interference should be kept to a minimum or removed entirely. Other important objectives, such coverage requirements, can generally be effectively addressed through direct policy measures. This can also be achieved by improving the conditions for widespread and affordable commercial services (such as removing sector-specific taxes).

7. **Licence duration should be at least 20 years to incentivise network investment.** The use of indefinite licence terms beyond the minimum period, and the presumption of renewal, can further enhance predictability.

8. **Competition can be supported by licensing as much spectrum as possible and limiting charges and other barriers to services.** Making available additional spectrum in capacity and coverage bands is key to supporting better quality, widespread, affordable mobile broadband services. Specific measures to increase competition, such as spectrum caps or set-asides, should be introduced only after assessing the benefits and costs of alternative options. In many cases, additional spectrum can bring the greatest benefit to society when it is made available to existing operators as their needs are greatest due to the rapid growth of data traffic on their networks.

9. **Voluntary spectrum trading should be encouraged to promote efficient spectrum use.** This supports improved mobile services by efficiently enabling unused, or lightly-used, spectrum to be transfered to operators who will make better use of it.

The importance of spectrum licensing

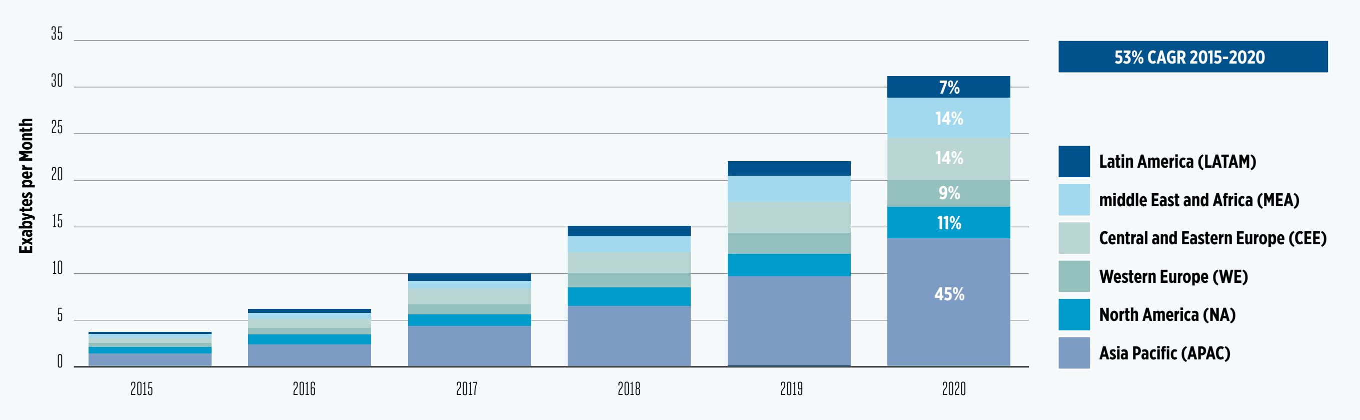
Growing demand for mobile broadband services is increasing the importance of countries' limited spectrum resources being used efficiently. The amount of spectrum made available and the terms and conditions governing its use are key determinants of whether the industry will have sufficient capacity to meet this demand while maintaining the quality and affordability of services.

Problems in spectrum allocation risk holding back not only the mobile industry but the wider economic and social benefits that are achievable through widespread access to mobile broadband, including increased employment, education and health benefits and the development of industries from agriculture to financial services. A 10 per cent increase in broadband penetration has been found to drive a 1.35 per cent increase in GDP for low-to-middle-income countries[2] and an even larger impact of a 3.19 per cent increase in GDP was found in a study focused on Latin America and the Caribbean.[3]

A key way in which mobile services drive economic and social opportunity is by expanding access to communications including high-speed Internet access. The ITU estimates that there are over 7 billion mobile subscriptions worldwide, up from 738 million in 2000 and that almost half of the world's population had access to mobile broadband in 2015.[4] Nonetheless, the ITU estimates that 4 billion people in the developing world are yet to gain Internet access.

Growth in use of smartphones and tablets enable a greater range of services to be accessed across mobile networks. Subscribers are using their devices for more data intensive services, with mobile video use growing rapidly and users increasingly using cloud-based services. Overall mobile data traffic is continuing to grow rapidly with Cisco expecting mobile data traffic to increase substantially in the years to 2020, with a compound annual growth rate 53%.

RAPIDLY GROWING MOBILE DATA TRAFFIC VOLUMES



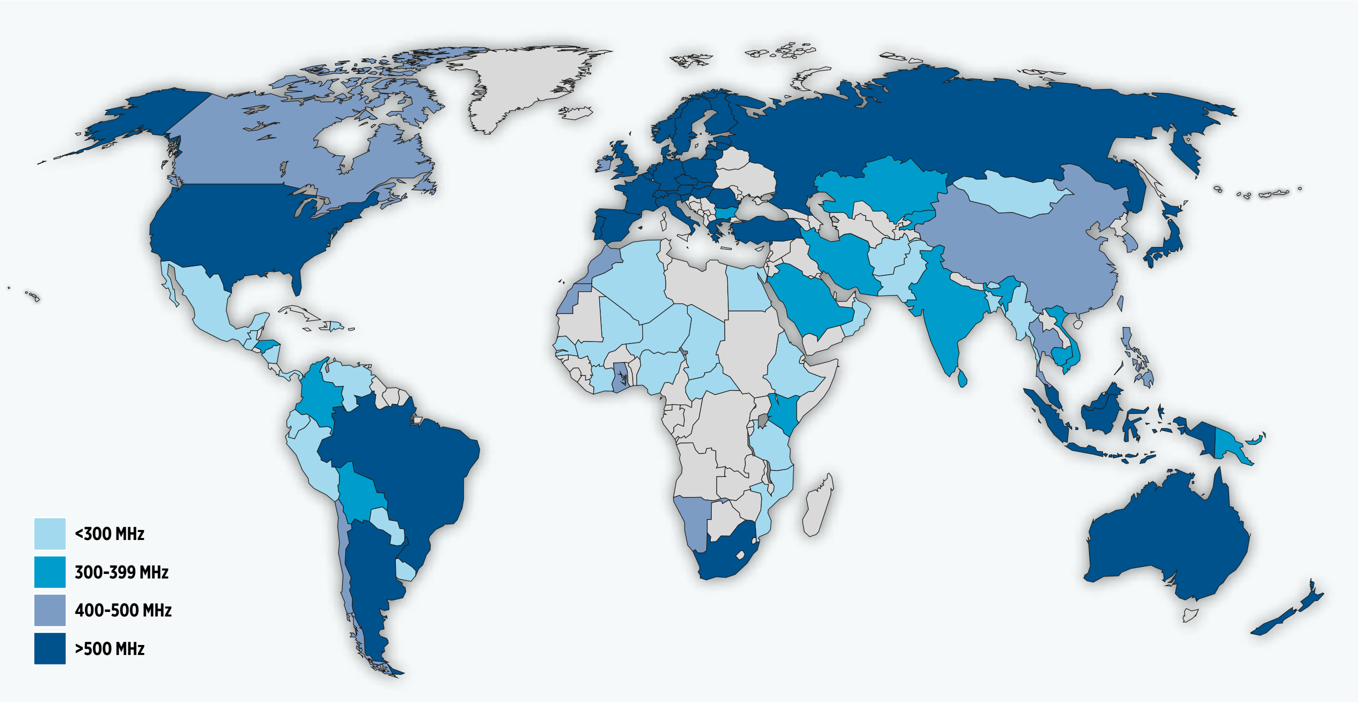
Source: Cisco VNI Mobile, 2016

2 Scott, Does Broadband Internet Access Actually Spur Economic Growth, 2012.

3 Inter-American Development Bank, Socioeconomic Impact of Broadband in Latin American and Caribbean Countries, 2012

4 ITU Statistics.

TOTAL SPECTRUM ASSIGNED FOR MOBILE SERVICES



Source: GSMAi, ITU and regulators websites (total spectrum calculated including both uplink and downlink FDD and TDD spectrum)

Technology improvements alone cannot deliver the required capacity. For example, even taking into account increased investment by operators in technology and networks, it is estimated in 2015 that the supply of licensed broadband spectrum in the US would need to increase by 50 per cent by 2020 to meet expected demand.[5] In many developing countries where growth in demand for services is also growing strongly, the supply of spectrum for mobile services is much more limited. Few countries in Africa, Latin America and parts of the Asia Pacific region have more than 400 MHz of spectrum assigned to mobile services.

To achieve the needed capacity, licensing authorities should prioritise:

- **making as much spectrum as possible available for mobile broadband including by re-allocating spectrum from less valuable existing uses; and**
- **ensuring that new, more efficient technology is deployed including 4G LTE, and in future 5G, so as to boost the capacity from the use of existing spectrum bands.**

The World Bank has noted that, in relation to making the Internet available, accessible and affordable: *"The most critical portion of the invisible mile involves spectrum management, which requires increasing the amount of spectrum available, ensuring competitive access, encouraging sharing of essential facilities, such as radio masts, and liberalizing the market for spectrum resale."* [6]

5 CTIA, Substantial Licensed Spectrum Deficit (2015-2019): Updating the FCC's Mobile Data Demand Projections, 2015

6 World Bank, Digital Dividends, 2016, p.25.

Increasing the amount of available spectrum will increase the volume and quality of mobile services that can be provided while simultaneously reducing service costs. A key opportunity to allocate further spectrum to meet mobile demand is provided by the spectrum becoming available as a result of the transition from analogue to more spectrally-efficient digital television. This relatively low frequency spectrum reduces the cost of deploying mobile broadband coverage as fewer base stations are required to cover the same geographic area. The GSMA has estimated that common adoption of the 700 MHz band could generate US$1 trillion in GDP growth in the Asia Pacific region alone between 2014 and 2020 including the potential to create 2.7 million new jobs, support 1.4 million new businesses and increase government revenues by US$171 billion.[7]

Authorities should continue to examine opportunities to free more spectrum for mobile services, including by undertaking cost benefit analysis of different uses where spectrum is likely to be under-utilised currently.

Operators also need certainty in relation to spectrum access to support the high level of investment required

At a time when substantial network investment is required, the mobile industry is also faced with the uncertainty created by many operators' existing spectrum licences approaching the end of their initial term. Mobile network investments have long payback periods and operators will not undertake the investment required if they are unsure whether they will lose the right to use current spectrum.

Uncertainty over future rights to use spectrum risks:

- **deterring investment in extending and upgrading networks and deploying services;**
- **reducing incentives to compete aggressively;**
- **the loss of service continuity for customers; and**
- **spectrum being left under-utilised.**

The timely renewal of existing licences within an established, predictable licensing framework will be critical to enabling the investment required to meet the demand for mobile broadband. Countries that get their licensing approach right can better realise the potential of mobile broadband, bringing substantial benefits to consumers and businesses in terms of innovative, high quality services and lower costs of provision. In the remainder of this report, we assess the approaches that authorities can take to ensure that the industry has access to the required spectrum to maximise benefits for end-users.

7 GSMA, GSMA Announces Asia Pacific Could Generate US$1 Trillion in GDP Though Spectrum Harmonisation for Mobile Broadband, 2012.

Approaches to assigning spectrum

Realising the potential of mobile broadband will require governments to release as much spectrum as possible as quickly as possible while providing sufficient certainty over future rights of use to facilitate network investments.

Spectrum can be used both in licensed and unlicensed formats, with spectrum either assigned to a specific operator or reserved for a technology and open to all users. Unlicensed spectrum is able to support the delivery of certain services using low-power technologies over short distances, notably the use of the 2.4 GHz and 5 GHz bands for Wi-Fi. However, if all spectrum were unlicensed many existing services would not be able to be offered because of the resulting interference between spectrum users.

Licensed spectrum is required for mobile services to ensure sufficient quality of service and customer value which, in turn, will facilitate the large investments needed to deploy high performance mobile networks with wide coverage. Licensing particular spectrum bands for mobile services can also support international harmonisation which delivers lower cost devices and equipment through scale economies. Dynamic spectrum access techniques are also being developed which will enable specific spectrum bands to be shared between multiple uses or users by avoiding signals being transmitted at the same time, although the technology is still at a relatively early stage.

A range of objectives may be considered by authorities when assigning spectrum licences:

- **promoting the efficient use of spectrum particularly by ensuring that the spectrum will be put to its highest value use;**
- **supporting competition in communications markets;**
- **ensuring service continuity for end-users;**
- **having a well-run, timely and legally robust process;**
- **potentially other policy goals such as achieving wide coverage; and**
- **in some cases, generating revenue to government.**

The extent to which different objectives are affected will depend on the particular market context. In some cases, an authority may be forced to balance competing objectives. Generally, overall benefits to society will be maximised where importance is attached to promoting efficient spectrum use and ensuring competitive communications markets. Using spectrum management to pursue other policy goals, including government revenue generation, can carry significant overall costs to society relative to alternative means of achieving those goals. For example, while limiting the amount of spectrum made available would raise spectrum prices, this would also increase the cost of mobile services and constrain the growth of the other sectors of the economy that rely on mobile communications. Governments will have greater revenue generating capacity in the long-term by supporting economy-wide growth including through enabling low cost deployment of mobile infrastructure.

Competition in communications markets can generally be achieved through making sufficient spectrum available to support several rival networks at efficient scale. Nonetheless, as discussed further in this report, spectrum assignment may sometimes raise challenging competition issues particularly in mature mobile markets.

General approaches for assigning spectrum

There are two main approaches used for assigning the rights to use a particular spectrum band:

- **Auctions in which the licence is assigned to the highest bidder (with that bidder either paying the amount they bid or, in some cases, the amount of the second highest bid);**
- **Administrative approaches (often called 'beauty contests') in which the licensing authority assigns the spectrum to the candidate that is considered to best meet a number of criteria such as financial resources, industry experience, technology and rollout plans and, in some cases, price offers.**

Hybrid approaches may also be used, these combine elements of the two main approaches such as where the licensing authority initially selects a short-list of bidders based on administrative criteria and then holds an auction to assign the licence between the shortlisted candidates.

	Advantages	Disadvantages
Auctions	■ Well-designed auctions result in spectrum being assigned to the operators who value it most and will generally therefore put it to use in the way that generates the greatest benefits to society ■ Seeks to discover the market value of spectrum and obtain a fair return on a vital national asset ■ Specific non-price objectives can be targeted through licence conditions but these should only be imposed following careful consideration and where other measures have been ruled out ■ Outcome is typically transparent and generally legally robust	■ Poor auction design can lead to spectrum being assigned inefficiently or in way that harms competition in communications markets (including as a result of high reserve prices limiting participation) ■ Inflated prices risk restricting the licensee's ability to invest in high quality networks with widespread coverage
Administrative assignment	■ Enables a range of criteria to be taken into account and for authorities to balance the trade-off between objectives ■ Authorities can select the level of the licence fee which may improve operators' ongoing financial viability and assist in raising capital for network investment ■ Ability to set network investment or coverage requirements to focus on delivering high quality services rather than raising state revenues ■ Can be quick and cheap to organise and is appropriate where spectrum demand does not exceed supply	■ Licences may be assigned to the candidate that presents an attractive proposal rather than the candidate that can make best use of the spectrum. Where operators fail to meet commitments after the auction, authorities may face difficult choices as to whether to cancel the licence or otherwise penalise the operator ■ Administrative assignment is vulnerable to bias or corruption and even the perception of such can lead to protracted legal disputes that delay spectrum being put to good use

There is no single best assignment approach but rather a need to assess the merits of each on a case-by-case basis. Auctions are most suitable when there is excess demand for the spectrum and hence the benefit of auctions in awarding spectrum to the operators which are most likely to put it to the best use helps maximise benefits to society. Administrative assignment may be suitable in cases where there is less demand, an authority wishes to consider multiple objectives, or where an authority wishes to avoid high licence costs which could impact network investment.

As important as the choice of general approach, is to ensure that the approach is implemented in a rigorous way. This includes identifying key issues through public consultation, weighing up the trade-offs in specific design choices (noting the importance of efficient spectrum use and ensuring competition in communication markets) and providing sufficient time and transparency so that potential candidates can make informed planning decisions.

Auction design

In using auctions to award spectrum, major design issues that need to be addressed include:

- **Avoiding coordinated or collusive outcomes in the auction: participants have the incentive to limit competition in the auction and achieve lower prices. In some cases, the auction rules may enable explicit collusion, such as the Swiss 3G auction in 2000 which allowed for bidders to form joint ventures with the result that the number of final bidders reduced from nine to four, the same number as licences available. In other cases, bidders may be able to tacitly collude including through using their bids to signal how the bidders would like to divide up the available lots.**
- **Supporting price discovery and truthful bidding: where the auction design enables bidders to discover information about market value based on bids by other operators, the auction can help promote efficient spectrum assignment. Effective rules can encourage truthful bidding and avoid gamesmanship. However, the basic price discovery function of an auction can be undermined by setting unreasonably high reserve prices (with risks of unsold spectrum and/or less funds available for investment).**
- **Ensuring the appropriate incentives for entry: some auction designs may discourage smaller operators and entrants from bidding if they perceive they will have little chance to outbid rivals or would only win if they have overestimated value. If not prevented by auction rules, operators may also engage in predatory and entry deterring behavior. This is particularly likely in auctions with bidder asymmetries and high costs of entry.**

Regulators have used a variety of auction formats including simultaneous multiple-round auctions, sealed bid auctions and combinatorial clock auctions. The choice of auction format can influence auction outcomes as well as the resulting competition in communications markets. Simultaneous multiple-round ascending auctions, which were initially the most common format for spectrum auctions, enable bidders to discover information about the value other bidders place on licences. This may help achieve efficient assignment where there is substantial uncertainty over valuation, but can be somewhat complicated for regulators to run or for bidders to participate in, especially if the bidder needs to aggregate licences. Sealed bid auctions are simple to run and can attract entrants but carry risks of inefficient assignment because of the lack of information available to bidders about the value others place on the licences. Combinatorial auctions are particularly suited to the assignment of multiple bands where there is complementarity between spectrum lots and where bidders have strong and divergent preferences for packages of spectrum. No format is likely to provide a perfect solution – even if one format is ‘better’ at meeting competition objectives, it may have other drawbacks, such as complexity or the risk of inefficient outcomes.

MAIN AUCTION FORMATS ADOPTED FOR SPECTRUM ASSIGNMENT

	Benefits	Risks
Simultaneous Multiple-Round Ascending Auction (SMRA) Lots are auctioned individually but simultaneously in discreet bidding rounds with ascending prices for each spectrum lot and the auction continues until no more bids are submitted	■ Efficient spectrum assignment is supported by the information revealed during the auction and by bidders with the highest spectrum valuations being able to outbid rivals ■ Relatively simple format ■ Works best for spectrum licences that are substitutes which therefore do not give rise to aggregation risks ■ Prices paid for similar licences are non-discriminatory as it is costly for dominant bidders to deter entry and makes it more likely that smaller bidders will not have to pay higher average prices	■ Bidder strategy can be complex when trying to aggregate multiple lots ■ May introduce gaming opportunities ■ Lots are assigned independently, giving rise to the risk of winning unwanted lots because of failure to win complementary lots ■ Aggregation risk distorts incentives and with strong synergies between lots, a SMRA cannot be expected to generate efficient outcomes (this can be mitigated by allowing withdrawals or allowing standing high bidders to 'switch' demand)
Sealed bids Each bidder submits a single offer and the licence goes to the highest bidder The bidder pays either their bid or, under a second price rule, the highest losing bid	■ Less vulnerable to collusion and can attract entry ■ Relatively easy and quick to run ■ Can raise more revenue than a multiple round auction where competition for the licence turns out to be weak	■ Limited information available to bidders as they have no insight into rivals' values ■ Use of the first price rule can lead operators suffering the winner's curse, in which they have overestimated the true value of the licence ■ May lead to spectrum being assigned inefficiently
Combinatorial Clock Auction (CCA) Multiple round auction allowing bids for packages of lots, rather than for individual licences. An initial ascending clock phase continues for each package of generic spectrum blocks until excess demand for each group is eliminated, followed by a final round of sealed bids to determine specific assignments	■ Supports flexible lot structures which help avoid aggregation risks (i.e. bidders ending up with unwanted combination of lots) and thereby support efficient assignment ■ Second price rule whereby prices paid by winners are set at the lowest hypothetical bid amount at which they could have still won encourages straightforward bidding based on own valuations ■ A flexible format that allows for use of spectrum floors and other constraints	■ Less price revelation than in an SMRA ■ Complex to administer and participate in as it requires bidders to develop valuations for many packages before the auction ■ CCA only works well if bidders can evaluate all the bidding options that are open to them ■ Can give rise to strategic gaming possibilities, allowing participants to raise rivals' costs, resulting in bidders potentially paying vastly different prices for spectrum

In addition to the choice of auction format, there are also various tools available to regulators in designing auctions to promote competition or increase the likelihood of efficient outcomes, although there are often trade-offs involved in their use.

REGULATORY TOOLS FOR USE IN AUCTIONS

	Benefits	Risks
Lot size	■ Smaller lots which can be aggregated can lead to more efficient spectrum assignment and provide for multiple operators having access to important spectrum	■ Lots that are too small increases the need for bidders to aggregate multiple lots and may lead to operators acquiring spectrum which they are unable to use
Spectrum caps and set asides	■ Helps smaller players/entrants to win licences by preventing individual bidders from acquiring an 'unduly large' share of the spectrum or specifically sets aside certain spectrum for such operators	■ May lead to spectrum being poorly used and can weaken incentives to grow customer base. Can penalise big operators whose large customer base gives them a need for more spectrum, and prevent operators from offering the fastest broadband speeds by limiting their ability to use techniques like carrier aggregation
Information available on bids	■ Limiting what information is made available during the auction can block signaling behavior and promote rivalry	■ Limiting information weakens price discovery which may impede efficient outcomes
Reserve prices	■ Reserve prices reduce gains from collusive behaviour and help governments achieve some minimum revenue for the spectrum even when demand is low	■ If set too high can discourage marginal bidders from participating and can lead to spectrum remaining unsold, thus risking restricting network investment leading to slower rollouts, slower speeds and reduced coverage

Problems of poor auction design

While auctions have attractive properties including the potential to promote efficient outcomes, their advantages can be undone by problems in the auction design and rules. Particular design choices raise the risk that spectrum may not end up with the operators that can best use the spectrum such as where authorities seek to impose an unsustainable market structure or set high reserve prices which may result in spectrum remaining unsold or limiting network investment. If bidders successfully coordinate, not only may spectrum be assigned inefficiently but the government would not receive the market value for the spectrum.

In the 2013 Czech 4G auction, bids reached triple the reserve price before the auction was cancelled because of concerns the prices would have led to high prices for 4G services and delayed operators' ability to launch the new services. After a new auction design was chosen, the spectrum sold for less than half the level of the earlier bids.[8] FICORA in Finland, also had to call a halt to their 4G auction after 9 months with no indication of ending. The original auction rules allowed bidders to shift their bids among the different blocks of spectrum being auctioned off, effectively reducing their bids between rounds. However, the updated rules required bidders to increase their offers in every round of bidding, with this new obligation the auction was completed within a month. The 2015-16 Thai auctions of the 900 MHz and 1800 MHz spectrum also encountered problems with high prices and with one of winners defaulting on its licence payment.

8 CTU, Press Release frequencies for LTE auctioned, 2013

900 MHz and 1800 MHz auctions in Thailand

900 MHz and 1800 MHz licenses were originally assigned in Thailand to the state-owned enterprises DTAC and TOT who allowed private firms to build and operate their networks. At the licence expiry date, the licences provided for the spectrum to be returned to the National Broadcasting and Telecommunications Commission (NBTC) for re-auction.

The SMRA auctions for the 900 MHz spectrum and 1800 MHz spectrum ran sequentially in November and December 2015. Four participants competed for this spectrum comprising the existing operators AIS, Digital DTAC and True as well as a new entrant Jas Mobile. The auction process required participants to remain at NBTC's premises until the end of the auction. The auctions ran for 33 hours and 66 hours each, with the 900 MHz auction allowing bidders a three-hour sleep break for each auction day while the earlier 1800 MHz auction had no such allowances. The high levels of competition, heightened by existing spectrum scarcity and uncertainty over future spectrum release, as well as the pressure imposed by the bidding schedule, drove the auction prices up such that the 900MHz spectrum was sold to True and Jas Mobile for THB151.9 (USD4.3 billion) and the 1800MHz was eventually bought at THB80.8 billion (USD2.3 billion) by True and AIS. Concerns about the level of these prices paid resulted in shares in the bidders falling to a three-year low.

The prices were much higher than prices internationally on a price per MHz per pop basis.[9] This has caused subsequent problems, with Jas Mobile defaulting on its licence fee payment and NBTC needing to re-auction the second 900 MHz lot in May 2016.

Conclusion on auction design

There is no single 'best' auction format. For regulators, a key challenge in auction design is managing the objectives of achieving efficient spectrum assignment while supporting competition in communications markets. Seeking to maximise auction revenues risks much greater costs to society, especially the digital economy, if competition in communications markets is undermined and network investment is limited as a result. Low participation can be a concern especially in mature mobile markets. There are a wide variety of tools available to regulators to address these issues including the choice of auction format, determination of spectrum lots, spectrum caps and set asides, bid information disclosure and reserve prices. However, these tools are often conflicting and their effectiveness will depend on local market conditions.

9 DotEcon, Thai break? Lessons from the 900MHz and 1800MHz auctions, 2016

Administrative assignments

Administrative assignment involves the regulator choosing which applicants' proposal best meets their objectives which may include coverage, quality of service and potentially a variety of wider social and economic goals. However, for an administrative assignment to work well, the selection criteria and process should be clear and the weight given to each objective should reflect its importance to society (with consideration of alternative, more targeted tools which could be used to meet more specific goals at lower cost). The use of vague and subjective criteria and a lack of transparency increases the risk of favoritism and corruption and the potential for the outcome to be challenged in the courts. Some of the tools to promote downstream competition in auctions can also be used in administrative assignments. Where authorities sets the licence fee, there may be a need to trade-off objectives and even where the objective is clear estimating the appropriate price can be challenging.

A particular problem of administrative assignment is the risk that successful applicants turn out to be unable to fulfil their offers particularly if market or technologies forecasts prove incorrect. Licensing authorities should set out in advance what penalties will be imposed should promises not be achieved. These penalties should be proportional to the significance of the breach of conditions.

Administrative assignments in Chile

Chile's regulator, Sub-Secretaria de Telecomunicaciones (SUBTEL), has used beauty contests for licensing spectrum, including for the award of the 850 MHz band for 2G services and in recent 700 MHz and 2.6 GHz awards. Licences are assigned after submissions of technical proposals, and only if there is a stalemate between the operators' proposals is there then auction between those operators. SUBTEL has used the licensing approach to award spectrum to new entrants, impose MVNO hosting obligations, as well as targeting particular network coverage, capacity and speed levels. Chile leads the region in mobile market development, with a network readiness score of 4.6 points, first in Latin America and 38th globally.[10]

While Chile has achieved high levels of network development, there are concerns that the licence obligations required are too onerous for new entrants, as well as if the tenders themselves disregard caps on total spectrum holdings. In the case of the 700 MHz auction, a case was brought before the competition watchdog, Tribunal de Defensa de la Libre Competencia (TDLC), on whether the bidding process for the 700 MHz band allowed for free and open competition. Awarding spectrum by beauty contests which result in a range of licence conditions can also make it more difficult for the spectrum to be traded later. This is an issue in Chile where AWS spectrum awarded in 2009 to new entrants was under-used despite the main operators' demand for the valuable spectrum.

10 World Economic Forum, Global Information Technology Report 2015, 2015

Choice of approach in the context of licence renewal

Where spectrum is already licensed to an operator, determining how that spectrum should be assigned when the existing licence approaches the end of its term raises a number of specific considerations. There are various renewal approaches available to regulators. A presumption of renewal allows current spectrum holders to renew their licences except under certain defined circumstances which are expected to arise relatively rarely. Where the rights to use spectrum are not renewed automatically, they may be put up for potential re-assignment either using an auction or administrative assignment. Hybrid approaches are also possible under which part of the spectrum is renewed and part made available for potential re-assignment.

APPROACHES FOR SPECTRUM LICENSING RENEWAL

	Advantages	Disadvantages
Presumption of renewal	■ High predictability which supports future investment in the sector ■ Minimises customer service disruption from operators losing spectrum and needing to reconfigure networks or exit the market ■ In conjunction with trading, supports efficient spectrum use over time	■ In some instances, spectrum may be better re-assigned (eg spectrum replanning, serious breach of conditions, spectrum left idle) ■ If not set out in original licence terms, may be considered unfair to unsuccessful bidders
Re-auctioning	■ Auction uses market to identify the true “opportunity cost” ■ Promotes efficient outcomes / efficient use of spectrum (i.e., those that value it most are allocated the spectrum) ■ Outcome is transparent and legally robust	■ Discourages long-term network investment and may be disruptive to existing businesses as incumbent operators risk losing critical spectrum ■ May be subject to ‘gaming’, therefore auction design is critical ■ Auction prices carry a greater risk of the licence cost undermining operators’ financial viability
Administrative assignment	■ Quick and cheap to implement ■ Promotes continuity of existing services ■ Works best if benchmarks are available from local precedent or other countries	■ Government may get prices wrong ■ Price setting may not be transparent and could be vulnerable to legal challenge ■ May fail if low competition
Hybrid solution	■ Attempts to balance achieving some predictability and some flexibility	■ Risk to investment and service continuity/QoS ■ Potential costs associated with reconfiguring networks ■ Trading off predictability for flexibility would only be beneficial in some circumstances

Uncertainty over future rights to use the spectrum may lead to operators ceasing investment in the development of their networks and competing less strongly to grow their customer base until the uncertainty is resolved. A failure to renew an operator's existing rights to use spectrum also may harm service continuity or quality of service to customers. Operators may also be forced to pay excessive fees to try to retain their existing spectrum rights (as was the case in India) particularly if the auction design does not adequately protect ongoing competition.

Issues with re-auctioning expiring 900 MHz licences in India

900 MHz licences were initially assigned in India in 1994 and 1995 on the basis of regional areas or 'circles'. With several of these original 900 MHz licences due to expire, India's Department of Telecommunications (DoT) re-auctioned the licences in February 2014 and March 2015. Existing operators faced a serious risk of losing spectrum critical for them to meet service demand with reasonable quality of service. With a significant overall shortage of spectrum being made available, operators were forced to bid aggressively against each other to seek to protect the viability of their existing operations. Final prices were much higher than reserve prices. Prices for the 900 MHz spectrum ended up being on average 1.7 times those of the 800 MHz spectrum sold in the same auction – indicating a high risk of distortion. The auctions also resulted in a redistribution of spectrum between the operators, with Reliance Communications (Rcom) only retaining licences in two of the seven circles where it licences were being re-auctioned.

The CEO of Bharti Airtel, Gopal Vittal, was quoted after the auction as saying *"auction design and the scarcity of spectrum have resulted in exorbitant bids to secure the spectrum, particularly in renewal circles, where huge investments have already been made on the assurance of a continuity of business enshrined in the licenses issued by the DoT.'"*[11] A later review[12] found that the auction "resulted in unreasonable prices, high debt levels for companies, and expensive charges for consumers. Many firms complained that they were forced into costly decisions that harmed their competitiveness and made it impossible to innovate in ways that consumers need in the 21st century." Rcom has subsequently lost subscribers to the two largest operators[13] suggesting that the re-auctioning of licences may also be adversely impacting competition.

11 Bharti Airtel media release.

12 Shamika Ravi and Darrell M. West, Centre for Technology Innovation and Brookings (2015), 'Spectrum policy in India'

13 Telegeography.

Authorities should attach weight to minimising uncertainty particularly by creating a presumption of renewal. For example, spectrum licences in Canada have a high expectation of renewal, unless a breach of licence condition has occurred, a fundamental reallocation of spectrum to a new service is required or an overriding policy need arises. A presumption of renewal can be considered equivalent to the use of indefinite licence terms, such as in the UK for spectrum used for mobile purposes, where the licences can only be revoked after a minimum period on spectrum management grounds and subject to a specified minimum notice period.

Where a regulator expects clear benefits from re-assigning some spectrum that would outweigh the significant costs involved, hybrid approaches can balance the expected benefits with the importance of protecting ongoing investment and service delivery.

Hybrid spectrum re-assignment approached in Hong Kong and New Zealand

Both the Office of the Communications Authority (OFCA) in Hong Kong and Radio Spectrum Management (RSM) in New Zealand have adopted hybrid approaches to address the expiry of existing spectrum licenses.

In Hong Kong, with the 2.1 GHz licenses due to expire, a decision was made to renew using a combination of administrative reassignment and auctions. The four incumbent licensees were offered first rights of refusal on two thirds of their existing spectrum holdings and the remaining third of the band was to be put up for auction. In April 2014, CSL was acquired by HKT, with the condition that the combined entity divest a further share of their combined 2.1 GHz holdings which was also included in the auction. While the combined CSL/HKT was barred from participation in the auction, the other two incumbents, SmarTone and Hutch were awarded spectrum, along with a new entrant China Mobile HK who won 2×19.6 MHz, thus returning the market to four operators.[14]

When the spectrum in the 800 MHz and 900 MHz bands were due to expire in New Zealand, RSM guaranteed the renewal of some of the spectrum to the incumbents, Telecom and Vodafone. However, RSM gave them two options for how much spectrum was renewed:

- **Telecom and Vodafone could each sell 2×5 MHz to a third party, and have the remainder of their rights renewed, or**
- **2x7.5 MHz of each company's management rights would not be renewed and the Crown would allocate them to a third party.**

The incumbents both selected to sell spectrum to new entrant, 2Degrees, and the three operator market structure has proved sustainable with 2Degrees gaining a market share of just under 24%.[15]

14 OFCA, Auction of Radio Spectrum in the 1.9 – 2.2 GHz band for the Provision of Public Telecommunication Services, Successful Bidder Notice, 2015

15 Commerce Commission, Annual Telecommunications Monitoring Report, 2015

Recommendations on general licensing and renewal approaches

Where spectrum is to be assigned for the first time, there is no single 'best' licensing approach and authorities should make their decision on the approach and design taking into account the specific market context. In choosing the assignment approach, licensing authorities should prioritise the objectives of promoting efficient use of spectrum and network investment while also ensuring effective competition in communications markets.

Whether an auction or administrative assignment is adopted, the details of the implementation of the approach are important. A decision not to automatically renew a spectrum licence should only be made where there are expected to be potential benefits from reassigning spectrum (such as more efficient spectrum use or greater competition) that are likely to exceed the costs (e.g. disruption to services and customers, the risk of deterring investment, customer service degradation and any required network reconfigurations).

Ensuring a predictable, timely and open licensing process

A predictable and timely licensing and regulatory framework enables operators to build the business case for the long-term network investment required to support the digital economy. Regulatory stability and transparency also helps improve the quality of licensing decisions and minimises the risk of protracted legal proceedings.

A long term spectrum management plan

Governments can maximise the social gains from its spectrum resource by developing a spectrum management framework which supports investment, the efficient use of spectrum and competition. The spectrum management framework should:

- **ensure that sufficient spectrum will be available for the services that will deliver the greatest benefits to society and that mechanisms are in place to identify and re-allocate spectrum where it is currently idle or under-utilised;**
- **setting out a timetable for future spectrum releases and licence renewal decisions;**
- **establish clear rights governing the use of particular bands to avoid intolerable interference and a robust compliance regime;**
- **base licensing decisions on a detailed assessment of the costs and benefits of a range of licensing options with particular regard to longer term impacts on investment incentives and sustainable competition (including recognising licensees' legitimate expectations);**
- **avoid unnecessary restrictions and conditions on the use of spectrum which can carry large costs and delay the introduction of new technologies and services;**
- **facilitate international harmonisation of the use of spectrum bands so as to support international roaming and realise scale economies in equipment manufacturing; and**
- **assign the responsibility for licensing decisions to an independent regulator required to follow specific, transparent criteria in making its decision and with an independent appeals process with the power to enforce its decisions.**

Many countries have recognised the importance of reforming their spectrum management as part of the development of National Broadband Plans. These plans set out targets to achieve widespread access to broadband as well as the way in which those targets will be achieved. Making further spectrum available and liberalising the use of spectrum can play a critical role in improving broadband access including in extending coverage and in ensuring affordable services. 134 National Broadband Plans were in force by the mid-2013 and the adoption of these has been associated with a significant increase (7.4%) in mobile broadband penetration.[16] The strength of such plans in promoting investment and confidence in the sector is promoted by their political support, comprehensibility, enforceability and the buy-in from stakeholders. Due to the quick moving nature of developments in the digital economy, these plans need to be reviewed and updated on a regular basis.

16 Broadband Commission, Why National Broadband Plans Matter, 2013

Three key elements of a spectrum management framework that can promote stability and transparency, which we discuss in further detail, are ensuring that there is:

- **a clear roadmap on both new spectrum releases and licence renewals;**
- **sufficient notice is given for decisions relating to licence expiry; and**
- **consultation on key decisions.**

Spectrum roadmap on releases and renewals

A spectrum roadmap is a plan for both government and stakeholders setting out the steps and timing in making available unused spectrum and in better utilising existing spectrum allocations. In particular, a spectrum roadmap should cover:

- **an audit setting out current use of spectrum and identifying any spectrum that could be re-allocated to higher value use;**
- **the schedule for future spectrum releases;**
- **how spectrum will be assigned including a framework for determining spectrum prices and other terms and conditions;**
- **the timing and process for spectrum renewal decisions;**
- **a plan for the introduction of technology neutral licensing and trading if not already in place.**

A spectrum roadmap is an important means of ensuring sufficient spectrum will be available to meet the requirements driven by changing technology and demand. Information on future spectrum release is critical in order for businesses to prepare investment plans, secure financing and develop arrangements for deploying particular technologies.

While it will not be possible or desirable to detail every approach in advance of analysing the expected demands for particular spectrum, where a menu of approaches will be considered investment risks can nonetheless be reduced by the authority setting out what factors or criteria they will use to choose between the specific approaches.

The Australian Communications and Media Authority (ACMA) publishes an annual update of their 5-year spectrum outlook. The current edition, published in September 2015, sets out their plans for an auction of residual 1800 MHz spectrum, reallocating 2 GHz licenses due to expire in 2017, reviewing planning arrangements in the 800 MHz and 900 MHz bands, review L-band (1.5 GHz) spectrum for applicability for mobile and opening up access to unsold 700 MHz lots. On the other hand, uncertainty over the dates for the use of the Digital Dividend in some countries in South America increases the risk to network investment and can lead to other spectrum being held for precautionary reasons even when it would deliver more value in other uses.

Digital Switchover planning and the 700 MHz band in Latin America

700 MHz is a key band for the provision of widespread, affordable mobile broadband services due to the band's propagation benefits. However, while a number of Latin American countries have made steps towards enabling the band's use for mobile broadband, there have been delays in clearing the band from its existing assignment for broadcasting.

As of May 2016, mobile operators in eight Latin American countries have been awarded 700 MHz spectrum for the purpose of 4G network deployment.[17] However, Colombia is the only country to have completed the digital switchover by migrating analogue TV services in the 700 MHz band to digital. A further four Latin American countries have ongoing switchover processes, while the remainder, including Argentina, Chile, Nicaragua and Panama where awards to mobile have occurred, have made no official announcements regarding switchover completion dates.

Uncertainty in the availability of this band carries a range of negative risks including the delay of 4G services and that operators that have already acquired the spectrum would have less incentive and ability to fund network launches in alternative bands.

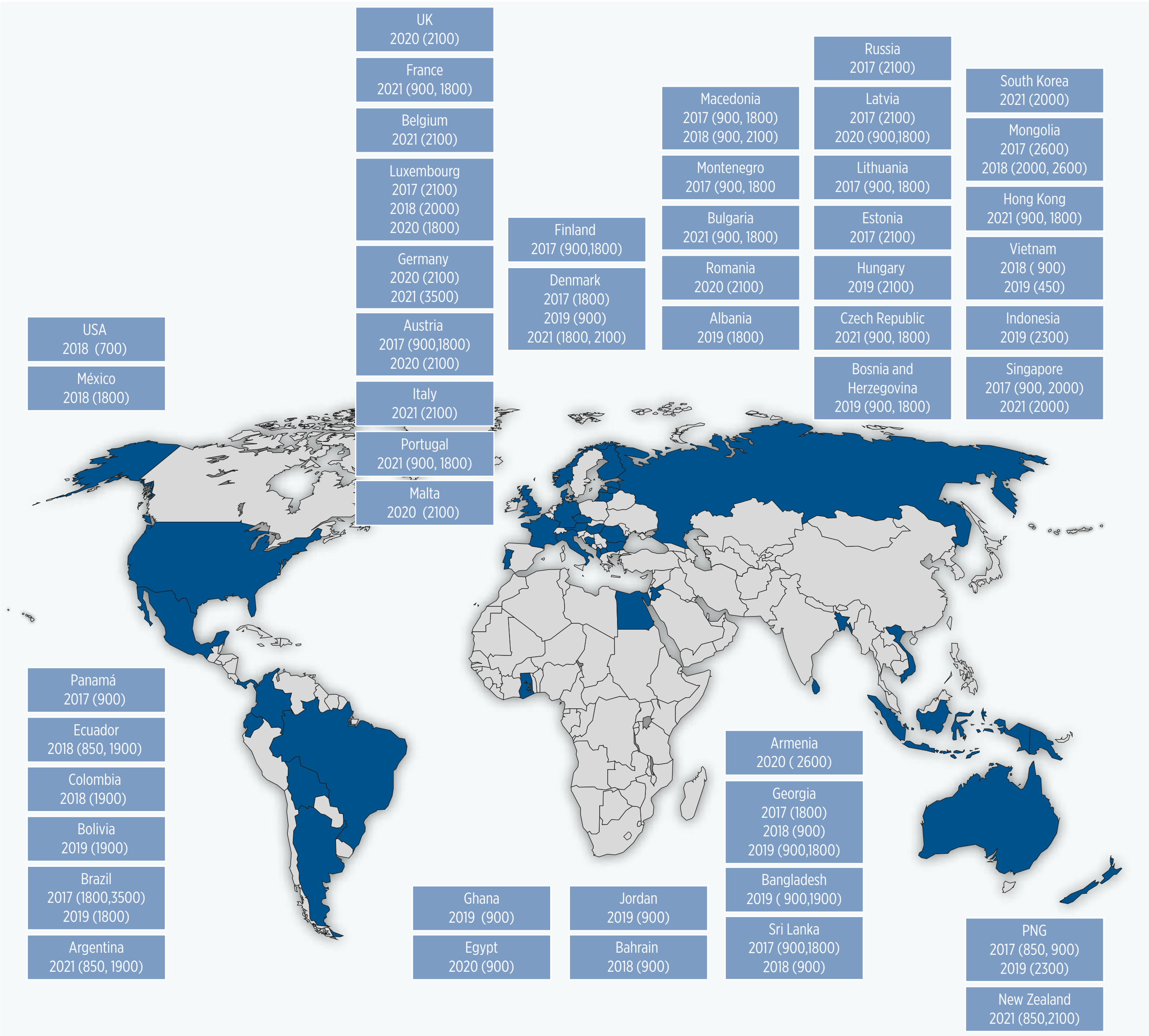
Timely licence renewal

Giving the complexity and cost of decisions to acquire spectrum, authorities should provide market participants with as much notice as possible of forthcoming assignment processes and decisions. Timing is particularly important for spectrum renewal decisions as the earlier renewal takes place before the date of licence expiry, the lower the risk of investment being reduced or postponed because of uncertainty over the period over which the operator will be able to recover the costs of the investment. This is a key issue in many markets currently as many existing spectrum licences are approaching the end of their term.

Early notice of renewal decisions also enables operators to better plan for investment and service continuity. For example, if some spectrum is not renewed, operators may be able to acquire other spectrum or make network investments that reduce the risk of service disruption to consumers. A minimum period for a licence renewal decision should be 5 years, as applied by some jurisdictions (e.g. the UK and New Zealand), to support ongoing investments in developing mobile networks.

17 5G Americas, LTE Deployment Status, 2016

EXAMPLES OF LICENCES APPROACHING THE END OF THEIR TERM



Consultation

Consultation supports efficient spectrum licensing by providing a forum for the perspectives and information of different industry stakeholders to be taken into account, including in relation to the likely effects of different options. Input from different stakeholders is essential to evaluating benefits and costs and determining the best approach prior to a licensing decision being made. For example, consultation can inform the choice of licensing and renewal approach, reasonable reserve prices or, for administrative approaches, the licence fees and the costs and benefits of imposing particular conditions. Setting out the reasons for decisions and providing a right of appeal can also improve the quality of decisions by protecting the rights of affected parties and ensuring decisions are reasonably based.

Recommendations on licensing process

Licensing authorities should ensure that the overall licensing framework offers stability and transparency to reduce regulatory risk and promote investment. National broadband plans and spectrum roadmaps are important ways in which the government can identify how to achieve widespread broadband access and incentivise high levels of private network investment. Given the large number of licences approaching the end of their current term, timely renewal decisions (ideally five years in advance of licence expiry) can facilitate ongoing network investment and enable planning so as to provide for service continuity to end-users.

Spectrum pricing

Where spectrum is auctioned, the spectrum licence price is determined by the auction itself. However, where spectrum is not auctioned, authorities will need to consider whether to levy charges for the use of the spectrum. In both cases, seeking to maximise state revenues risks much greater costs to society, especially the digital economy, if competition in communications markets is undermined and network investment is limited as a result.

Authorities set spectrum licence fees for three main purposes:

- **to recover the administrative cost of licensing process and spectrum management (e.g. a 'user pays' model);**
- **to encourage efficient spectrum use; and**
- **to raise revenue for the government.**

Efficiency in markets is promoted where users take into account the opportunity cost of a resource. The opportunity cost of spectrum is the value the spectrum would have if used in the next best alternative. Where there is no excess demand for the spectrum band, then the opportunity cost of the spectrum will be zero. However, where there is excess demand for spectrum, setting prices to reflect the opportunity cost of spectrum may promote efficient spectrum use in markets where spectrum is not able to be traded. Nonetheless, it is important that spectrum charges are set conservatively to avoid the risk that valuable spectrum goes unsold, and therefore is not put to a positive socioeconomic use. Where spectrum is tradeable, operators can be expected to take into account the value of the spectrum in other uses (i.e. the potential sale price for the spectrum) and hence spectrum charges will not generally be needed to achieve efficient spectrum use.[18]

Governments may seek to raise higher revenues by setting licence fees that exceed the opportunity cost of the spectrum. The higher the level of licence fees, the greater the risk that no operators will acquire the spectrum and the benefits to society from the use of the spectrum will be lost. High licence fees may also reduce the number of viable competitors both through the cost of the fees themselves and by making operators more vulnerable to changes in market conditions.

High spectrum fees also carry risks to network investment. High charges may reduce the funds available for investment or lead to higher debt levels which increase the cost of raising additional capital. The impact of high spectrum prices on consumers could be significant. A recent study[19] compared the price paid in Europe for 800 MHz licences to the number of 4G connections, the level of 4G penetration and the level of 4G coverage. The findings showed that countries where the cost of 800 MHz licences were lower had higher 4G market penetration and network coverage two years after having launched LTE services in the band.

18 The UK regulator has argued that operators may not fully take into account the opportunity cost of spectrum. Given the spectrum is generally a valuable asset, it is unlikely that operators do not manage their spectrum resources efficiently. However, even if this were the case, setting annual charges would then raise the ongoing costs of service provision and this can be expected to flow through into higher end-user prices and/or reduced network investment thus impacting the quality and reach of services.

19 Arthur D Little and the GSMA, The socio-economic benefits of greater spectrum policy harmonisation in the EU, 2015

High fees may also reduce expected future returns to investment. In the context of licence renewal, authorities should be particularly careful not to set fees that effectively seize returns on earlier risky investments. Doing so, will deter operators from making future investments where there are significant market or technology risks, despite the potential for such investments to benefit society.

Authorities should also ensure that they do not inadvertently deter investment and competition through the way in which spectrum charges are imposed. For example, fees set based on some measure of the size of operators can discourage operators from competing to grow their customer base while fees based on the size of the network may deter network investment.

Spectrum pricing in Kenya

The Communications Commission of Kenya charges licensees both an exclusive spectrum bandwidth assignment fee and a spectrum usage fee.[20] The Assignment fee is charged on based on the assigned bandwidth, while the spectrum usage fee varies based on the number of transceivers (TRXs) in the network using the following formula:

Spectrum usage fee =
100,000 × TRX in network × weighting factor

This pricing structure discourages network rollout, as deploying more TRXs increases the spectrum fees payable by the operator, thus negatively impacting mobile coverage and quality of service.

20 Communications Commission of Kenya, Frequency Spectrum Fees Schedule

Comparative assessment of pricing approaches

There are a range of spectrum pricing approaches with differences in terms of:

- **their ability to meet particular objectives (e.g. recovery of regulatory costs, promoting efficiency or government revenue objectives);**
- **whether charges are levied as an upfront lump sum or annually or a combination of upfront and annual charges); and**
- **whether the authority select the absolute level of the charge or whether it varies with revenues or some other measure.**

Prices that reflect the market value of spectrum will help promote efficient spectrum use. Auctions and spectrum trading can directly determine market value. Where these market mechanisms are not used, authorities may seek to estimate the market value of spectrum (e.g. administrative incentive prices). One way in which to estimate market value is to consider the costs operators would avoid by gaining an additional increment of spectrum. In particular, operators with more spectrum, need fewer cell sites to supply the same traffic volumes. The incremental value of spectrum can be estimated on the basis of this trade-off taking into account the network being modelled as well as traffic forecasts. An alternative approach is to estimate market value using benchmarks of recent auctions. Both approaches require the use of assumptions and may have strengths and weaknesses in particular contexts. For example, the accuracy of benchmarking depends on market prices being available for comparable spectrum offered in comparable markets and subject to similar terms and conditions. Ofcom's use of benchmarking to set annual licence fees in the UK for 900 MHz and 1800 MHz spectrum shows how complex benchmarking can become with significant scope for error.[21] For important spectrum bands where the cost of errors can be high, the use of both avoided cost modelling and benchmarking can improve accuracy.

Setting an upfront licence fee is often seen by economists as preferable to annual charges because once the fee is levied it is a sunk cost which will not affect service prices. However, upfront fees carry greater risks to operators particularly smaller operators and when future technological and market development is uncertain. Where authorities impose annual charges or new charges for licence renewal, regulatory risks to investment can be reduced by authorities following a transparent pricing framework with clear criteria. As noted with regard to the example of Kenya above, setting prices by reference to an operator's customer base or its network size risks deterring competition and investment. Such pricing may also undermine efficient spectrum use as operators with few customers would face minimal spectrum charges.

21 Ofcom, Annual license fees for 900 MHz and 1800 MHz spectrum, 2015

PRICING APPROACHES FOR SPECTRUM

Pricing Approach	Advantages	Disadvantages
Prices set to recover administrative costs of spectrum management	■ Appropriate where there is no excess demand for spectrum	■ May not lead to efficient spectrum use where there is excess demand for the spectrum and where spectrum assignment is not market based
Auction	■ Can provide a transparent and objective way to set prices that support efficient spectrum use	■ Flaws in auction design (e.g. high reserve pricing, limited spectrum availability or insufficient information on forthcoming awards) can result in inefficiently inflated prices or spectrum remaining unsold. This may restrict competition and risk higher mobile retail prices and/or limiting network investment, thus delaying improvements in quality and the reach of services. Changes in market conditions may mean that auction prices turn out to have been too high with the risk that existing operators prove unviable and exit
Share of revenue	■ Shares risk between government and operator and can promote new entry	■ Requires modelling based on assumptions
Avoided cost modelling of spectrum value	■ Provides a direct estimate of the value of an increment of spectrum	■ Risk to investment and service continuity/QoS ■ Potential costs associated with reconfiguring networks ■ Trading off predictability for flexibility would only be beneficial in some circumstances
Benchmarking	■ Simple and transparent where close benchmarks exist	■ Will be inaccurate if the analysis does not fully account for differences in factors impacting on market value

Reserve prices

Reserve prices are used in auctions to help discourage non-serious bidders and ensure a floor price for spectrum in case competition for the licences is weak. However, reserve prices should be set conservatively so as not to undermine the price-discovery function of the auction which is central to the market-based approach to spectrum management. If reserves are set too high then valuable spectrum may go unsold, or sold at such a high price that consumers may suffer due to limited competition and high prices and/or through underinvestment in mobile networks resulting in poorer quality of service.

Recent evidence shows that high reserve prices are a growing concern. A study[22] found that in most recent auctions (51%) over the past 10 years, the gap between the final price paid and the reserve price is negligible, suggesting the government rather than the market determined the outcome. Such non-market based prices mean operators may be paying more for spectrum than its competitive market value which risks lower network investment and higher consumer prices.

22 Plum Consulting, Reserve prices in spectrum auctions: why size matters, 2016

The same study also found that a significant number of recent auctions ended up with unsold licences. For example, in the Digital Dividend auction in Australia in 2013 the level of reserve prices set by the Government led to one of the three Australian mobile operators withdrawing before the auction and 30 MHz of spectrum in the 700 MHz band being left unsold. The consequence of this is that this spectrum is not being used to supply services to consumers (potentially leading to higher priced and less competitively offered 4G services) and the government failed to obtain revenues from the spectrum that might have been earned had it sold.

High reserve prices and auction inefficiencies in Africa

While beauty contests to assign spectrum have been more common in Africa in the past, auctions are now being used more frequently. There have sometimes been issues in auction design with, for example, a number of recent 4G auction failing to assign available spectrum particularly where reserve prices have been set at high levels compared with reserve prices set elsewhere.

TABLE 1 - SUMMARY OF THE IMPACT OF HIGH RESERVE PRICES ON RECENT AFRICAN SPECTRUM AUCTIONS

Pricing Approach	Year	Band	Spectrum available	Spectrum unsold	Reserve Price ($million per lot)
Mozambique	2013	800 MHz	2×25 MHz	2×25 MHz	30 per 2×5 MHz
Ghana	2015-16	800 MHz	2×20 MHz	2×10 MHz	67.5 per ×10 MHz
Nigeria	2015-16	2.6 GHz	2×70 MHz	2×40 MHz	16 per 2×5 MHz
Senegal[23]	2015-16	700 MHz, 800 MHz, 1800 MHz	2×30 MHz 700 MHz band 2×20 MHz 800 MHz band 2×30 MHz 1800 MHz band	2×30 MHz 700 MHz band 2×20 MHz 800 MHz band 2×30 MHz 1800 MHz band	55.24 per concession (each concession of 2×10 MHz 700; 2×5 MHz 800; 2×10 MHz 1800)

Unsold spectrum can lead to reduced coverage and slower services, or some services not even being offered or offered at a higher price to recover the costs of operators needing to deploy greater network equipment. High reserve prices can also be counter-productive if government revenues end up lower because of the failure to sell all spectrum.

23 In June 2016, after the January 2016 failure of the 4G spectrum auction, the state-owned operator, Sonatel, renewed their operating licence and gained extended rights to use additional spectrum for 4G, paying $55 million for 2×10 MHz 800 MHz and 2×10 MHz 1800 MHz for 4G use.

Where competition is expected to be strong, reserve prices can be set as minimum safety net as competition in the auction will ensure a fair price for the spectrum.

Recommendations on spectrum pricing options

Spectrum prices should promote, and not undermine, the optimal use of spectrum for the benefit of society. A danger of governments setting higher charges to raise revenue is that fewer competing operators will be viable or end-user prices will be higher limiting the benefits that would have been achievable through affordable mobile services. High spectrum fees also reduce the funds available for investment thus negatively affecting the quality, speed and reach of mobile broadband services. High fees can also lead to higher debt levels which raise the cost of raising additional capital. High annual fees may also reduce expected future returns to investment. In the context of licence renewal, authorities should be particularly careful not to set fees that effectively remove returns on earlier risky investments. Doing so, will deter operators from making future investments where there are significant market or technology risks, despite the potential for such investments to benefit society. Licensing authorities should set reserve prices conservatively to allow the market to determine a fair price and to reduce the risk of leaving spectrum unassigned.

Setting non-price terms and conditions

Spectrum licences have traditionally contained a range of non-price terms and conditions which go beyond those necessary to manage interference between users. Providing for flexible spectrum use by limiting licence conditions enables spectrum be redeployed at a time of rapid technology and market changes and brings down the cost of service provision.

Technology and service neutrality

Restricting the use of spectrum to particular technologies and services exacerbates scarcity of spectrum and prevents customers from gaining access to new services. Removing restrictions that limit the use of spectrum to particular services or technologies (beyond those needed to manage interference) enables a country to maximise the benefits from its spectrum resources on an ongoing basis. Operators' ability to introduce new, more spectrally efficient, mobile technologies (including LTE, LTE advanced and in future 5G) will be critical to meeting exponential growth in demand for mobile data services. A number of countries only allow for licences to be made technology neutral after payment of fees. High charges for changing licences to be technology neutral risks delaying the benefits of new technology to end-users.

Technological neutrality in Guatemala

Guatemala was an early adopter of technology neutral licences. Since 1996, licensees have been allowed to decide which service and technology to implement within the licensed spectrum. Guatemala's Superintendencia de Telecomunicaciones (SIT), awards licences with conditions set only on permitted interference, frequency band and duration of the licence.

The flexibility provided to the operators in Guatemala allowed them to develop efficient networks, with penetration and subscriber traffic increasing relative to neighbouring countries while prices were kept relatively low.[24] Operators were also able to move to new technologies, such as 3G and 4G, without needing for new spectrum to be licensed or existing conditions changes. Technology neutral licences have since been adopted more widely across Latin America.

24 ITU, Spectrum Management for a Converging World: Case Study on Guatemala, 2004

Licence obligations

Licensing authorities often impose additional obligations on licensees aimed at achieving particular policy objectives. These can include obligations relating to universal access, such as coverage and service commitments, as well as obligations relating to the promotion of competition. Where a licence is assigned using a beauty contest, rather than an auction, commitments to meet non-price criteria can come to dominate the assignment process.

When mobile spectrum was licensed to only a single incumbent operator, imposing a series of obligations as part of that operator's licence represented a relatively straightforward way to achieve particular objectives. However, the development of competition in communications markets raises the need to regularly review which policy objectives remain relevant and which operators should be subject to any obligations. As a result, licence obligations can often result in greater costs than benefits.

Overarching licence obligations

Bangladesh is an example where the licensing authority sought to use licence renewal to meet other objectives that had nothing to do with the efficient use of spectrum. For example, the regulator included obligations on employment regulation (limiting employment of foreign nationals), a social obligation fund and corporate social responsibility. There is a strong case for such regulatory issues to be addressed within a separate regulatory framework – with their own consultation process – and should be removed from the licence renewal framework. Bangladesh's licensing authority also required an IPO of 30% of the equity within 2 years, although local financial/capital markets were unlikely to be established enough to support the required financing.

Coverage and service obligations

Many licensing authorities have imposed obligations on licensees to provide a particular level of service coverage within a specified timeframe or included requirements to offer certain services, or quality of service as well as measures relating to universal access and consumer protection goals.
In deciding whether to impose such obligations, licensing authorities should consider:

- **the benefits and costs of such obligations; and**
- **whether there are less costly means to achieve the objectives.**

Whether a particular regulatory obligation is required to support universal access goals will depend on the specific market circumstances. Competition often drives the widespread availability of affordable mobile services given that coverage and price are key means by which operators seek to gain a competitive advantage over their rivals.

Stringent coverage or service requirements carry risks. Obligations may force operators to deploy networks and services faster than economically or commercially sensible to do so. For instance, this could arise where technology is still at an early stage with a number of technical flaws remaining or where equipment prices are relatively high before more widespread international take-up. Obligations may also force operators to incur losses (e.g. by deploying networks in advance of sufficient demand for the services) which can create financial difficulties particularly for entrants without established cash flows.

Costly licence obligations in Argentina and Peru

The 2014 auction in Argentina of 4G 700 MHz and AWS (1700 MHz/2100 MHz) spectrum included a set of stringent coverage obligations. Licensees were required to roll out 4G services to all localities with over 500 inhabitants, approximately 98% of the population. This target would place the Argentinian 4G network coverage well ahead of the global coverage level forecast by the GSMA for 4G (~62%) and even 3G (~85%) by 2020.[25] These obligations are unlikely to be practical or would be ruinously expensive for the mobile operators, especially given the low population density in rural areas.

The licence renewal process faced by Telefónica Móviles in Peru for their 850 MHz and 1900 MHz spectrum holdings took close to 2 years, commencing in November 2010 with negotiations continuing until January 2013. In order to secure the licence renewal and not have spectrum returned to the regulator, Telefónica agreed to comply with certain requirements including the provision of free internet in government institutions and coverage extensions. Telefónica estimated the cost of meeting these commitments to be $1.2 billion.

25 GSMA, Mobile Broadband reach expanding globally, 2014

Extensive coverage obligations imposed on all licences may lead to costly duplication of network infrastructure. A number of regulators have sought alternative ways to ensure access in rural areas while avoiding inefficient network duplication:

- **the German regulator imposed a 'shared' obligation on all operators who acquired 800 MHz to coordinate to ensure coverage in rural areas before rolling out to urban areas; and**
- **one of the 800 MHz licences in Sweden included an obligation to provide mobile broadband to locations currently lacking access to other forms of broadband.**

Where obligations are imposed they should be made clear prior to the auction or assignment process so that operators can develop a viable business case. Costly obligations would be likely to be reflected in lower auction prices. Governments should therefore assess whether the impact on auction revenue is an appropriate trade off to extend mobile coverage or whether the adoption of an alternative approach, such as providing targeted government funding for the extension of one network in underserved areas, would be more efficient. A competitive tender could also be held to identify the lowest level of government subsidy required for an operator to extend coverage to the target area.

Where operators fail to meet their licence conditions (as was the case with 3G licence conditions in European countries including France, Spain and Sweden), regulators are confronted with the dilemma of whether to take the drastic step to revoke the licence with potential harm to competition or postpone or abandon the licence condition. Relaxation of licence conditions can lead to legal challenges by other operators who have met conditions or by potential new entrants who may have bid for the licence if they had known the obligations would not be enforced.

An alternative to imposing rigid coverage and service obligations is to support the commercial provision of services in rural areas including releasing spectrum in lower frequency bands, allowing for network sharing and removing or minimising mobile-specific taxes and charges. Measures that improve the commercial viability of extending coverage are more likely to be achieved, and at lower cost, than seeking to enforce licence obligations.

Minimum 20-year terms for new licences

The longer the duration of a licence, the greater the certainty provided for operators to undertake long-term investments in rolling out networks and in deploying new services. Investors would be reluctant to undertake investments if the licence runs for a shorter period than the expected payback period and if there is uncertainty over whether the licence will be renewed again in the future.

On the basis of the expected payback period for substantial new network investment, many countries including Canada, New Zealand, the UK and more recently Australia have decided to provide for a minimum term of 20 years for new mobile licences. Such a term will help support investment in 4G and in the near future 5G. Perpetual spectrum licences, with a minimum notice period for revocation, or a presumption of renewal can avoid unnecessarily introducing uncertainty over renewal as a result of a fixed term.

Longer licence terms both support and are supported by a move towards a more market-based approach to spectrum management. Longer licence terms provide the certainty for operators to take advantage of increased flexibility to introduce new technologies and be more willing to trade spectrum. The risk of long licence terms locking spectrum into outdated, inefficient use is also greatly reduced when licensees are allowed to change the use of spectrum or sell to another party that can make better use of it.

Providing greater certainty for licensees in Australia

In 2015, the Australian Communications and Media Authority (ACMA) and the Department of Communications published their Spectrum Review Report, setting out plans to reform Australia's spectrum policy and management framework. The review highlighted the benefits of extending licence duration and recommended increasing the maximum duration from 15 to 20 years. The ACMA and the Department consider that this extension balanced the benefits of "providing users of spectrum with greater certainty to innovate and invest whilst supporting the development of secondary markets" with the risks of "reducing government flexibility as circumstances change".

Recommendations on non-price terms and conditions
Authorities should limit conditions on the use of spectrum to those necessary to safeguard against harmful interference. New spectrum licences should be technology and service neutral. Where governments have particular coverage or other policy objectives, they should consider the range of alternatives available to meet those objectives including supporting commercial provision of widespread and affordable access. Mobile licences should have a minimum 20-year term to provide for sufficient certainty to support mobile network investment which have long pay-back periods

Promoting competition through licensing

As access to spectrum is essential for the supply of mobile services, the way that spectrum is assigned and how it is managed on an ongoing basis can impact on the level of competition in mobile markets.

In general, governments can best promote competition by making as much spectrum available as possible and by limiting charges and other conditions on the industry so that multiple operators will be viable. Specific additional measures to increase competition only make sense where competition is not already effective, additional players would be sustainable and where the competitive gains outweigh any loss arising from spectrum being used less intensively.

In assessing whether to impose particular measures to promote competition, licensing authorities should:

- **Assess what would be the level of competition in the absence of the measures. Where competition is already expected to be effective then imposing additional obligations may bring little additional benefit while carrying costs such as in terms of spectrum not being assigned to its most valuable use or the market becoming excessively fragmented resulting in higher costs and prices.**
- **Identify whether there are ways to achieve effective competition that do not constrain the ability of any operator to support growing data usage by existing customers or attract new customers. For example, reducing mobile-specific taxes and licence fees and freeing additional spectrum can improve the viability of all players in the market.**

Whether particular measures are to be introduced or retained to protect or promote competition, it is important to evaluate the costs and benefits of each measure to ensure that benefits do exceed costs and that the particular measure is chosen that is expected to achieve the policy aim at the least cost. Authorities should aim to avoid penalising successful operators by having their spectrum rights re-assigned to players that have failed to attract as many customers.

Where an authority is assessing whether to renew some existing spectrum rights so as to promote competition, the authority should evaluate the effects of reassigning different amounts of the spectrum. The more spectrum that an existing operator is required to release, the more likely it is the operator will need to turn to more expensive solutions to try to retain sufficient capacity to serve existing customers and the greater the risk that service quality will suffer. On the other hand, an entrant with a relatively small customer base would not be expected to need the same capacity as a larger player. Spectrum caps and the amount of any spectrum set aside for new entrants should be carefully determined so that all operators can deploy networks in a technically and economically efficient manner. Further, before such caps and set-asides are applied, authorities should undertake a rigorous market analysis to ensure that there are in fact players or potential new entrants who can make efficient use of any released spectrum.

Licensing approaches to promote competition
A range of specific measures have been used in practice with the aim of promoting competition particularly in the early stages of market development.

Spectrum caps and set-asides

Spectrum caps limit the quantity of spectrum that can be held by an operator. Spectrum set-asides reserve a particular block of spectrum for a particular bidder or type of bidder such as a new entrant.

Spectrum caps and set-asides can be effective in attracting entrants to participate in licensing assignment processes and they can also limit later market consolidation leading to a loss in competition. However, these measures may lead to less efficient spectrum use as operators with larger customer bases may have greater need for additional spectrum. Fragmented spectrum holdings can also raise the overall industry cost of service deployment and risk preventing some services from being able to be offered. For example, tight restrictions on LTE spectrum can impede both the speed and the services offered, noting that LTE can use contiguous spectrum for carrier sizes up to 2 x 20 MHz.[26]

Spectrum caps previously imposed in many countries have been modified or removed entirely as additional spectrum in new frequency bands has been made available. However, in Latin America, tight spectrum caps are still in place in a number of countries (often ranging from 40 MHz to 80 MHz) with many operators already at this ceiling which risks costly network solutions and impairs quality of service and competition.

Spectrum caps and facilitating market entry in the New Zealand 700 MHz auction

In 2013-14 New Zealand's Radio Spectrum Management conducted an auction for the 700 MHz spectrum (i.e. the 'digital dividend' spectrum). The auction took place over three rounds, with the first two assigning quantities of spectrum and the final round focussing on preferred placement in the band.

The auction rules set spectrum caps of 2×15 MHz for the first round and, in the event that not all lots were sold, a relaxed limit of 2×20 MHz in the second round. These caps were set after considering both theoretical arguments and benchmarking international spectrum caps used in digital dividend auctions. The 2×15 MHz cap was selected to enable all existing operators to provide effective services in the band while the relaxed 2×20 MHz cap would optimise the use of the technology for better services.

In the first round of the auction, the three incumbents acquired, at the reserve price, eight of the nine available 2×5 MHz lots. In the second round, the final lot was acquired for close to four times the reserve price. The flexible spectrum caps enabled the smallest operator to acquire 2×10 MHz of spectrum at reserve price, with the two larger operators then competing aggressively for the final lot.

26 Future LTE-A systems will support the aggregation of non-contiguous spectrum and the ability to create effective bandwidths in excess of 2 x 20 MHz.

Open access requirements

Open access licensing approaches involve spectrum being licensed to a particular provider that will then be required to provide wholesale access to competing retail providers. Such models are put forward as ways to support greater coverage or the introduction of new technology such as LTE through pooling demand while protecting competition at the retail level. Various proposals have included a significant role for government such as under a Public-Private Partnership (PPP) approach in which government contributions are made for shared network investment, land assets and/or preferential land access rights. In assessing the case for open access models, governments should first consider whether competing providers would be viable as mobile competition has generally been effective in achieving widespread access and the introduction of new technologies and services at affordable prices. It might be that competition is only not viable in some areas of the country. The ownership of the wholesale network would also be important. If owned by an operator also active at the retail level, there could be opportunities for anticompetitive discrimination. If owned by all operators, there may be difficulties in reaching agreements on investment and financing for network extensions or upgrades. If governments retain an equity stake, there could be a risk of the operator coming under pressure to favour particular groups or businesses or to protect the operator against competition should alternative networks in the area prove viable. The access price of the wholesale network is also likely to require ongoing regulation.

Allowing operators commercially to share networks in parts of the country where multiple infrastructure would be uneconomic is likely to be a more practical and cost effective way to achieve coverage objectives. The government could also offer a subsidy for network coverage to be provided to an area with operators bidding on the basis of which operator would be willing to provide coverage to the area for the least subsidy.

Wholesale licensing in Rwanda

The Government of Rwanda and Korea Telecom (KT) entered into a Public Private Partnership (PPP) to deploy a wholesale LTE network in the country using 800 MHz and 1800 MHz spectrum. This launched in November 2014 as Olleh Rwanda Networks (oRn), and network operators rapidly announced their plans to launch LTE services.

There have been a number of problems; prices were originally considered prohibitively high and in February 2015 oRn was obliged to reduce its LTE tariffs by 70%, from RWF4,100 to RWF1,300 per GB and further reductions in tariffs have been required in 2016. Additionally, take-up of LTE services in Rwanda has been low, in part due to the high prices for LTE packages, but also due to the unaffordability of LTE devices. This has left a tranche of 800 MHz and 1800 MHz spectrum underutilised.

27 oRn, Company Profile, 2016

ARE SPECIFIC MEASURES NEEDED TO PROMOTE COMPETITION?

Assessing competition as part of licensing

Is the market effectively competitive?

YES → **Licence to operator with highest value use**

NO ↓

Are there ways of making the market more competitive with less costs than through restricting licensing

YES → **Take other measures e.g. release additional spectrum**

NO ↓

Are the advantages expected to exceed the cost of restricting licensing?

NO → **Licence to operator with highest value use**

YES ↓

Administrative assignment

- A licensing authority may believe that competition can best be promoted by assigning spectrum to a particular player
- Practical where there is a clear alternative operator able to use the spectrum effectively
- Can lead to inefficient spectrum use if spectrum would deliver higher value with another operator
- Carries risk to service continuity and investment in the context of licence renewal

Auction with spectrum caps/ set-asides

- Can promote overall competition in markets where it is limited
- Provides smaller players/ entrants with equal opportunity to compete for the spectrum set-aside and thereby encourage greater participation in auctions
- Can lead to inefficient spectrum use including if spectrum is too fragmented to support optimal service quality
- Carries risk to service continuity and investment in the context of renewal

Open access requirement

- Ensures equal access for all operators to services and infrastructures
- Can support the introduction of new technologies, the development of infrastructures and the entry of new competitors
- Limits the potential harm of a single provider although preferential access issues may arise if vertically integrated provider
- Competition will generally deliver better outcomes to consumers than a single provider model

Spectrum re-assignment in mobile mergers

Spectrum licensing has been a key issue in the assessment of a number of recent proposed mobile mergers by regulators. For example, requirements to divest spectrum holdings were important in the clearance of the mergers: H3G Austria/Orange (2012), H3G Ireland/O2 (2014), and Telefonica O2/E-Plus (2014).

Whether or not a spectrum divestment is in the overall interests of society requires a comprehensive analysis of the likely effects on the divestment on competition and the efficient use of spectrum. For example, a merger that enables the parties to use a larger block of spectrum may enable LTE to be delivered at the best possible speeds. Requiring the divestment of significant spectrum to a new entrant might lead to that spectrum being poorly utilised relative to a situation in which it was available to meet the needs of operators with larger customer bases. This could lead to higher end-user prices and lower quality of service. Requiring large spectrum divestments may also deter parties from proposing mergers in the first place, even when they would bring overall social benefits.

Recommendations on promoting competition through licensing

Governments can best promote competition by making available as much spectrum as possible and by limiting taxes, licence fees and other conditions that risk limiting the number of viable competing operators.

In competitive markets licensing spectrum to the bidder who values it the most can be expected to lead to the optimal use of a country's spectrum. However, where competition is not effective, then governments may wish to assess the likely benefits and costs of specific restrictions on licensing aimed at promoting competition. Generally, there will be a need to weigh any potential competitive gains with potential effects on the efficiency of spectrum use and the resulting quality and cost of services to end-users.

* Neul assumed 15000 end points in a cell at 0.4 bps taking into account overheads, modulation efficiency and spectrum efficiency. The resulting basic spectrum requirement was 50 kHz (ie 3.3Hz per device) which increased to 400 kHz (i.e. 26.7Hz/device) when assuming a frequency reuse factor of 8.

Spectrum trading

Allowing spectrum rights in new and renewed licences to be traded between operators is an important way to ensure that spectrum continues to be used efficiently over time. In particular, trading encourages efficiency by allowing for spectrum rights to be transferred to those who will make better use of them.

Benefits of voluntary spectrum trading

In helping to reduce spectrum shortages faced by some operators while ensuring valuable spectrum does not lie fallow, trading can allow for a country's spectrum resources to be used more intensively thereby supporting higher volumes of services, increased service quality and lower costs of service provision. In being voluntary, spectrum trading enables the parties that have the best information on the value of spectrum in specific uses to determine whether a trade would be value enhancing (i.e. a buyer will only acquire the rights if they are prepared to pay a price at least equal to the seller's valuation of the spectrum). Voluntary trading also reduces risks for operators including market entrants as they are able to sell rights that they end up not needing while also having the opportunity to acquire new rights as they grow. The ability to trade licences can ensure that spectrum is used efficiently without any need for further charges to be imposed by government.

There is growing experience with spectrum trading globally including in Australia, Canada, most of the European Union, Guatemala, New Zealand and the USA as well as trading being introduced more recently in countries such as India. This experience highlights that certain measures can help facilitate trading in the interests of consumers.

- **Trading is more likely to take place where there is substantial available spectrum and where there is high degree of predictability including in relation to future spectrum availability, the regulatory framework and where licences have sufficiently long terms for the buyer of the rights to undertake investments to make use of the spectrum. Spectrum trading is made difficult where decisions about whether licences are to be renewed and the conditions that will be attached to the new licences are made close to the expiry date of the existing licences.**
- **Authorities should be notified of the trades taking place so that it is clear who holds spectrum usage rights. Notification also enables authorities to assess whether a proposed trade would create any risks to competition. Spectrum trading could be subject to competition law or to specific ex ante competition assessments.**
- **While some authorities have been concerned that spectrum trading may lead to windfall gains, it is the potential for gains that motivates efficiency-enhancing spectrum trades to the benefit of society. While some operators may make gains, there are many operators that have incurred significant losses in acquiring spectrum. A gain may simply represent a return on the risks of acquiring spectrum. There is no reason to tax gains from spectrum sales any more than gains from the sales of other business assets.**

A regulatory framework that supports voluntary spectrum trading offers the potential for substantial benefits to society from ensuring the ongoing efficient use of spectrum.

* These Inter-site distances of 500m and 1732m, have corresponding site coverage areas on an idealised tri-sector hexagonal grid of 0.216km2 and 2.6km2 respectively. For comparison, the same areas with a circular coverage pattern would have cell ranges of 0.26km and 0.91km (i.e. approximately half of the inter-site distances).

Introduction of spectrum trading in India

In October 2015, India's Department of Telecommunications published Guidelines for Trading of Access Spectrum by Access Service Providers allowing mobile operators to trade any frequencies that they have held for over 2 years. Operators can acquire spectrum holdings up to a maximum of 25% of the entire spectrum allocation in any given licensing region, or 50% of the spectrum in a given band. The regulation has enabled trades to take place even within a few months of its introduction. For example, Bharti Airtel has acquired spectrum from smaller operators with less need for the spectrum and potential trades between other operators are being discussed.

FIGURE 1 – BHARTI AIRTEL SPECTRUM TRADES IN INDIA SINCE REGULATION INTRODUCED

	Original licensee		Recipient of traded spectrum
March 2016	**Videocon (0.77%*)**	1800 MHz band spectrum across 6 circles →	**Bharti Airtel (23.85%)**
January 2016	**Aircel (8.42%)**	2.3 GHz band spectrum across 8 circles →	**Bharti Aircel (23.85%)**

* Share of wireless subscribers, November 2015, TELECOM REGULATORY AUTHORITY OF INDIA

For India, with its highly fragmented mobile market in which there were 12 mobile operators in November 2015, trading is proving to be a timely and practical way to rationalise spectrum holdings. The trades will improve spectrum utilisation levels thus helping to reduce network congestion and support higher quality data services.

Issues in implementation

Markets work best when there are well-specified, enforceable, property rights, low transactions costs, and competition is effective. Authorities can support efficient spectrum trading by ensuring that these conditions are present to support the development of spectrum markets.

Markets are based on a private property rights system and trading bandwidth requires a clear and commercially sensible and defensible definition of initial property rights or entitlements. A spectrum licence may specify the right to exclusive usage in terms of frequency and geography (and potentially in relation to a time dimension) as well as reasonable interference levels both in terms of allowable levels of interference caused by the licensee to other spectrum users and the maximum levels of interference which the licensee must accept experience from others. As experience of spectrum trading in developed countries grows, developing countries will be well-positioned to learn from their experience enabling trading to be introduced in the longer term at lower risk.

IMPLEMENTATION ISSUES FOR SPECTRUM TRADING

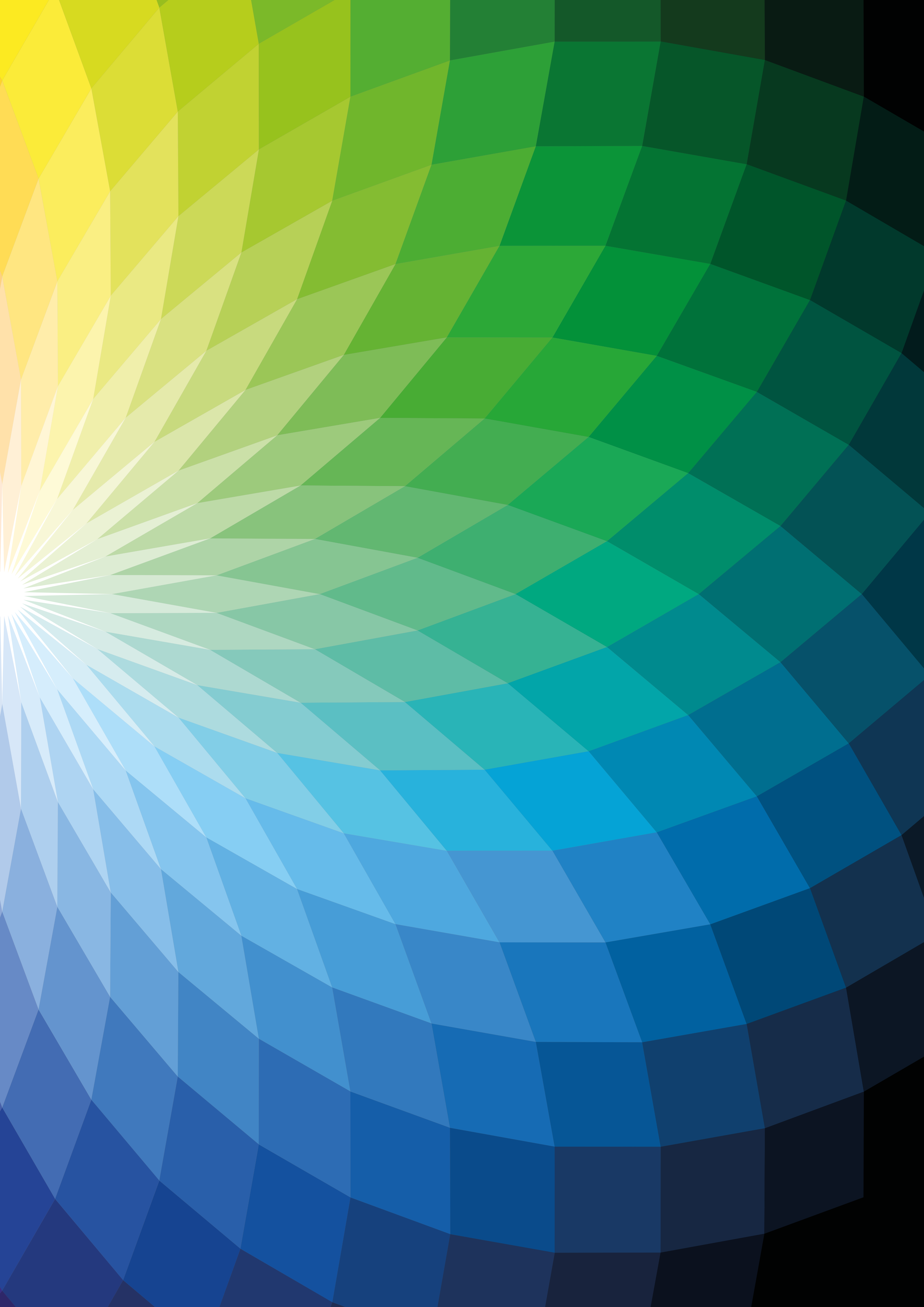
	Key issues
Well specified spectrum rights	Defining 'well defined, technology neutral, property rights' in the context of spectrum has proved to be complex, and there is no universally agreed right adopted by the ITU. In general, the more flexible the property right used, the more problematic interference control. In the absence of an internationally agreed definition, regulators should conduct a cost benefit analysis regarding the appropriate level of flexibility for their market. It is likely that for spectrum currently allocated to mobile services most of the economic benefits will flow from trading between operators.
Licence renewal	Uncertainty over future rights to use the spectrum can act as a major barrier to spectrum trading. There may be few buyers of spectrum rights if there is only a short tenure left and significant uncertainty over whether a right will be renewed.
Transaction costs	Transactions costs will also affect market efficiency. These will in part be a function of the frequency and ease of trading. In the absence of a secondary market, the only way to trade spectrum may be by acquiring a firm which holds a licence subjecting them to costs of acquisition and subsequent costs of disposing of other assets owned by the acquired company. Additionally, a licence acquired this way will likely be for a large amount of bandwidth while secondary markets should allow parties to divide or aggregate spectrum. Transaction costs can also be reduced by ensuring that detailed information on current spectrum holdings is made available, as well as plans for future spectrum releases. Allowing the development of specialist spectrum trading brokers can also help reduce transaction costs.
Competition issues	Whether trading would lead to a loss in competition would depend on: ■ the amount of spectrum available to competitors; ■ the degree of competition in communications markets. Accordingly, whether a particular transaction should be prohibited on competition grounds is likely to require a case-by-case review which could potentially be under general competition law (as occurs in New Zealand). Safe harbours could be determined and acquisitions permitted if the operator has a market share below a certain level and if the spectrum acquired represents only a small share of spectrum suitable for supplying that service.
Taxation of gains	Trading may result in existing licensees earning financial gains over the price originally paid for the licences, which it may be argued should belong to the government. However, the gains provide the incentive for efficiency-enhancing trades and the larger the tax imposed on these gains, the less likely they are to take place. Governments will need to determine how best to meet revenue requirements, taking into account principles of efficiency, equity and simplicity. A large tax on gains from spectrum sales would be likely to come at a substantial cost to efficiency.

Recommendations on trading

Licensing authorities should allow voluntary spectrum trades between operators and facilitate trading through clearly defined spectrum rights, long licence terms and limited administrative costs. In advance of a formal spectrum trading framework being established, authorities should be prepared to assess proposals for particular trades subject to consultation and consideration of any risks to competition or of heightened interference.

Transparent and well-timed licence renewal processes and information on spectrum availability, pricing and conditions would also facilitate trading.

Spectrum trades should be subject to competition law and/or ex ante competition assessments. Competition issues should be assessed taking into account the specific circumstances of each trade, although certain safe harbors could be established such as where the operator acquiring the spectrum has a market share below a certain threshold and/or the spectrum represents a relatively small share of the overall spectrum available for those services.



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GSMA Spectrum

Effective Spectrum Pricing: Supporting better quality and more affordable mobile services

Full Report
February 2017

The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with almost 300 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces industry-leading events such as Mobile World Congress, Mobile World Congress Shanghai, Mobile World Congress Americas and the Mobile 360 Series of conferences.

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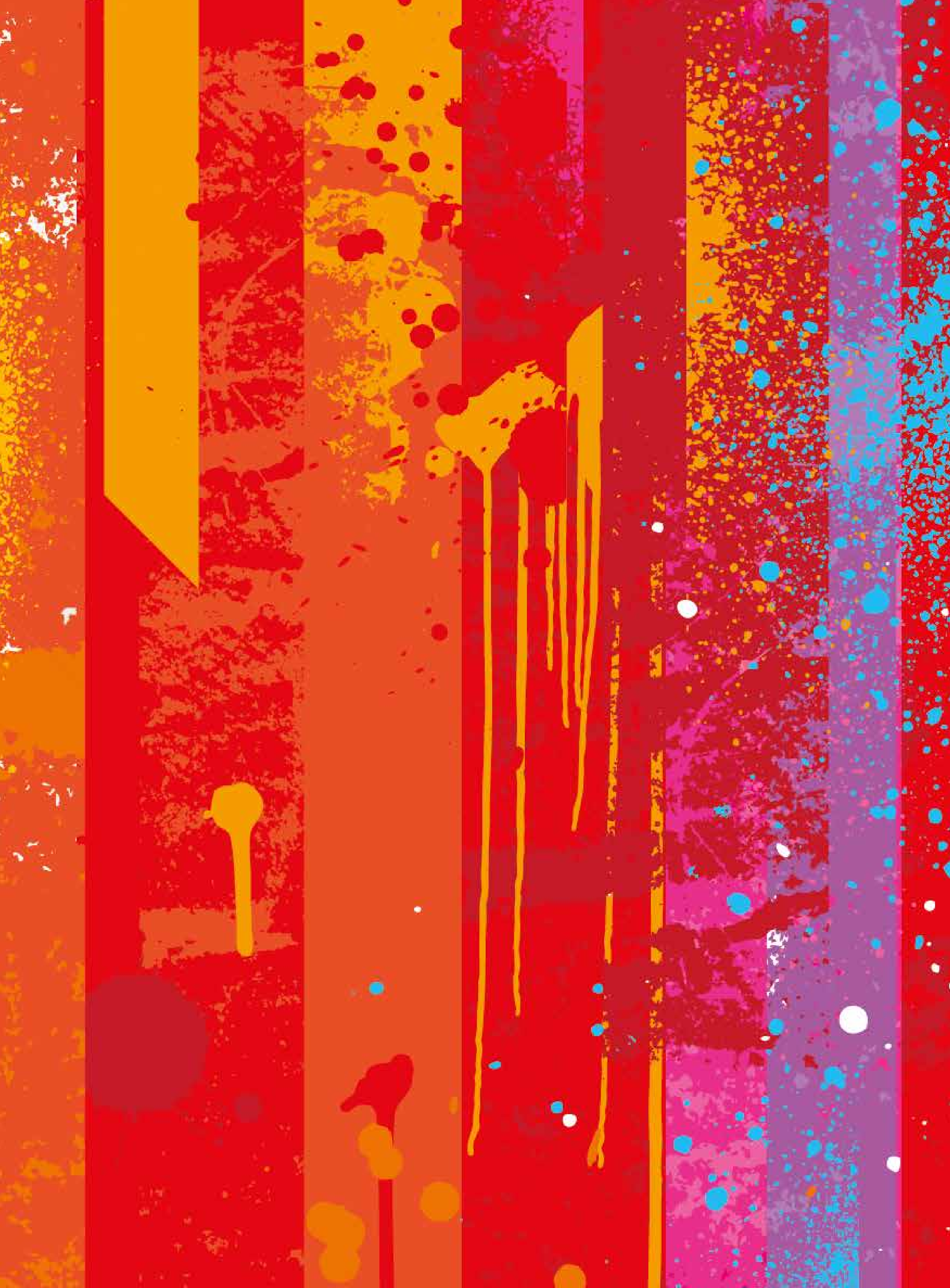
Contents



Executive Summary

Radio spectrum is the key input underpinning the mobile industry. In this report, NERA Economic Consulting explores the relationship between the pricing of radio spectrum and the success of countries worldwide in developing markets for next-generation mobile data services. In the past, some observers of the industry have suggested that the amount of money that operators spend on spectrum should have no impact on the development of mobile services, as spectrum costs are sunk. This report firmly rejects that viewpoint by demonstrating that high spectrum prices negatively impact consumers and efforts to maximise revenues from spectrum auctions can damage the wider economy.

The report presents new empirical evidence, consistent with related academic literature, that links high spectrum spend with:

1. **Lower quality networks and reduced take-up of mobile data services owing to reduced incentives for investment;**
2. **Higher consumer prices for mobile broadband data; and**
3. **Lost consumer welfare with a purchasing power of US$250bn across a group of countries where spectrum was priced above the global median.**

The right price for spectrum

The main rationale for charging a price for spectrum, whether through upfront fees or annual charges (or both), is to promote its efficient use. Price is an objective tool for regulators to distinguish between the business cases of potential users. Of course, pricing also generates revenues for the State and – in some countries – raising revenue is identified as an additional objective in spectrum awards. However, even governments that place a high importance on revenues should prioritise efficiency in allocation, so as to minimise the risk of award failure and maximise benefits to society. A regulator engaged in best practice should set auction reserve prices that are below a conservative estimate of true market value to enable price discovery and facilitate efficient allocations.

Both theoretical and empirical work from academia inform us that, in industries with natural limits on the number of viable operators, high input costs depress incentives for investment and price competition. Although upfront fees paid for spectrum are sunk, they continue to weigh on the business decisions made by operators and their owners throughout the licence term, and affect their approach to future spectrum awards. This observation reinforces the point that policymakers should never seek to price above the fair market level, as the revenue upside (if any) is more than offset by the risk of award failure and the long-term downsides for consumers.

How spectrum prices impact mobile services, the economy and consumers

To explore the link between spectrum prices and investment and competition in mobile services, we conducted our own empirical research, using data from NERA's database of spectrum awards, covering 325 spectrum band releases across 60 countries from 2000-2016. We observe that, over the last eight years, both reserve prices and price outcomes have trended upwards.[1] While price outcomes for many awards remain moderate, the upward trend appears to be driven by a growth in the number of high price auctions, including many where reserve prices were set well above the global mean.

1 A three-year moving average of spectrum prices from 2008 to 2016 shows the average final price paid for spectrum sold at auction increased 3.5 fold, while average reserve prices increased over 5-fold.

Consistent with the academic literature, we also find statistical evidence linking higher spectrum prices to low investment in 4G and higher consumer prices for data. For countries holding spectrum awards from 2008-2016, we developed a 4G wireless score, which measures the quality and uptake of next-generation data services. We found that countries with lower spectrum costs have higher wireless scores than those with higher costs, after allowing for differences in economic development. We also found that countries with lower spectrum costs have lower consumer prices for data. By incorporating these findings into an econometric model of demand for data services, we demonstrate that high prices for spectrum are destroying billions of dollars in consumer welfare. If all countries in our dataset that have high spectrum prices had instead sold spectrum at the median price level, this could have generated incremental value for society with a purchasing power of US$250bn.

In other words, where governments adopt policies that extract excessive financial value from the mobile sector in the form of high fees for spectrum, a significant share of this burden is passed onto customers through higher prices for mobile and lower quality data services.

Mistakes in spectrum pricing

Mistakes by policymakers when pricing spectrum can be grouped into three broad categories:

1. **Reserve prices and annual fees set above true market value. We highlight multiple examples linking high prices to award failure, including recent 4G processes in Mozambique, Ghana, and Senegal.**
2. **Artificial scarcity or uncertainty over future spectrum availability. We highlight the case of India, where a combination of over-pricing and delays in releasing spectrum has led to inflated valuations and also caused valuable spectrum to go unsold.**
3. **Inappropriate award rules. We identify award rules that create risk for bidders or options to foreclose competition. For example, we highlight distorted price outcomes in Austria, where the auction design put enterprise value for incumbent operators at risk, and the damaging effects of onerous coverage obligations in Argentina.**

These blighted spectrum awards are contrasted with more positive examples, notably Sweden, where the regulator has a track record of setting fair reserve prices, bringing spectrum to market in a timely manner and managing risk for bidders, for example in relation to rural roll-out. We do not think it is a coincidence that Sweden has amongst the highest wireless scores and lowest consumer prices for mobile data in our dataset.

Observations from other industries

Mobile communications is one of a wide range of industries dependent on essential inputs provided by public authorities. We surveyed a number of industries and compared their approaches to pricing and allocation to policies used in the mobile sector. We also sought to understand how these practices varied across industries depending on the characteristics of that industry, namely: the level of competition in downstream markets; the risk profile of the investment; and whether the resource is renewable (like spectrum) or depletes (e.g. minerals).
In those industries with similar attributes to mobile, regulators engaged in best practice:

- **rely on the market to set prices;**
- **encourage full utilisation of the resource;**
- **take measures to mitigate risk for operators; and**
- **adopt a long-term perspective to social value creation.**

For example, best practice regulation of the airline industry prevents airports from exploiting monopoly power when pricing airport landing slots, and encourages full utilisation of capacity. In Europe, such policies have supported huge growth in air travel, including the low-cost carrier revolution. By analogy, pricing spectrum above market level or holding back spectrum from the market is equivalent to encouraging airports to cut the number of flights and raise landing fees, in the hope of raising more revenues from airlines, at the expense of paying travellers.

Recommendations

With the increase in spectrum bandwidth needed to support high data traffic in a 4G and 5G world, fair pricing techniques will become ever more important to support efficient spectrum allocation, promote healthy investment in networks and encourage sustainable competition to support affordable services. Countries that persist with excessive pricing, constrain available spectrum, or enact conditions, rules or policies that place undue risk and cost burdens on operators, risk experiencing a widening gap in quality and pricing of the mobile services available at home versus abroad. Actions that depress growth and competition in mobile services have obvious negative implications for the broader economy, with the result that long-term losses in consumer welfare and tax revenues will outweigh any short-term gains from unduly high upfront or annual spectrum fees.

We have four recommendations for best practice in spectrum pricing:

1. **Set modest reserve prices.** Minimum prices for spectrum – taking into account both upfront reserve prices and annual fees – should be set below a conservative estimate of market value, so there is scope for competition and price discovery in auctions.
2. **Prioritise spectrum allocation.** Regulators should aim to bring spectrum fully to market as soon as it is needed, and provide clear signposting for future releases (e.g. through a spectrum roadmap). Because spectrum is a renewable resource, when it is left unallocated for any prolonged period, welfare benefits that would have accrued to consumers are lost forever.
3. **Help operators manage risk.** Prices paid for spectrum can be distorted if bidders in spectrum awards face undue risks. Regulators can mitigate such effects, for example by avoiding award rules that put enterprise value at risk, and off-setting onerous overage obligations with comensurate price concessions.
4. **Adopt a long-term perspective.** When policymakers plan spectrum awards, they should ideally prioritise long-term welfare benefits over short-term revenues. Measures that de-politicise spectrum pricing, such as devolving decisions to independent regulators or undertaking cost-benefit analysis are advised and are becoming more common.

1. What is the right price for spectrum?

Radio spectrum for deploying mobile networks is in limited supply. Only frequency bands that are integrated into mobile handsets and network infrastructure can be used to provide services. To provide a quality mobile broadband service (without undue interference), operators require exclusive access to adequate spectrum bandwidth, across multiple frequency bands. This, in turn, tends to limit the number of mobile network operators that can be accommodated in any given geographic area, and provides a rationale for governments to manage access to spectrum and charge for spectrum licences.

How regulators decide to price mobile spectrum bands has a big impact on the evolution of mobile services. If prices are set too high or are otherwise distorted by poor policy choices, this will negatively affect investment decisions, which may be manifested in slower data speeds, reduced network capacity, or reduced scope for price competition in mobile services. In contrast, if prices are set at fair levels, they can help ensure that spectrum use generates maximum benefits for society, while also raising revenues for the state, directly through spectrum fees and, more importantly, indirectly through accelerated GDP growth and tax revenues. The value of the mobile economy – which relies on spectrum – is sizable. According to the GSMA, in 2015, the mobile economy (directly and as an enabler of adjacent sectors and services) contributed US$3.1tn to global GDP (i.e. 4.2%) – and paid US$430bn in taxes (excluding spectrum payments). It also directly provided 17 million jobs and supported a further 15 million indirectly.[2]

We begin this chapter by setting out the core components of spectrum price. Our key point here is that a spectrum price includes not just the upfront fee but also any annual charges associated with spectrum holdings. We then discuss the rationale for spectrum pricing, as a tool to promote efficient use of spectrum. We make the point that even governments that place a high importance on revenues should prioritise efficiency in allocation, so as to minimise risk of allocation failure and maximise benefits to society. Next, we explore the notion of effective pricing for spectrum and how this may be achieved in practice. We make the case that a regulator engaged in best practice should set prices below a conservative estimate of true market value to allow for price discovery in an auction. This argument is reinforced by theoretical and empirical evidence that mobile operators do not, in practice, treat spectrum prices as sunk costs, and that high prices depress incentives for investment and retail price competition.

2 The Mobile Economy Report 2015, GSMA.

1.1. The components of spectrum price

Regulators impose a variety of upfront fees and annual charges on mobile network operators for licences to access mobile spectrum. These fees and charges together form the price that mobile operators must pay for the spectrum necessary to deploy their networks.

The price for spectrum sold has up to three components, as illustrated here (if the spectrum is awarded directly without an auction, then the competitive premium, which arises from bidding activity, is not relevant):

UPFRONT RESERVE PRICE + **COMPETITIVE PREMIUM** (IN AUCTION, IF ANY) + **ANNUAL FEES** (DISCOUNTED COST OVER LICENCE TERM)

Approaches to setting fees vary widely: some regulators put more weight on upfront fees, others on annual fees; some set low reserve prices and rely on the market to determine an adequate competitive premium; others opt for fixed fees or higher reserve prices that limit the range of possible price outcomes. There are advantages and disadvantages to each approach. When looking at award outcomes, commentators often focus only on the upfront price (reserve price plus competitive premium) and neglect the annual fees. This is misleading, as the cumulative cost of fees over the licence term may be substantial. In general, the relative weight placed on different components of spectrum prices is less important than the aggregate level.

Auctions are now the most widely used mechanism for allocating mobile spectrum, especially amongst countries with larger populations. They are particular widely used for awards of new mobile bands, and also are used where a regulator decides not to renew expiring spectrum licences but to re-award them.

For example, in the EU, 24 out of 28 countries used auctions to allocate 800 MHz spectrum, and 12 out of 28 countries used auctions to re-allocate 900 MHz spectrum. Regulators invariably set a reserve price for radio spectrum. Sometimes, as in Sweden or Germany, reserve prices are set at a modest but non-trivial level sufficient to deter frivolous entry, and to ensure winners pay at least the “opportunity cost” of denying the next-best use case (e.g. broadcasting). In other cases, as in France, the reserve price may be set closer to the perceived market value of the spectrum, in an effort to guarantee substantial returns for the treasury.

Even in countries where administrative processes are used for some or all awards of mobile spectrum, fixed prices are often set with reference to auction outcomes, either at home or abroad. For example, in the UK, licences for 900 MHz and 1800 MHz spectrum were renewed rather than re-auctioned, but the annual fees were set with reference to the outcome of the UK 4G auction and other comparable awards in Europe.

In addition to upfront fees, most regulators impose annual fees on operators, which are at least sufficient to recover the administrative costs of managing spectrum. Such fees are usually set proportional to the amount of spectrum, and may vary by band. Often, regulators (e.g. Denmark) set higher administrative fees for bands designated for use by higher value services, such as mobile, and for bands with particularly attractive propagation characteristics, such as sub-1 GHz spectrum. Typically, even with such variation, these fees are modest relative to the value of the licence. However, some regulators (e.g. Mexico) impose higher annual fees, which go well beyond the levels required for administrative cost recovery. In this case, these fees become an important component of the reserve price, and expectations for potential auction prices should be moderated accordingly.

The price of spectrum should not be confused with its value to operators, which depends on a combination of estimated incremental revenues and avoided costs from deploying the spectrum, less any incremental costs associated with licence conditions. In a properly functioning market, companies bid to acquire spectrum when their estimated value (adjusted for commercial risk) exceeds the price. When regulators attach licence conditions – such as rural coverage obligations or quality of service commitments – to spectrum licences, they may reduce the value that operators place on spectrum. This in turn reduces the willingness to pay of operators for additional spectrum, and thus reduces the market price of spectrum.

1.2. Spectrum pricing – a tool for promoting efficient use and maximising benefits to society

Efficiency and revenues

The academic literature on pricing of scarce resources attaches primary importance to allocating those resources efficiently so that the benefits for society from its use are maximised. For example, in relation to spectrum, Martin Cave and William Webb say that:

"The radio spectrum is a resource of great significance to all modern economies. The importance of services supported by radio spectrum has grown markedly in recent years, especially as more and more mobile communications applications take hold among the world's population. It is thus critical that this increasingly important resource is allocated efficiently, in a way that ***maximises the benefits which people gain from their individual use of services*** *such as mobile telephony …"* [3]

Leading regulatory bodies, such as the European Commission and FCC (United States) also identify efficiency as the primary objective in spectrum allocation. Efficiency is a universal concept that should apply to every government body concerned with regulating spectrum, whatever the size or wealth of the country concerned. An efficient spectrum allocation is one in which spectrum is distributed amongst operators in a way that allows them to collectively generate the greatest welfare for society, including both consumers and firms. When an efficient allocation is achieved, other goals, such as maximising the economic benefits for individual users of services and promoting a competitive mobile market should also be achieved.

Spectrum pricing also generates revenues. For many regulators, notably those in Germany and Sweden, revenue is not a priority – their focus is on the longer-term benefits to consumers and the broader economy through promoting mobile services and a digital society. However, for others, revenue generation may be an important policy consideration, for fiscal reasons and to demonstrate a "fair return" for taxpayers. For example, the United States and Indian governments have both opted to set revenue targets for major mobile auctions, albeit with mixed outcomes. Inevitably, the importance attached to revenues will affect decisions on spectrum pricing, in particular regarding a regulator's perspective on the minimum acceptable price outcome. Nevertheless, it is important to recognise that regulatory goals for spectrum awards are not all equal.

3 Martin Cave and William Webb, Spectrum Management - Using the Airwaves for Maximum Social and Economic Benefit, Cambridge University Press, 2015, p.42. Emphasis added.

Maximising benefits to society by promoting efficient use should always be the primary objective. Revenues should always be a secondary objective. Spectrum pricing is a tool that can help regulators achieve an efficient allocation, which also offers the added benefit that it generates revenues. As we will demonstrate in this paper, with appropriate safeguards against low revenue outcomes, award rules that prioritise efficiency are the best approach to minimise risk of allocation failure and maximise benefits for society (including tax revenues) over the medium-to-long term.

The role of price mechanisms in promoting efficient use of spectrum

Price mechanisms, implemented through primary awards or secondary trading, encourage spectrum to flow to the operators that can generate the highest value. To understand this point, it is helpful to consider the simplest case of one licence and two bidders, as illustrated in Figure 1: the strongest bidder (with bid amount A) should win the licence, and the price (B) is set by the bid amount of the second highest bidder. B also represents the "true market value", as it is the price that should emerge in a properly functioning market in which all participants reveal their true willingness to pay.

FIGURE 1: TRUE MARKET VALUE (B) FOR A SINGLE LICENCE AUCTION

An efficient allocation is not possible at a price above A, as no rational bidder would buy the spectrum licence. Failing to sell a licence because it is over-priced imposes an opportunity cost on society.[4] This includes not only producer surplus[5] that would have flowed to the operator but also, more importantly, lost consumer welfare from the service enhancements and lower mobile data prices that would have flowed from the deployment of the spectrum. Although the spectrum may still be allocated later, the lost welfare benefits during the delay can never be recouped. Such costs can be very high. For example, Hausman (1997) calculated the loss in consumer welfare associated with the 7-10 year regulatory delay in approving the widespread availability of mobile telephones in the United States at up to $24.3bn a year in 1983 dollars.[6]

In contrast, an efficient allocation is possible at any price below A, as the strong bidder will always have a business case to buy the licence. In principle, this is true even if the licence were given away at zero price to another bidder, as any inefficiency can be resolved through trading. However, in practice, as Coase (1960) and Myerson and Satterthwaite (1983) observed, the secondary market is not necessarily a panacea, as there may be barriers to trade, such as transaction costs[7] and informational asymmetries.[8]

Therefore, it is prudent for governments to aim for an efficient primary outcome if possible, and rely on the secondary market to resolve future changes in the efficient allocation.

Spectrum auctions typically involve multiple licences or units of spectrum that can be aggregated to form licences. In a multi-unit auction, point A in Figure 1 is equivalent to the valuation of the weakest winning bidder, and point B is the valuation of the strongest loser (which could be another bidder or a winner that would have been willing to buy more spectrum). In all cases, the general principle that spectrum should be always priced lower than the value of the weakest winner (A) holds.

Although an efficient outcome is possible at any price between zero and A, this does not mean that an efficient outcome is equally likely at any price level in this range. Auction theory – backed by observations from actual spectrum auctions – tells us that efficient outcomes are less likely at either very high or very low prices. More specifically, award failures are most likely when regulators try to price above or close to true market value (B). Good practice would recommend setting the price below B (the strongest loser value) to allow his participation.

4 The opportunity cost to society is the loss of potential gain from using the spectrum in the period when it instead goes unsold.

5 Producer surplus is an economic measure of the difference between the amount a producer of a good (or service) receives (price) and the minimum amount the producer is willing to accept for the good (cost). The difference, or surplus amount, is the benefit the producer receives for selling the good in the market.

6 Hausman, J (1997), "Valuing the effect of regulation on new services in telecommunications", Brookings Papers on Economic Activity, Microeconomics.

7 Ronald H Coase (1960), "The Problem of Social Cost", Journal of Law and Economics. 3 (1): 1–44.

8 Roger Myerson and Mark A. Satterthwaite, "Efficient mechanisms for bilateral trading", Journal of Economic Theory 28 (1983): 265-281.

The following considerations are particularly relevant for setting reserve prices for mobile spectrum:

1. **Valuation uncertainty.** Spectrum valuations are based on long-term business cases, involving assumptions about network deployment, and technical and commercial trends. Many of these assumptions are uncertain and subject to a variety of external risks, so valuations are typically subject to a wide margin of error. Of course, if it is difficult for a bidder to value a spectrum licence, it is even more difficult for a regulator to do so. A reasonable regulator may try to estimate both “A” and “B”, but should assume a wide error band. If a regulator is prioritising efficiency, then this implies a need for caution when setting reserve prices, so as to avoid the risk of inadvertently pricing too high and not selling spectrum.
2. **Price discovery.** As mobile operators usually deploy spectrum in similar ways, there is typically a high degree of common value in their business cases for spectrum. Also, bidders are often uncertain about the same factors, such as the timing of availability of handsets incorporating new bands or future growth in data demand. Accordingly, bidders may benefit greatly from price discovery during an auction. Auction theory tells us that price discovery can ease common-value uncertainty, and encourage bidders to bid a higher proportion of value (equivalent to raising B in Figure 1). This is especially relevant in auctions with many spectrum lots, where bidders can vary their demand. Of course, price discovery is only possible in a multi-round auction setting when bidding starts at prices below the true market level.
3. **Cost recovery.** Governments incur costs when managing radio spectrum. In the case that spectrum is allocated for exclusive use, it is reasonable for governments to expect the licensees to cover those costs, including making a contribution to common costs. Cost recovery, which is often covered through annual fees, may be seen as a lower bound for the price of mobile spectrum.
4. **Demand reduction.** In certain market situations, if the minimum price for spectrum is set at a very low level relative to the true market value (B), then bidders may have a financial incentive to reduce their demand at prices below valuation. In principle, this could be achieved by merging bidder groups, unilaterally dropping demand for spectrum lots, or taking advantage of auction rules to tacitly coordinate demand reduction across operators. Demand reduction may result in lower auction revenues, and may or may not be a concern from an efficiency perspective. This is a rationale for not pricing bands known to be valuable at very low levels. However, it is not a strong rationale for pricing above a conservative estimate of market value, not least as there are other tools (such as auction design) that can be used to reduce incentives for demand reduction, if this is a concern.
5. **Bidder asymmetry.** Within each market, there are often predictable asymmetries between bidders, for example between entrant and incumbents, or between incumbents in terms of market share or financial backing. In some cases, such asymmetries may deter participation by entrants or act as a focal point for demand reduction. If regulators are concerned that competition in the award process will not materialise, they may be inclined to set higher reserve prices. However, this comes with significant risks as if operators perceive that reserve prices are set too high, for example above B, they may refuse to acquire licences, as they anticipate that there are no other buyers at these prices. Such impasses are bad for everyone: the government does not get its revenues, operators do not get their spectrum, and welfare benefits to consumers and society at large are delayed. Overall, concerns about competition linked to bidder asymmetries provide a rationale pricing relative to market value, but still being conservative so as to ensure the price is below B.

1.3. Effective pricing of spectrum

In an auction, an efficient allocation of spectrum will materialise provided that bids reflect the true relative values of operators. Government can facilitate this by engaging in effective pricing practices.

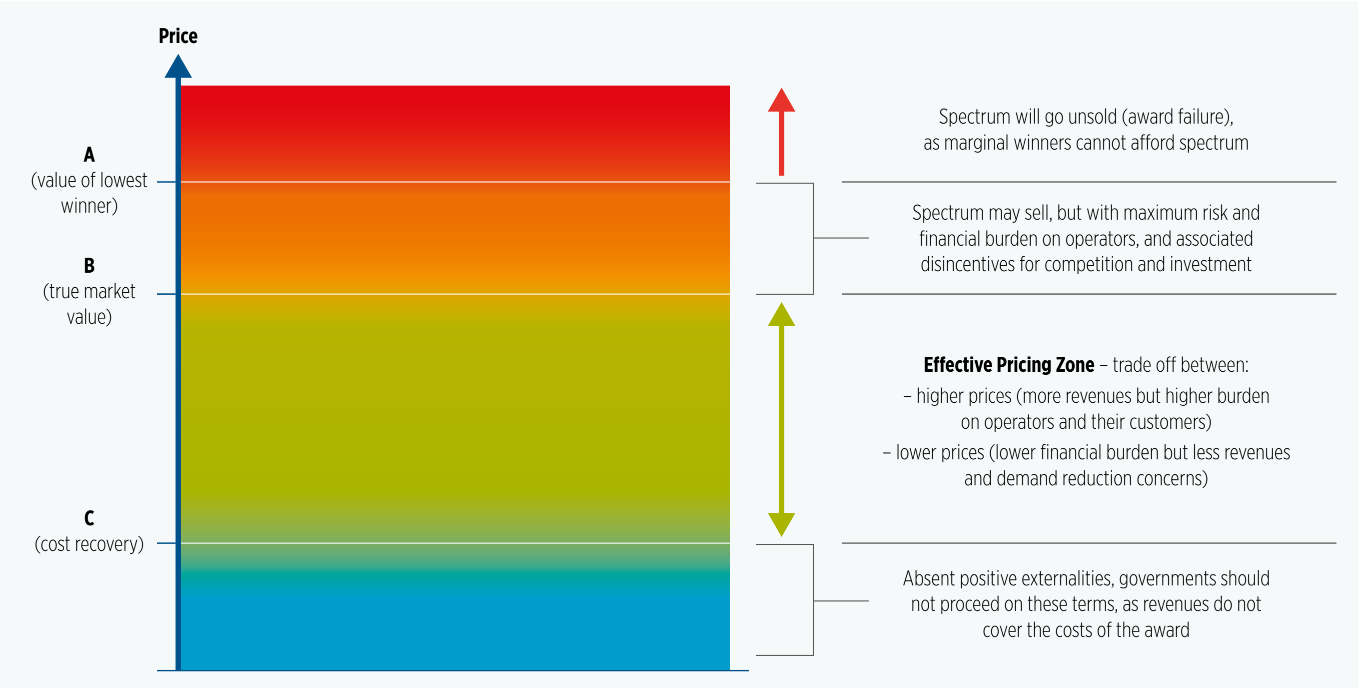
In the context of a primary award, this requires that initial prices be set:

- **below a conservative estimate of market value, so there is scope for competition and price discovery in auctions; and**
- **no lower than the costs of managing the spectrum.**

By true market value, we mean the price that would emerge from a well-functioning market in which bidders submit bids based on the intrinsic value of the spectrum to them. In turn, intrinsic value should reflect the costs that operators expect to avoid from deploying the spectrum and any increased profits from being able to offer a more compelling service proposition to customers. Such values will, in turn be affected by the conditions attached to the spectrum licence.

The range for effective pricing is illustrated in Figure 2.

FIGURE 2: EFFECTIVE PRICING OF SPECTRUM



When deciding where to set the minimum price within the effective price zone, policymakers must confront the risk asymmetry between setting prices too high or too low. If the price were inadvertently set above true market value, there is a material risk of award failure, with valuable spectrum going unused and consumer welfare gains delayed. Obliging any operator still willing to acquire the spectrum to pay more than market value may also be perceived as unfair, as it involves expropriation of the reasonable returns a company can expect in a competitive market. In contrast, in an auction setting, if minimum prices are set at a low level, the market will usually still identify the efficient outcome. Even if there is demand reduction, this may have no impact on efficiency and, while the state may lose some revenues, there is no equivalent to the welfare losses owing to unallocated spectrum in the high-price case, and indeed, in a competitive market, lower spectrum costs could be expected to be passed through to the market in the form of lower pricing.

The reality is that it is extremely difficult for any party to estimate market value. Even if a regulator would like to set prices at market value, it is most unlikely that it would pick the right level. This, of course, is a key rationale for auctioning spectrum. The assumption in an auction is that bidders themselves should be best at valuing spectrum, and that well-designed rules should provide incentives for them to validate and reveal relevant information about their valuations.

Regulators who are not focused on revenues find it easy to manage this risk asymmetry. They set prices at modest levels that they believe to be safely below true market value (i.e. in the low-to-mid area of the effective pricing zone in Figure 2), and rely on competition between bidders to determine the efficient outcome and final price. Of course, this approach creates some possibility that prices are lower than they could have been, in case the auction is not fully competitive. Many regulators, such as those in Germany and Sweden, accept this: they are much more concerned about realising welfare gains for consumers than they are about whether they could have extracted more money from the industry in selling the spectrum.

For regulators for whom revenue is important, setting prices is more challenging. If they wish to set prices closer to the true market value, they necessarily will need to expend time and effort trying to estimate that value. There are two approaches: modelling the business case of potential bidders; and benchmarking prices from other awards. Both approaches, can provide insights into the potential value of the spectrum. However, the estimates they produce should be treated with caution as they depend on many assumptions and are inherently uncertain. We explore the risks associated with such approaches further in Chapter 3, where we highlight examples of regulators that have over-estimated the value of licences, often because they have attributed too much reliability on benchmarks or failed to consider local market conditions or the costs of onerous licence terms when setting prices. This usually results in valuable spectrum going unsold, as with the 2016 auction of 700 MHz in India.

1.4. Investment incentives and consumer prices – two further reasons for caution when pricing spectrum

It is sometimes argued that, provided that the allocation is efficient, higher revenues should always be preferable to lower ones. This is based on two lines of thought. Firstly, standard economic theory predicts that sunk costs are irrelevant to investment and pricing decisions. Several commentators, such as Kwerel (2000)[9] and Wolfstetter (2001)[10], have argued that upfront spectrum fees are sunk costs, as they are inescapable, and do not vary with output or even if a firm fails. Secondly, it has been suggested that an efficient sale of radio spectrum is an example of “a distortion-free tax”, which may be preferable to other revenue mechanisms, such as income tax. These arguments tend to suggest that a regulator that fails to extract the true market value (or even any price up to A in Figure 2) was leaving money on the table.

9 Evan Kwerel, Federal Communications Commission, 2000, Spectrum Auctions Do Not Raise the Price of Wireless Services: Theory and Evidence, available at: http://wireless.fcc.gov/auctions/data/papersAndStudies/SpectrumAuctionsDoNotRaisePrices.pdf

10 Elmar Wofstetter, 2001, The Swiss UMITS Spectrum Auction Flop: Bad Luck or Bad Design?, https://www2.wiwi.hu-berlin.de/institute/wt1/research/2001/swiss_umts_flop.pdf

Such arguments are, however, flawed for two reasons. Firstly, higher prices are inherently risky, as they are more likely to be associated with award failure. Therefore, as both Kwerel and Wolfstetter accept, the sunk cost argument does not provide a justification for setting prices at a level that risks spectrum going unsold. Secondly, more sophisticated theory backed by empirical observation contradicts the notion that firms ignore sunk costs when making decisions on investment and pricing. Far from being a distortion-free tax, the literature suggests that high upfront input costs can depress investment and reduce price competition, especially in settings when there are only a small number of operators. Given the scale of the mobile sector and its role in facilitating broader economic activity, this implies that high spectrum prices are bad for economic growth.

There are three distinct and complementary explanations why firms do not behave as if upfront spectrum costs are fully sunk. These come from the fields of traditional economic theory, financial theory and behavioural economics. We describe each one here and summarise them in Figure 3. They provide a clear theoretical and empirical basis for the argument that high spectrum prices are harmful to society. As we will show in Chapters 2 and 3, this argument is also supported by quantitative and case study analysis of 4G investment and pricing. Taken together, this evidence reinforces the case that policymakers should never set reserve prices above a conservative estimate of true market value.

The hold-up problem

Although standard economic theory predicts that sunk costs are irrelevant to investment and pricing decisions, this is predicated on the notion that such decisions do not influence future choices. The classic example is a factory that invests in a machine that cannot be sold again. The upfront cost of the machine is sunk and as it cannot be recovered should not influence future decisions on the price of the products created using the machine.[11] Kwerel (2000), Wolfstetter (2001) and others have argued that spectrum auctions are one-off transactions and that spectrum licence prices are thus sunk costs.

However, this simplistic interpretation of licence fees as sunk costs does not consider the dynamic effects that high spectrum prices have over the long term. The sunk cost argument ignores the repeated nature of auctions and investments into the mobile sector. When spectrum is priced above true market value, it reduces the firm's profits which, to a large extent, are the returns on the investments that it has already made (for example in its network) and which are now sunk. In the short run, operators that need more spectrum may decide that they have little choice but to accept such terms. However, in the long term, they will respond by lowering their expectation of returns on future investments. This will reduce overall investment and may even lead to market exit or consolidation if operators cannot earn sufficient returns on their investments. In the economic literature, this phenomenon is referred to as the "hold-up problem".[12]

11 Walter Nicholson, 1978, Microeconomic Theory, Hinsdale, Illinois: The Dryden Press, p.223.

12 Hold-up arises when the return on one parties' sunk investments can ex post be expropriated by another party. In the case of spectrum licences, the government can expropriate the returns on other sunk investments (such as in network infrastructure) made by a mobile operator by overcharging for access to spectrum. The hold-up problem has played an important role as a foundation of modern contract and organisation theory. The associated inefficiencies have justified many prominent organisational and contractual practices. See for example William P. Rogerson, 1992, Contractual Solutions to the Hold-Up Problem, Review of Economic Studies, Vol 59, pp. 777-794.

FIGURE 3: WHY FIRMS DO NOT TREAT UPFRONT SPECTRUM FEES AS SUNK COSTS

1. Hold-up problem (Economic theory)	■ Spectrum awards are recurring transactions, not one off events ■ If firms perceive that their expected returns will be extracted in successive auctions, they will moderate their investment behaviour accordingly (and may even exit)
2. Internal financing constraints (Financial theory)	■ High auction prices may exhaust access to scarce lower cost internal funds, displacing other investment activity ■ Access to capital from multinational parents or external sources may be rationed in response to low profitability
3. Observed pricing decisions (Behavioural economics)	■ Empirical evidence suggests that in sectors with naturally constrained competition, firms with high sunk costs are more reluctant to engage in price competition ■ High upfront licence fees may act as a signal for market participants to set higher prices

Constraints on internal financing

The pricing structure for spectrum is fairly unique. Spectrum sold in auctions usually requires a large upfront payment followed by smaller annual fees. The upfront payment is usually financed internally. High upfront payments therefore reduce internal funds available for other projects. According to the “pecking order model”, the cost of financing increases with asymmetric information. Internal funding is cheaper than external funding, as external providers of finance have much less information about these investments than the mobile operator and thus require a higher risk premium. Using external sources to fund these other projects may mean that they are no longer profitable as returns may be insufficient to cover the higher risk premium.

Globally, the mobile market is characterised by a number of multinational companies that operate in a large number of countries. Headquarters have a finite budget available that they can allocate to different regional markets. With this structure in place, it is quite natural that funds are diverted from less attractive markets to markets with higher expected profitability.[13] As we have already discussed, profitability of sunk investments is directly linked to spectrum prices. Artificially high spectrum prices in a country can therefore lead headquarters to allocate less to a high spectrum-price market in the future. In the literature, this phenomenon is referred to as “de-escalation” or “reverse sunk-cost effect” owing to financial constraints.[14]

13 Stein, Jeremy C, 1997, Internal Capital Markets and the Competition for Corporate Resources, The Journal of Finance, Vol. 52, pp. 111-114.

14 McAfee, Mialon, and Mialon, 2010, Do Sunk Costs Matter?, Economic Inquiry, Vol. 48, No.2 pp. 323-336.

Observed pricing decisions

In classic microeconomic theory, firms maximise profits by setting prices such that marginal revenue equals marginal cost.[15] Sunk costs, such as upfront spectrum fees, do not feature in this version of the price-setting process. Some early studies on the relationship between spectrum fees and consumers prices appeared to confirm this assessment.[16] However, more recent research in the field of behavioural economics suggests that this classical view is a poor reflection of how firms actually make decisions. In particular, in sectors with imperfect competition in which firms have some degree of flexibility over the prices they set, researchers have observed a tendency for prices to inflate over the theoretically efficient price if sunk costs are increased.

In one simulated experiment, **researchers found that upfront fees for entry licences produced high short term prices for consumers in markets with a small number of participants.** In addition, the average price for consumers remained high long after the upfront entry fee was paid. Researchers then examined if the increase in prices were specific to the allocation mechanism (either a fixed fee or an auction). The results showed that the method of allocation did not affect price levels, but the simple presence of an entry fee in a market with limited competition increased prices paid by consumers. The experiment's result directly contradicts the classic economic argument that prices only reflect marginal cost.[17]

In another experimental study, researchers showed that varying sunk costs produce different outcomes for consumer prices. Specifically, the experiment was set up in a way that the market could either produce a stable high-price outcome or a stable low-price outcome. In situations of high sunk costs, firms tended to select the high-price equilibrium whereas in situations of medium-to-low sunk costs, firms tended to select the low-price equilibrium. Overall welfare, therefore, could be described as following a "reverse U" pattern, where moderate sunk costs produced the optimal level of welfare.[18]

15 Put differently, an operator will increase its profit by expanding production provided that the revenue from producing an extra unit of a good or service exceeds the cost of producing that extra unit.

16 Evan Kwerel, 2000, Spectrum Auctions Do Not Raise the Price of Wireless Services: Theory and Evidence, FCC

17 Offerman and Potters, 2006, Does Auctioning of Entry Licences Induce Collusion? An Experimental Study. Review of Economic Studies (2006), Vol. 73, pp. 769-791.

18 Buchheit and Feltovich, 2001, Experimental Evidence of a Sunk-Cost Paradox: A study of Pricing Behaivor in Bertrand—Edgeworth Duopoly. International Economic Review, Vol. 52, pp. 317-347.

2. How spectrum prices impact mobile services, the economy and consumers

In the previous chapter, we addressed best practice in setting spectrum prices, and highlighted theoretical and empirical evidence that high prices can depress incentives for investment and price competition. In this chapter, we present the results of our own quantitative analysis of spectrum prices and their impact on competition and investment in 4G services. We observe that, over the last eight years, both reserve prices and price outcomes have trended upwards. While price outcomes for many awards remain modest, the upward trend appears to be driven by a growth in the number of high price auctions, including many where reserve prices were set well above the global mean. Consistent with the academic literature, we also find statistical evidence linking higher spectrum prices to low investment in 4G and higher consumer prices for data.

As an illustration of the negative impact of high spectrum prices on consumers, we apply an econometric model to our data set in order to estimate the relationship between mobile prices and data consumption. We then assess the sensitivity of spectrum costs on consumer welfare and auction revenues. Our model implies that if all countries in our dataset that have spectrum prices above the median had instead sold spectrum at the median price level, this could have generated incremental value for society with a purchasing power of US$250bn. This value reflects gains in consumer surplus[18] owing to greater price competition in the downstream market, which more than offset losses in auction revenues. Note that this approach only captures a fraction of the consumer benefits of lower spectrum prices, as it does neither consider the negative impact on quality owing to lower investment nor the knock on effects on other industries, given the role of mobile data as an enabler of economic activity.

Looking ahead, the mobile industry will begin the transition to 5G in around 2020. This next generation of service will require roll-out of new infrastructure and a greatly expanded spectrum base to support a huge increase in network capacity and data speeds. In a world where spectrum scarcity is reduced and total spend on communications services is plateauing, this should mean that prices paid for spectrum will fall sharply. Countries that try to resist this trend, either by restricting spectrum availability or overpricing newly released spectrum, are likely to find themselves falling even further behind in availability and take-up of next generation data and associated connectivity services.

2.1. The growth in high price spectrum awards

There have been four major waves of spectrum awards for mobile, each linked to a new generation of technology. We focus here on the two most recent waves:

- **The 3G era, which began in 1999. A larger number of awards of spectrum designated for 3G took place from 2001-2002, with a small number of further awards occurring over the following years. This era primarily involved the award of 2100 MHz and AWS spectrum bands.**
- **The 4G era, which began in around 2008. There has been a significant increase in the number of spectrum awards, covering a range of bands, including 700 MHz, 800 MHz, AWS-3 and 2600 MHz, as well as liberalised spectrum in existing mobile bands, such as 900 MHz, 1800 MHz and 2100 MHz.**

19 The difference between the total amount that consumers are willing and able to pay for a good or service and the total amount that they actually pay (i.e. the market price).

Figure 4 charts the history of major awards for mobile spectrum since 2000. From 2000-01, there was a large number of awards of spectrum suitable for 3G (2100 MHz and PCS). This was followed by a quiet period of five years, with relatively few spectrum awards, which coincided with the slow launch of 3G services. Since late 2007 (when Norway awarded the 2600 MHz band), there has been a significant increase in the number of awards each year, driven by the need to find new bands and repurpose old ones for 4G mobile broadband. This period coincides with a take-off in consumer demand for mobile data services.

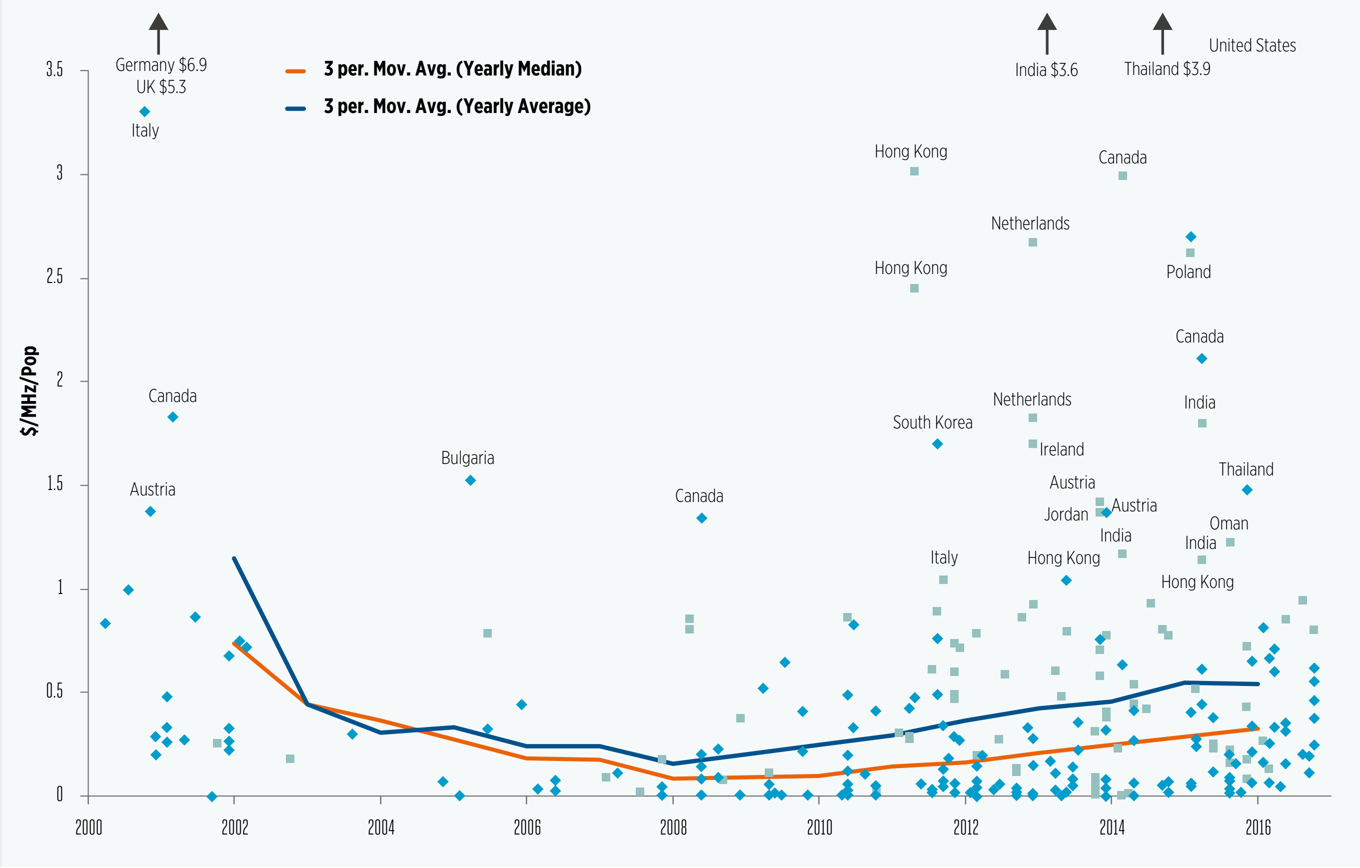
This growth in the number of awards is a worldwide phenomenon. Historically, medium and lower income countries have lagged behind higher income countries in bringing new mobile bands to market. However, in recent years, the gap in release times has tended to fall, as countries worldwide spot the opportunity to grasp immediate benefits from ubiquitous mobile data and 4G deployment. For example, Morocco (2015) and Kenya (2016) have already awarded spectrum at 800 MHz, just 3-4 years behind the typical European release date.

With the release of new spectrum in bands such as 700 MHz, 800 MHz, AWS-3 and 2600 MHz, many countries have seen an increase in mobile spectrum in the order of 70% or more since 2008. In countries where TDD bands at 1500 MHz and 2300 MHz have been released, this figure rises to over 100%. Much larger bands at higher frequencies, such as 3400-3800 MHz, have also been earmarked for release.

In Figure 4, we also plot a moving average of prices for mobile spectrum over the 2000-2016 period. This follows a U-shaped path. The beginning of the 3G era coincided with the so-called “tech bubble”, which generated huge enthusiasm regarding the potential of 3G data services. This was reflected in the very high prices achieved in some early awards, most notably the UK and German 3G auctions in 2000, which raised an exceptional $5.30 and $6.90 per MHz/pop respectively. Subsequently, there was a sharp drop in prices for 3G spectrum, and most awards for the remainder of the 2000s generated modest prices. Since 2008, however, there has been an upward trend in prices, coinciding with the take-off of 4G services.

In market economies, the price of spectrum should reflect the balance between supply and demand. Given the growth in spectrum availability, rising spectrum prices imply that growth in demand must be outpacing supply. It is true that companies need a lot more spectrum capacity to service a huge expansion of data traffic. However, in mature mobile markets, this increase in traffic has not been matched by any growth in revenues; in fact, average revenue per user (ARPU) has declined in many markets. In this context, it seems odd that average prices should be rising (notwithstanding the scope for growth in countries with less developed mobile sectors). Certainly, this implies that many mobile operators must be spending a much larger proportion of revenues on spectrum than ever before.

FIGURE 4: GLOBAL TRENDS IN SPECTRUM PRICES, BY BAND AND AUCTION, 2000-2016

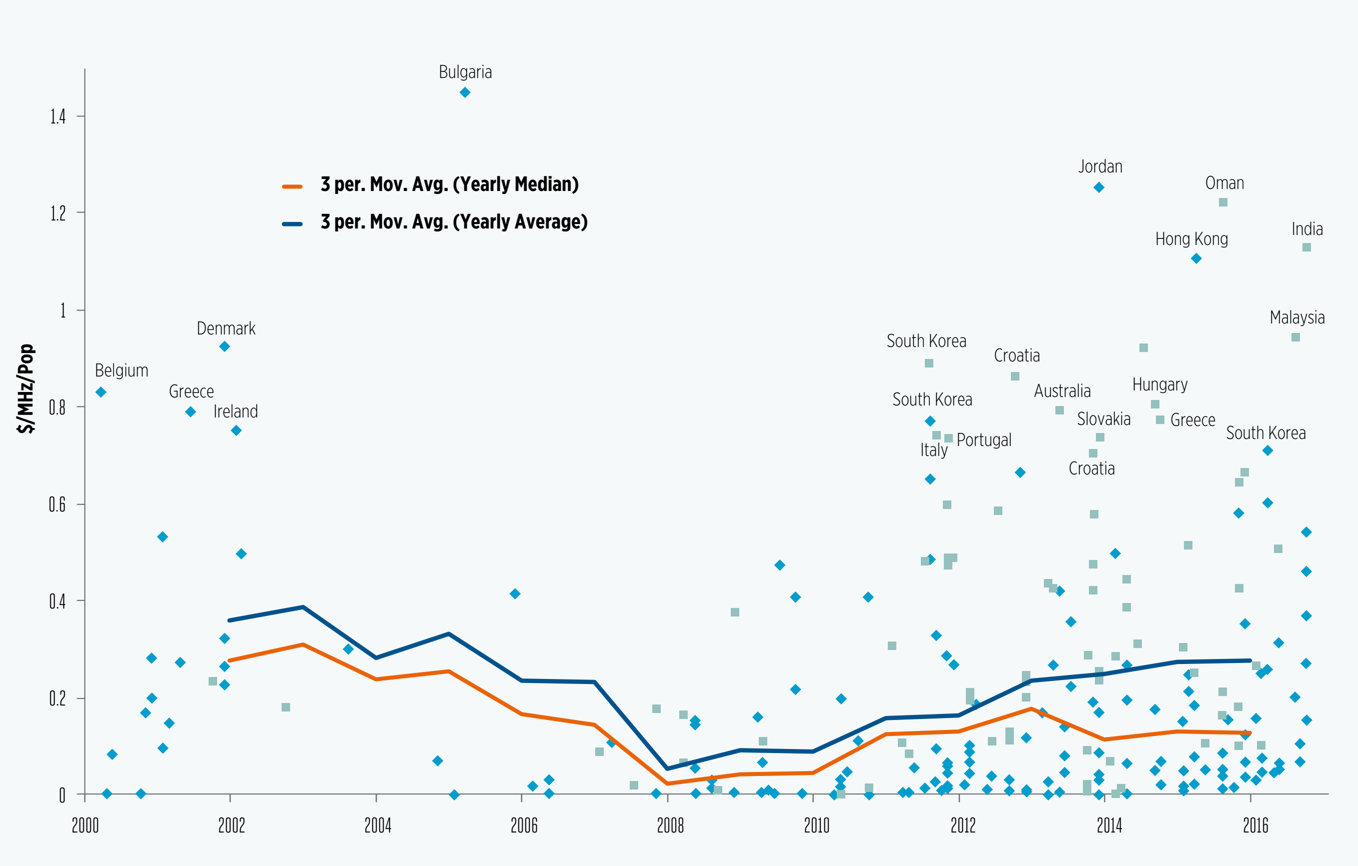


Notes: Green = Prices for coverage bands below 1 GHz) (700 MHz, 800 MHz, 850 MHz and 900 MHz); Blue = Prices for capacity bands above 1 GHz (PCS, AWS, 1800 MHz, 2.1 GHz and 2.6 GHz).

Prices per MHz pop are adjusted for inflation and were converted to USD using IMF purchasing power parity (PPP) rates. Prices are also adjusted for licence duration, based on a standard 15 years, using a 5% discount rate.

Source: NERA Economic Consulting Global Spectrum Auction Database.

FIGURE 5: GLOBAL TRENDS IN SPECTRUM RESERVE PRICES, BY BAND AND AUCTION, 2000-2016



Notes: Green = Reserve prices for coverage bands below 1 GHz (700 MHz, 800 MHz, 850 MHz and 900 MHz); Blue = Reserve prices for capacity bands above 1 GHz (PCS, AWS, 1800 MHz, 2.1 GHz and 2.6 GHz).

Reserve prices include both upfront payment and discounted value of any substantive annual fees associated with the spectrum, discounted at 5% per annum. Reserve prices per MHz pop are adjusted for inflation and were converted to USD using IMF purchasing power parity (PPP) rates. Reserve prices are also adjusted for licence duration, based on a standard 15 years, using a 5% discount rate.

Source: NERA Economic Consulting Global Spectrum Auction Database.

Why are spectrum prices rising in an era when spectrum supply is expanding but revenues are flat? The data highlights two possible explanations:

1. **An increase in the incidence of high price awards; and**
2. **An upward trend in reserve prices (as illustrated in Figure 5).**

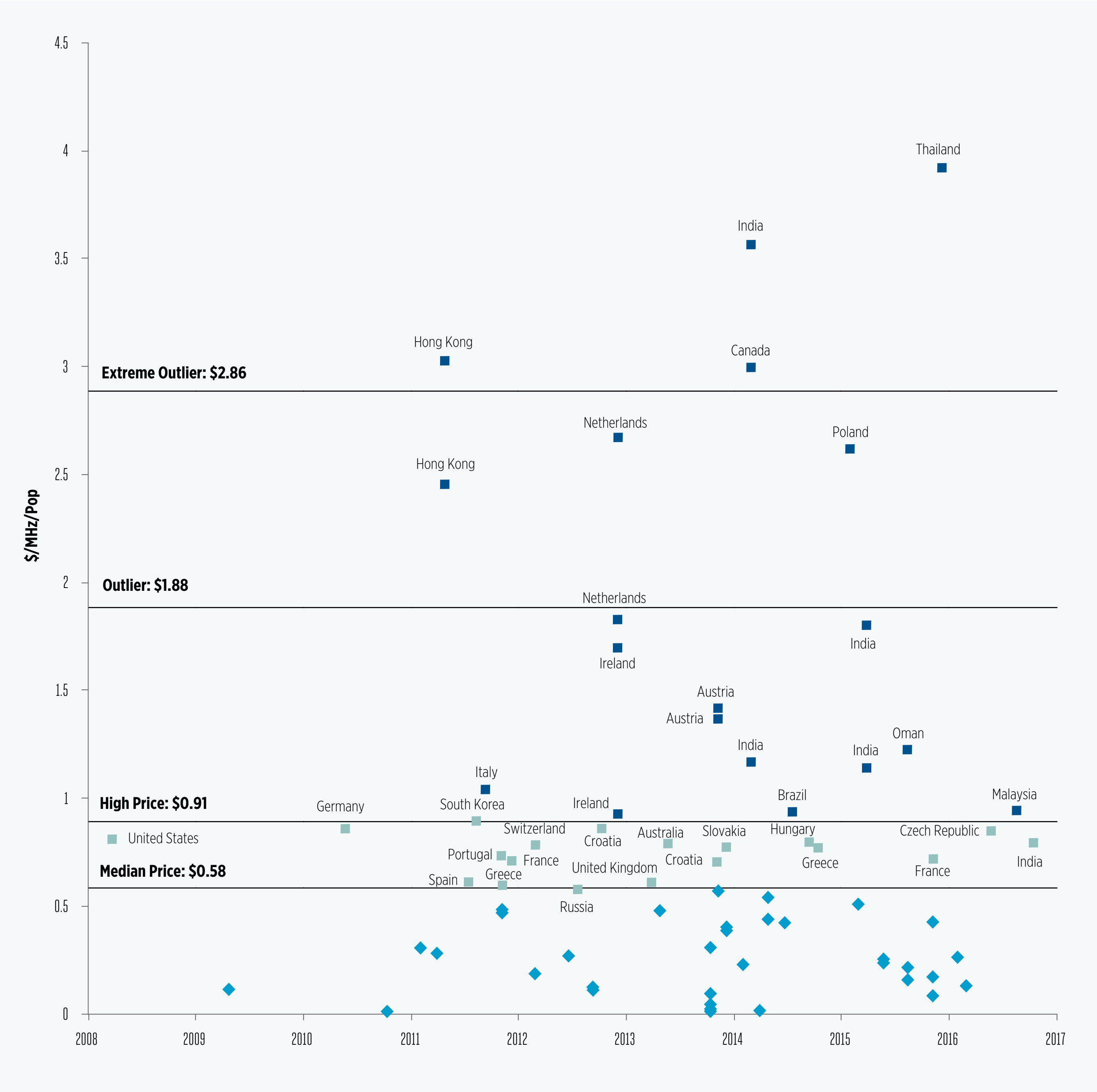
Starting in 2012, there has been a marked increase in the number of awards that ended with high prices, including a number that are statistical outliers to the sample. This is illustrated in Figure 6 and Figure 7. Between 2013 and 2016, there were 27 high price and outlier observations in the coverage and capacity bands, compared to only 19 between 2008 and 2012. This is based on analysis using standard statistical techniques to separate price outcomes in the 4G era (2008-16) for coverage bands (sub-1 GHz) and capacity bands (above 1 GHz) into five groups: below median prices; above median prices; high prices; outliers; and extreme outliers.

For illustrative purposes, we label countries with prices above the 75% percentile as high prices. This approach understates the problem of overpricing, as it compares prices across countries with very different income levels. While prices have been adjusted using purchasing power parity exchange rates[20], no further adjustment has been made to reflect huge differences in the spending power of consumers, nor the impact of coverage and other obligations that may lower the value of licences in some countries. In practice, the appropriate definition of a high price will vary by country, depending on local factors, and could be much lower for some countries, especially low income markets with uncertain growth prospects (for example, see the case studies in Chapter 3.1 on Mozambique, Ghana and Senegal), or those that attach costly conditions to licences (for example, see the case study on Argentina in Chapter 3.3). The price outcomes that we identify as outliers are ones where prices are so high that they would not be treated as plausible observations for comparative purposes in a statistical exercise.[21]

20 Differences between real and adjusted revenues can be large. For example, in 2012, the Romanian award of 900 MHz raised $0.25 per MHz/pop unadjusted, which more than doubles to $0.57 per MHz/pop after adjusting for purchasing power and licence duration. However, purchasing power is only a rough proxy for differences in costs of access to communications services. In particular, such adjustments may be insufficient to address issues in some markets with large population groups that lack the income needed to afford basic communication services.

21 In order to identify outliers we used a standard statistical technique. The IQR is defined as the observations between the 1st and 3rd quartile. Outliers are classified as being above an "inner fence," and extreme outliers are classified as being above the "outer fence." Inner fence = 3rd quartile + 1.5*IQR. Outer fence = 3rd quartile + 3*IQR.

FIGURE 6: COVERAGE SPECTRUM PRICES BY CATEGORY (2008-2016)

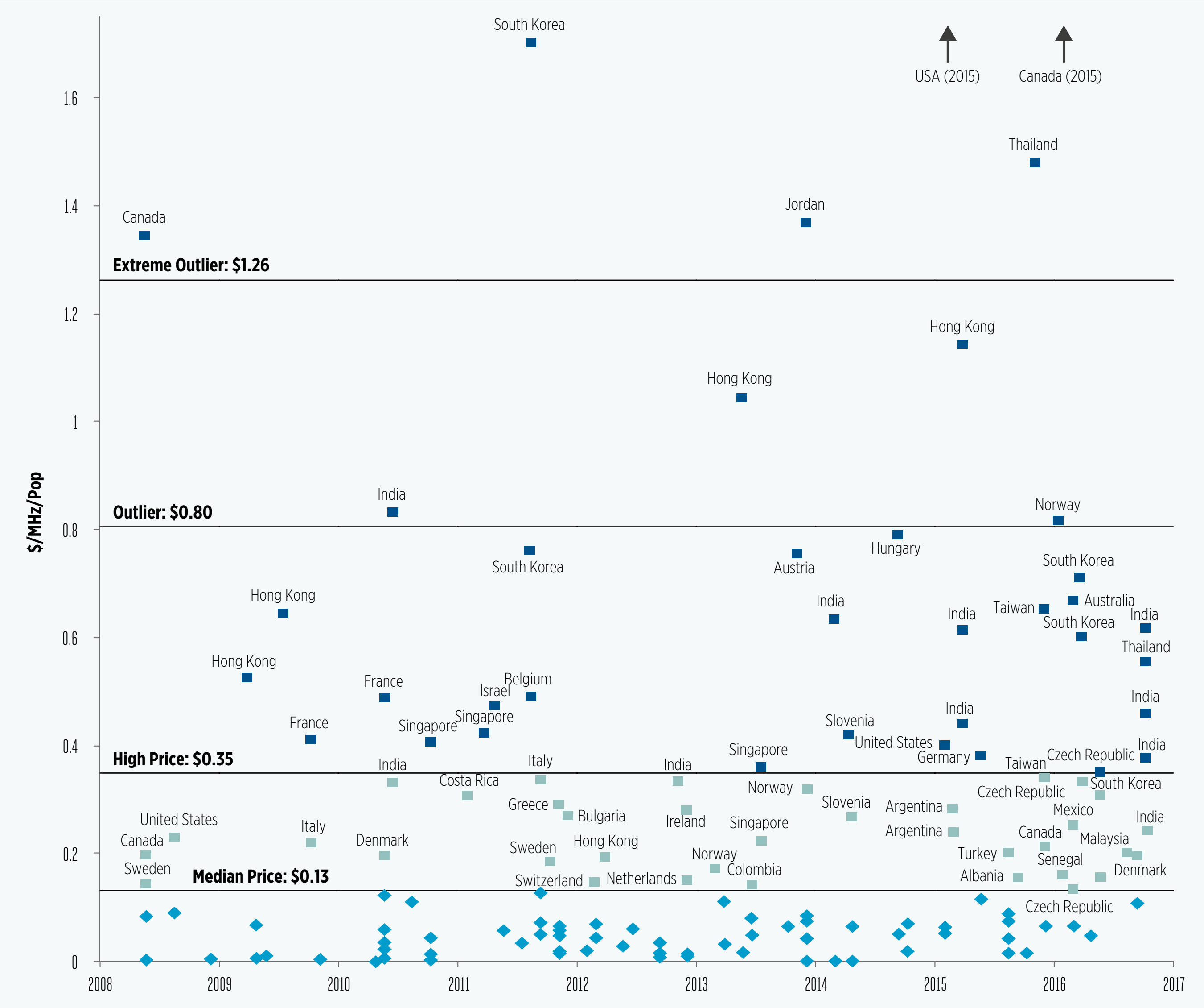


Notes: Coverage spectrum bands include 700, 800, 850 and 900 MHz bands; prices are adjusted for PPP exchange rates, inflation and licence duration, and include annual fees.

Light Blue = observations ≤ median price; Green = observations > median price ≤ 75th percentile; Dark Blue = observations > 75th percentile, including statistical outliers.

Source: NERA Economic Consulting Global Spectrum Auction Database.

FIGURE 7: CAPACITY SPECTRUM PRICES BY CATEGORY (2008-2016)



Notes: Capacity bands include AWS, PCS, 1800 MHz, 2100 MHz and 2600 MHz; prices are adjusted for PPP exchange rates, inflation and licence duration, and include annual fees. Colour key same as Figure 6.

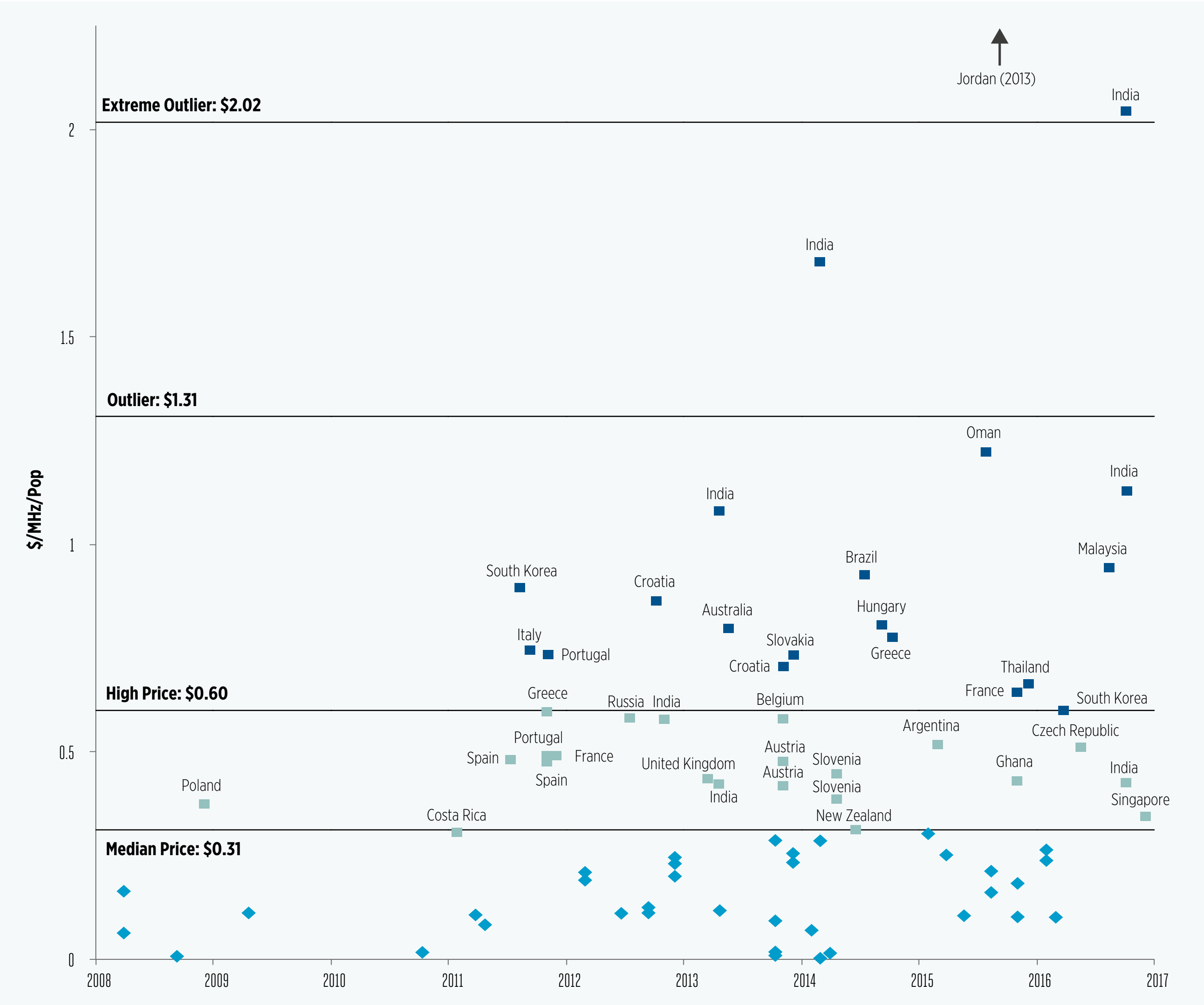
Source: NERA Economic Consulting Global Spectrum Auction Database.

The increase in high spectrum price outcomes can in part be linked to an increase in reserve prices. The upwards trend in reserve prices since 2008 is illustrated in Figure 5. Observe also the widening gap between average reserve prices and median reserve prices. This implies that the average is being dragged up by a minority of awards with exceptionally high reserve prices.

In Figure 8 and Figure 9, we provide a more detailed look at reserve prices for coverage and capacity bands in the 4G era, again using statistical techniques to differentiate awards by price level on a band-by-band basis. As with price outcomes, we also observe a growing incidence of awards in which reserve prices have been set at statistically high or extreme levels. Between 2013 and 2016, there were 38 high price and outlier observations in the coverage and capacity bands, compared to only 18 between 2008 and 2012.

This increase may be attributable to some countries using benchmarks from selected high price 4G award outcomes as justification for setting their own prices at high levels. Our case study research also highlights many recent examples of awards where core mobile spectrum is going unsold and/or is selling at reserve, which typically occurs when reserve prices are set above true market value.

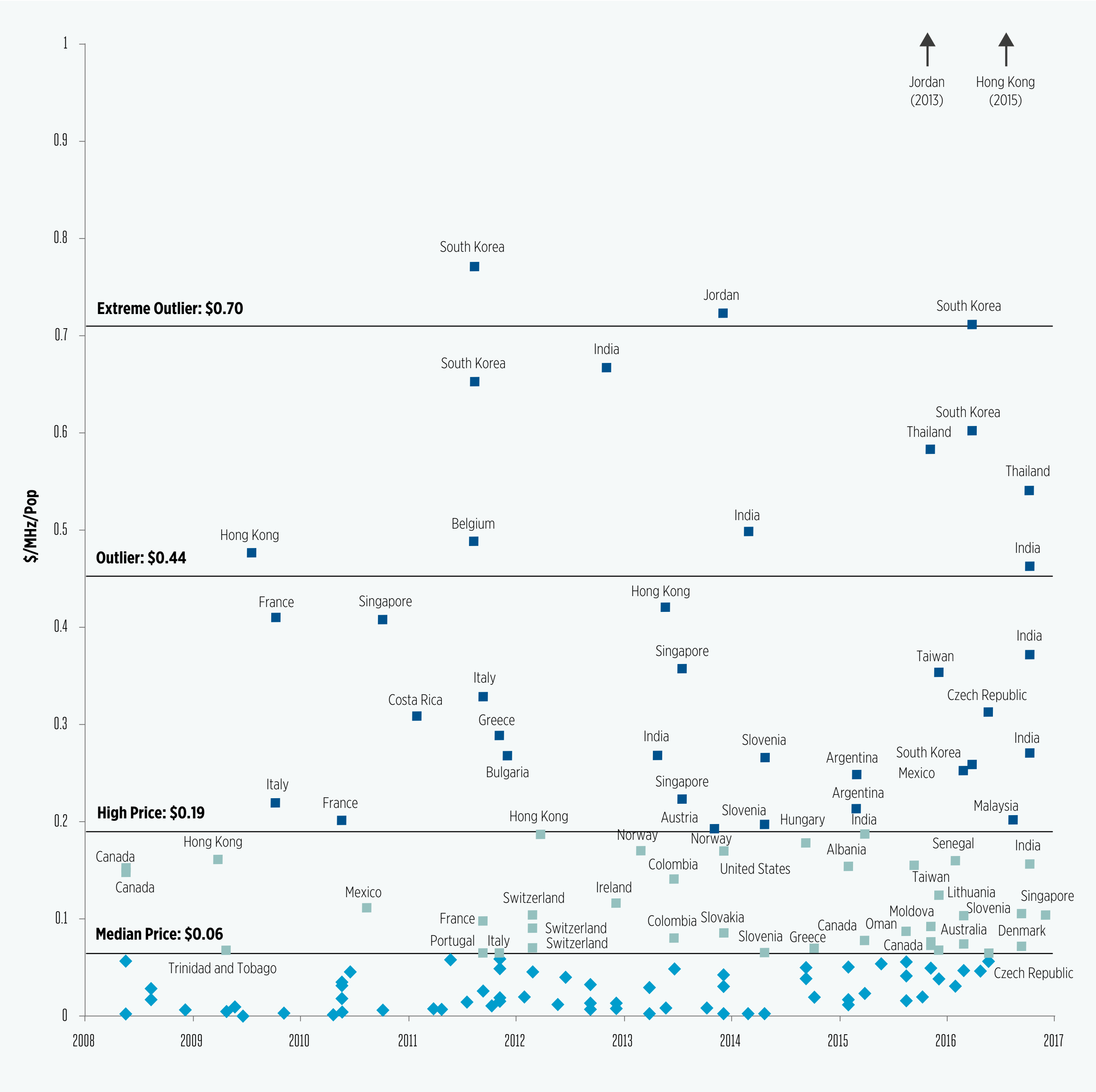
FIGURE 8: COVERAGE SPECTRUM RESERVE PRICES BY CATEGORY (2008-2016)



Notes: Coverage spectrum bands include 700, 800, 850 and 900 MHz bands; prices are adjusted for PPP exchange rates, inflation and licence duration, and include annual fees. Colour key same as Figure 6.

Source: NERA Economic Consulting Global Spectrum Auction Database.

FIGURE 9: CAPACITY SPECTRUM RESERVE PRICES BY CATEGORY (2008-2016)



Notes: Capacity bands include AWS, PCS, 1800 MHz, 2100 MHz and 2600 MHz; prices are adjusted for PPP exchange rates, inflation and licence duration, and include annual fees. Colour key same as Figure 6.

Source: NERA Economic Consulting Global Spectrum Auction Database.

In summary, while it is apparent that many countries are running awards which produce modest spectrum prices, there is a growing incidence of high price outcomes. Were this simply the result of strong competition between bidders with robust business cases, this would not be a concern. However, as our work in Chapter 3 shows, many of these high price outcomes are attributable to government policies that set excessive reserve prices, or distort valuations and bidding behaviour. Given the linkage between high spectrum prices and consumer welfare losses, owing to unallocated spectrum and disincentives for investment and price competition, the escalating frequency of high and extreme pricing events may be a sign of significant problems ahead.

2.2. Evidence linking lower spectrum prices to greater investment in mobile networks

In Chapter 1.4, we presented evidence from the academic literature linking high prices for scarce inputs to lower rates of investment. To test whether this relationship holds true for mobile spectrum, we undertook our own cross-country analysis of spectrum prices and investment in 4G services. Here, we set out our methodology and source data, and present our findings. For both higher and middle income countries, we observe a significant statistical link between higher spectrum prices and inferior 4G experiences for customers, which is likely attributable to lower rates of investment in next generation networks.

Methodology and source data

Theory suggests that operators experiencing high spectrum licence costs will have less incentive to invest in their networks. To test this relationship, we require proxies for the total financial burden on operators and their investments in next generation networks. We focus on the 4G era, using data from 2008-2016.

In order to make comparisons of spectrum costs across countries, prices are typically expressed as a price per MHz/pop (i.e. price divided by MHz and total population), and measured in a common currency, adjusted using either real or purchasing power parity exchange rates. This approach is appropriate when comparing prices for similar frequency bands. However, this approach may not capture the financial burden and the strain on internal financing, as it does not consider the volume of spectrum sold and the aggregate spend. Since 2008, many countries have sold spectrum in multiple bands, which have together imposed a large aggregate financial burden on operators. For example, in the Netherlands in 2012, winning bidders spent almost $4.7bn or $280 per pop on spectrum across five bands. To capture this, we consider total spectrum costs across all bands on a per pop basis.

NERA maintains its own database of prices for mobile spectrum awards for countries around the world. This includes data on both upfront fees from auctions or direct awards, and, where relevant, incorporates annual fees for awarded spectrum. We used these prices to construct an index of the total financial burden on mobile operators from spectrum purchases in each country where we had comprehensive award data for the 2008-2016 period. We consider total industry expenditure rather than individual operator expenditure, owing to the difficulties of compiling comparable investment data for individual operators.

Many national mobile operators are subsidiaries of larger operators and not required to publish disaggregated data on their annual capex and opex. Therefore, we cannot directly observe expenditure on 4G networks for operators or countries worldwide. Instead, it is necessary to identify a proxy for network investment. To do this, we developed a “wireless score” which measures the quality and uptake of next-generation data services in each country using actual user data.

Our wireless score has three components:

3G/4G COVERAGE (%)

*

4G SUBSCRIBERS (%)

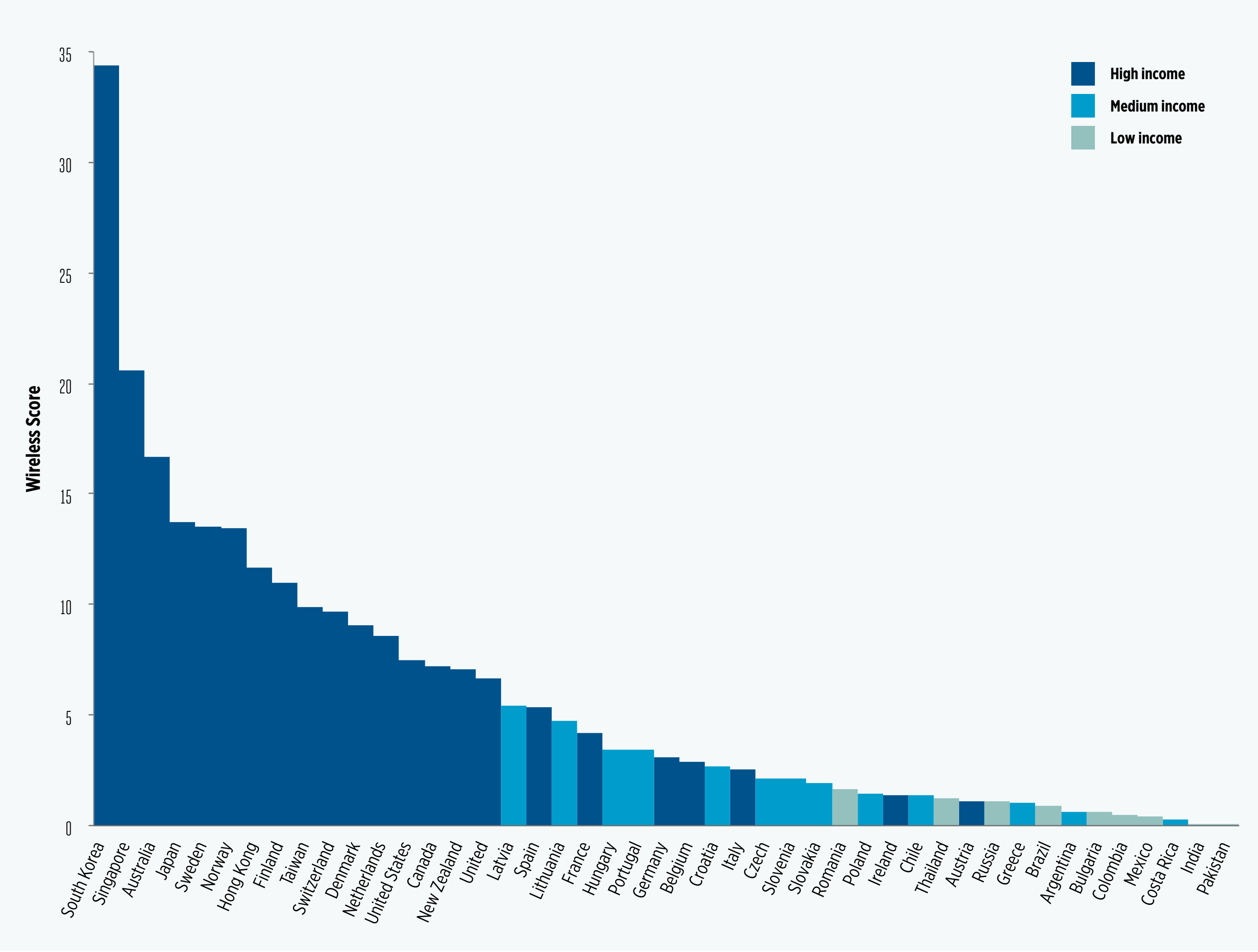
*

AVERAGE SPEED (Mbps)

We include both coverage and speed, because they are the main determinants of quality of service. For coverage, we use data for the percentage of time when users have access to a high-speed network, as this is a better proxy for comparing the actual ability of users to access mobile data than geographic coverage, given huge differences in population dispersal between countries.[22] We do not differentiate between 3G and 4G coverage, as – in many countries – 3G may provide a near-4G experience. We include 4G subscriber share as a % of total population in the score so as to ensure it reflects progress in 4G rollout, as opposed to just 3G.[23] Average speeds are measured in megabits per second based on observed user experience.[24] To arrive at a single score, we multiply the three numbers: in effect, our wireless score is a weighted measure of mobile data speed.

Figure 10 shows the wireless score for each country included in our analysis.

FIGURE 10: WIRELESS SCORE BY COUNTRY



Source: NERA Economic Consulting, using data from OpenSignal.com and Telegeography GlobalComms database.

22 Coverage data is from OpenSignal.com.

23 Subscriber data is from the Telegeography GlobalComms database.

24 Speed data is from OpenSignal.com.

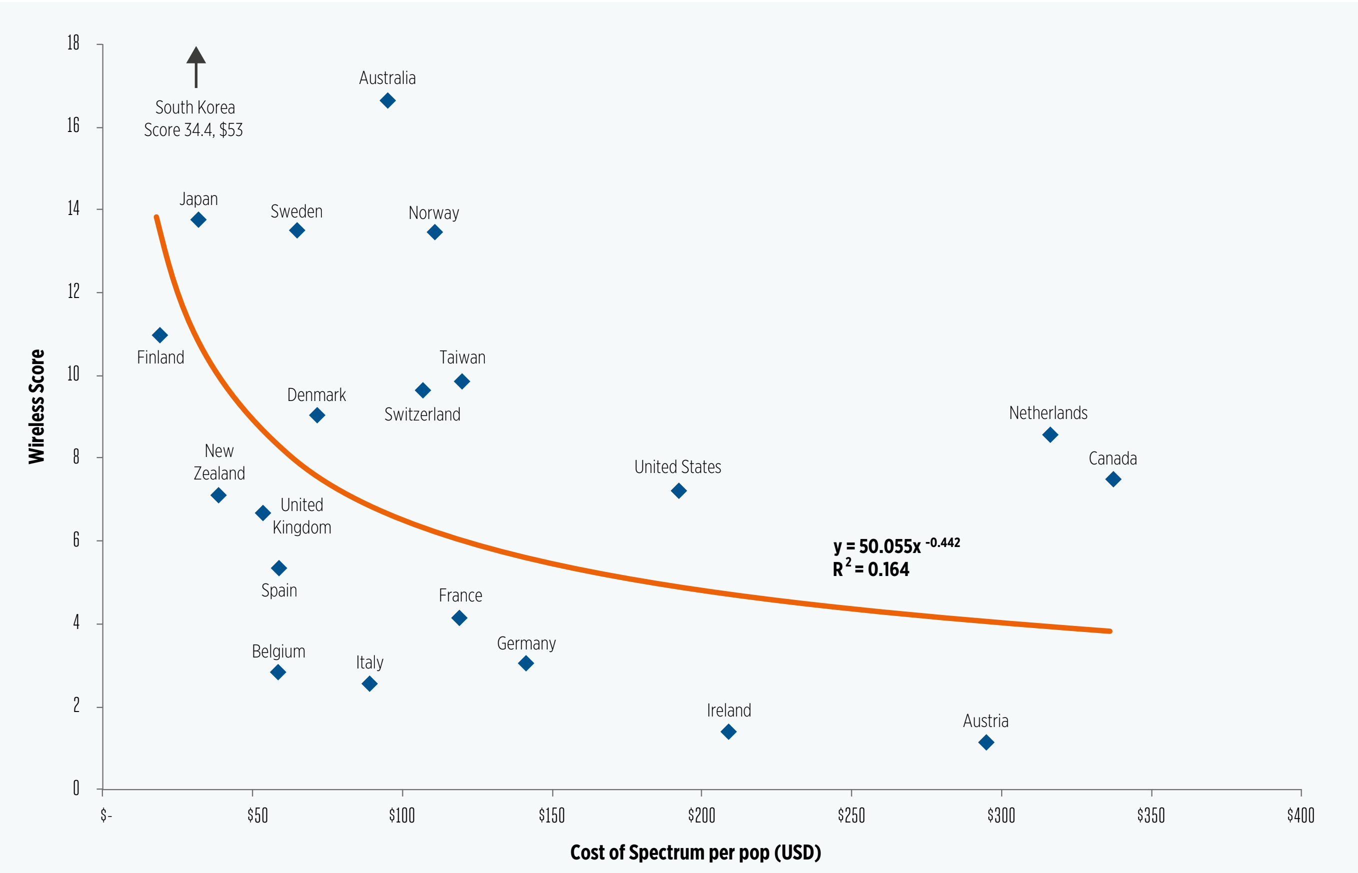
Countries differ widely in their uptake of 4G services and the coverage and speeds experienced by users. Countries with higher incomes typically have substantially higher wireless scores than countries with medium incomes, who in turn typically have substantially higher scores than lower income countries. This is hardly surprising, given that 4G technology was first launched in higher income countries, while many lower income countries in our sample have only recently launched services. Moreover, consumers in higher income countries have greater ability to pay for and more scope to use next generation mobile data services. We determined that the best way to account for these differences was to divide the sample into three groups of countries: higher income; medium income; and lower income, based on GDP per capita.[25]

Findings

For all three country groups, we found a correlation between lower spectrum costs and higher wireless scores. These results support the hypothesis in the academic literature that high input costs suppress investments. They directly contradict the more simplistic hypothesis that licence costs do not affect investment because they are sunk costs. Although spectrum cost is one of a number of factors that causes differences between countries in network investment, the results indicate that they are an important factor.

The relationship between spectrum costs and wireless score for higher income countries is reported in Figure 11.

FIGURE 11: SPECTRUM COSTS AND WIRELESS SCORE IN HIGH INCOME COUNTRIES



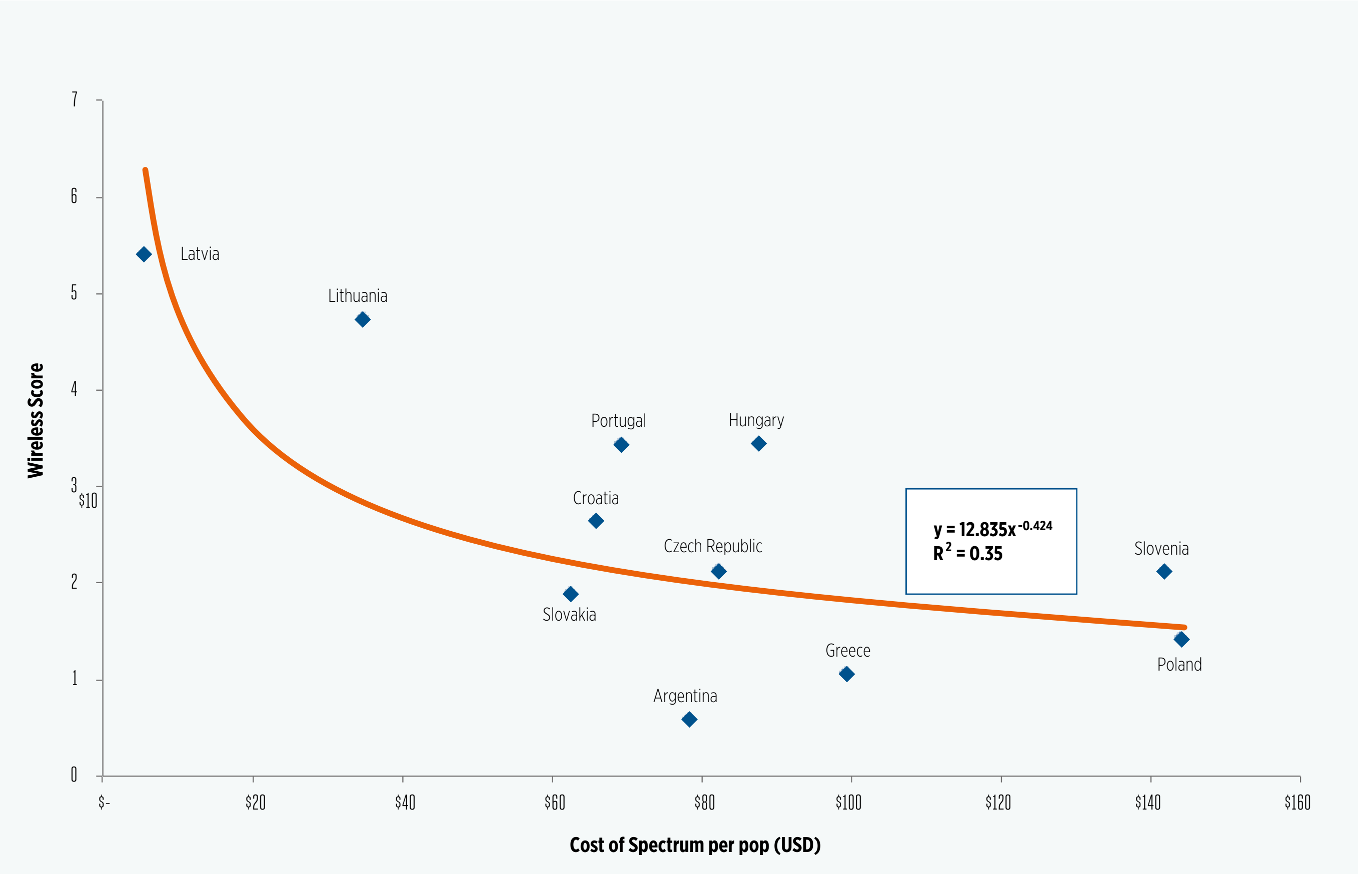
Notes: South Korea is located off the top left hand side of the graph; it has an exceptionally high wireless score (29.5) and modest cost of spectrum per pop ($53). We excluded Hong Kong and Singapore from our analysis, as they are city states and much easier to cover with 4G.

Source: NERA Economic Consulting using data from OpenSignal.com and Telegeography GlobalComms database.

25 We define high income as any country with GDP per capita above USD 25,000, medium income as between USD 11,000 and USD 25,000, and lower income as below USD 10,000. We use 2015 data from the International Monetary Fund (IMF) to determine income by country.

The relationship between spectrum costs and wireless score for middle income countries is reported in Figure 12. The relationship shown here is even stronger than for higher income countries, but the sample is smaller: only 12 countries, ten of which are in Europe.

FIGURE 12: RELATIONSHIP BETWEEN SPECTRUM COSTS AND WIRELESS SCORE IN MIDDLE INCOME COUNTRIES



Notes: Excludes Chile, which is an outlier owing to late adoption of 4G, which depresses its wireless score.

Source: NERA Economic Consulting with data from OpenSignal.com and Telegeography GlobalComms database.

We also explored the relationship between spectrum costs and wireless score for lower income countries. This sample of countries is small and much more heterogeneous than the other groupings, for example ranging from Pakistan, with a GDP per capita of $1,450, up to Mexico at $9,010.[26] Although the observed relationship is consistent with the hypothesis (and strongly significant if two extreme outliers from the sample of ten countries are dropped), all the countries have low wireless scores. Given that many of them only recently launched 4G services, we think it would be premature to place any great weight on observed differences between wireless scores. Nevertheless, it seems reasonable to anticipate that as 4G services mature in these countries, the same negative relationships as observed for the medium and higher income country groups will emerge.

2.3. Evidence linking lower spectrum prices to greater price competition

In Chapter 1.4, we also presented evidence from the academic literature linking high prices for scarce inputs to disincentives for price competition. To test whether this relationship holds true for mobile spectrum, we extended our cross-country analysis to consider the relationship between spectrum prices and downstream prices for mobile data. As above, we set out our methodology and source data, and then present our findings. For both higher and middle income countries, we observe a significant statistical link between higher spectrum prices and higher consumer prices for data.

Methodology and source data

Theoretical and empirical research in the area of behavioural economics has highlighted a link between high sunk costs and higher prices for consumers. To test whether this relationship holds for spectrum costs, we compared spectrum costs (on a per MHz Pop basis) and observed prices in September 2016 for wireless data for each country in our sample. We again divided our sample into three groupings, based on GDP per capita, so as to avoid the results being distorted by the relationship between price levels and ability to pay in countries with very different income levels.

Wireless plans vary substantially across countries and across mobile operators. To make them comparable and to identify a representative price for 1 GB of data, we selected (or constructed with add on 'data packs') a 'representative plan' for every mobile network operator within a country.[27] The price of each MNO's plan was then divided by the number of gigabytes in the representative plan. Each country's representative price for 1 GB of data was then calculated using the weighted average (subscriber share) of all the representative plans available in the country.[28]

Findings

For all three country groups, we found a correlation between lower spectrum costs and lower consumer prices for data services. These results support the hypothesis that high input costs suppress incentives for price competition. As with investment, they directly contradict the more simplistic hypothesis that licence costs do not affect competition because they are sunk.

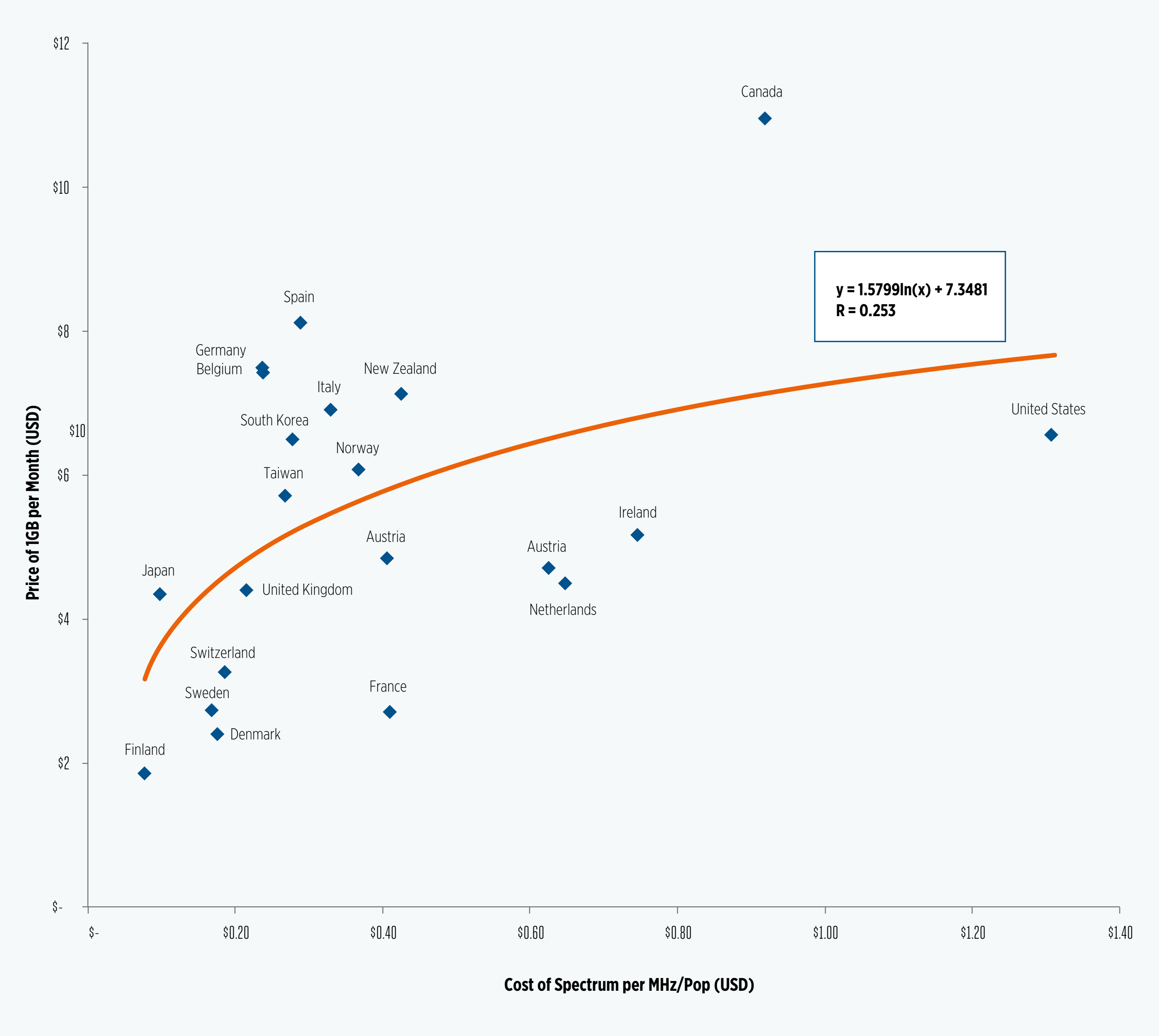
Figure 13 shows the negative relationship between the cost of spectrum and data prices in higher income countries. The relationship is again nonlinear, implying that proportionally greater gains for consumers through lower prices are possible as spectrum costs are reduced.

26 Using IMF 2015 data.

27 The representitive plans were constructed to have approximatly 10 GB of data per month as well as the highest SMS/voice minute combination. We add SMS and voice, as these are usually included in mobile plans in most countries. For example, in the United States, there are no limits on these services, whereas, in some other countries, SMS and voice attract premium fees (e.g. Singapore). We would not be comparing like for like if we ignored relatively expensive voice and SMS add on services in Singapore and only focused on data. We set a threshold of 15 GB per month for unlimited plans or for countries that price based on speed (Finland), given typical usage rarely exceeds this level.

28 Note that we intentionally chose not to use average revenue per user (ARPU) in this analysis. ARPU is not a good indicator for the prices that consumers face in different countries as it includes a decision by users on how much to consume. For example, consumers in a high-price country may decide to consume very little data whereas consumers in a low-price country may decide to consume a lot of data. Thus, the ARPU in two countries may be similar even though actual prices are very different.

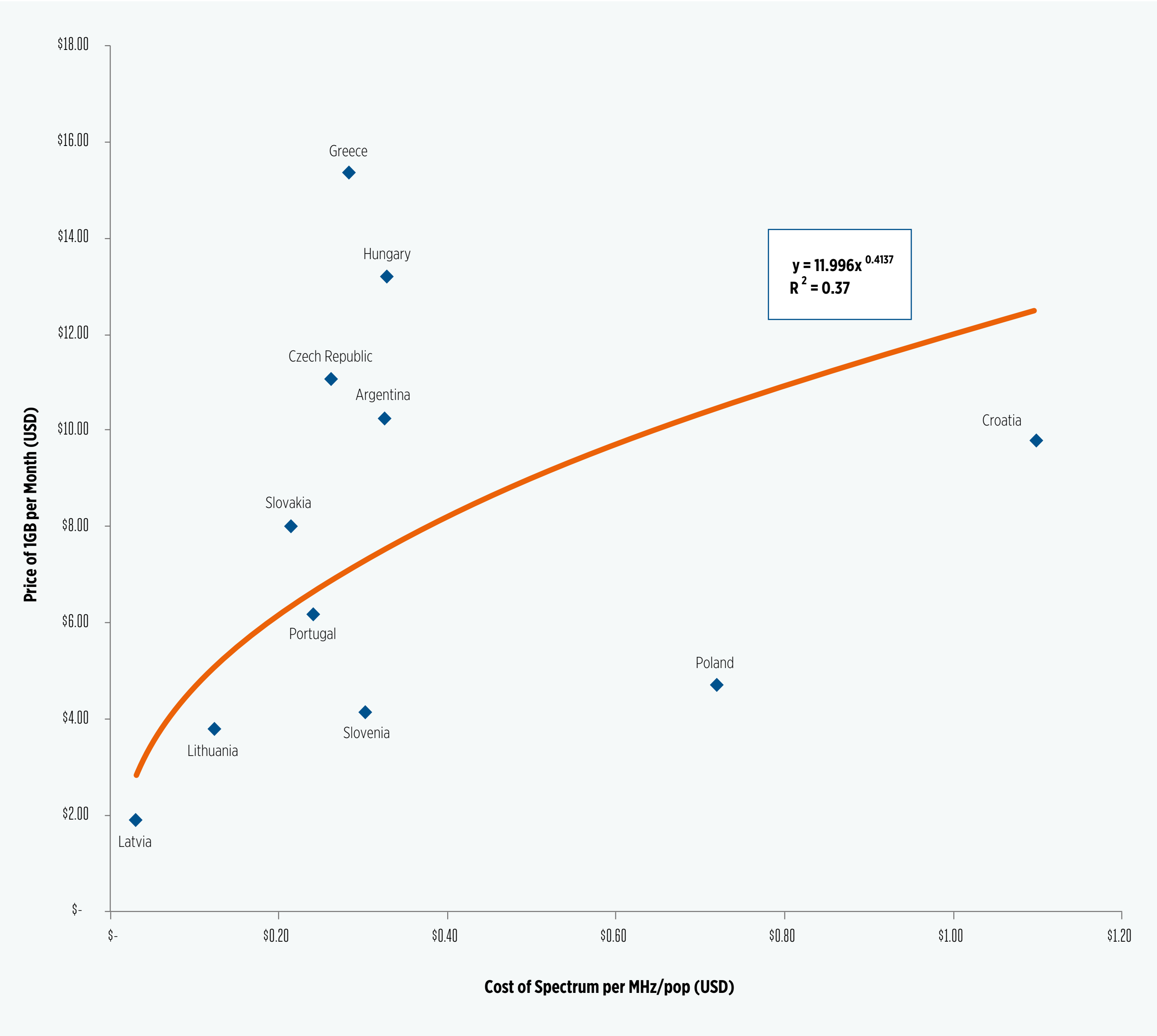
FIGURE 13: PRICE AND SPECTRUM COST RELATIONSHIP IN HIGH INCOME COUNTRIES



Source: NERA Economic Consulting.

The relationship is even stronger for middle income countries, as illustrated in Figure 14, albeit with a smaller sample size.

FIGURE 14: PRICE AND SPECTRUM COST RELATIONSHIP IN MIDDLE INCOME COUNTRIES



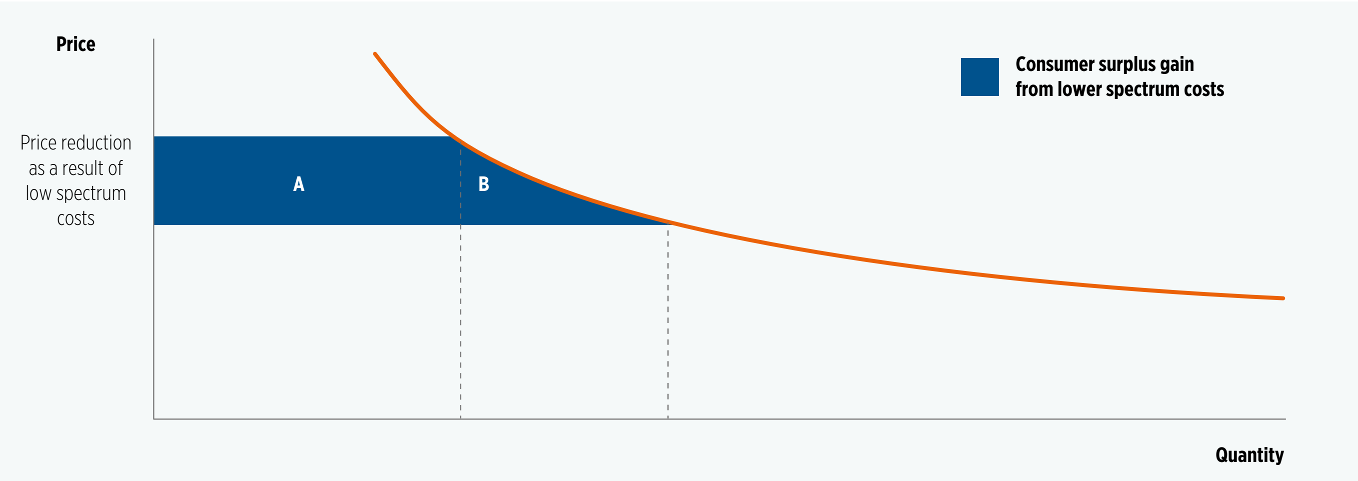
Source: NERA Economic Consulting.

For lower income countries, the relationship is in the same direction but not statistically significant. Again, as with our investment analysis, we think our sample of lower income countries is too small and heterogeneous and launched 4G too recently to place any great weight on observed differences between countries. Nevertheless, there is nothing to suggest that these countries will not follow the same path as the higher and middle income groups.

2.4. Evidence linking lower spectrum costs to gains in consumer welfare

We have shown that a reduction in spectrum costs can support a reduction in consumer prices for mobile data. This in turn should lead to an increase in the quantity of data services consumed. We illustrate this using a standard demand curve in Figure 15. The gain in surplus for consumers is equal to the blue shaded area. This consists of a transfer of surplus from producers to consumers (area A) owing to price competition, and previously unrealised surplus (B) generated by the increase in the quantity consumed. In effect, surplus that producers would have otherwise retained in order to fund spectrum costs (area A) is, in the counterfactual scenario of lower spectrum costs, competed away through lower prices. The resulting expansion in consumption also enables society to reclaim additional surplus (area B).

FIGURE 15: CONSUMER SURPLUS IMPACT OF PRICE REDUCTION



Building on our analysis of the relationship between spectrum prices and prices for mobile data, it is possible to construct an econometric model of demand for mobile data. We take the methodology developed by Hazlett and Muñoz (2004) to model demand for mobile voice in the early 2000s[29], and apply this to mobile data in 2016. The model takes into account the cost of spectrum, data prices and data consumption (quantity), as well as a number of explanatory variables for demand, including GDP per capita, urbanisation and mobile market concentration. A detailed explanation of the model is provided in Annex 1.

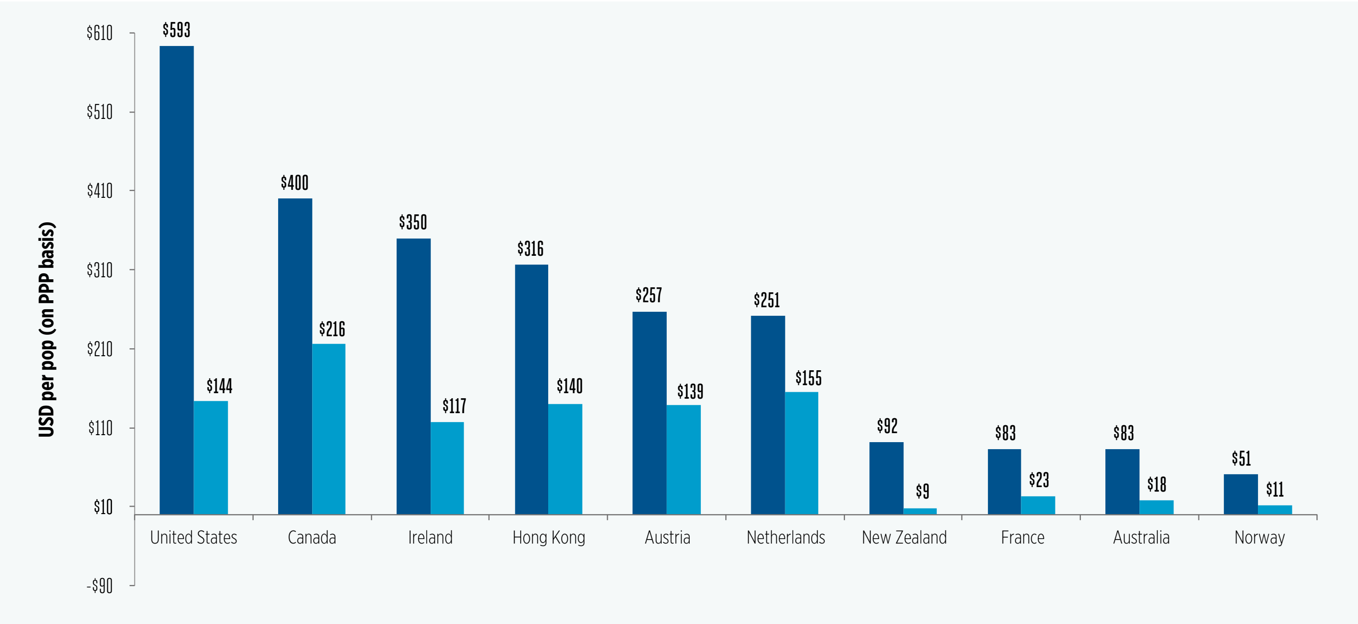
We use this model to calculate the potential welfare gains from lower spectrum costs (via lower data prices), as illustrated in Figure 15. Specifically, for each country which has a cost per MHz per pop above the median for its peer group, we ask what gains in consumer surplus are possible if the cost of spectrum was reduced to the median level. For peer groups, we use the same three categories – higher, medium and lower income – based on GDP per capita.

29 Hazlett and Muñoz, 2004 to today's era of high level data consumption. See Hazlett and Muñoz, 2004, A Welfare Analysis of Spectrum Allocation Polices. AEI-Brookings Joint Centre, pp. 4-18.

Across our sample of 32 countries, 15 had costs above the median level for their peer group. We estimate the aggregate gain in consumer surplus from reducing spectrum costs to the median level across these countries to be $445bn. This gain would come at the expense of reduced government revenues of $192bn. Thus, the net welfare gain for consumers in these countries from lower spectrum prices would be $253bn in total or $118 per person. All these figures are in purchasing power terms (with real exchange rates, our numbers would be lower).

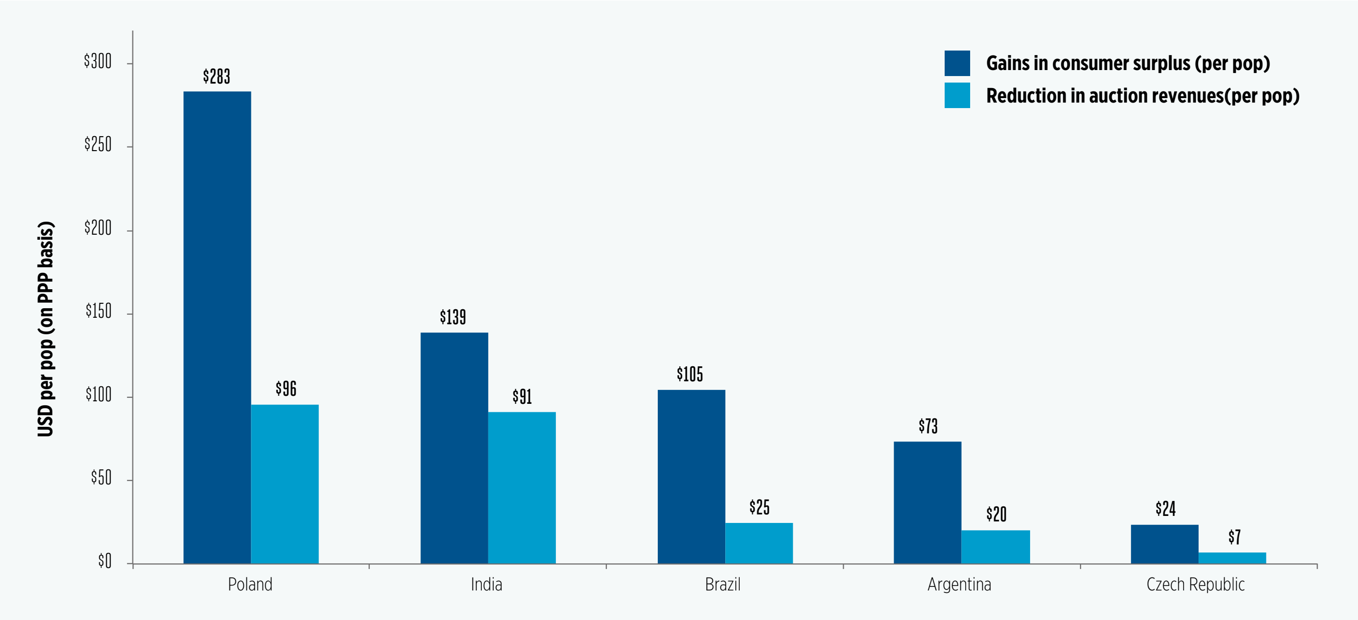
Figure 16 and Figure 17 provide a breakdown of the estimated welfare effects for countries in our sample with above median prices. Individual country calculations should be interpreted with caution, as our global model necessarily cannot account for local factors which may push the true market price up or down.

FIGURE 16: IMPLIED SCOPE FOR NET GAINS IN CONSUMER SURPLUS FROM LOWER SPECTRUM COSTS FOR SELECTED HIGH INCOME COUNTRIES



Source: NERA Economic Consulting, using data from various sources.

FIGURE 17: IMPLIED SCOPE FOR NET GAINS IN CONSUMER SURPLUS FROM LOWER SPECTRUM COSTS FOR SELECTED MIDDLE AND LOWER INCOME COUNTRIES



Source: NERA Economic Consulting, using data from various sources.

2.5. Spectrum pricing and the outlook for 5G

The price of mobile spectrum over time should reflect the evolving equilibrium between its supply and demand. Supply is driven by the release of new bands, and constrained by the availability of equipment to use those bands. Demand is driven by growth in consumer demand for mobile data, and constrained by the ability of mobile operators to monetise that value. Looking forward, it is apparent that supply of spectrum is set to increase rapidly, an appropriate regulatory response to forecasts of huge growth in mobile data demand. However, unless operators can find new sources of revenue, the price they can afford to pay for spectrum must decline.

The following are the key trends:

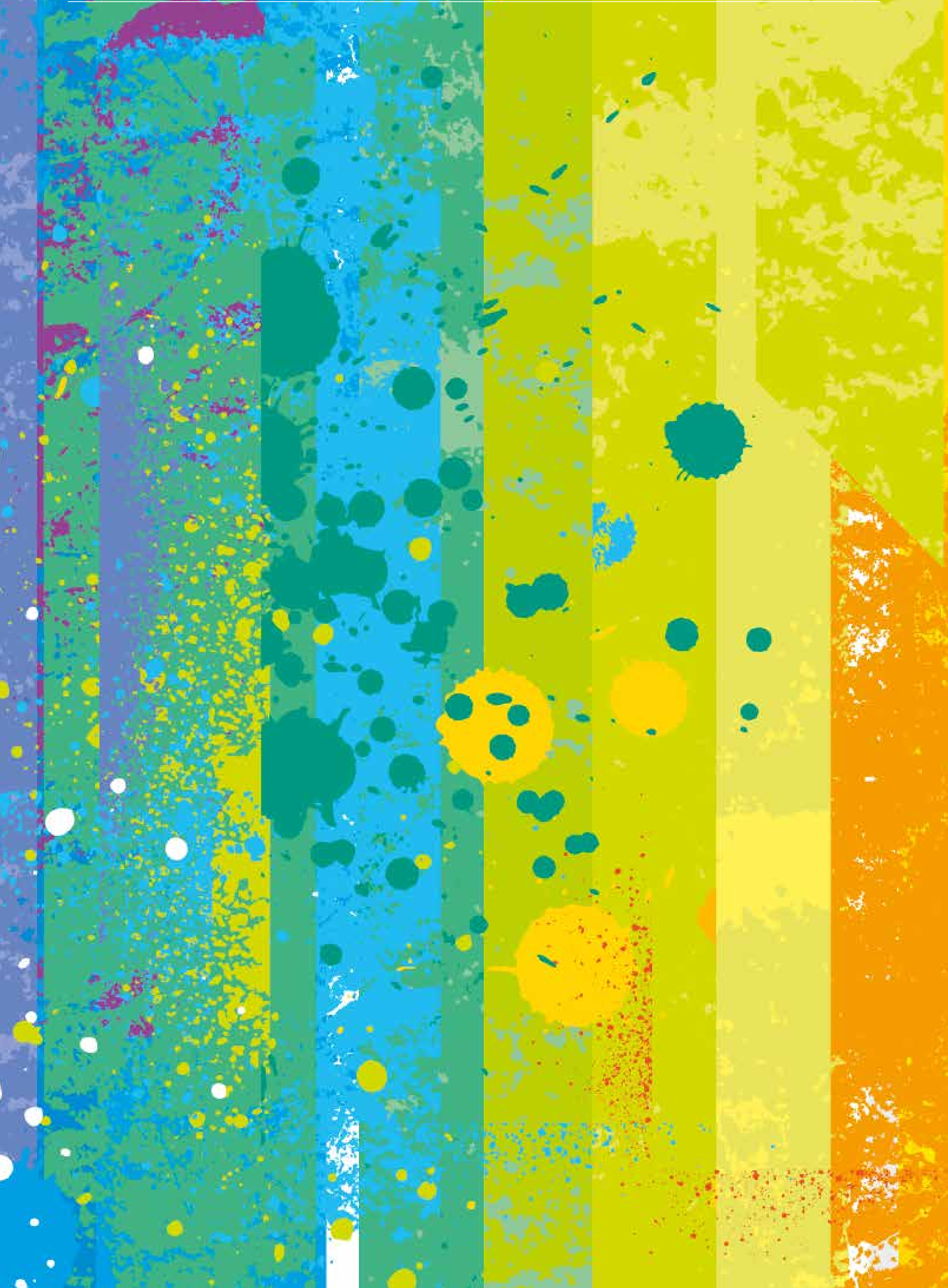
- **More spectrum.** The next five years will see an increase in spectrum availability, especially at higher frequencies. For example, in Europe, the release of spectrum at 700 MHz, 1500 MHz, 2300 MHz and 3400-3800 MHz has the potential to increase total spectrum for mobile from just 340 MHz in the 3G era to over 1,000 MHz by 2020. Looking further ahead, regulators are also exploring options for operators to access much larger swathes of frequency available in bands above 5 GHz.
- **More flexible technology.** This huge expansion in spectrum availability is supported by advances in antenna technology, which have made it possible for next-generation handsets to support all these frequency bands. Other technology advances are enabling operators to exploit ever larger blocks of spectrum, so as to expand capacity and headline speeds. For example, with 4G LTE, some operators are now aggregating up to three blocks of 20 MHz, and 5G may be deployed using much larger blocks of spectrum.
- **Rising demand for data.** MNOs are experiencing exceptional growth in mobile data traffic. This rise is driven by a growing number of users connected to faster networks doing ever more of their everyday tasks and enjoying more and more entertainment on their smartphones. While there is uncertainty over the level of future data demand, all industry experts predict massive growth.[30]
- **Huge investment required.** The next generation of networks that will support this demand will require roll-out of expensive new infrastructure, including densification of macro cells and roll out of small cells, in particular to exploit higher frequency bands. This point is made notwithstanding the potential to deploy spectrum as an alternative to some investment in network capacity.
- **Limited revenue growth.** In many advanced countries, subscriber penetration is well above 100% and ARPUs are not increasing.[31] Against this background, the ability of operators to monetize the growth in demand for mobile data, for example through fixed-mobile convergence or new value-added services linked to the Internet of Things, is uncertain.).

In summary, the current outlook is for reduced spectrum scarcity but uncertain scope for operators to generate revenues from mobile networks. This implies that prices paid for spectrum should fall, especially as future releases are increasingly focused on higher frequency bands. Countries that try to resist this trend, either by restricting spectrum availability or overpricing newly released spectrum, are likely to see large amounts of spectrum go unallocated. Such outcomes would constrain the ability of operators in those countries to develop new services, and act as a disincentive for them to invest and compete in the provision of next-generation services. Given the evidence that a growing minority of countries have engaged in high spectrum price practices in recent years, this points to an escalating divide between countries in the development of their mobile ecosystem.

Taking a more positive perspective, a lesson from our analysis is that by embracing policies that avoid inflating spectrum prices, countries have the opportunity to realise more rapid availability and adoption of next generation network services than would otherwise be the case. This observation may be particularly important for lower income countries, where there is greatest potential to grow the market for mobile data. Prompt and extensive deployment of the latest mobile technologies can stimulate the development of the whole digital ecosystem. This, in turn can increase the competitiveness of national companies and bring services like education, healthcare or banking to areas or citizens that otherwise would have scant and expensive access to them, if at all.

30 See, for example, GSMA, 2015, 'Data demand explained', which compares forecasts across four industry observers, available at: http://www.gsma.com/spectrum/wp-content/uploads/2015/06/GSMA-Data-Demand-Explained-June-2015.pdf.

31 According to data from Telegeography Global Comms Database, 67 out of 83 mobile operators in OECD countries reported declining ARPUs between 2010 and 2015. This excludes 9 operators where 2015 data is not yet available.



3. Mistakes in spectrum pricing

A striking feature of spectrum auctions over the last two decades has been the huge variation in price per MHz paid for similar spectrum, after adjusting for population and local economic conditions. As we highlighted in Chapter 2, there are many examples of awards generating prices well above average levels, and the instances of such high price outliers has increased in recent years. The variations in price are simply too great to be explained by differences in local mobile market conditions, such as market penetration or revenues per user. Sometimes, high prices may simply be the result of strong competition between current and aspiring mobile operators. This should not generally be a concern for regulators. However, in recent years, more often than not, high prices can be linked to decisions by local policymakers, in particular with regards to reserve prices. This in turn implies that many countries are implementing pricing policies that discourage roll-out of next-generation mobile services and constrain consumer welfare.

Mistakes by policymakers when pricing spectrum can be grouped into three broad categories, as illustrated in Figure 18. Firstly, and most obviously, reserve prices and annual fees may be set above the true market value. This approach is often associated with award failure. Secondly, high prices may result from artificial scarcity or uncertainty over future spectrum availability, factors that inflate valuations. Thirdly, inappropriate award rules create risks for bidders or options to foreclose competition, which oblige or tempt operators to overpay.

FIGURE 18: COMMON MISTAKES IN SPECTRUM PRICING

Source: NERA Economic Consulting

Often, in cases of high price spectrum allocations or failed awards, more than one of these policy errors is present. For example, if spectrum availability is artificially constrained, this may support excessive reserve prices and create gaming options for operators to foreclose competition.

We discuss below each type of mistake, illustrated by examples from awards around the world. We specifically focus on awards where high prices or award failure can be linked to errors in policymaking, because these are the areas where regulators can and should do better. A suitably empowered regulator should have control over setting fees, managing spectrum releases and designing award formats. They can also set rules that discourage incentives for anti-competitive bidding or prevent clearly undesirable outcomes, such as one party acquiring too large a share of the available spectrum.

We are less interested in cases where high spectrum prices were driven primarily by competition between operators and aspiring entrants. It is not the job of regulators to protect mobile operators from fair competition and it is unrealistic to expect them to protect operators from market bubbles. For example, the eye-watering prices realised in the UK and German 3G auctions in 2000 were primarily the result of unduly optimistic views regarding the commercial potential of 3G, as opposed to policy error. More recently, the record prices achieved in the US AWS-3 were primarily driven by competition between operators and other bidders, rather than intervention by the FCC, and likely reflect local market factors not present in any other national market.

As an antidote to our list of blighted spectrum awards, we conclude this chapter by presenting the case of Sweden which has one of the highest wireless scores and amongst the lowest consumer prices for mobile data in our country sample. In a number of interviews with mobile operators, it was cited as an example of better practice in spectrum pricing. PTS was praised for setting fair reserve prices, bringing spectrum to market in a timely manner and clearly signposting future releases, and setting auction rules that supported its policy objectives, including rural roll-out, with minimum distortion to valuations and competition.

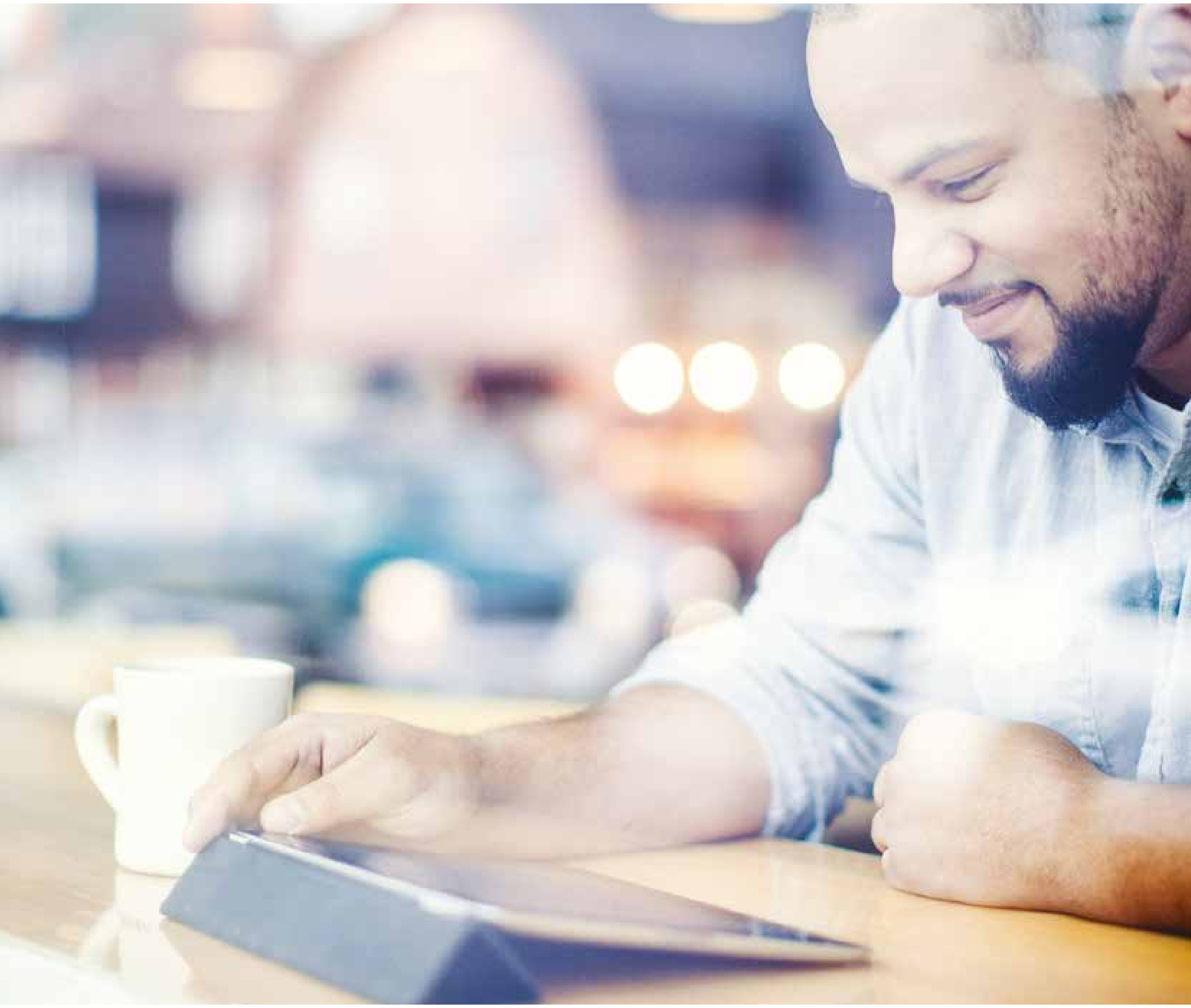
3.1. Excessive minimum prices

The most obvious mistake that some governments or regulators have made is to set minimum prices for spectrum that are too high, i.e. above the fair market value. If the regulator is fortunate, they may find a price point at which all or most of the spectrum sells. More typically, over-pricing results in substantial amounts of spectrum going unsold and also acrimonious disputes between the regulator and incumbent operators. Failure to sell spectrum in this case is clearly inefficient, preventing the use of a scarce resource to provide valuable services for consumers. Sometimes, it also means lower revenues for the government, as the regulator could have raised more money overall by selling the entire band at a lower price.

Where no spectrum sells, the situation may eventually be resolved by the launch of a new award process at a lower reserve price. Typically, this takes several years, as it may require time (or sometimes a change of government) before a regulator is ready or able to change its approach. A more complicated situation may occur where some but not all of the high priced spectrum sells. When this happens, it creates a divide between the interests of operators who have bought spectrum (typically larger incumbents) and those that refused (typically smaller incumbents or potential entrants). This may make it even harder for the regulator to adjust downwards the reserve price for future awards, especially if there is the possibility of legal challenge from operators that bought spectrum.

High upfront reserve prices

The classic example of spectrum being overpriced is the 2100 MHz band in France. We describe the saga of the French allocation of 3G licences in the box on page 42. In retrospect, it is obvious that the initial (fixed) reserve price was set too high, as it was based on the very high 3G prices realised in the UK and Germany. However, because some spectrum did sell to incumbents at the high fixed fee, it was subsequently difficult for the regulator to adapt the price and licence terms in the way needed to sell all four licences. As a result, operators were saddled with high spectrum costs, 2x15 MHz of prime spectrum went unsold for a decade, and consumers likely suffered as a result of enduring disincentives for operators to invest and compete to a maximum extent.



France – The 3G licence saga

French regulator ARCEP launched its first award of 3G spectrum in August 2000, with applications due January 2001. Unlike the UK and Germany, which had run competitive auctions with modest reserve prices, France opted for a beauty contest with high fixed prices: four 2x15 MHz licences for $4.5bn each, $18bn in total. The enormous reserve price was influenced by the outcomes of the UK and German auctions, earlier in 2000. The decision backfired. Against a background of a worldwide collapse in market sentiment towards 3G, only two of the three incumbents – Orange and SFR – applied for licences, and no entrants participated.

After lengthy deliberations, ARCEP launched a new contest for the remaining two licences in September 2002. Despite slashing the licence price by over 80% to €619m ($565m) each plus 1% of 3G revenues, it was only successful in persuading the third incumbent, Bouygues, to buy a licence. ARCEP also gave the same price reduction to Orange and SFR.

ARCEP tried again to sell the 4th licence in 2007, with similar terms. This contest drew one application, from Free Mobile, but this was rejected as Free wanted to pay in instalments rather than upfront. After further consultations, in August 2009, ARCEP launched a new procedure for awarding a 2x5 MHz 3G licence. In December, it was announced that Free Mobile had acquired the licence for €240m ($350m). The remaining 2x10 MHz was sold in equal parts to SFR and Orange in February 2010.

The entire process of allocating the spectrum took almost ten years, during which time valuable spectrum went unused. The incumbent operators were saddled with paying fees above the true market value, but these fees also acted as a barrier to new entry. At the time of the 2009 award, France had consumer mobile prices "among the highest in Europe."[32] Since 2010, the relative success of the new entrant Free (as compared to other recent entrants in European markets), which now has a 17.7% market share, may be evidence that the 3G process constrained incumbent incentives both to invest and compete over the preceding decade.

With the new wave of auctions for 4G spectrum since 2010, there have been a significant number of award failures which can be linked to high reserve prices. The incidence of such events seems to have picked up in recent years, consistent with the uptick in high spectrum price outliers we identified in Chapter 2.1. We suspect this is connected to two factors: (1) a surge in the number of spectrum awards in medium and lower income countries, where regulators may face stronger political pressure to consider revenue outcomes; and (2) an emerging trend for regulators to rely on (often inappropriate) benchmark price outcomes from prior awards when setting reserve prices.

32 ARCEP, Results and summary of the award procedure for the fourth 3G licence, 18 December 2009.

In the box below, we describe the recent award failures in Ghana, Mozambique and Senegal, all caused by prices being set at levels that local operators say are too high. A common theme across the three auctions is the use of international benchmarks to set reserve prices. While the regulators have not disclosed their methodologies, the suspicion is that they have placed substantial weight on prices from more developed mobile markets, and have made insufficient adjustment to account for differences in consumer spend on mobile services. Whereas Mozambique sold no spectrum, Ghana and Senegal are potentially in a worse position because they sold just one licence, in each case to the market leader. As in France in the 2000s, local regulators now face a difficult political choice between reducing prices (which might require them to refund the market leader) or hanging tough in the hope others will eventually buy. This may mean a long period of reduced competition in 4G services.

Mozambique, Ghana and Senegal 4G – History repeated

Mozambique, Ghana, and Senegal all provide recent examples of countries that have overpriced 4G licences, leading to valuable spectrum going unsold. Each appears to be repeating a variant of France's 3G saga.

Mozambique was one of the first countries in Africa to offer 800 MHz, with an auction scheduled for June 2013. Instead of offering the usual six blocks of 2x5MHz, regulator INCM offered only five lots, an apparent attempt to use artificial scarcity to drive competition between the three incumbent operators, in case no new entrants participated. However, the auction failed to attract any applicants, as all parties baulked at the reserve price of USD 30 million per block ($0.12 per MHz per pop). Our understanding is that the reserve price was calculated using worldwide benchmarks for 800 MHz auctions (mainly from Europe), but insufficient adjustment had been made for the small size of the local telecommunications market. As of September 2016, the spectrum remains unallocated, limiting options for mobile operators to expand 4G coverage and capacity. However, with no spectrum sold, Mozambique at least has the option to start the entire process again with reduced prices.

In Ghana, the current situation draws even closer parallels with France. In December 2015, the regulator, NCA, proposed to auction two 2x10 MHz lots of 800 MHz spectrum, with the objectives to: provide valuable spectrum to the mobile industry; generate revenues for the government; and foster growth in the existing mobile internet. However, its decision to set a reserve price of USD 67.5 million per lot ($0.13 per MHz per pop) has put all these objectives at risk. Three of the four incumbent mobile operators declined to participate. Only the market leader, MTN Ghana – which has a 47% subscriber market share, acquired a licence. Ghana now faces the possibility of sector monopolisation as the market migrates from 3G to 4G.

A similar saga has begun in Senegal. In November 2015, regulator ARTP launched a tender to award 4G mobile licences with a reserve price of about USD 50 million. One month later, ARTP received a letter signed by all three incumbent mobile operations calling for a price reduction. ARTP refused, arguing that the prices were based on benchmarks from awards at 700 MHz, 800 MHz and 1800 MHz in over 20 other countries and appropriate given local market potential. It is unclear which benchmark countries were used, but given the bands mentioned, it seems likely that many were from much more developed markets. All three mobile operators subsequently boycotted the 4G auction. However, ARTP reported in June that market leader Sonatel will acquire a 4G licence as part of a USD 220 million package that will also renew all its existing mobile and fixed line licences. Again, this risks creating a competitive asymmetry in the market.

Examples of other countries that have failed to sell 4G spectrum owing to high reserve prices include:

- **Australia (2013), where the government intervened to price 700 MHz at A$311m per 2x5 MHz block (US$1.36 MHz/pop), with the specific objective of raising revenues. It missed its revenue targets, as only six of the nine 2x5 MHz blocks from this core 4G band sold. Notably, #3 operator VHA declined to bid, while #2 operator Optus bought only two blocks. As of 2016, ACMA, the Australian regulator, is consulting on selling the residual spectrum.**
- **India (2012-16), where a large amount of spectrum, especially in sub-1 GHz bands, has gone unsold owing to exceptionally high reserve prices (see case study under spectrum scarcity below);**
- **Jordan (2013), where the regulator offered large packages of spectrum across the 800, 1800, 2100, 2300 and 2600 MHz bands. It set very high upfront fees for each band, ranging from $0.37 up to $1.36 per MHz/pop unadjusted (or $0.72 up to $2.68 after adjusting for purchasing power). It also demanded a 10% revenue share. All operators refused this offer. However, in 2014, market leader Zain subsequently had an offer to buy 2x20 MHz at 1800 MHz for $200m accepted, and the regulator raised the 1800 MHz reserve to reflect this. Subsequently, Orange bought 2x10 MHz at 1800 MHz for $100m. The other spectrum remains unallocated.**
- **Romania (2012), where the regulator failed to sell 2x5 MHz at 800 MHz and 2x40 MHz at 2.6 GHz, in a multi-band auction with four competing bidders. The two large operators, Orange and Vodafone, each bought 2x10 MHz at 800 MHz. However, the reserve price at 800 MHz of US$0.22 per MHz/pop ($0.50 on a PPP basis) was too steep for the country's two smaller operators, Cosmote (which bought one 2x5 MHz block) and RCS & RDS (which did not buy any).**

The failure of these countries to sell valuable spectrum may be contrasted with the relative success of Morocco's 4G auction in January 2015. Morocco allocated a total of 240 MHz of spectrum (60 MHz each at 800 MHz and 1800 MHz, and 120 MHz at 2500 MHz), split equally across three packages, which were won by the three incumbent bidders. In a sealed bid, all spectrum sold at a price close to the reserve price per licence of DH 500 million plus a contribution of DH 239m to cover band clearing costs (US$77m per bidder). The price per MHz pop was $0.06, well below, for example, the $0.13 sought in Ghana, even though Morocco's GDP per capita is more than 40% higher. Overall, the government still realised a substantial windfall for taxpayers, but at a level which should not impede investment and competition in 4G services.

High annual fees

High annual fees can also create difficulties for regulators trying to set reserve prices for new spectrum awards. In many countries, annual fees for frequency bands are set separately from awards, sometimes by legal statute. If set at a substantial level, then minimum upfront fees in auctions must be reduced accordingly to prevent award failure. In the worst case, regulators may be left with no flexibility to price spectrum appropriately.

On page 43, we discuss the example of Mexico, where annual fees as a proportion of total spectrum cost are unusually high. This has become a source of contention, with some mobile operators complaining that fee levels are unsustainable, given their requirements for more spectrum to meet the demand for new data. This was an issue in the Mexico AWS auction, where prior government decisions and precedents on prices left the regulator IFT with little flexibility on setting reserve prices for AWS spectrum.[33]

This challenging situation may be contrasted with Denmark, where annual fees are set at a low level, sufficient to recover spectrum management cost. For example, the 2016 fee for 1800 MHz spectrum was only Kr 56,000 ($10,000) per MHz, compared to MXN 40m ($2.9m) per MHz for AWS spectrum in Mexico. At the Danish level, annual fees place no constraint on reserve prices, leaving the regulator with great flexibility to vary upfront fees between bands and auctions based on local demand conditions.

33 NERA Economic Consulting advised the IFT on design and implementation of this auction.

Mexico AWS – High annual fees limit independent regulator's options

In Mexico, spectrum fees for legacy mobile bands were set by law (Ley Federal de Derechos) and subject to annual increases. When the fees were established, they were supposed to capture 70% of estimated market value; however, this was at a time when relatively little spectrum had been released. As operators have secured more PCS and AWS spectrum, the aggregate fee burden has increased substantially. Such costs fall particularly heavily on the country's second and third largest operators –Telefónica and AT&T – owing to their modest market shares of 24% and 9% respectively, compared to 67% for market leader Telcel.

For the 2016 AWS auction, the annual fees for AWS spectrum was set at MXN 400m ($29m) per annum index linked, per 2x5 MHz block. This is equivalent to $0.17 per MHz/pop.

This exceptionally high annual fee created significant challenges for the regulator IFT in designing the award process. While it could be reasonably certain that it would sell all available AWS-1 spectrum, which was usable immediately, the outlook was less certain for AWS-3, where equipment was not yet available. IFT decided to set a much lower upfront fee per 2x5 MHz block for AWS-3 than for AWS-1:

- **AWS 3: Upfront payment of MXN 65m ($0.0025 per MHz/pop).**
- **AWS 1: Upfront payment of MXN 937m ($0.04 per MHz/pop).**

Despite IFT's decision to set a minimal upfront fee for AWS-3 spectrum, one 2x5 MHz block went unsold. The smaller operators have both argued that it was the high annual fees that deterred their participation in the auction. While the largest operator (Telcel) bought the maximum permissible amount of spectrum (and might have bought more if permitted), AT&T acquired only 2x10 MHz of AWS-1 spectrum, and Telefónica did not participate.

3.2. Artificial scarcity of spectrum

High spectrum prices can often be linked to artificial scarcity of spectrum. It is obvious that if the supply of a scarce resource is constrained, its price will increase. Although spectrum allocation for mobile is coordinated at an international level, countries follow very different approaches to the release of frequency bands. While some of these differences reflect legitimate factors, such as challenges in clearing legacy users or differences in the development of local markets, it is also the case that some countries appear to have deliberately held spectrum back. Other causes of high prices include artificially constraining supply for incumbents, through entrant reservations, or uncertainty over the roadmap for future spectrum releases.

Holding back spectrum from the market

Developing countries have generally been slow to bring new mobile spectrum bands to market. Often, this reflects domestic regulatory challenges and issues with clearance or liberalisation of legacy bands. Certain countries have also deliberately held back spectrum from the market in order to increase award revenues.

While holding back spectrum from the market may mean you get higher revenues for the spectrum you do sell, the downside is significant:

- **It involves warehousing a valuable resource, thus constraining development of new services and scope for competition;**
- **Any premium that winning bidders pay may be reflected in an expectation of greater profits owing to a less competitive market, i.e. at the expense of consumer surplus;**
- **Lost consumer welfare owing to lower quality, higher priced services in the years that spectrum availability is constrained can never be recovered;**
- **High prices achieved in such auctions may generate unrealistic expectations that they can be repeated in subsequent awards, setting in train a path to future award failures owing to excessive reserve pricing.**

The evolution of spectrum awards in India since 2010 provides a case study of how government-induced artificial spectrum scarcity has supported high spectrum prices, which generates unrealistic expectations for further revenues from future awards, leading to excessive reserve prices and large swathes of spectrum going unallocated. We explore the Indian case in the box on page 47. Egypt is another example where operators have been in dispute with the government over timely release of spectrum for 4G services at fair prices.

Artificial scarcity of spectrum is most common in lower and medium income countries, where regulatory mandates to promote efficient allocation may be less embedded. Such practices are typically precluded in countries that have strong independent regulators and/or well defined rules for spectrum management. For example, EU law requires that countries make available new spectrum bands in a timely manner, and the European Commission actively monitors the progress of member states in this regard.[34] While EU member states do vary in the speed in which they have brought 4G bands to market, very long delays are rare and countries typically release frequency bands in their entirety.

34 See, for example: European Commission Press Release, Europeans suffering because most Member States are too slow delivering 4G mobile broadband spectrum, Brussels, 23 July 2013, available at: http://europa.eu/rapid/press-release_IP-13-726_en.htm

India – spectrum scarcity inflates auction prices

Between 2010-16, India has held six auctions for mobile spectrum, more than any other country over this time period. Each auction has typically included only subsets of the total frequencies normally associated with IMT bands, with significant variance across regions. The process for determining which frequencies are made available when has also been fraught with uncertainty, meaning that operators lack a clear roadmap regarding their options to acquire spectrum in the future.

The 3G auction in 2010 was a key milestone in the development of the mobile industry in India. It supported the entry of a large number of new operators, many backed by established international operators. These companies collectively paid a steep price for the spectrum they won ($16bn). This likely reflected the perceived value of entering one of the world's largest markets by population rather than the intrinsic value of the spectrum.

Since the 3G auction, the government has in effect adopted a twin strategy of (a) drip feeding spectrum into the market; and (b) ratcheting up the reserve price for new spectrum, based on prices paid in previous auctions. This has had predictable results. Firstly, as spectrum remains artificially scarce, some frequencies are selling at ever-higher prices. Secondly, a large amount of spectrum has failed to sell because operators have been forced by the high reserve prices to ration their demand. Finally, the allocation of frequencies across bands has been distorted by the relative levels of reserve price. In particular, operators have perversely focused on capacity spectrum rather than sub-1 GHz spectrum, because the latter category has become so expensive.

The October 2016 auction featured a much greater quantity of spectrum, spread across seven bands, than previous awards. Had this entire spectrum sold, it would have contributed substantially to ending artificial spectrum scarcity in India. Instead, the auction flopped, with just 41% of the airwaves available sold and the auction raising only $9.8bn, against a reserve price of $84bn. Bidding was heavily focused on high band frequencies, whereas 700 MHz and 900 MHz received no bids.

The Indian market has great potential, but until operators have the chance to acquire substantive spectrum holdings at realistic prices, the deployment of next-generation data networks will remain stunted. Moreover, deployment will likely focus on urban areas at the expense of rural ones, as most operators cannot acquire the sub-1 GHz spectrum they need to cost effectively cover the rural population. This should be particularly alarming in a country with an exceptionally high rural population that has limited access to fixed line communications.

Squeezing the supply of spectrum for incumbents

While regulators in OECD countries rarely act to hold back spectrum from the market, they have sometimes created artificial scarcity for incumbent operators through measures that reserve spectrum for entrant bidders. If this leaves too little spectrum available to meet the minimum demands of large incumbents, this may result in operators paying very high prices for the spectrum that they do win. Typically, in such cases, high prices for winning incumbents are offset by much lower prices for entrant bidders.

Three recent 4G auctions where actual or de facto reservations for recent entrants had a huge impact on spectrum prices were the Canadian 700 MHz and AWS-3 auctions and the Netherlands multi-band auction:

- **In Canada in February 2014, market leader Rogers paid C$3.3bn (US$3bn) for a near national 2x12 MHz lower 700 MHz band footprint, while rivals Bell and Telus (who operate a network and spectrum share) paid C$1.7bn (US$1.5bn) in aggregate for a clearly inferior footprint that straddled the lower and upper bands. In the subsequent AWS-3 auction in March 2015, Bell and Telus in aggregate paid C$2bn (US$1.6bn) for a national 2x15 MHz footprint, while Rogers won nothing. Each auction also featured entrants who secured (actual or de facto) reserved spectrum at steep discounts. The asymmetric auction outcomes were shaped by entrant caps and reservations that precluded auction outcomes in which all incumbents could secure satisfactory amounts of spectrum.**
- **In 2012, the Netherlands ran an auction for five bands, including the 800, 900, 1800 and 2100 MHz bands in their entirety, raising €3.8bn (US$5bn), well above pre-auction expectations. The auction was shaped by decisions to (1) reserve 2x10 MHz at 800 MHz for a new entrant; and (2) not impose any spectrum caps on bidders. This meant that at least one incumbent would fail to win 2x10 MHz in this core LTE band. Each incumbent also faced the risk of not winning back sufficient 900 MHz and 1800 MHz spectrum to maintain their legacy 2G businesses.**

In both these cases, incumbent operators were likely obliged to pay much more than the true market value, absent measures to promote entry. The authorities in Canada and the Netherlands obviously hoped that new entry will stimulate consumer benefits through greater competition, but it remains to be seen if this is the case, and whether such benefits can offset the disincentives for competition and investment that may result from the high prices paid by established operators.

Failing to provide a roadmap for future spectrum releases

A related issue is the failure of some regulators to provide a roadmap for future releases of spectrum, including renewal and liberalisation of existing bands. This makes it difficult for companies to value new spectrum, as they cannot properly assess their future options. The uncertainty may distort relative valuations, resulting in inefficient outcomes with some companies buying too much and others too little.

Argentina has been cited as a country that has a poor record of signposting spectrum awards. There was a gap of nearly 15 years between the award of 3G and 4G spectrum, and – during this period – operators had to manage with 40-50 MHz each. In the 2014 auction for 700 MHz and AWS spectrum (see box on page 51), operators had to contend with high reserve prices, onerous coverage obligations and uncertainty over future spectrum availability, not least as the 2600 MHz band is currently allocated to fixed wireless access services. The situation in Argentina may be contrasted to the typical approach in Europe, where regulators flag bands for future release many years in advance. For example, in the UK in 2012, Ofcom began consulting on plans to release 700 MHz, even though an auction is not expected before 2018 and band clearance would not be complete until 2020.

Some regulators have been criticised for the opposite problem of bringing spectrum to the market too soon. For example, in 2010, Switzerland proposed to include 2100 MHz in its multi-band auction, even though existing licences did not expire until 2017. The regulator presumably believed that combining all bands in a single auction would make it easier for operators to manage substitution risks across bands. However, this approach meant that operators would have to pay upfront for something they could not use for seven years. This issue, amongst others, likely contributed to a delay in the multi-band award, until 2012.

Meanwhile, in 2014 in Brazil, operators were obliged to bid for 700 MHz licences and commit to covering the costs of re-tuning broadcast equipment so as to allow clearance of incumbent TV broadcasters. It could be five years or more before Brazilian operators are able to access this valuable spectrum nationwide. The latest timetable is for spectrum to be released one year after the analogue TV switch off, which will be staggered on a regional basis from October 2016 to December 2018. The timetable for several major cities has already been set back once, and further delays are possible.

3.3. Bad award rules

Prices in spectrum auctions will always reflect the conditions under which bidders are competing for the scarce resource. If those conditions are distorted, then the price may deviate from the fair market level.

Our final category covers a range of policies, award rules and licence conditions that create risk for bidders, and distort award outcomes, including:

- **Onerous or ambiguous licence obligations;**
- **Rules that promote insincere bidding;**
- **Rules that put enterprise value at risk; and**
- **Rule that incentivise anti-competitive bidding.**

Onerous licence obligations

Governments often attach conditions to spectrum licences as a way of influencing the behaviour of operators in the downstream consumer or wholesale markets. Network rollout conditions covering population, geography or specific locations, are the most common form of obligation. Examples of other conditions include obligations to host MVNOs, provide roaming access to entrant operators, and paying costs to cover band clearance. Whenever an operator is obliged to take actions that go beyond its commercial self-interest, they impose a cost, and thus reduce the value of the spectrum licence.

With respect to their impact on spectrum pricing, regulators commonly make three types of mistake when imposing conditions on licences:

1. **The conditions are ambiguous or too onerous (sometimes not credible);**
2. **They are badly structured – in particular, obligations that could be fulfilled by one operator or shared across operators are instead applied to all operators; and**
3. **Reserve prices are not adjusted to reflect the financial burden of meeting the obligations.**

Onerous obligations have a similar effect to increasing the reserve price. They stifle scope for price competition in the auction, and decrease incentives for (other forms of) investment and competition in the downstream market. Many Latin American countries – including Argentina, Brazil, Colombia – have higher consumer prices and lower wireless scores than European countries with equivalent GDP. This may be attributable to the widespread application of onerous coverage obligations on all operators. For example, in the box on page 51, we highlight the case of Argentina, where a combination of high prices and onerous coverage obligations on 700 MHz likely contributed to the failure of new entrant Airlink.

Argentina would likely have had a better outcome if it had adopted an approach closer to that used in Denmark or Sweden. These two countries use different auction formats but there are three common themes in their approach to coverage. Firstly, rural coverage obligations are only attached to low band spectrum, such as 700MHz or 800 MHz, suitable for wide area coverage. This makes them feasible. Secondly, obligations are either tied to specific spectrum blocks available in the auction or the auction format is set up in a way that ensures that only one operator will ever be obliged to cover a specific uneconomic area. This avoids wasteful duplication of infrastructure and makes such investments more economic. Thirdly, both countries use modest reserve prices and have adopted pricing structures that allow those bidders that take up a coverage obligation a discount. This allows operators to express a value on taking the obligation and stimulates competition in the award.

Argentina – Onerous obligations and high prices create uncertainty about future investment

In Argentina, there was a gap of nearly 15 years between the award of 3G and 4G spectrum. During this period, operators had to manage with 40-50 MHz each. Consequently, when 700 MHz and AWS spectrum was finally released in a combined award in 2014, incumbent operators had little choice but to participate.

They did so on very onerous terms:

- **High reserve prices – $0.23 per MHz per pop for 700 MHz and $0.22 for AWS spectrum.**
- **Harsh coverage obligations which went far beyond what an operator might build on commercial terms:**
  - Requirement to cover all cities with a population of over 500 (approximately 98% of the population) within 5 years; and
  - Requirement to cover 26,000 km of roads.
- **Upfront fees and any penalties for non-fulfilment of obligations to be payable in US dollars, not Argentinian pesos.**

They also bid with no certainty regarding future availability of spectrum, not least as the 2600 MHz band is currently allocated to fixed wireless access services. This meant that any operator that skipped the auction would face not being able to offer a competitive 4G service for an indefinite period.

All the spectrum sold, raising $2.23bn in total, modestly above the reserve price. However, one winning bidder – new entrant Airlink – subsequently defaulted on its first auction payment and had its licence withdrawn. It appears that external investors baulked at the prospect of investing in a start-up facing very high upfront spectrum costs and tough roll-out obligations. The spectrum it won remains unsold with no information provided about when it could be made available to incumbents.

Looking forward, the remaining incumbents face the challenge of roll-out obligations which many believe are unrealistic and will have to be renegotiated. As of October 2016, the 700 MHz band has not yet been released to operators: the deadline for clearance (July 2016) has already passed and broadcasters are in litigation with the regulator. In the meantime, high costs are likely to dampen incentives for 4G investment and price competition in the cities, which suggests that Argentina is likely to remain close to the bottom of our wireless score rankings (see Figure 10).

Rules that promote insincere bidding

Auctions work best when bidders bid truthfully, submitting bids that reflect their true, undistorted valuations. A key requirement is that bids are committing. If bidders can renege on their bids at little or no cost, then auctions may be vulnerable to over-bidding, resulting in prices that are inflated well beyond true market value. In certain situations, bidders may also be able to place bids that they know they will not win, thus distorting prices for opponents but not themselves.

There have been a number of 4G auctions where the auction rules contained loopholes or lacked credibility, leading to perverse price outcomes:

- **In 2012, the Czech Republic took the extraordinary step of cancelling its multi-band 4G auction owing to "excessive prices", after bids topped $1 billion. Pavel Dvorák, chairman of the CTU warned that: *"Such excessive prices of the auctioned frequencies would have to negatively translate into excessive charges for fast mobile internet ... We therefore consider it necessary to step in and prevent future negative consequences for the customers."* [35] The auction lost credibility because the rules contained a loophole that could potentially enable a bidder to escape its commitment, so no one could be sure that other bidders were sincere. Later the same year, with the loophole closed, a re-run of the auction raised $423m, with some capacity spectrum going unsold.**
- **In 2013, the Finnish 800 MHz auction lasted for an incredible nine months, owing to a loophole in the rules that allowed prices to fall as well as rise. The spectrum eventually sold at prices close to reserve, with the three bidders sharing the spectrum equally. This is a rare example where it is clear that spectrum sold below true market value.**
- **In 2015, the Polish 4G auction also took nine months to conclude. As prices climbed to high levels, confidence in the auction was eroded owing to concerns that bidders might exploit a loophole enabling them to renege at no cost on their licences. The regulator stepped in, first to pause the auction and then announce a sealed bid finale. Ultimately, the entire spectrum sold for $2.3bn, but entrant winner NetNet declined to pay for the 800 MHz lot that it won. In this case, it seems likely that competition from an insincere bidder may have pushed prices beyond true market value.**

Even in auctions without such loopholes, price distortions are possible on a band-by-band or even a lot-by-lot basis if incumbents have predictable and inflexible demand. For example, in Canada's AWS auction in 2008, a large entrant set-aside ensured that the three incumbents could predictably be expected to buy the rest of the spectrum. Entrant bidders took advantage of this to repeatedly bid on more expensive spectrum outside the set-aside (knowing they would be overbid) as a way of delaying competition with rivals for the set-aside spectrum. The result was that the incumbents were obliged to pay substantially more than the entrants for spectrum that should have had identical value.

35 For a detailed analysis of the Austrian auction, see: Maarten Janssen and Vladimir Karamychev, Gaming in Combinatorial Clock Auctions, University of Vienna.

Rules that put enterprise value on the line

A common feature linking many high price spectrum auctions is that bidders are competing not just for spectrum, but also their relative position in the downstream market. This is always true for potential entrant bidders but may also be true for incumbents, where access to incremental spectrum may be essential to their ability to compete for customers. As demand for data grows, an incumbent operator that fails to maintain a critical mass of 4G capacity spectrum could be permanently diminished as a competitive force or even being knocked out of the market.

In recent years, many countries have held large multi-band awards, many including 900 MHz and 1800 MHz spectrum, where existing licences were approaching expiry. Such large auctions offer both advantages and disadvantages. At their best, such events make it easier for bidders to manage substitutability and complementarity across bands, and thus identify the optimal spectrum portfolio for their needs. At their worst, they open up the possibility that an incumbent could suffer serious network disruption or even be knocked out of the market, especially where they face losing access to legacy spectrum. In such settings, a bidder's enterprise value may be on the line, meaning they could be induced to bid very aggressively. This creates the potential for grossly inefficient spectrum allocation, as bids may be based on bets about implications for downstream competition rather than the incremental value of the spectrum.

In the box on page 55, we explore the example of the 2013 Austrian multi-band auction, where three incumbents unexpectedly fought a fierce battle for 800, 900 and 1800 MHz spectrum. The high prices and a very asymmetric allocation can be linked directly to auction rules that encouraged competition for enterprise value. The Austrian auction may be contrasted to more modestly priced multi-band awards in countries such as Slovenia and Montenegro, where similar auction formats were run with greater transparency and spectrum caps that protected incumbents from the risk of losing spectrum essential to their business.

Austria – enterprise value on the line

Austria's multi-band auction for 800, 900 & 1800 MHz took place in 2013. It was a very important auction, mixing legacy 2G spectrum and key 4G bands. However, it was not expected to be a high price event, as only the three incumbents had qualified to bid. The market had recently been reduced from four players, following the merger of the two smallest operators.

The regulator, RTR, however, adopted policies that appear to have been designed to stimulate competition between the three operators, who might otherwise have been willing to share out the spectrum at modest prices.[36] Firstly, they selected a combinatorial clock auction (CCA), a format that discourages unilateral demand reduction.[37] Secondly, they took the unusual step, for a CCA, of hiding information about aggregate demand, meaning that bidders were bidding blind. Finally, they adopted lax spectrum caps, which left open the possibility that one of the bidders could be shut out by the other two. This created risk for the incumbent operators, who each had minimum demands to maintain their legacy 2G networks and be competitive at 4G.

With each company's enterprise value on the line, bidding was fierce. Final prices, at €0.84 per MHz/pop were – by some distance – the highest in Europe for a 4G award. The final spectrum allocation was also highly asymmetric, with the largest operator, Telekom Austria, winning 50% of the spectrum, while its smaller rival Three was shut out of the 800 MHz band.

In the aftermath, it appears that all parties were embarrassed by the result. RTR put out a statement implying that the high prices were the result of bidders making inflated bids for large packages they knew they would not win as a way of increasing prices for rivals. Meanwhile, all three operators released statements criticising the auction format, with some warning that investment would suffer. For example: T-Mobile said that *"If one of the three operators was unable to afford spectrum, they would not be able to provide 4G services, and we came very close to that scenario. Therefore, the prices set are at the market value of the entire company, rather than the market value of the spectrum,"* [38] and Three described the auction as a *"as a disaster for the industry because the high pricing is likely to see rural rollouts abandoned"*.[39]

As illustrated in Figure 11, as of 2016, Austria has the lowest wireless score amongst our sample of 23 high income countries.

36 For a detailed analysis of the Austrian auction, see: Maarten Janssen and Vladimir Karamychev, Gaming in Combinatorial Clock Auctions, University of Vienna.

37 For further explanation, see: Richard Marsden and Soren Sorensen, Strategic Bidding in Combinatorial Clock Auctions, in Bichler, M and Goeree, J, Handbook of Spectrum Auction Design (forthcoming, Cambridge University Press).

38 http://telecoms.com/201711/t-mobile-austria-confirms-intent-to-appeal-auction-results/.

39 https://www.telegeography.com/products/commsupdate/articles/2013/10/22/a1-scoops-half-of-spectrum-spoils-h3g-brands-process-a-disaster-for-industry/.

Incentives for anti-competitive bidding

In auctions where enterprise value is at stake, the valuations and bids of some parties may be inflated owing to expectations of anti-competitive benefits from blocking rivals from access to spectrum. In the worst case, governments may embrace rules that actively entice operators to pay high prices in return for the potential to eliminate competition. Perhaps the most notorious example (widely cited in the spectrum auction literature) is the Turkish 2G auction in 2000, which we describe in the box below, where the winner of the first 2G licence was de facto able to block bidders for the second licence.[40] As discussed above in relation to high reserve prices, any auction where reserve prices are inflated to a point where smaller operators are priced out of the market potentially has this feature.

Turkey - unintended consequences

The 1800 MHz award in Turkey is widely cited in the academic literature as a good example of how not to run a spectrum auction. The authorities offered two identical 1800 MHz licences in sequential auctions. For reasons that are unclear but may reflect a misguided effort to increase revenues, the rules set the reserve price of the second licence at the final price of the first licence.

The winner of the first block (Is-TIM) strategically placed a very high bid on the first licence. This was effective in pricing out competition for the second licence, which went unsold. As a result, incumbents Telsim (now Vodafone) and Turkcell were each unable to win any 1800 MHz spectrum. A further licence was granted directly to state-owned Turk Telecom. Subsequently, Is-TIM and Turk Telecom merged in 2004 to form Avea.

This approach shows the obvious folly of trying to price new awards based on the outcome of previous ones. Not only did Turkey delay bringing valuable spectrum to the market and artificially constrain the number of operators able to launch 1800 MHz networks, but it also likely secured much less revenue than if it had sold all the spectrum.

3.4. How to avoid mistakes

The many mistakes in spectrum pricing that we described above can be avoided if regulators follow these three rules:

1. **Price spectrum to sell.** The key to selling spectrum is to set a reserve price below a conservative estimate of market value, ideally relying on competitive bidding to determine if a higher price is justified.
2. **Bring spectrum to the market as soon as it is needed.** Regulators who sit on valuable spectrum are destroying value for consumers that can never be recovered. Ideally: spectrum should be released as soon as there is a supporting ecosystem and operators are ready to plan deployments; bands should be cleared and released in their entirety; and future awards should be appropriately signposted.
3. **Manage risk for bidders.** Regulators should carefully consider the impact of licence terms, such as duration and roll-out obligations, on value, and reflect this in spectrum pricing decisions. In particular, coverage requirements should be realistic and the most onerous obligations, when considered necessary, should be shared rather than duplicated across operators, with reduced reserve prices to reflect the burden.

In the box on page 57 we highlight the case of Sweden, where the regulator PTS has followed each of these rules. Since the mid-2000s, when it first embraced a market-led approach to spectrum management, PTS has held a succession of successful spectrum awards. We do not think it is a coincidence that Sweden has one of the highest wireless scores and amongst the lowest price levels for data services in our country sample.

40 For example, see: Paul Klemperer, What Really Matters in Auction Design, Journal of Economic Perspectives, Volume 16, Number 1 – Winter 2002, p176.

Sweden – better practice in spectrum pricing

PTS has a policy of using auctions for assignment of licences when there is competition for spectrum. Since 2003, it has held ten spectrum auctions, with a further two currently planned. Its priority is always an efficient allocation to the users who express the highest values. PTS has no explicit mandate to raise revenues, but is happy to do so as a by-product of securing an efficient outcome.
Sweden has a policy of setting modest reserve prices, such that it is confident the spectrum will sell if there is a use case. It often prices at a low but non trivial level, but does set higher prices when it is clear there will be demand at that price level (e.g. 800 MHz).

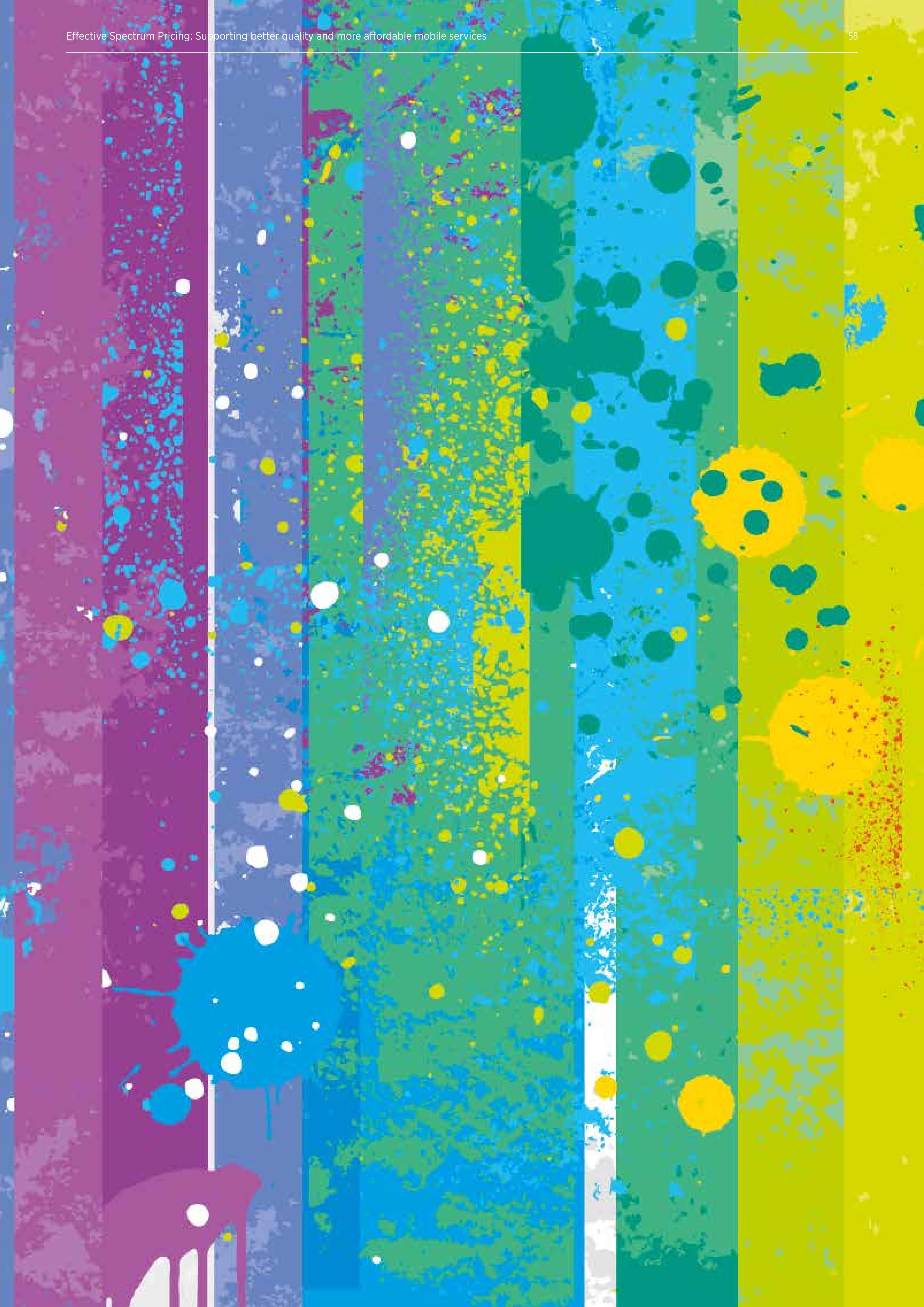
This approach has resulted in a series of competitive auctions for major mobile bands, in which prices have significantly exceeded the reserve level:

- **2.6 GHz (2008): Paired Reserve $0.005, Sold $0.14;**
- **1800 MHz (2011): Reserve $0.01, Sold $0.18; and**
- **800 MHz (2011): Reserve $0.11, Sold $0.28.**

All of Sweden's spectrum auctions have been single band awards. Our understanding is that this is a natural outcome of their efforts to bring spectrum to market as soon as practicable. Indeed, Sweden has always been amongst the first countries in Europe to clear and release new 4G spectrum bands. Where feasible, entire bands are always released at the same time.

A benefit of this approach is that each individual auction is a relatively low risk event for operators, as only a modest proportion of total spectrum is ever available at any one time. Indeed, this has allowed Sweden to embrace typically lax spectrum caps within auctions, as it has never faced a situation where there were serious concerns about an auction outcome creating risks to downstream competition.

Sweden also takes other steps to reduce risk for bidders. The mobile licence term is 25 years, amongst the longest in the world. It does not impose coverage obligations on frequency bands above 1 GHz. With respect to 800 MHz, PTS took the decision that a coverage obligation was required to ensure service in selected rural areas. It attached this obligation to only one 2x10 MHz licence, so as to avoid unnecessary infrastructure duplication. It further adopted an innovative approach of allowing operators that bid for this licence to commit to spending between SEK150m-300m ($22m-44m) on specified rural coverage, and count this amount towards their bid. This created an implicit discount for taking the coverage obligation which encouraged active competition between operators for the associated licence.



4. What do other industries do?

Mobile communications is one of a wide range of industries dependent on essential inputs provided by public authorities. The terms, conditions and selection criteria that authorities use to allocate those inputs may cast light on potential ways to improve spectrum management, and support effective pricing of spectrum.

We surveyed a number of industries and compared their approaches to pricing and allocation to policies used in the mobile sector. We also sought to understand how these practices varied across industries depending on the characteristics of that industry, such as the level of competition or risk profile of the investment. In this chapter, we describe the survey, and explain some lessons that can be taken from those industries' experiences. Our key observation is that best practice in pricing and allocation is always tailored to the characteristics of the industry.

In those industries with similar attributes to mobile, regulators engaged in best practice:

- **rely on the market to set prices;**
- **encourage full utilisation of the resource;**
- **take measures to mitigate risk for operators; and**
- **adopt a long-term perspective to social value creation.**

4.1. Survey of pricing and allocation practices across industries

We surveyed twelve other industries in a number of countries. The common theme across these industries is the presence of private suppliers dependent on an input supplied or regulated by the government.[41] The inputs themselves vary, including: essential resources for the production process (e.g. spectrum licences or mineral extraction rights); licences to operate in a regulated activity (e.g. taxi medallions or toll highway concessions); and customers from publicly supplied services (e.g. social security patients cared for at private hospitals).

These industries are very different. To identify patterns and isolate policies that may be applicable to spectrum pricing, we identified three key dimensions:

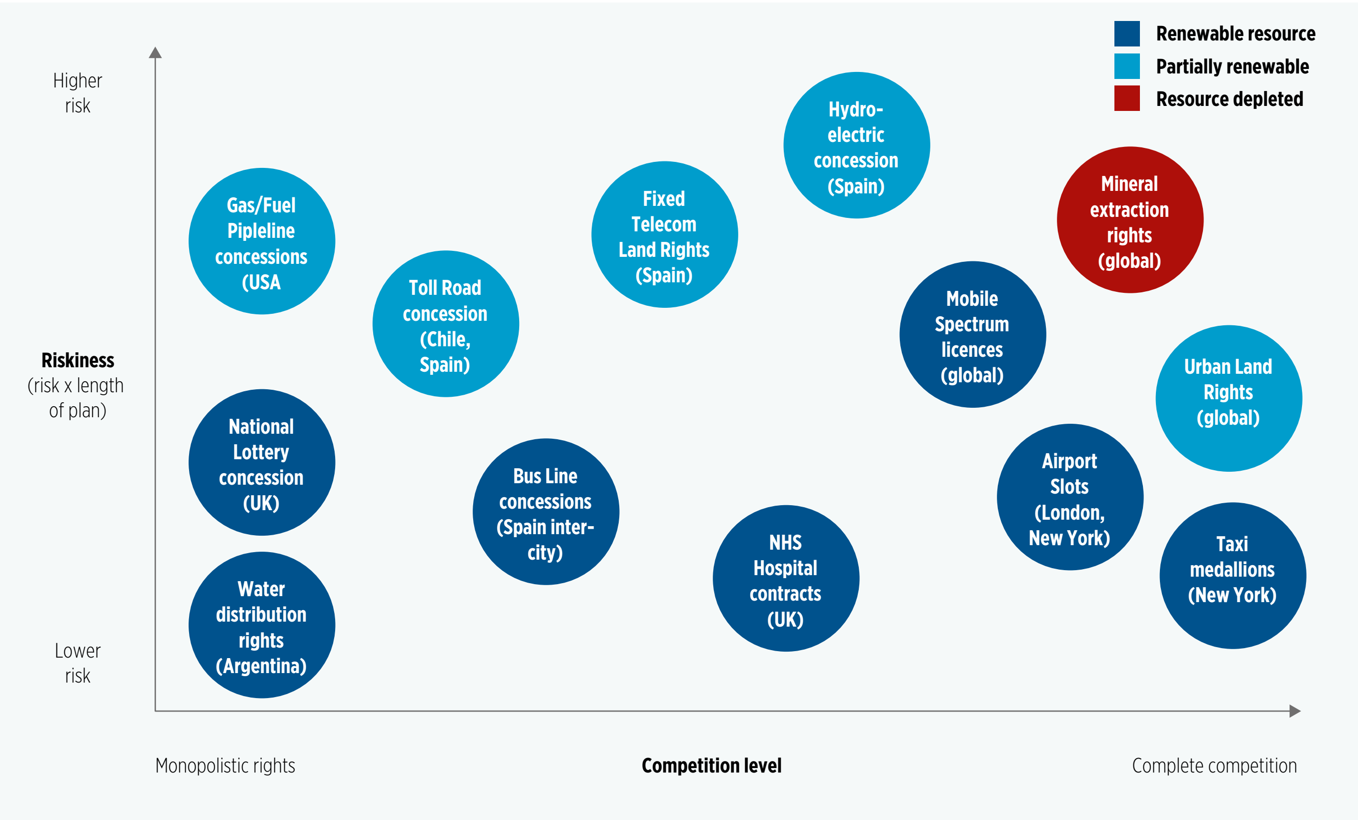
- **Competitiveness.** Mobile communications are competitive worldwide, with three or four mobile network operators in most countries. Industries in our survey that have competitive downstream markets include air travel, taxis, electricity generation and mineral trade. Other industries are only partially competitive: they have local monopolies but face intermodal competition from other activities (e.g. toll road operators or bus line concessionaires[42] face competition from free roads, private cars, railways and airlines). Finally, some industries operate under full monopoly, such as water distributors and gas pipelines.
- **Risk.** By risk, we mean the probability that the company will not achieve the profitability expected in its business plan during the term of its licence. Here, we consider two related dimensions: the intrinsic riskiness of the business; and the length of the business plan. Even the most stable industries are prone to changes in technology, demand, costs and regulation that are more likely to appear the longer the timeframe required to make a return on investment.
- **Renewability.** Another relevant dimension is what happens to the input resource once it is used by the private company. In some cases, like spectrum, water flows or airport slots, the resource is not altered by use: the availability of radio frequencies or airport slots in one period of time is the same irrespective of how intensely they have been used or not in the previous period. In some others, the resource remains in place but is altered by its use; this is the case with land, toll roads or dams. Finally, there are resources like minerals that are depleted when exploited.

41 In some cases the input is not supplied by the government itself, but by any other branch of the public administration (e.g. a sector regulator) or a state-owned organisation (e.g. Social Security or National Health Service), or by a private company (e.g. an airport) that is regulated.

42 Bus lines are operated under exclusive concessions in many countries, e.g. Spain. In other countries (e.g. France) there is free entry and exit to the industry.

A classification of industries along these dimensions is shown in Figure 19. The closer two industries are in the graph, the more likely that best practices in one industry may provide insights for the other.

FIGURE 19: COMPARISON OF SURVEYED INDUSTRIES BY RELEVANT ATTRIBUTES



Source: NERA Economic Consulting.

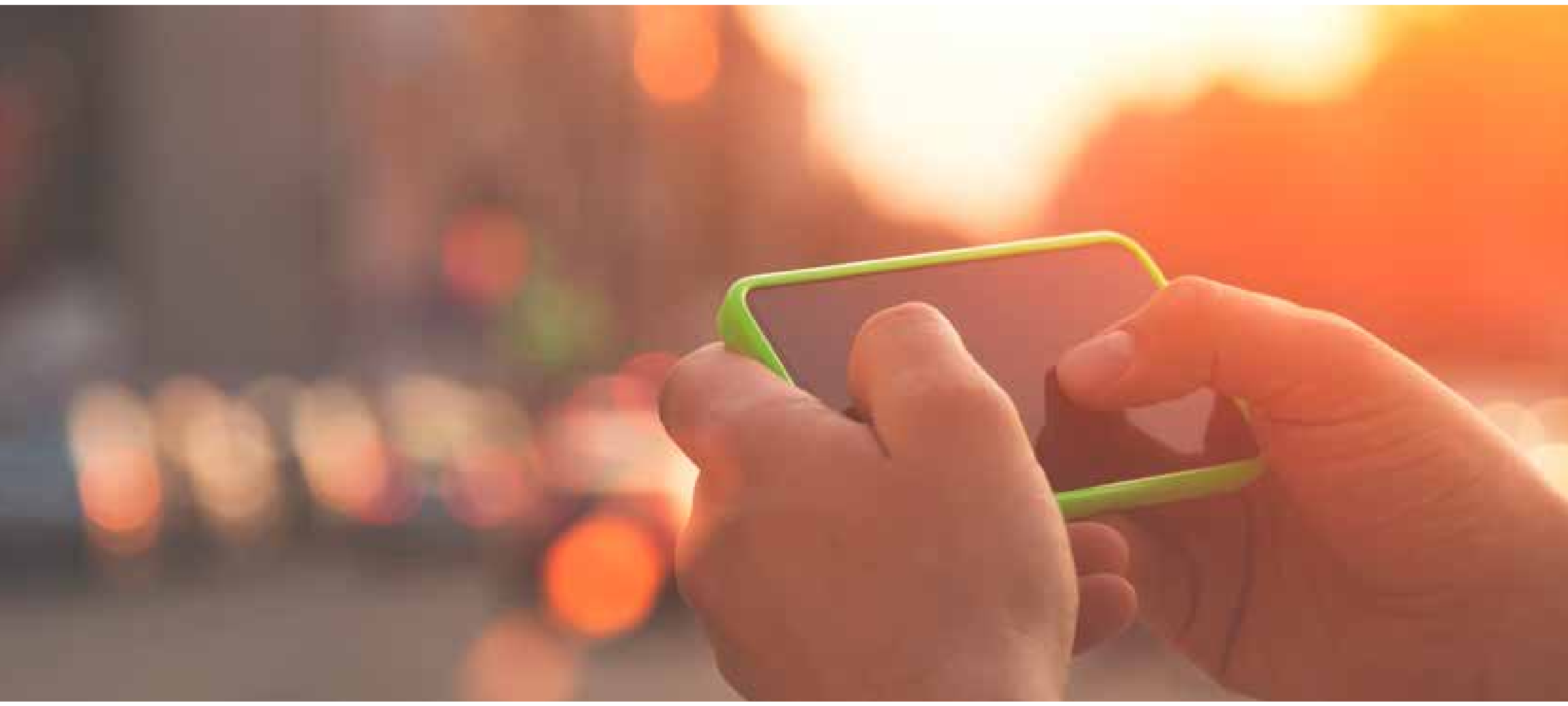
4.2. Lessons from other industries

We observed how policymakers responsible for other industries have managed access to state-supplied inputs to ensure that customers receive affordable and quality services. These range from actions designed to enable the growth of competitive industries to those that support a sustainable and affordable supply of monopoly services. In cases of best practice, the appropriate actions are tailored to the structure of the market, based on what can be achieved with and without intervention, and careful consideration of the impact of pricing and associated policy decisions on the behaviour of operators.

Our main observations are summarised in Figure 20 and set out in detail below:

FIGURE 20: LESSONS FOR SPECTRUM AWARDS FROM OTHER INDUSTRIES

MARKET LED PRICING	FULL ALLOCATION	RISK SHARING	LONG-TERM APPROACH
Spectrum is a competitive market input: – In competitive markets, policymakers use the market to promote efficient allocation and set market prices – This contrasts with monopoly markets, where licence fees and consumer prices are linked and linked and tightly regulated	**Spectrum is a renewable resource:** – When values cannot be stored, policymakers maximise welfare by allocating all available capacity – Trade-off between price and time is only relevant when resource depletes	**Mobile network investments carry risk:** – Policymakers can raise the value of licences through risk sharing – Risk mitigation is particularly relevant when licence obligations are onerous	**Welfare maximisation requires a long-term perspective:** – Consumer welfare generation throughout the life of the licence should be the priority of awards – Decisions on allocation and price should be objective and evidence-based



1. In competitive industries, let the market take the lead in pricing

It is standard practice for regulators to charge fees or provide subsidies when granting a licence or concession tied to an essential input controlled by the state. Fees are applied for ventures that are expected to be profitable and subsidies for operations that offer valuable benefits to society but are expected to be unprofitable.

Looking across other industries, a distinction can be drawn between how prices are determined, based on the competitiveness of the downstream industry:

- **Competitive industries.** When downstream industries are competitive, regulators often adopt simple pricing practices and allow the market a leading role in setting prices. For example, many countries use auctions to allocate exploration rights for minerals, and many cities and regions use auctions to allocate transport licences, such as bus routes and taxi medallions. As an alternative approach, some authorities award licences at fixed prices, but allow the secondary market to determine their value: this approach has been widely adopted at congested airports. In a primary award, inventory is usually priced to sell (i.e. reserve prices are set below expected market value), as the state's priority in most cases is to ensure full allocation.
- **Monopoly markets.** In monopoly markets, pricing structures are typically more complicated, owing to concerns about profitability, windfall gains and monopoly pricing power in the downstream market. For example, in the case of water distribution and toll roads, licence fees and consumer prices are linked and tightly regulated to ensure a fair balance over the licence term between the interests of the state, the operator and consumers. In these types of industries, it is more common for regulators to demand revenue shares and/or cap rates of return.

Mobile telephony is at the competitive end of the spectrum of industries relying on an essential input controlled by the state. This implies that spectrum allocation and pricing can be largely devolved to the market, and that windfall gains should not be a major concern, as they will be competed away, either through a spectrum auction or downstream competition. It is clear from our study that many countries are following this approach through use of auctions and/or fair reserve pricing. However, some governments appear to be treating spectrum as if the mobile industry was more akin to a regulated monopoly, where price regulation is necessary to promote the proper functioning of the industry and to prevent windfall gains. This is manifested through imposition of high reserve prices and revenue share requirements on operators.

In the box on page 63, we address the experience of the airline industry, where market reforms have facilitated a huge expansion in air travel, especially owing to low cost services. Regulatory measures that constrain the prices that airports can charge for airport slots and incentivise them to expand capacity have been a crucial part of this success story. By analogy, policies that promote access to spectrum and discourage excessive pricing of spectrum can be expected to maximise the scope for growth in availability and use of 4G and 5G services.

Airlines – a thriving consumer industry built on affordable access to airport slots

Air travel has become common and affordable since its liberalisation in the early 1980s to 1990s. Competition and innovation have allowed what used to be a luxury service to become a mass market. For example, low cost tickets have made it possible for students and workers to commute between countries in Europe and for low-wage migrants to keep in touch with their families and culture. Mass tourism enabled by low cost air travel has been an important driver of economic growth in many countries.
The essential input for airlines is airport slots, including take-off and landing slots, and access to gates and terminal capacity. At the beginning of the liberalisation process, the main bottleneck for new carriers to enter the market was the incumbent's control of airport slots in major cities, such as London. Air authorities launched several initiatives to make slots more accessible to new entrants, without hampering the ability of incumbent carriers to meet their demand.

In the UK, for instance, these measures included:

- **Regulatory oversight of the prices that airports can charge for airport slots, based on the principle that prices should be non-discriminatory across airlines and reflect the cost of the services provided. Such regulations are designed to prevent airports from exploiting monopoly power, and encourage them to invest in new capacity and quality of service as a way of increasing revenues.**
- **Promoting competition between airports, for example through the 2009 Competition Commission decision requiring Heathrow owner BAA to sell its other London airports, Gatwick and Stansted. This reform reduced BAA's monopoly pricing power and created incentives for airports to compete.**
- **Legal decisions at UK and European level which upheld the right of airlines to buy and sell airport slots. These decisions created important flexibility at congested airports, such as Heathrow, where airlines are given indefinite (grandfathered) rights to slots subject to use-it-or-lose-it obligations.**

As a result, the overall utilisation of airports across the UK and especially around London has increased hugely. Most notably, secondary airports, with cheaper slots, have emerged as hubs of low-cost airlines. More efficient use of existing resources has also allowed total industry capacity at congested airports to outpace the investment in new runways and terminals.

2. With renewable resources, welfare is maximised when capacity is fully allocated

Spectrum cannot be stored and value is lost if frequencies are not used at a given time. In other industries where resources are similarly renewable – such as airport slots, hydroelectric generation and irrigation rights – regulators seek to promote full utilisation in each time period, so as to maximise consumer welfare. High market prices for renewable inputs are (correctly) interpreted as evidence that greater supply is needed, and are often a source of political concern, owing to the link between input prices and consumer prices.

In industries that depend on renewable inputs, it is generally taken for granted that customers will end up paying for artificial scarcity of the input. Reducing a scarce input has two obvious effects. Firstly, it implies a corresponding reduction in output in the downstream market, and therefore higher prices for consumers. Secondly, when a given amount of input is needed for a supplier to be viable, scarcity may reduce the number of suppliers in the industry, thus reducing competition.
Consider the case of airport slots. Absent environmental externalities, such as noise concerns, airport operators are incentivised to maximise capacity utilisation at congested airports. Any other approach would mean fewer destinations and/or lower frequencies on existing routes for consumers (see box on page 63). In many countries, both airports and airlines have been privatised, and airport slots change hands through secondary market transactions. This means that the state has no direct revenue interest in the prices of slots. It is noteworthy that, in this context, high slot prices at London Heathrow were a key evidence point underpinning the economic case to expand capacity through construction of a third runway. By analogy, countries with high spectrum prices should prioritise releasing more spectrum.

As with spectrum, industries dependent on scarce renewable resources are typically tied to specific locations. Provision of new capacity is often subject to long lead times but can have a big impact on the geographically-constrained downstream market. Best practice involves provision of roadmaps for future capacity. For example, Spanish hydroelectric concessions are managed through "Planes de cuenca" (River basin plans). These plans provide details of the new water flows that will be made available for hydroelectric generation and the year when concessions will be allocated. This way, bidders for today's concessions have reasonable certainty over the future evolution of their competitive environment.

The situation of markets based on renewable inputs contrasts with extractable resources, such as oil or mineral rights, where there is a genuine trade-off between exploiting resources now or saving them for the future. Public authorities in countries with finite reserves of commodity natural resources often actively manage the release of extraction rights, and expand or contract allocations in response to market price signals, so as to manage revenue flows and safeguard value for future generations. In general, countries are price takers rather than price setters, and national roadmaps are somewhat less important because markets for raw materials are global.

When policymakers manipulate the price of spectrum by holding back frequencies from the market or fail to signpost future allocations, they are effectively treating spectrum as if it were a global commodity whose value can only be realised once. Yet, it is a national renewable resource, which will generate returns for society over and over again and, as we have shown in Chapter 1, the costs of holding it back can be huge.

3. Policymakers can increase the value of licences through risk sharing

Risk management is key to the viability of capital intensive industries such as mobile communications. The business model involves large upfront investments in supporting network infrastructure, which is paid for by uncertain revenues over a long time horizon. There are various ways in which governments can help mitigate the risks inherent in such investments.

Risk limitation not only benefits the concessionaire's shareholders, but also consumers. Cost of capital is one of the largest cost components in capital-intensive activities, and it is driven by the risk perceived by investors and lenders. High costs of capital can harm consumers in multiple ways: they may prompt the supplier to raise consumer prices or lower quality so as to improve profitability; or even prevent a project from going ahead. Government measures that decrease the perceived risk should lower the cost of capital of the operator, and thus improve customer welfare. Of course, these must be weighed against the cost of such support.

In many capital-intensive industries, where there are high upfront costs and long time horizons, compensation mechanisms are used to cover operators against risks beyond their control, such as regulatory changes, demand slumps, inflation spikes or foreign exchange movements. Often, these are offered in exchange for regulatory checks on the ability of the operator to set prices and define downstream services. For example, with toll roads, governments may guarantee minimum revenues, or extend the duration of the licence to allow the operator to recover all of its initially accepted costs, but only in return for tightly regulated toll fees. As discussed in the box on page 66 Chile has pioneered new methods aimed at mitigating external risk for private investment in toll roads.

When compared to other capital intensive industries in our sample, the mobile industry requires less support than most because it has a strong, consumer-based business model with potential to generate substantial revenues. As the market is competitive, regulatory constraints on pricing and quantity decisions are typically limited. Accordingly, mobile operators do not require the type of revenue guarantees developed, for example, for Chilean infrastructure projects. Nevertheless, the general principle embraced in Chile of building a regulatory and pricing framework that reduces risks for operators is still relevant. In particular, where policymakers adopt policies aimed at obliging spectrum licensees to make investments in networks that are not commercial viable, they should take into account the increased risk for operators when setting upfront spectrum prices and other licence terms..

Chile – better practice in risk management

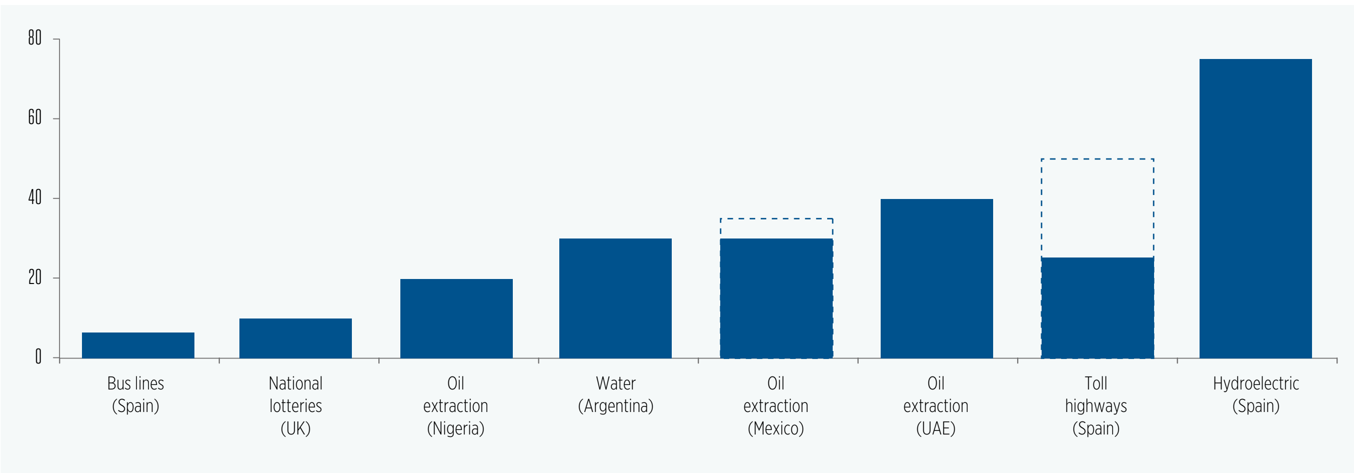
Chile has had particular success with the implementation of flexible-term concessions to mitigate demand risk in public infrastructures. The Chilean Public Works Concession Law defined the possibility of using the sum of total revenues – discounted or not – required by the concessionaire as the main economic variable for tendering concessions. The law led to the development of the "least present value of revenues" (LPVR) mechanism. Under this approach, the contract ends when a predetermined amount of accumulated revenues, as fixed by the terms of the contract, is ultimately reached.[43]

The first concession using LPVR in 1999 was the Santiago–Valparaíso highway (Route 68), which attracted four bidders. Since then, the least present value of the revenues (LPVR) has been used as the main criterion to award highway and airport concessions.

The LPVR approach was particularly effective in mitigating the effects of an economic recession on the profitability of the concession during the recession endured by Chile between 1998 and 2002. During this period, the government was obliged to vary the contract terms of many concessions in trouble by changing them from fixed-term to flexible-term contracts. The only concessions that were not renegotiated were the ones that had already been awarded under the LPVR approach.

One of the most effective solutions to providing investment certainty to mobile operators is to extend spectrum licence terms. As illustrated in Figure 21, licence durations vary widely across industries. Licence durations are generally longer in more capital intensive industries. For example lottery and bus concessions have licence duration of between 6 to 10 years whereas hydroelectric dams may have a licence term of up to 75 years.[44] Based on this comparison, the widespread use of 15-year licence terms for spectrum appears too short. Regulators worldwide could increase investment certainty for mobile operators by adopting the European Commission proposal for minimum 25-year licences, or the US approach of de facto indefinite rights.

FIGURE 21: DURATION OF CONCESSIONS OR LICENCES (YEARS) FOR SELECTED INDUSTRIES



Source: NERA Economic Consulting, using data from various sources.

43 For more details on the Chilean use of flexible term concessions, see e.g. José Manuel Vassallo, Flexible-Term Highway Concessions. How Can They Work Better?, Transportation Research Record: Journal of the Transportation Research Board, No. 2187, Transportation Research Board of the National Academies, Washington,D.C., 2010, pp. 22–28.

44 Some industries have even abandoned licence durations altogether. For example, oil extraction rights in the UK and Russia cover the time needed to extract the oil in the awarded field. Similarly, fixed telecommunication access to rights of way in European countries is typically indefinite as well.

4. Welfare maximisation requires a long term investment perspective

Investment in most infrastructures is perceived as an enabler of growth and competitiveness across an economy, and thus the level of investment is considered alongside the gains to society that are expected to materialise over time. This is the case, for example, with electricity, roads, harbours or airports, all of which enable companies and workers to be more productive and conduct business across the country and internationally more easily. This is also the case with dams and irrigation channels, which contribute to the improvement of land productivity and allow food production growth to outpace population growth. Similarly, a long-term perspective is needed for mobile networks which, in many areas, are now the main telecommunications infrastructure and often the only one potentially affordable to all citizens.

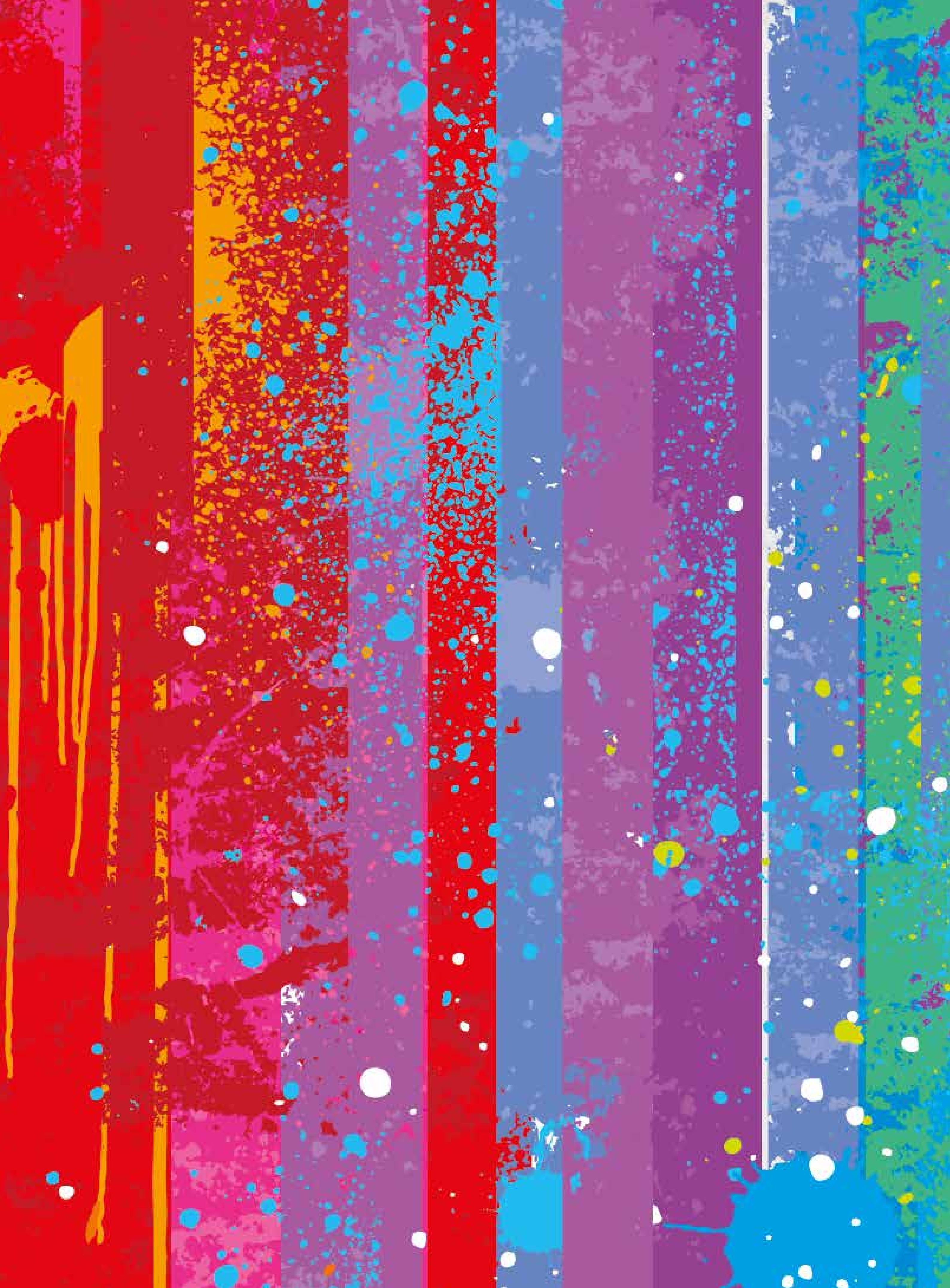
Many large infrastructure projects require state subsidies in order to proceed. In recent years, policymakers in many countries have come under intense pressure to embrace more transparent techniques to demonstrate the value of individual projects. In Europe, EU countries have responded by passing legislation which mandates the use of Cost-Benefit Analyses (CBAs) for projects over €50m initiated after 2014.[45] CBA is an analytical tool that directly assesses the welfare change attributable to the project, when compared to alternative interventions, and sets this against investment costs. When used effectively, it can help de-politicise spending decisions by providing an objective, evidence-based assessment of the case for government investment.

Consumer welfare is usually one of the main award criteria for infrastructure concessions. In monopoly situations, governments are often willing to forego cash payments from the concessionaire in exchange for lower prices for consumers and better outcomes for society. For example, this is the general case for public work concessions in Chile, for toll highways and bus lines in Spain, and for water distribution concessions in Argentina. Similarly, when tendering for the right to run the National Lottery, the UK National Lottery Commission focuses on the ability of the operator to generate returns for good causes over the licence period. In 2000, this led to the rejection of a bid offering the highest percentage contribution to good causes, as the Commission concluded that a rival bid would generate higher sales, and thus higher contributions overall.[46]

Mobile networks may appear different from other infrastructure because they are commercially viable without government support, and operate in competitive markets that require less regulation. In general, mobile operators pay to access the market, through acquisition of spectrum licences, and receive few if any subsidies for network provision. **Nevertheless, the principle that governments should aim to maximise welfare generation over the licence term still applies.** Happily, theory and practice has shown that this can largely be achieved through competitive awards which allocate spectrum based on willingness to pay. However, if governments enact policies that artificially inflate prices for spectrum, they risk constraining investment and competition, and reduce scope for welfare creation. This is analogous to picking an inferior infrastructure project because the upfront subsidy is lower or increasing fees for a monopoly concession but allowing the concessionaire to pass on those costs to customers through higher prices.

45 See European Commission, Guide to Cost-Benefit Analysis of Investment Projects, Economic appraisal tool, December 2014.

46 National Audit Office (May 2002), "Awarding the new licence to run the National Lottery", p.3.

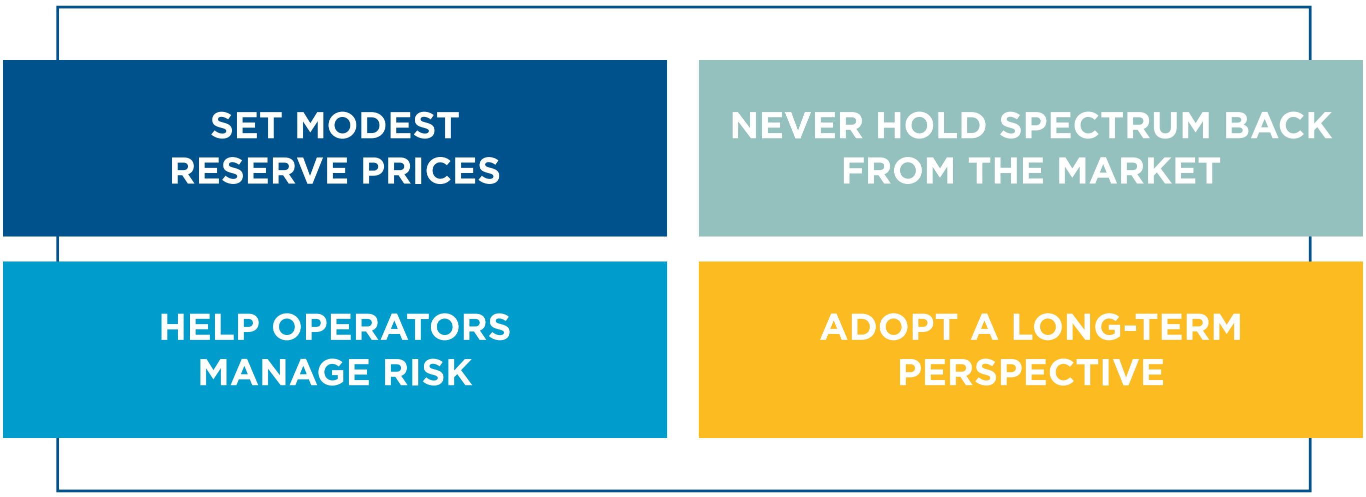


5. Best practice for setting spectrum prices

With the increase in frequencies needed to support high data traffic in a 4G and 5G world, effective pricing techniques will become ever more important to support an efficient spectrum allocation, promote investment in infrastructure and encourage sustainable competition. Countries that persist with excessive pricing, constrain available spectrum, or enact conditions, rules or policies that place undue risk on operators, will likely experience a widening gap in quality and pricing of the mobile services available at home versus abroad. Actions that depress growth and competition in mobile services have obvious negative implications for the broader economy, with the result that long-term losses in tax revenues will likely outweigh any short-term gains from unduly high upfront spectrum fees.

In this chapter, we set out our recommendations on measures that together should maximise the likelihood of effective spectrum pricing, thus supporting investment in high quality services and price competition to drive affordable services. Our four areas of recommendation are summarised in Figure 22.

FIGURE 22: RECOMMENDATIONS ON BEST PRACTICE IN SPECTRUM PRICING



#1

5.1. Recommendation #1:

Set modest reserve prices

By reserve price, we mean the sum of any upfront payments and (discounted) annual fees. The primary objectives for any regulator when setting reserve prices should be to promote an efficient allocation of spectrum, one that will maximise long-term benefits for society. This is best achieved by allowing the market to identify the price. Such an outcome is only possible if reserve prices are set conservatively, below the expected market value. Otherwise, there is a risk that genuine demand is choked off. Annual fees should typically be set at modest levels, for example sufficient to recover spectrum-management costs. If a regulator decides or is required to impose higher annual fees, they become an important component of the reserve price, and expectations for potential auction prices should be moderated accordingly.

In this report, we have identified compelling empirical evidence, backed by economic theory, that high prices for spectrum depress operator incentives to invest and compete, resulting in lower quality and higher prices for consumers. This provides a further rationale for conservative reserve pricing. Of course, sometimes auctions may produce unusually high prices owing to competition between bidders; if this is what is required to identify the efficient users then so be it; but policymakers would be ill-advised to try to engineer such outcomes.

We recognise that governments may have legitimate concerns about valuable spectrum selling “too cheaply”. This is a rationale for pricing at a substantive level but not at a level that could plausibly be close to the market price. International price benchmarks can be helpful in identifying a value range in which a “fair price” for spectrum may sit, and thus provide a reference point for setting reserve prices. However, when benchmarking, it is crucial to pay close attention to differences in local conditions across countries and awards that may affect operators’ ability to pay. In particular, policymakers should be wary of placing too much weight on high price outliers, which usually have unique explanations, often rooted in policy error.

#2

5.2. Recommendation #2:

Prioritise spectrum allocation

Spectrum is a renewable resource. When spectrum suitable for mobile is left fallow (or used to provide other, less valuable services), welfare benefits that would have accrued to consumers are lost forever. One of the most effective welfare-creating policies that a regulator can adopt is to release spectrum bands as soon as local operators have a business case to deploy them. Artificially constraining the supply of spectrum – a policy that has been used in a number of markets, most notably India – may boost prices paid for spectrum, but this comes at a huge cost for society in terms of lower competition and reduced quality of service in the downstream market.

Operators typically rely on a portfolio of spectrum, across frequency bands with different characteristics, to operate their networks. Valuing the impact of spectrum is challenging, especially in countries where many mobile bands have not yet been released. The best regulators provide roadmaps for future spectrum availability, so operators can understand their future options and can value spectrum with greater certainty. Good roadmaps reduce the risk that bids for spectrum are distorted, resulting in prices that are either too low or too high.

#3

5.3. Recommendation #3:

Help operators manage risk

The business model for running mobile networks is inherently risky as it involves substantial upfront investment in spectrum licences and network infrastructure, which are then recouped through revenues from consumers over many years. The viability of an operator also depends on maintaining access to a critical mass of spectrum, one sufficient to support growing demand for capacity for 4G data. Prices paid for spectrum can be distorted if bidders in spectrum awards face undue risks.

There are many ways that regulators can help reduce risk for operators, and thus reduce the potential for distorted allocation and pricing outcomes. These include:

- **Avoiding award rules that create options for bidders to foreclose the market or expose bidders to risk of outcomes where enterprise value could be lost;**
- **Applying realistic coverage and quality of service obligations (ideally ones that avoid needless duplication of networks in non-commercial areas), and setting reserve prices that take into account the cost burden on operators; and**
- **Adopting longer licence terms (e.g. 20-25 years or guaranteed renewal rights) that match the life of mobile network investments.**

#4

5.4. Recommendation #4:

Adopt a long-term perspective

Investment in mobile network infrastructure will be a key enabler of growth and competitiveness in national economies worldwide for the foreseeable future. When policymakers plan spectrum awards, they should be focused on maximising welfare benefits over the long term, by stimulating competition and investment, not on short-term revenue benefits. In recent years, many countries have launched ambitious national plans for ICT (information and communications technology) development. Timely award of mobile spectrum at prices that promote full allocation and efficient use should be a cornerstone of such plans.

Ideally, spectrum award rules should be divorced from government budgetary decisions. This is easy to say but hard to achieve in practice, especially where governments face fiscal deficits. One way to de-politicise decisions on spectrum pricing is to delegate them to an Independent Regulator with appropriate objectives to prioritise long-terms benefits for consumers through efficient use of spectrum and sustainable downstream competition. Another is for regulators to adopt the cost-benefit analysis frameworks that are widely used in other infrastructure-based industries as a tool to ensure that long-term benefits for society are not ignored when making input pricing and allocation decisions.

Appendix A. Econometric model of welfare impact of high spectrum costs

In this appendix, we provide a description of the econometric model we used to estimate the welfare losses from high spectrum costs, as presented in Chapter 2.4. We follow the methodology used by Hazlett and Muñoz (2004) for mobile voice to estimate a demand curve for mobile data services in 2016.[47] Our model is based on data from 32 countries.

The consumer welfare produced through consumption of a good is a function of both the price paid for the good and the quantity consumed. Price and quantity are therefore the main variables in the model. These variables are endogenous, as they are jointly determined by the interplay of demand and supply in the market: the price that consumers pay affects the quantity consumed and the quantity consumed affects the price that consumers pay. In econometrics, this is referred to as a "reverse feedback affect" and ordinary regression techniques have been shown to provide poor results in these situations. We therefore use an Instrumental Variable (Two Stage Least Squares) model to estimate the demand for mobile data. In the first stage, we estimate price as a function of a number of variables that mainly impact the supply of mobile data (not demand).[48] In the second stage, we estimate the demand function or the quantity of mobile data consumed as a function of a number of variables affecting demand including the predicted price from the first stage. Using the predicted price rather than the observed price removes the feedback effect.

The inputs used in the model are summarised in Table 1. We also considered other inputs. Wi-Fi availability was tested as a substitute for mobile data usage, but was not statistically significant and was removed.[49] In the price equation, we considered labour costs as well as industrial electricity costs. Labour costs were highly correlated with GDP and thus dropped, while industrial electricity costs were not statistically significant in the price equation.

47 Hazlett and Muñoz, 2004 to today's era of high level data consumption. See Hazlett and Muñoz, 2004, A Welfare Analysis of Spectrum Allocation Polices. AEI-Brookings Joint Centre, pp. 4-18.

48 Note that in order to arrive at an unbiased estimate of the second function, we need to include all other variables included in the second function in the first function as well.

49 We used the average time that handsets are connected to wifi networks as a proxy. Data from OpenSignal.com.

TABLE 1: INPUTS INTO ECONOMETRIC MODEL

Variables	Description and Data	Role in Model
Quantity Consumed (GB per Month)	The average amount of data per month consumed by wireless subscribers within a country. Data was collected from Tefficient reports and Cisco modelled data.	Second Stage Dependent Variable
Price (USD per GB/ Month)	The price paid by consumers in a country. In order to standardise across countries, we created a representative mobile plan for each country, based on information collected from local operator websites in September 2016. The prices are expressed in PPP-adjusted US dollars. This variable is the same as used in the price analysis presented in Chapter 2.3.	Second Stage Endogenous Variable and First Stage Dependent variable
GDP Per Capita (USD/ pop)	A higher GDP per capita implies higher disposable income for consumers and a higher demand for data; however, GDP per capital also implies more network maturity, which can depress consumer prices. We use data from the International Monetary Fund's 2015 database.	Independent variable in First and Second Stage Regressions
Urbanisation (% urban pop)	Urbanisation is included as a proxy for the difficulty of rolling out a wireless network in a country. In general, higher urbanisation means that greater capacity is required in small crowded areas. This requires higher densification of the network (more cells to cover a small area and can increase the cost of sites (higher rents, more stringent planning regulations.) On the other hand, lower urbanisation means that more cells are required to cover the same population. We use data from the World Bank Database.	Independent variable in First Stage Regression
Herfindahl-Hirschman Index (HHI)	HHI is a measure of market competition, and is a proxy for the pricing power of operators. Increasing competition in a market is associated with lower prices owing to the greater scope for consumers to move to an alternate provider. HHI is derived from total subscriber share by country using data from the Telegeography GlobalComms database.	Independent variable in First Stage Regression
Cost of Spectrum (USD per MHz/pop)	The purpose of the model is to understand the impact of spectrum cost on consumer welfare via the impact on consumer prices. We use the same spectrum cost data as used in our analysis in Chapter 2.3.	Independent variable in First Stage Regression

We use the following specification for the price equation (first stage):

$$\ln(\mathit{price}) = \beta_0 + \beta_1 \ln(\mathit{gdppc}) + \beta_2 \ln(\mathit{urbanisation}) + \beta_3 \ln(\mathit{hhi}) + \beta_4 \ln(\mathit{spec\_cost})$$

The Demand Equation (second stage) is defined as:

$$\ln(\mathit{quantity}) = \beta_0 + \beta_1 \ln(\overline{\mathit{price}}) + \beta_2 \ln(\mathit{gdppc})$$ [50]

The results of the regression are summarised in Table 2.

50 Note: $\ln(\overline{\mathit{price}})$ are the predicted values from the price equation.

TABLE 2: REGRESSION RESULTS

	First Stage Regression	Demand equation
Independent variable	Price	Quantity
Explanatory variables:		
Constant	4.24**	-0.78
Price (IV)	-	-1.15***
GDP	-0.60***	0.29*
Urbanisation	1.15**	
Spectrum cost	0.37***	
HHI	0.78*	
R^2	50%	54%

Notes: Significance levels: *** at the 1% level, ** at the 5% level, and * at the 10% level.

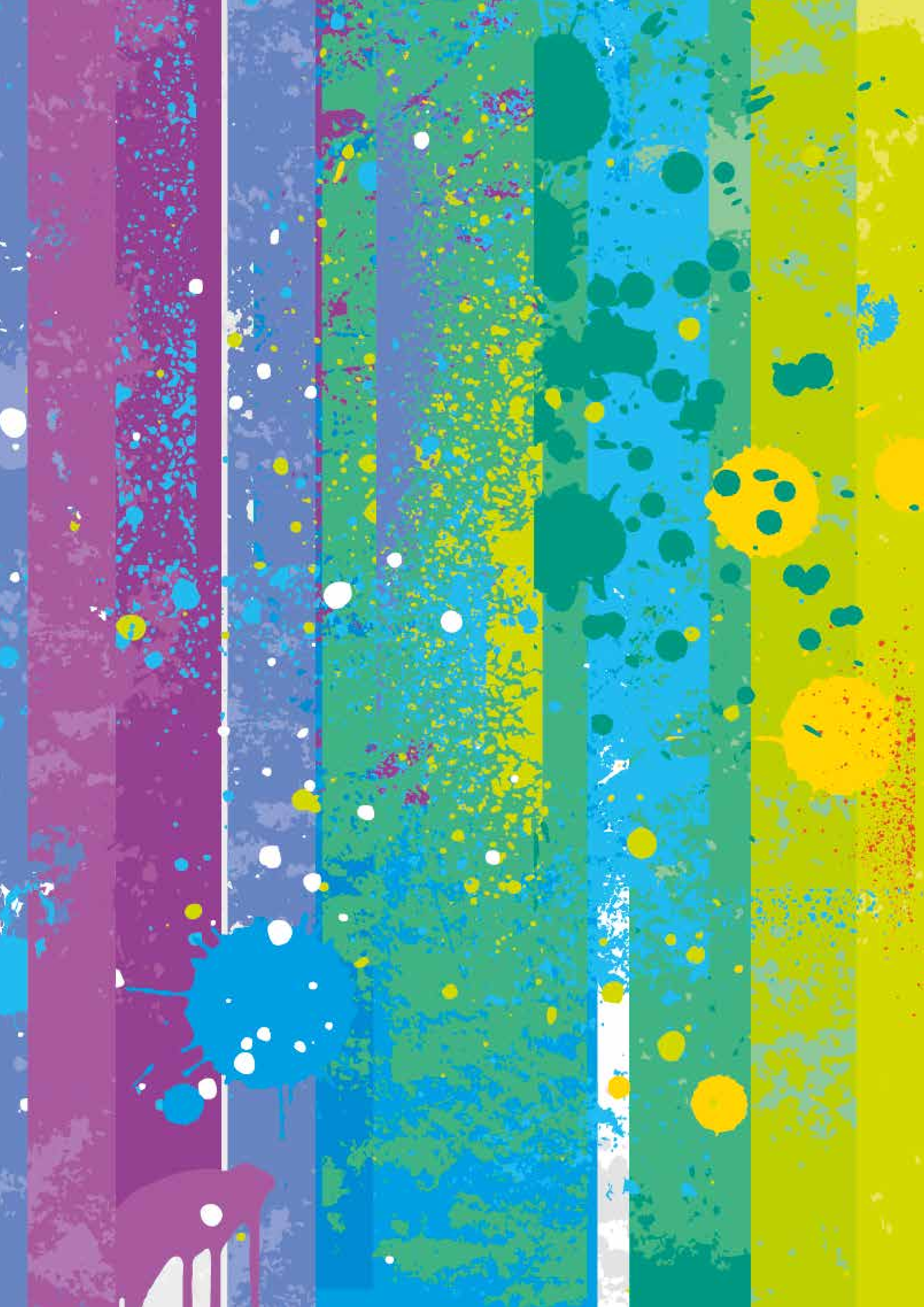
We find that:

- **Spectrum costs have a statistically significant positive impact on prices paid by consumers.**
- **Prices in countries with higher GDP per capita are generally lower. This can be attributed to the fact that mobile networks are more mature in developed countries and thus the cost of delivering a GB of data is lower.**
- **In countries with higher urbanisation, prices are general higher. This may reflect the increased focus on investment in urban capacity to meet 4G demand, and high rental and planning costs of urban sites.**
- **Higher market concentration (as measured by the HHI index) is associated with higher consumer prices, but the statistical relationship is much weaker than for the other factors (only significant at the 10% level).**
- **The quantity of data consumed is negatively affected by price. Higher prices lead to less data consumed. Note that data demand is elastic; if the price increases by 1%, the quantity demanded goes down by more than 1%. This means consumers are sensitive to prices.**

Using the system of equations from the regression, we simulated the shift in the demand curve from reducing spectrum costs, and used this to predict the change in consumer surplus.

To simulate the shift in the demand curve, countries were divided into peer groups based on GDP per capita. The cost of spectrum of all countries with a cost of spectrum above their respective group median was lowered to the peer median. A new demand curve was constructed for each country using the variables and coefficients from the original model except for the decreased cost of spectrum. Once the new demand curve was constructed, we calculated the change in consumer surplus between the original and new demand curves using standard economic techniques, as illustrated in Figure 15. Lost auction revenues, as a result of the price reduction, were set against the gains in consumer surplus, so as to determine the net benefits for society. All values are expressed in US dollars on a purchasing power basis.

Notes



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Index of Reports

No.	Title	Author	Date
1	Licensing to support the mobile broadband revolution	GSMA	May-12
2	Future spectrum requirements estimate for terrestrial IMT	ITU	Dec-13
3	The Evolution of Mobile Technologies: 1G to 2G to 3G to 4G LTE	Qualcomm	Jun-14
4	Best practice in spectrum licence renewals - A toolkit for licensing	GSMA	Dec-14
5	NGMN 5G White Paper	NGMN	Feb-15
6	Future Mobile Spectrum Requirements: Creating a Sustainable future for	GSMA	Jul-15
7	IMT Vision - Framework and overall objectives of the future development	ITU-R	Sep-15
8	Assessment of spectrum-related support for take-up and usage of mobile	Analysys Mason	Nov-15
9	Enabling UK growth: Public Sector Spectrum Release Programme annual	UK Government	Apr-16
10	5G Vision, characteristics and Requirements	GSA	Jun-16
11	Best practice in mobile spectrum licensing	GSMA	Sep-16
12	5G Spectrum Public Policy Position	GSMA	Nov-16
13	5G Trials and Tribulations: A Guide to Global 5G Operator Tests	sdx central	Dec-16
14	Open letter to the Secretary for Commerce and Economic Development	HKT	Dec-16
15	Paper published by HKT regarding **"the Facts about the Admin Fee - and why Spectrum Costs drive increases in the Admin Fee"**	HKT	Dec-16
16	Paper published by HKT regarding **"Spectrum Supply in Hong Kong"**	HKT	Jan-17
	(A) Key Communications Statistics	OFCA	Mar-17
	(B) Data & Statistics Wireless Service	OFCA	Apr-17
	(C) Prepared Remarks of FCC Chairman Tom Wheeler 'The future of Wireless: A Vision for U.S. Leadership in a 5G World'	National Press Club	Jun-16
	(D) FCC Makes 150 Megahertz of Contiguous Spectrum Available for Mobile Broadband and other uses through Innovative Sharing	FCC	Apr-15
	(E) FCC Takes Steps to Facilitate Mobile Broadband and Next Generation Wireless Technologies in Spectrum above 24 GHZ	FCC	Jul-16
	(F) Broadcast Incentive Auction and Post-Auction Transition	FCC	May-17
	(G) Consideration on Spectrum for 5G	MIIT	Nov-16
	(H) IMD World competitiveness Yearbook 2016: Competition	IMD	Year 2016
	(I) World Radio-Communication Conference allocates spectrum for future innovation	ITU	Nov-15
	(J) Decision of the European Parliament and of the Council on the use of the 470-790 MHz frequency band in the Union	EN	2016/0027
	(K) Second Consultation on Proposed Framework for the Allocation of Spectrum for International Mobile Telecommunications ("IMT") and IMT-Advanced Services and for the Enhancement of Competition in the Mobile Market	IDA	Jul-15
	(L) NCC Announces Winners of the 4G Mobile Auction. A Total of TWD118.65 billion raised in license fees	NCC	Oct-13
17	Paper published by HKT regarding **"Spectrum Trading in Hong Kong - Why are we waiting?"**	HKT	Jan-17
18	The 5G economy: How 5G technology will contribute to the global	IHS	Jan-17
19	Update on 5G spectrum in the UK	Ofcom	Feb-17
20	Paper published by HKT regarding **"What is True 5G? And why Spectrum is so Important?"**	HKT	Feb-17
21	Huawei is making slow progress in 5G than Ericsson and Nokia	Telecomlead	Feb-17
22	Samsung SM-G950F Galaxy S8 TD-LTE (Samsung Dream) - Frequency Bands and Network Compatibility	FrequencyCheck	2017
23	Effective Spectrum Pricing: Supporting better quality and more affordable mobile services	GSMA	Feb-17
24	Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016-2021	CISCO	Feb-17
25	Forging Paths to 5G	ITU	Feb-17
26	The 5G era: Age of boundless connectivity and intelligent automation	GSMA	Feb-17
27	Valuing spectrum in Thailand: what can we learn?	Plum	Apr-16