COMPETITION ECONOMISTS GROUP

Assessment of approaches to the 900 MHz and 1800 MHz spectrum upon expiry of existing assignments

Response to the Communications Authority's Second Consultation Paper

Non-confidential (some information redacted)

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COMPETITION ECONOMISTS GROUP

Table of Contents

1 Executive summary

1. CEG has been asked by Hong Kong Telecom (HKT) Limited to assess proposed arrangements for 900 MHz and 1800MHz spectrum upon expiry of the existing licences in 2020/21 put forward in the Second Consultation Paper of 14 February 2017 (the Consultation) of the Communications Authority (CA). The report evaluates which approach best meets international best practice and the CA's statutory duties.

2. CEG is a group of economic and financial experts with substantial experience in advising governments, regulators, industry bodies and operators on spectrum policy and auctions as well as the analysis of the likely effects of regulatory interventions. We have assessed the alternative options available to the CA based on international experience and the specific circumstances of the Hong Kong mobile market.

3. We find that for regulators tasked with the same or similar objectives to those of the CA and in mobile markets as competitive as that of Hong Kong, international best practice is for spectrum licences to be automatically renewed or granted perpetually. Specifically, we identify best practice in international markets as the automatic renewal of spectrum licences (or equivalently granting perpetual licences) as the default position, with re-auctioning of the spectrum only occurring in exceptional circumstances. Re-auctioning of all or part of a spectrum licences is instead generally carried out to remedy an uncompetitive market structure – a situation which is not relevant to Hong Kong. In contrast, the CA's position is to re-auction spectrum at the end of the fixed term of the spectrum licence, unless policy reasons indicate otherwise. We find evidence of re-auctioning of licences leading to lower investment, later technology launch dates and potential risks to competition compared with markets in which licences have been automatically renewed.

4. Specifically considering the market circumstances in Hong Kong, we find that automatic renewal is likely to best meet the CA's duties. While there are strong economic arguments to use auctions to allocate spectrum initially, different considerations come into play for re-auctioning spectrum that is already in use. Our findings consider the following issues:

   - Automatic renewal is the option that best ensures service continuity. Operators do not face any risk of the loss of the use of the spectrum at a critical time when operators are already severely constrained in being able to meet rapidly growing demand for mobile data.
   - Automatic renewal also promotes the efficient use of spectrum by avoiding uncertainty which risks distorting investment choices for operators. This includes refraining from new investments that would better use the available

spectrum and given the fact that the CA's proposals carry a greater risk of making spectrum allocations less, rather than more, efficient.

- Automatic renewal will also promote effective competition by best ensuring that the intense competition in Hong Kong's mobile market is maintained. There is little prospect that re-auctioning of spectrum will lead to increased competition or sustainable new entry, but re-auctioning carries real risks of undermining the very factors that support prevailing competition including risks to pricing, quality of service and investment.
- Automatic renewal also enables operators to maintain significant investment programmes without having to curtail investment because of uncertainty over the period for which they will continue to be able to use the spectrum.

5. The objective of spectrum management should be to maximise the welfare of Hong Kong citizens. Alternative management options for spectrum renewal should be assessed based on the benefit-cost ratio that each is expected to deliver. The CA's current proposal to re-auction 60% of the 900/1800 MHz spectrum would carry substantial costs and risks and these can be expected to exceed any benefits from the proposed approach. A negative expected benefit-cost analysis result arises from:

- A significant risk of a loss in service quality for existing customers. The analysis of the CA's consultants on service continuity seem to underestimate future traffic growth. Their forecasts are at a fraction of independent third-party forecasts for similar high income countries. For example, Plum's forecast of data traffic per subscriber in 2023 is 49% of Cisco's forecast for Japan for 2021 and 39% of Cisco's forecast for Korea of 2021. Plum has also not considered the cost of the investments required to maintain reasonable quality of service to meet likely future traffic and whether such investments are practical or would be commercial to undertake given the costs relative to the diminishing benefit of further network investments with limited spectrum. We consider that key aspects of Plum's analysis should be re-done with more reasonable traffic forecasts and with additional analysis conducted on the viability of the investments required to maintain service continuity. Additionally, we note that the level of redaction in the Plum report makes it difficult to properly respond to their findings.
- Considerable uncertainty for existing operators of spectrum continuity given that much of the spectrum to be re-assigned will be through an auction process. This is likely to have adverse impacts on the incentives for existing operators to invest in new network infrastructure and compete for customers in the run-up to the auction.
- Potential adverse impacts on the ability of some operators to compete post-auction if the reassigned spectrum leaves some operators with spectrum allocations too small relative to their customer bases to allow them to compete effectively for new customers.

- The potential for the auction itself to lead to sub-optimal market outcomes, including high spectrum costs, gaming by bidders to increase rivals' costs as well as the potential delays from running an auction compared to allocating the spectrum through an administrative process. These impacts are likely to be exacerbated by the lack of guidance on the timing of future spectrum release and the absence of spectrum trading.

6. There are superior alternatives to the CA's proposals that mitigate these risks while promoting further investment and innovation in the market. We recommend that currently unallocated mobile spectrum is released as a matter of urgency, that spectrum trading should be introduced and that forward-guidance on the medium-term plans for spectrum availability be published. Given that competition is already effective and that the CA's proposals carry a greater risk of reducing (rather than improving) the efficient allocation of spectrum, it would be preferable for the CA to provide a first right of refusal (RFR) over all currently allocated spectrum.

2 Introduction

7. In this section, we set out the context for the CA's decision and the decision-making process that the CA has proposed for reassigning the 900/1800 MHz spectrum including its characterisation of the policy options. We then discuss the economic objective of spectrum management and compare the CA's policies with market-based approaches observed in best practice jurisdictions.

8. Finally, we identify the general economic implications of the policy options facing the CA. We conclude that a policy of reauctioning spectrum could have harmful effects including to inflate the cost of spectrum in the industry and hence raise barriers to entry, reduce/distort investment in physical capital and/or lower quality and increase concentration in the industry.

2.1 Context for the CA's decision

9. Section 32G(1) of the Telecommunications Ordinance (TO) establishes a statutory duty for the CA to promote the efficient allocation and use of the radio spectrum. Section 4(4) of the Communications Authority Ordinance further stipulates that the CA, in performing its functions, must have regard to certain matters if they appear relevant in the circumstances including fostering of an environment that supports a vibrant communications sector, encouraging innovation and investment in the communications market; promoting competition and the adoption of best practices in the communications market for the benefit of the industry and consumers.

10. The CA may also have regard to the Radio Spectrum Policy Framework (RSPF) to the extent that there would be no inconsistency with the objectives and provisions of the TO. The RSPF states that Hong Kong's spectrum policy and management aims to:

- Facilitate the most economically and socially efficient use of spectrum with a view to attaining maximum benefit for the community;
- achieve technically efficient use of spectrum to facilitate the introduction of advanced and innovative communication services and strengthen Hong Kong's position as a telecommunications and broadcasting hub;
- fulfil Hong Kong's regional and international obligations relating to the use of spectrum;
- strengthen Hong Kong's strategic position as a world city and the gateway between the Mainland of China and the world; and
- ensure that necessary spectrum is reserved for services by or on behalf of the Government.

11. The RSPF also notes that "*The policy inclination is that a market-based approach will be used where there are likely to be competing demands unless there are overriding public policy reasons to do otherwise*". In addition, the Framework states that whether a spectrum assignee shall have their usage of spectrum renewed or be given a right of first refusal, this decision should be made "*after taking into account the spectrum policy objectives [set out above] as well as all other relevant factors, including but not limited to any other public interest considerations*."

2.2 The CA's decision making

12. In its first round of public consultation, the CA considered three options for re-assignment of the 900/1800 MHz spectrum. The options considered were:

    a. An offer of a first right of refusal to the existing rights holders (Option 1);

    b. A re-assignment of all the spectrum by auction to the existing spectrum users (Option 2); or

    c. An offer of first right of refusal for part of the spectrum to the existing users with an auction of the remainder of the spectrum (Option 3 – which is a hybrid of the first two options).

13. In its second public consultation, the CA proposes that the hybrid option (Option 3) be adopted with a first right of refusal for the re-assignment of 2x5 MHz of spectrum. The CA decision is based on a view that mobile operators have sufficient access to other spectrum assignments to support the provision of 3G and 4G services at the necessary quality of service, even if the incumbents were unable to obtain any of the 900/1800 MHz spectrum in the auction of the remaining spectrum.[1]

14. The CA also used a hybrid approach in relation to the 1.9 – 2.2 GHz band, although in that case the incumbent operators were given the right of first refusal in relation to two thirds of the relevant spectrum. The CA is now proposing that the right of first refusal will apply to only 40% of the 900/1800 MHz spectrum.

15. In essence, the CA decision making process appears to be to not deviate from the reassignment of spectrum at auction at the end of a licence terms unless there are specific circumstances that would indicate otherwise. In its second-round consultation, the CA states:[2]

> *The CA is of the further view that there is no overriding public policy reason supporting a complete deviation from the market-based approach [auction] thus justifying adoption of the fully-fledged administrative-*

[1] Page 7 of Second Public Consultation, paragraph 9.
[2] Para 9 of Second Public Consultation.

assigned approach under Option 1 [first right of refusal] for the Re-assignment of the 900/1800 MHz Spectrum.

16. That is, the *default position* of the CA is to re-auction spectrum at the end of the fixed term of the spectrum licence, unless policy reasons indicate otherwise. The CA's default position stands in contrast with the best practice approach in international markets with established competition where the default position is to offer a first right of refusal to the existing holders. In effect, best practice in competitive markets is to automatically renew or equivalently grant perpetual licences as the default position, with re-auctioning of the spectrum only occurring in exceptional circumstances. This report discusses the potential harmful effects that are created by the CA's approach.

2.3 The objectives of spectrum management

17. The fundamental purpose of spectrum management should be to contribute to economic growth and the economic prosperity of the people of Hong Kong. This is achieved by ensuring that spectrum is allocated to its most productive use and that users have ongoing incentives to efficiently use scarce spectrum resources.

18. The creation of spectrum licences which provide for the exclusive use of spectrum is intended to coordinate users of spectrum to the benefit of society. Absent licences, spectrum is a form of common good which has the following characteristics:

- Non-excludable – no party can be effectively prevented from consuming the good; and
- Rivalrous – the marginal cost of providing the good to one more individual is very low, such that the enjoyment of the good by one party does not adversely affect another party's enjoyment of the same good.

19. In an environment where spectrum is scarce, there is a risk that the value of spectrum for particular uses such as mobile services which require minimal interference would be lost in a tragedy of the commons, with competing spectrum users unable to resolve the costs they impose on one another. As noted by Faulhaber (2005) the advocates of open access and the resolution of rights using social norms is, at best, hopeful:[3]

Commons advocates have used Ellickson and the ensuing legal literature on norms to suggest that social norms and mores can act as a substitute for regulation. But the more careful application of game theory by Mahoney and Sanchirico proves this bias toward cooperative norms is misplaced; we rely on it at our peril. Moreover, in a commons regime, the number of

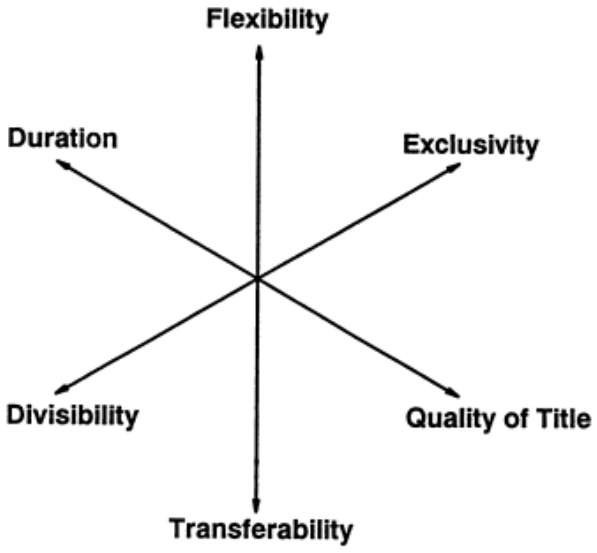
[3] Faulhaber, The question of spectrum: technology, management, and regime change, 2005.

> *"neighbors" is likely to be large and their relationship is unlikely to be long term, so cooperative equilibria are unlikely to exist. Realistically, in commons or markets, court-enforced law or regulation is a necessity whenever cheating could be short-term profitable.* ***Reliance on norms is romantic but fanciful****. [emphasis added]*

20. The creation and distribution of licences with an expectation of renewal for the use of spectrum creates a 'market system' that generates incentives for spectrum users to maximise the long-term value of the scarce spectrum resource. A market-based approach to spectrum management is stronger the more certainty and predictability is given to market participants. The more certainty provided to licence holders, the more likely it is that licence holders will make decisions that maximise the productive value of the spectrum.

21. Figure 1 (reproduced from Scott, 1988[4]) visualises six characteristics or rights in the interest in real property (exclusivity, quality of title, transferability, divisibility, duration and flexibility). It is important to recognise that these property rights are not binary (i.e., the rights do not simply exist or not exist) but rather the extent to which a right is granted can be observed on a continuum (as noted by Scott (1988), each might run from 0 to 100 percent).

Figure 1: Six characteristics of interests in real property



Source: Scott (1988)

[4] Scott, A., "Development of property in the Fishery", *Marine Resource Economics*, Volume 5, pp. 298-311.

22. The following table assesses the CA's spectrum management decision making process in relation to these interests and the implications for the incentives of licence holders to maximise the long-term value of the scarce resource.

Table 1: Interests provided to licence holders by CA

Interest	Rank	
Exclusivity	◕	Spectrum licences granted by the CA allow use free of interference, allowing licence holder to exploit the full potential of the spectrum
Quality of Title	◕	Licence holders have the ability to enforce exclusivity, which provides certainty to make investments
Transferability	○	The lack of ability to freely transfer licences limits the ability of spectrum to be used in its most productive way. The periodic transfer at the end of the fixed licence term means that in-period use may be inefficient[5]
Divisibility	◕	The licence holder can divide spectrum, but the lack of transferability will lead to fragmentation which will limit the ability to maximise the value of the spectrum
Duration	◔	The limited duration of the licence, and the absence of a first right of refusal for the full spectrum holding, means that licence holders do not have an incentive to maximise the long-term value of the scarce resource
Flexibility	◕	Flexibility includes the entitlement to use the property for whatever purpose the owner decides. In the case of spectrum this would cover technological neutrality of spectrum licences, allowing the licence holders to advance new technologies that increase the value of the spectrum. The limited duration of licences in Hong Kong would however deter technology deployment

Source: CEG analysis

23. It can be observed from Table 1 that the market system created by the CA spectrum management decision making process is likely to result in attenuated interests, which will weaken the incentives for licence holders to maximise the value of scarce spectrum resources. In particular, the limited duration of the licences and the absence of a first right of refusal distort the incentives for licence holders to pursue value enhancing uses of the spectrum. The implications of this for the efficiency and incentives to invest is discussed in later sections. In the following section, we discuss the range of market-based approaches to spectrum management.

5 In 2007, the Government indicated its intention to introduce spectrum trading subject to resolving some implementation issues (see paragraph 5.3 of the Radio Spectrum Policy Framework issued in April 2007). In 2009, after a consultancy study, the Government repeated its support for the introduction of spectrum trading. Nevertheless, since then, the Government has taken no action to introduce spectrum trading. Instead, in response to recent queries, the Government has indicated its intention to engage another consultant to further study the matter in the light of the substantial changes in the mobile telecommunications market since the last consultancy study was conducted.

2.4 Market-based approach to spectrum management

24. Market-based approaches to spectrum management are defined in the RSPF as "*methods relying on market forces to ensure the efficient use of spectrum as a public resource*". We raise two potential issues with the CA's focus on a market-based approach. First, creating a mechanism with market-like features (i.e., where there is competitive bidding for spectrum) should not be the objective of the CA. Rather, the objective should be to promote the interests of end-users, taking into account effects on end-users in terms of service continuity, efficient use of spectrum, competition and investment. Markets generally work well for consumers. However, the CA should ensure that the approach it adopts will actually meet its statutory duties under the TO and be in the best interests of end-users.

25. Second, we question the characterisation of re-auctioning of spectrum already in use as market-based. Generally, across the economy, licences with a right to renewal provide predictability. This enables asset owners to invest in the development of the assets where this will bring value. Where other parties could make better use of a right, the existing owner is generally able to sell the remaining term of that right. As discussed in the previous section, a market-based system for spectrum management is achieved by creating licences for the use of spectrum.

26. The arrangements proposed by the CA, however, contain elements more aligned to a 'command and control' system than one based on market driven mechanisms. These 'command and control' mechanisms include a spectrum 'takeback', allocating a portion of re-assigned spectrum through an RFR process with prices based on a regulated pricing formulae with regulated auction reserve prices. None of these elements are typical of market based allocation methods. A market based allocation method would replace the existing proposals with an automatic renewal of the spectrum assignments combined with a reliance on *ex-post* competition law and consumer protection.

27. The establishment of spectrum licences has brought enormous benefits relative to command and control approach to spectrum management. As observed by Hazlett (2011):[6]

> *The liberalization of private property rights has yielded extremely large social gains, permitting complex market structures to develop. No other form of spectrum allocation, including the command and control once thought necessary to avoid the tragedy of the commons and the spectrum commons recently heralded as signalling the obsolescence of Coasean property rights, supports such productive social coordination.*

[6] Hazlett, T.W., Porter, D., and Smith, V., "Radio Spectrum and the Disruptive Clarity of Ronald Coase" *Journal of Law and Economics*, 2011, Vol.54, No. 4, Markets, Firms and Property Rights: A Celebration of the Research of Ronald Coase, 2011, pp. S125-S165.

28. The hallmarks of an effective market-based approach to spectrum management is based on establishing rights of duration and transferability. The best practice jurisdictions identified in section 3 have established automatic renewal/perpetual licences and secondary trading market that are consistent with a market-based approach. Restricting spectrum trading and taking back a share of spectrum for re-assignment is a regulatory intervention (akin to command and control) which is the antithesis of a market-based system.

29. While the use of an auction is a market-based mechanism for the initial allocation, the restriction on the term of the licence imposed by the CA (and prohibitions on trading spectrum) is appropriately characterised as an administrative or regulatory intervention. In our view the CA incorrectly characterise the options under assessment. Specifically, the CA characterise:

- the option which re-assigns all the spectrum by auction as a "fully-fledged market-based approach" when this would be better characterised as an administrative option that involves the regulator periodically making unforeseeable decisions as to the future use of spectrum; and
- the option to offer a right of first refusal to current licence holders as a "fully-fledged administratively-assigned" approach when this would be consistent with well-functioning market-based systems that default to a perpetual spectrum licence.[7]

30. These mischaracterisations, in part, lead the CA to pursue a spectrum management option on the incorrect assumption that it is 'market-based' and even at the expense of the CA's primary statutory duty to promote the efficient allocation and use of the radio spectrum. While it may be correct that an auction of the 900/1800 MHz spectrum would lead to an outcome where the parties that value the spectrum most highly obtain that spectrum going forward, it does not follow that over time, adopting a policy of periodically re-auctioning spectrum would best promote its efficient use.

31. The policy arguments for auctioning spectrum licences are reasonably strong for initial allocations of spectrum. However, the CA has incorrectly assumed that these policy arguments carry over to the reallocation of spectrum.

32. In fact, the reallocation of existing spectrum licences poses a different set of challenges compared with the initial allocation of spectrum. With the initial release of spectrum, the aim of the allocation process is to achieve allocative efficiency, in that spectrum is supplied to the party that values it the most, and thus generates the most social value from the spectrum licence. A decision to re-auction spectrum, however, impacts not only the post-auction allocation of spectrum but also the efficient use of the spectrum within the current period. The efficiency of re-

7 See page 6-7 of Second Consultation Paper, 14 February 2017

auctioning of spectrum is severely complicated by timing issues, optimal licence duration and asset lifecycles.

33. The complications and inefficiencies associated with spectrum renewal have been known for some time (see Levin (1962) and Levin (1970)). As noted by Levin (1970):[8]

> *One final problem arises from the special difficulties posed by the reauctioning of existing licences – in contrast with initial auctioning of new grants … there is no question that competitive bidding for renewal rights is a far more complicated and potentially perverse matter than the letting of new grants for the first time.*

34. The following sections discuss the implications of periodic renewal by reauction. They discuss early observations by Levin (1962) on reauctioning spectrum at the end of a licence period having two significant harmful effects. First, it will bid up the costs that operators need to pay for spectrum over time which will inhibit entry (reducing competition). Second, the increase in uncertainty over future access to spectrum will shorten the investment time horizon for users of the spectrum reducing investment and quality standards (relative to the case where such uncertainty did not exist) and ultimately reducing the welfare of end users. Similar issues are discussed in later sections of this report.

2.4.1 Inflates the capitalised cost of spectrum, raising the cost of entry

35. In the absence of spectrum trading in Hong Kong, a policy of automatic reassignment would mean that a buyer would need to acquire an operator's business in order to utilise the spectrum (as occurred when HKT purchased CSL). In this case, the buyer's upfront costs at least reflected the future earnings that the seller would expect from the spectrum. As in any trade, the minimum that a buyer will need to pay is the present value of the seller's expected future earnings from utilising the spectrum (and the other assets of the business). The buyer may also need to pay a premium if there are other potential buyers (equal to the present value of the other potential buyer's expected earnings).

36. The calculation of the future value of earnings would naturally be based on the assumption of future automatic renewal of the spectrum. That is, the present value of future earnings would be calculated over a perpetual time horizon (increasing the amount that would need to be paid in circumstances where businesses holding spectrum are traded). Equally, those upfront costs would be able to be recovered over a perpetual timeframe.

[8] Levin, H. J. (1970), "Spectrum Allocation without Market" *American Economic Review*, 60(2), 209-218.

37. In contrast, the reauctioning of spectrum at the end of the licence period will raise the cost of acquiring spectrum. To see this, we consider two cases.

38. The first case is one in which the current owner of the spectrum would not have otherwise sold the spectrum to potential buyers (in a world in which the spectrum was automatically renewed). In this case, the reauctioning of the spectrum would mean that the current owner would at least need to pay the bids of the other parties at the auction. As observed by Levin (1962):

> *Under an auction scheme even these reluctant station owners would be forced to match the premiums which potential buyers offered to the Licensing Authority. Premiums that might well have been rejected by station owners as inadequate would in fact be paid by potential buyers to the Authority itself. Higher capital charges would result if station owners were forced to outbid these rivals….*[9]

39. The significance of this is that if a policy of automatic renewal were adopted these buyers' offers would have been rejected and the capitalised costs of spectrum in the industry would have been lower. That is, over time the process of reauctioning spectrum that would not otherwise have been traded on market terms, inflates the industry-wide costs of spectrum.

40. This result is consistent with the implications of general transaction tax theory, which shows that the effect of transactions taxes (e.g., stamp duties) is to inflate the costs of assets as the present value of cashflows of the asset must take into account future trading of the asset.

41. The effect of inflating the costs of spectrum (referred to as capital charges by Levin (1962)) is significant as it will artificially create a barrier to entry into markets that utilise spectrum (reducing competition in downstream markets) resulting in higher final (retail) prices for services.

42. The second case is one in which the current owner of the spectrum would have otherwise traded their business to a buyer with a higher valuation of expected earnings. In this case, the reauctioning of spectrum makes no difference to the capitalised cost of spectrum as the spectrum would have been traded at least at the price level that reflects the current holders future expected earnings (up to the amount alternative potential buyers would be willing to pay).

2.4.2 Harms future investment and service quality

43. Under a policy of automatic renewal, the time horizon for decision making by the operator is perpetual. The assumption that the CA will automatically renew in all

9 Levin, H.J, "Federal Control of Entry in the Broadcast Industry", *The Journal of Law & Economics*, Vol. 5 (Oct., 1962), pp.49-67.

future periods means the level of future investment and the level of service quality will be chosen that maximises the value of the spectrum to the operator.

44. In a competitive downstream environment (and in the absence of significant externalities) this would reflect an efficient trade-off between investment and service quality. That is, it would be the trade-off which is most attractive to end-users. For example, if an operator selected an unattractive trade-off, its services would be substituted by end-users for the services of operators offering more attractive trade-offs. The competitive process can be relied on to deliver reasonably efficient outcomes.

45. In contrast, a policy of reauctioning spectrum at the end of each licence period creates "renewals uncertainty" which impacts negatively on investment choices and service standards. As noted by Levin (1962), it would be reasonable to assume that:[10]

> *"… anything that shortens the broadcaster's time horizon would reduce his long-run investment in program production and physical plant, the period he will wait for returns, and his service standards too … sharp increases in renewal uncertainty … would … have these effects."*

46. The effect of a policy reauctioning spectrum means that operators' investment time horizon is shorter. It must account for the uncertainty associated with the outcome of an auction at the end of the licence period. This is particularly problematic when the asset lifecycles do not match the period (arbitrarily) set for spectrum licences. As discussed in section 4.4, this could lead to perverse and inefficient investment choices including (i) inefficiently delaying investment or (ii) under investing in network equipment relative to spectrum.

47. It is important to note that in addition to investment effects, the policy of reauctioning spectrum would likely be harmful to service quality. In a competitive market, each operator will face this renewals uncertainty. The closer the time comes to the end of the licence period, the shorter will be each operator's investment time horizon and the greater will be the temptation/incentive for each operator to reduce service standards.

48. The competitive tension amongst operators will mean that no single operator can asymmetrically reduce discretionary investment and services standards, and the industry as a whole will find it difficult to attract capital when faced with renewal uncertainty. This will either reduce absolute investment and service quality or raise the expected returns of investors to fairly compensate for the risk created by reauctioning policy. This will inevitably harm end-user welfare either through inefficiently low quality or higher charges.

[10] Ibid.

3 International approaches to spectrum licence renewal

49. This section summarises the practices and experiences of other countries in the regulation of radio spectrum. We identify the approaches to spectrum renewal that have been adopted internationally, the objectives being targeted by the regulator in these renewal processes, the market status at the time of the renewal and any evidence of the approach having beneficial or harmful effects. Based on this review, we have identified the approach we believe represents best practice in the context of the Hong Kong mobile market.

50. Our review of approaches applied as existing licences reach their end of their term has identified five categories of approach (see Table 2).

Table 2: International approaches to mobile spectrum licence renewal

Renewal approach	Country and date
Automatic or with high expectation of renewal	Australia (2015), Bangladesh (2012), Brazil (2016), Canada, Czech Republic (2015), Hungary (2013), Italy (2017), Lithuania (2006), Pakistan (2007), Poland (2014), Portugal (2006, 2007, 2016), Singapore (2008) South Africa (2004), USA
Automatic with indefinite licence term	UK (2015)
Administrative re-assignment	Belgium (2009), France (2006), Japan (2012), South Korea (2011), Sweden (2011), Switzerland (2008)
Hybrid re-assignment with partial auction	Denmark (2009), Greece (2011), Indonesia (2012), Italy (2011), New Zealand (2007), Sweden (2009), Spain (2011)
Full auction	Germany (2015), Hungary (2014), India (2014, 2015), Ireland (2012), Netherlands (2012), Norway (2013, 2004), Romania (2012), Singapore (2013) and Switzerland (2012)

Source: GlobalComms Database, TeleGeography, regulator websites and news reports

51. In the next sub-section, we review the reasons for the adoption of these different renewal approaches before considering the market experience with each approach and its relevance to Hong Kong. We find that automatic renewal approaches have generally been adopted in those countries with similar market circumstances and regulatory objectives to Hong Kong, while re-auctioning approaches have been adopted in countries where these differ. Additionally, we find evidence indicative of the uncertainty of the loss of current spectrum access associated with re-auctioning of licences having harmed investment relative to other countries.

3.1 Rationale for choice of renewal approaches

3.1.1 Automatic renewal and perpetual licence terms

52. Automatic renewal or high expectation of renewal ('Automatic renewal') allows current spectrum holders to renew their licences except under certain defined circumstances which are expected to arise relatively rarely (e.g., spectrum replanning to support the entry of new services, a serious breach of licence conditions or spectrum being left idle for an extended period). In the UK, new spectrum licences are issued on a perpetual basis with revocation possible in only a limited range of circumstances and with a reasonable notice period being given. A right of first refusal can also be considered equivalent to automatic renewal as in all cases operators have the option to relinquish spectrum.

53. Under automatic renewal, any charge for future use of the spectrum is determined by the licensing authority and sometimes additional licence conditions may be imposed such as relating to coverage. Any spectrum that is relinquished by the operators is available to be re-assigned by the authority.

54. Automatic renewal and equivalent approaches have been widely adopted. We have identified 15 markets in which they have been used since 2004.

55. Objectives identified by the regulators for their selection of an automatic renewal approach include:

- Guarantee of continuity:
  - As stated by the Australian regulator "*reissue of licences will provide certainty about the continuity and operation of mobile and wireless communication networks*"[11]
  - Industry Canada has stated that this approach means "*licencees will generally be eligible to continue operating and serving their customers, under the terms of a new licence, after the expiration of their current licence term*" [12]
  - Ofcom: "*In particular, reassignment by the regulator typically takes significant time and resource. The spectrum may also lie idle for a period as the regulator prepares for reassignment. While it may be possible to reduce this problem through the use of overlay auctions, the approach of an indefinite duration together with spectrum trading seem likely to offer a simpler and less costly way of ensuring the spectrum is used efficiently.*"[13]

[11] Patel, T., *Australian govt seeks $3.2 billion for spectrum licences renewal*, 2012, RCR Wireless News.

[12] Government of Canada, *Decisions on the Revisions to the Framework for Spectrum Auctions in Canada and Other Related Issues*.

[13] Ofcom (2008), *Digital Dividend review: band manager award*, para 6.13.

- Minimise disruption to consumers;
  - The IDA in Singapore stated this would "*avoid unnecessary spectrum churn and more importantly, service disruption to end-users*"[14]
- Perception that the existing spectrum arrangement is effective and efficient;
  - In the USA, renewal is contingent on the incumbent having "*provided "substantial" service during its past licence term. "Substantial" service is defined as service which is sound, favorable, and substantially above a level of mediocre service which might just minimally warrant renewal*"[15]
- Promoting investment;
  - Industry Canada has stated that high expectation of renewal "*does help to create increased certainty for investment in the marketplace*"
  - Ofcom's decision noted "*Furthermore, incentives to invest closer to the end of the licence duration are significantly reduced given that electronic communications networks generally require continual investment. This lack of investment could result in detriment to citizens and consumers. The alternative of licences with an indefinite duration removes the requirement for return to the regulator, removes the risk of discouraging investment and creates additional opportunities for the market to secure the efficient use of the spectrum, particularly in the presence of spectrum trading*."[16]

3.1.2 Administrative reassignment

56. Administrative re-assignment approaches involve the regulatory authority determining both the future holder and the price of the spectrum at the end of the original licence period. This approach has been adopted in six of our benchmark countries.

57. Administrative reassignment has often been adopted in order to address specific market or licence dynamics. The French regulator, ARCEP, re-assigned spectrum to support the entry of a fourth operator. ARCEP stated that "*the arrival of the new player is expected to have a favourable impact on the mobile telephony market's momentum and, more generally, be a positive element in the development of electronic communications services in France*" and that "*The new entrant is also expected to stimulate existing operators whose current status is established and sound*" [17].

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14 Decision and explanatory memorandum issued by Infocomm development Authority of Singapore on the framework for the reallocation of spectrum in the 900Mhz and 1800Mhz frequency bands

15 Cornell University Law School, CFR, section 90.743 Renewal expectancy

16 Ofcom (2008), *Digital Dividend review: band manager award*, para 6.13).

17 Arcep (2009), *4th 3G licence*

58. Spectrum may also be reassigned to improve efficiency; either to improve utilisation or to remedy fragmented spectrum holdings, allowing spectrum licence holders to maximise their contiguous spectrum holdings and therefore improve the quality of service they can offer. For example, in Belgium a fourth 3G licence and rights to acquire 900 MHz and 1800 MHz spectrum were granted in 2011 to Tecteo Telenet Bidco (TTB). However, TTB failed to use the spectrum and the 3G licence was returned in 2014 and the 900 MHz and 1800 MHz spectrum was "repartitioned" to redistribute the spectrum to the three Belgium mobile operators.[18]

59. While administrative re-assignment procedures provide the regulator with substantial control, there is the risk of regulatory failure. In particular, there is the risk that re-assignment harms investment incentives, while the limited transparency inherent in the process may lead to authorities taking decisions on the basis of factors unrelated to ensuring efficient use of spectrum and maximum benefit to end-users. For example, in Japan, the use of administrative approaches to assignment has led to criticism, with their approach being described as "*opaque and arbitrary… leaving applicants unsure of what is required and opening MIC to accusations of favouritism or political manipulation*"[19].

3.1.3 Re-auctioning of spectrum

60. A number of regulators have re-auctioned spectrum licences where existing licences are coming to the end of their term, either adopting a full auction with all expiring licences made available or a hybrid approach, with some of the spectrum reserved for the incumbent licencee or reassigned using a different method.

61. Full auctions have been carried out in countries including Germany, Hungary, India, Ireland, Netherlands, Norway, Romania and Switzerland, while hybrid approaches were adopted in Denmark, Greece, Germany, Indonesia, Spain and Slovenia.

62. Typical reasons for the re-auctioning of licences include:

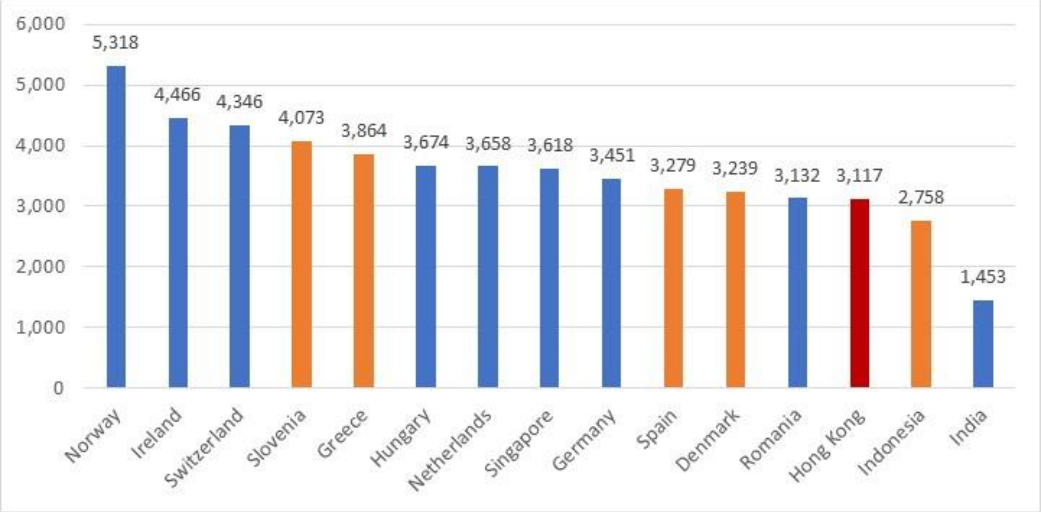
- Attempts to support new entry:
  - In the Romanian market, the 900MHz and 1800Mhz spectrum was auctioned as part of a 2012 multiband award, with the regulator ANACOM stating its objectives were to "*stimulate competition, investment and innovation in the communications market. Furthermore, the mechanism was designed to offer equal conditions to all the players present in the Romanian market and to the potential new-entrants*"[20]. The process led to a fifth player (2K) obtaining some spectrum as well as some spectrum

18 BIPT, *Fourth 3G licence, 2011*.
19 Janka, John P., *The Technology, Media and Telecommunications review*, 2015.
20 Agcom article, *Agcom submits to Public Consultation the Documents of the Spectrum Auction to be held this year, 2012*.

remaining unsold.[21] However, by 2015, 2K exited by selling its licence to one of the four remaining operators.[22]

- The 2013 auction in Singapore included 40MHz of 1800MHz spectrum ringfenced for a new entrant, however the IDA received no interest and this spectrum reverted to the incumbent operators at the reserve price.[23]
- In Germany, the 900MHz and 1800MHz bands were auctioned as part of the 2015 multiband award following the merger of Telefonica and E-Plus to "*ensure non-discriminatory broadband spectrum holdings for all mobile operators and to prevent a distortion of competition*".[24]
- As shown in Figure 2, countries that have adopted auctions for spectrum at the end of their licences have tended to have much more concentrated markets than Hong Kong. The Figure uses the Herfindahl Hirschman Index (HHI), a standard measure of market concentration which is calculated as the sum of the squares of the market shares of the firms in the market. India and Indonesia are exceptions although re-auctioning in these cases reflected other objectives as we discuss below.

Figure 2: Market concentration (HHI) in countries re-auctioning expiring spectrum licences (blue) or re-auctioning some of the expiring spectrum (orange)



Source: CEG based on GlobalComms Database

21 Ancom (2012), *Results of the spectrum auction for mobile electronic communications*

22 Telegeography, *Digi entering 4G data segment via 2K Telecom licence takeover*

23 Infocomm Media Development Authority, *1800 MHz Spectrum Right (2013) and 2.5 GHz Spectrum Right (2013) Auction ("4G Auction")*

24 Decision of the President's chamber of the Bundesnetzagentur fur Eletrizitat, Gas, telekomminikation, Post and Eisenbahnen BK1-11/003

- Efficient spectrum use
  - In Indonesia, the existing allocation of the 2.1 MHz spectrum was highly inefficient with a mix of blocks allocated to 3G and others allocated to fixed wireless access.[25]
- Revenue generation (the price is set by the market is generally higher than the one set one set by regulator).
  - The TRAI in India considered revenue maximisation to be an "*important objective*"[26] in their adoption of an auction process. The market structure in India has also proven unsustainable (potentially impacted by the spectrum fees paid) with the number of operators expected to fall from 11 at the start of the year to 6 this year.[27]

63. However, re-auctioning does create uncertainty and risk to operators. In Ireland, the uncertainty over the timing and outcome of the auction process was reported as "*frustrating operators' plans to roll out 4G networks*".[28]

64. Additionally, there is a possibility that the spectrum will return to the hands of the incumbent licencees, thus making the expense and uncertainty of an auction unnecessary. The Netherlands' auction took place over 185 rounds, lasting from 31 October to 14 December 2012[29], and while there was some small movement in spectrum holdings, the 900MHz and 1800MHz frequencies approaching their expiry dates remained in the hands of the three incumbent spectrum holders (while the MVNO Tele2 acquired 800 MHz spectrum). Similarly, the 2013 re-auction of the 1800MHz spectrum in Singapore resulted in the operators largely retaining their existing holdings apart from the largest operator, Singtel, acquiring 2 x 5 MHz from its smaller competitor M1.[30]

65. Hybrid approaches combine the risks and benefits of full auctions and automatic renewals with the precise balance between risks and benefits depending on the details of the approach and the market circumstances. Regulators have stated that their objectives in adopting hybrid approaches is designed to encourage new entry while ensuring network continuity.

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25 Judijanto presentation, "Auction for allocating frequency for IMT-2000: the Case of Indonesia" https://www.itu.int/osg/spu/stn/spectrum/workshop_proceedings/Presentations_Abstracts_Speeches_Day_2_Final/Danny%20Setiawan%20-%20Loso%20Judijanto%20-%20ITU_SPECTRUM_3GAUCTION_LOSO_v7.pdf

26 TRAI, *Consultation paper on Valuation and Reservice Price of Spectrum* N06/2013.

27 Mobile World Live Blog (https://www.mobileworldlive.com/blog/blog-will-consolidation-place-incumbent-indian-operators-on-solid-ground/).

28 Telegeography, *Ireland inches closer to 4G wireless spectrum auction*.

29 Agentschap Telecom Ministries van eocnomische Zaken, *"Multiband frequentieveiling"*.

30 Spectrum holdings pre-auction at TRPC, Spectrum Policy in Singapore, 2012 and post-auction at Infocomm Media Development Authority, 1800 MHz Spectrum Right (2013) and 2.5 GHz Spectrum Right.

- Denmark's regulator refarmed 2×5MHz of 900MHz and 2×10MHz of 1800MHz spectrum from incumbent operators' holdings and offered these for an auction in which the three largest incumbents were barred from participating. This "*was an attempt to improve competition in the downstream market by encouraging new entry"* and allowed Hi3G Denmark to enter the market.[31] Two of the Danish operators subsequently sought to merge in 2015 but were prevented from doing so by the European Commission (although these operators already share their network).
- Greece auctioned the 900MHz and 1800MHz bands in 2011 to "*foster competition in the Greek telecommunications market to the benefit of consumers*"[32] while "*safeguarding, under the appropriate terms, of the continuous 2G services provision from current providers*".[33] The re-auctioning did not lead to new entry. One of the operators criticised the high reserve prices set for the auction: "*the approach used to set the price for the renewal of mobile spectrum is driven solely by short-term revenue gains*".[34]
- The RSM in New Zealand renewed the 800MHz and 900MHz spectrum holdings of the two incumbent operators under the condition that they sell 2×5MHz of their spectrum holdings to a new entrant to create a three-operator mobile market.[35] The two incumbent operators were each able to retain 2x15 MHz of the relevant spectrum. This process was adopted as it "*supports competition in the relevant markets, minimises the risk of stranded investment, avoids undue disruption of services, facilitates the migration to new technologies, and maximises the opportunity for new investment in the spectrum*".[36]

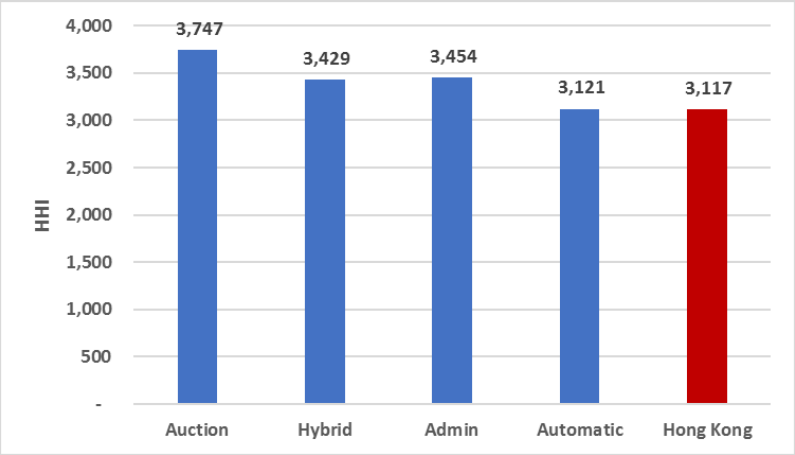
3.1.4 Market dynamics and the choice of renewal approach

66. The promotion of competition is a key argument used by many regulators in support of an auction approach to spectrum renewal. As noted above, HHI is a standard measure of market concentration. We have examined the mobile market HHIs in the year of a country's renewal process (for renewals from 2009 forward) and found that those markets where spectrum licences were re-auctioned tended to be relatively highly concentrated markets (i.e. with HHIs above average). On the other hand, automatic renewal tends to be adopted in more competitive markets with

31 Ofcom, Recent European awards, Annex 8.
32 EETT, *Liberalisation of the use of 900Mhz and 1800Mhz spectrum bands and assignment of the relevant rights of use*.
33 EETT annual report 2011.
34 O'Brien Kevin J., "*Terms of spectrum Auction in Greece Rankle Operators"*, The New York Times, 2011.
35 Radio Spectrum Management, *Renewal of 800/900Mhz cellular rights*.
36 RSM, *Expiry of spectrum rights 2013, Implementation and renewal of 800-900-cellular services cabinet-paper*.

relatively low HHI. As shown in Figure 3, Hong Kong's HHI is broadly in line with the low average HHI of those countries that have used an automatic renewal.

Figure 3: Average HHI for markets where licence renewal processes occurred 2009-2016

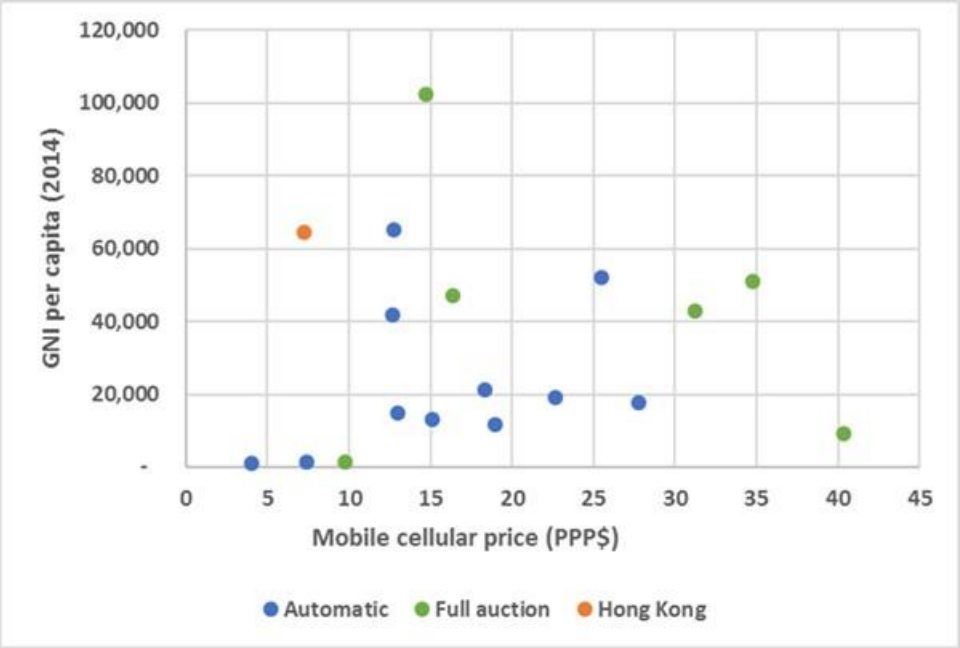


Source: CEG based on GlobalComms Database

67. Hong Kong's relatively low mobile prices are also indicative of a highly competitive market. The ITU's data for pricing of a mobile-cellular sub-basket in 2014[37] shows that the price level in Hong Kong as percentage of income (GNI) is the second lowest globally. When considering the affordability of services in all countries where renewal processes have occurred, there is an apparent relationship between high GNI per capita levels and affordability of services. As shown in Figure 4, those countries that adopted an automatic renewal approach tend to be further to the left, i.e., having relatively low prices, compared with prices of other countries with similar income levels which re-auctioned the spectrum. In other words, automatic renewal is more likely in countries with relatively low mobile prices and re-auctioning is more common in countries with relatively high mobile prices.

37 See Table 4.2 ITU, *Measuring the Information Society Report*, 2015.

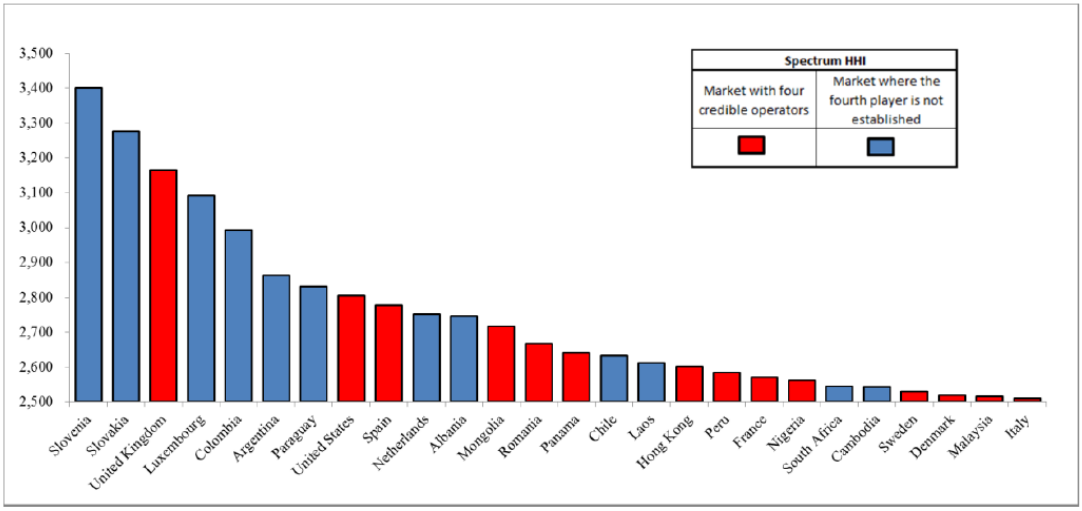
Figure 4: Relationship between cellular service affordability and GNI per capita



Source: ITU

68. While some international regulators have decided to re-auction spectrum to attempt to remedy highly imbalanced spectrum holdings, this consideration does not appear relevant in Hong Kong. First, Hong Kong's spectrum holdings are not concentrated compared with other 4-operator markets (see Figure 5).

Figure 5: Concentration of spectrum holdings across 4-operator markets (HHI of spectrum shares) from NERA



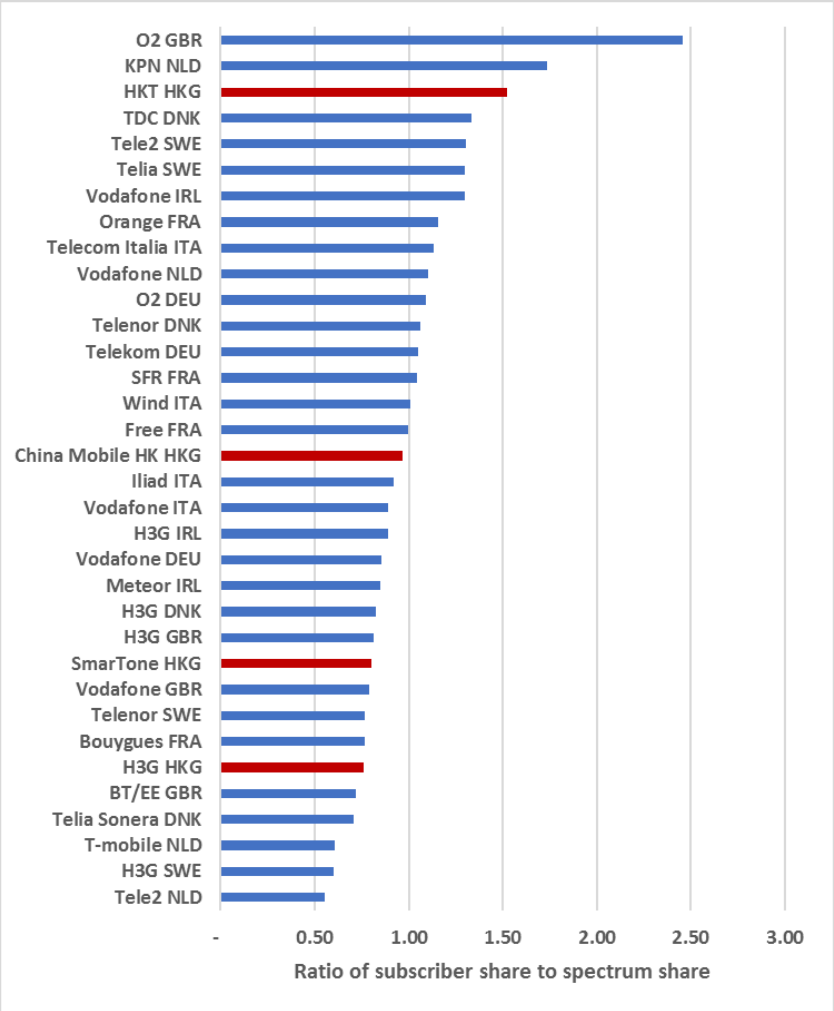
Source: Reproduction of Figure 6 of NERA, *The case for spectrum caps that support efficient, pro-competitive outcomes in the award of PSSR spectrum,* January 2017. Markets in which fourth player is not yet established is where fourth player has a market share less than 5%.

69. Second, while HKT has little spectrum relative to its subscribers, the proposed auction would not remedy this. We have reviewed the spectrum holdings and mobile subscriber numbers of all operators in the benchmark markets (i.e. other 4-operator markets with similar income levels where licences expired).[38] HKT have a very high ratio of subscriber share to spectrum share of 1.53, as shown in Figure 6, compared with both their national competitors and the international benchmark operators. Even a comparison of 320 operators worldwide shows that HKT has very little spectrum for its subscriber share – HKT is in the bottom 15% of operators for its ratio of its spectrum share to its subscriber share (i.e. the inverse of the subscriber share to spectrum share).[39] Re-auctioning that leads to HKT losing some of its existing spectrum will exacerbate this relative spectrum shortage and be likely to be inefficient in itself (as HKT is likely to generate the greatest value to society from the spectrum given the needs of its larger customer base) as well as risking HKT's ability to effectively compete (i.e. to maintain competitive quality of service with rival operators).

38 This has not been possible in those markets where spectrum is assigned regionally rather than nationally or where data on spectrum holdings at the time was not available.

39 Figure 7 of NERA, *The case for spectrum caps that support efficient, pro-competitive outcomes in the award of PSSR spectrum*, January 2017.

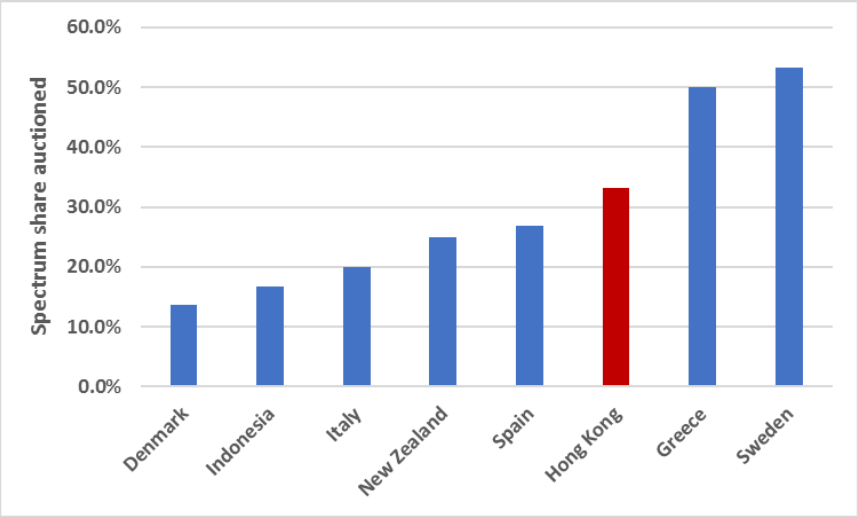
Figure 6: Ratio of subscriber share to market spectrum share for mobile operators in international markets



Source: CEG based on GlobalComms Database

70. When implementing hybrid approaches, regulators have tended to re-auction a smaller share of the relevant spectrum than is proposed to be re-auctioned in Hong Kong (see Figure 7). This suggests that other regulators have tended to find that re-auctioning a smaller share would better balance the potential for new entry against the risks to service continuity and investment.

Figure 7: Share of spectrum bands auctioned in hybrid approaches



Source: Regulator websites and auction documents

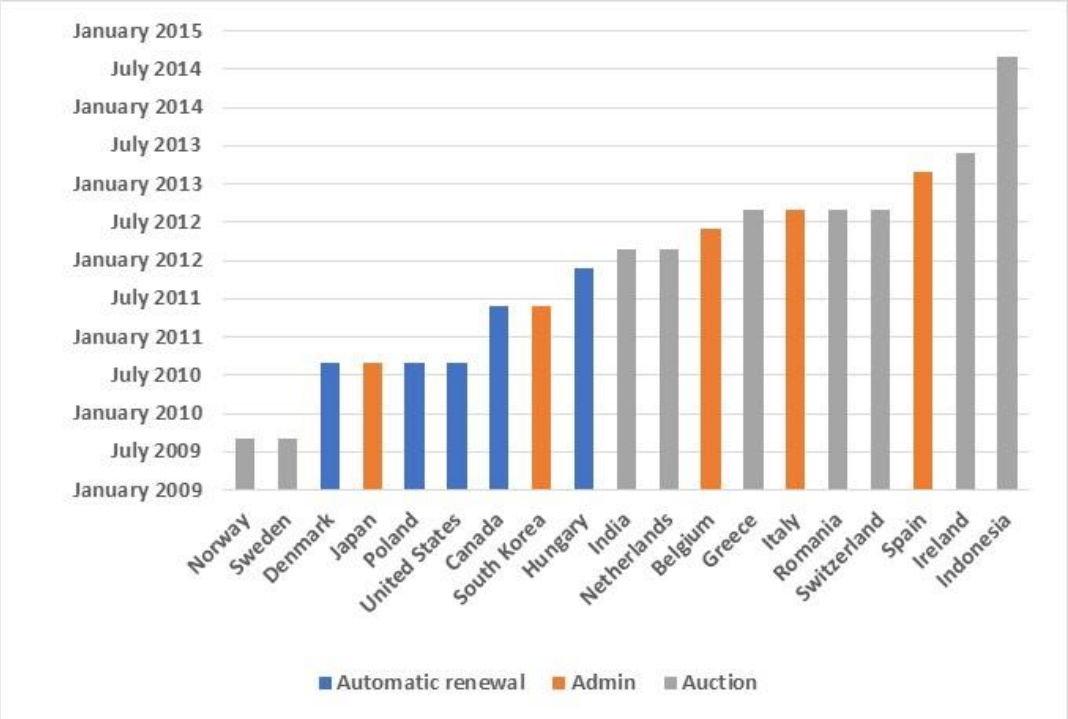
71. When considering the three of these approaches in which both the 900MHz and 1800MHz bands were up for auction, Denmark, Spain and Greece, it is notable that except for Greece, where regulator revenue was noted as a rationale for adopting an auction approach, less than 30% of the available bandwidth was auctioned.

3.2 Impact of renewal approaches on market outcomes

72. While it is difficult to attribute market outcomes to any single factor given the range of factors impacting on mobile markets, we have examined whether outcomes in markets appear to have been affected by the choice of re-licensing approach.

73. Re-auctioning of spectrum carries potential risks of delaying investment and the introduction of new technologies until future access to spectrum is clear. We have considered markets where existing licences expired in the period 2009-2014 – this is a period when it is likely that investment decisions would have been related to launch of 4G. Figure 8 shows that those countries where automatic renewal or administrative reassignment approaches were adopted tended to have earlier 4G launch dates than in countries where licences were re-auctioned. Countries that adopted a hybrid approach have been assigned to the re-auctioning, automatic renewal or administration re-assignment groups based on whether 50% or more of the relevant spectrum was re-auctioned, automatically renewed or administratively re-assigned respectively.

Figure 8: Date of first 4G network launch in benchmark markets with processes 2009-2014



Source: CEG based on GlobalComms Database (countries using a hybrid approach have been assigned to the auction, administratively re-assigned or automatic renewal categories based on whether 50% or more of spectrum was re-auctioned, administratively re-assigned or automatically renewed).

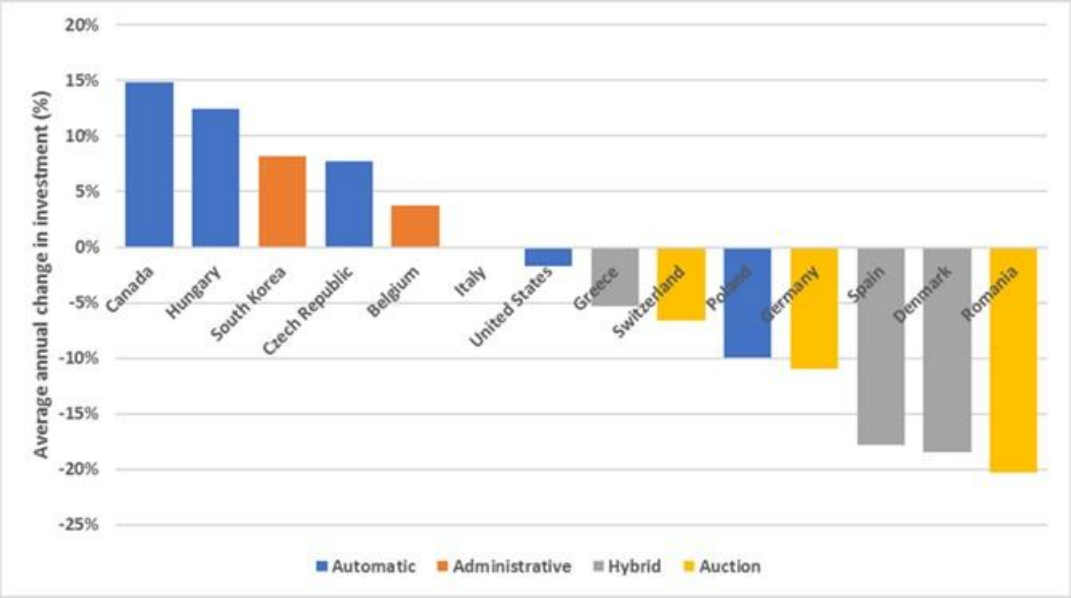
74. Even countries with relatively low income levels, such as Poland and Hungary, could launch 4G services much earlier than countries with higher GDP per capita such as Switzerland and Ireland, suggesting that re-auctioning may be the cause for the late launch of 4G in Switzerland and Ireland. In Ireland delays in committing to an auction plan were stated to be "*frustrating operators' plans to roll out 4G networks*"[40], with one operator stating that "*We don't want to push ahead before ComReg auctions spectrum because they'll find another way to pull the rug from under us… We have the money sitting there to invest, the government wants us to invest but we're stuck waiting for the auctions to begin*".

75. We have additionally considered the impact of the relicensing approach on investment levels. We have examined the average annual change in investment in mobile markets over the period 2004 to 2013 for high income countries where there was a relicensing process between 2009 and 2015. If re-auctioning or hybrid approaches deter investment, we would expect countries which adopted these approaches to have a reduction in investment in the years leading up to the auction.

40 Telegeography (2012), *ComReg's auction of 4G spectrum 'imminent', but telcos frustration grows*

As shown in Figure 9, countries that re-auctioned all or some of the spectrum (coloured in yellow or grey) were more likely to have experienced a fall in mobile investment compared with countries which provided for automatic renewal of licences.

Figure 9: Average annual change in mobile investment



Source: CEG based on ITU data on mobile communication investment data.

76. Investment levels may also be affected by operators needing to pay large fees to renew their licences. For example, in India the risk of losing spectrum required for ongoing service continuity resulted in significantly higher prices (~1.7×) for the 900MHz spectrum than the 800MHz spectrum sold in the same auction. The MD and 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 licences issued by the DoT*"[41]. Similarly, in German, the auction become a bidding war for the 1800MHz spectrum as Vodafone attempted to increase their holdings in the band from 2×5.4MHz. Reviews of the bidding behaviour indicated that this cost the industry a collective €3 billion.[42]

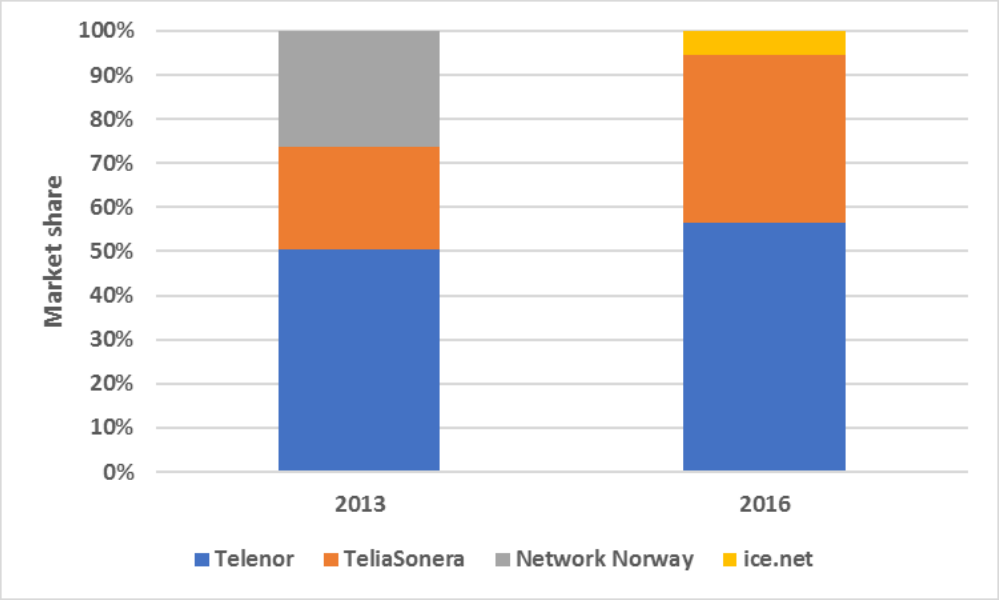
77. A further risk of re-auctioning is that the new spectrum holdings lead to reduced competition. In Norway, where 4G networks were launched before the 2013 re-auction of the 900MHz and 1800MHz bands, the third market operator, Network

41 Airtel, *Bharti Airtel Acquires Prime Spectrum*

42 Telecoms.com (2015), The german spectrum auction: Failure to negotiate?

Norway, did not win any spectrum, instead this was all acquired by TeliaSonera, Telenor and new entrant Telco Data[43]. Following this loss of spectrum, Network Norway exited the market, selling its operations to Telia Sonera. The company said "*the sale was prompted by changes to the structure of the Norwegian market as a result of the licence auction in December 2013*"[44]. While Telco Data has since launched in the market as ice.net, they have, as shown in Figure 10, been unable to gain a significant market share. Their market share is much lower than the share previously held by Network Norway with the result that market concentration has significantly increased.

Figure 10: Mobile market shares in Norway pre and post 900MHz and 1800MHz auction



Source: CEG based on GlobalComms Database and Regulator (NPT) website

43 Norwegian Communications Authority, Auction N 14(800/900/1800Mhz)
44 PolicyTracker (2014), Tele2 leaves Norwegian market following spectrum auction

4 Assessment of alternative approaches against the CA's objectives

78. In this section, we first assess the main alternative approaches against the four objectives adopted by the CA:

- ensuring customer service continuity;
- promoting efficient spectrum utilization;
- promoting effective competition; and
- encouraging investment and promoting innovative services.

79. We show that reassigning spectrum via auction is more likely to undermine, rather than promote, the CA's four objectives. We also demonstrate the economic basis as to why automatic spectrum renewals or perpetual spectrum assignments would best promote the CA's objectives. Finally, we set out the importance of a rigorous regulatory impact analysis for significant regulatory interventions such as the approach to the future use of valuable spectrum and identify key deficiencies in the analysis undertaken to date underlying the CA's proposals.

4.1 Ensuring service continuity

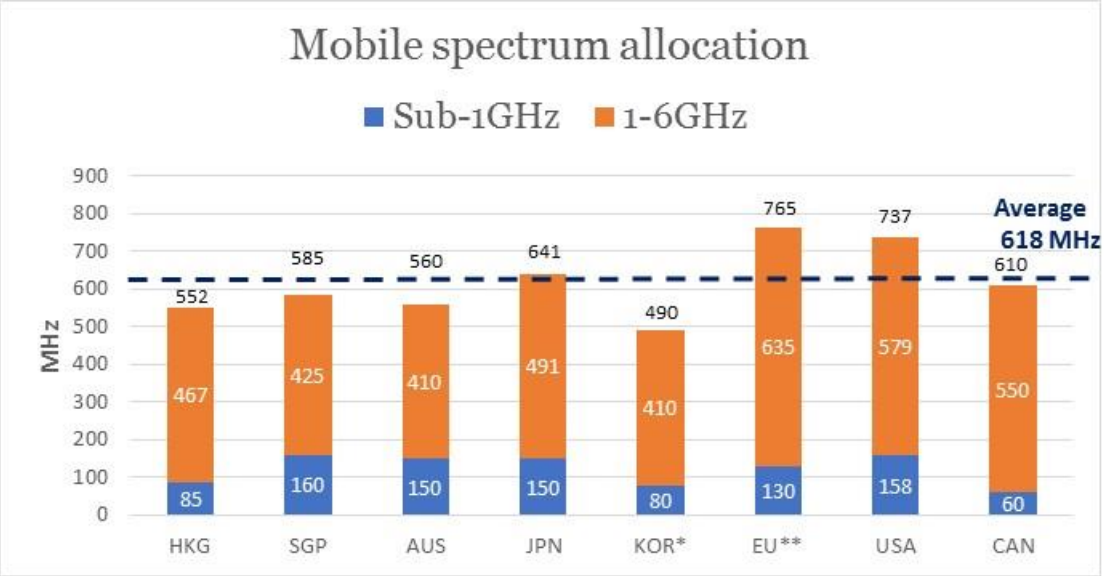
80. The Second Consultation concludes (para. 77) that the proposed hybrid approach Option 3 "*can be just as effective in meeting the objective of ensuring service continuity as Option 1* [administrative re-assignment through the offer of a right of first refusal]." Underlying this conclusion is the opinion of the CA's consultants that, even in the event of a loss of the spectrum not subject to a right of first refusal, each operator would still be able to supply 2G, 3G and 4G services at a reasonable quality of service in 2020/21 and beyond.

81. The conclusion of the CA's consultant is extraordinary considering the following fact:

> *Spectrum allocated in Hong Kong that can be used for mobile services is not high compared with leading international markets*

82. The Plum Report (Figure 1-2; and updated in Figure 11) shows Hong Kong has allocated less spectrum for mobile services than many other key markets. The total 552 MHz of spectrum allocated to mobile in Hong Kong compares with the average of 603 MHz of the other countries shown (and can also be compared with 741 MHz allocated in the UK and 750 MHz that will be allocated in Canada by the end of 2017).

Figure 11: Hong Kong allocates relatively little spectrum to mobile services



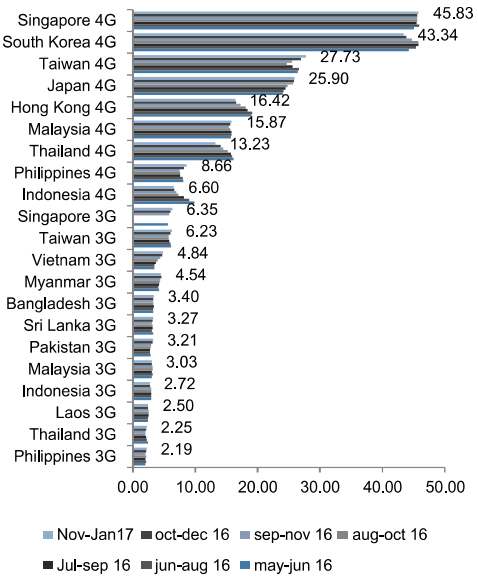
*Source and notes: National regulators, GlobalComms Database. *In South Korea, the authorities auctioned in 2016 frequencies in a total of five bands including 40Mhz of 700Mhz spectrum that went unsold (given the high reserve price set). **EU is based on assignment of harmonised bands in leading top 10 EU countries.*

Quality of service is already being affected by spectrum constraints

83. There is evidence that quality of service has already been harmed in Hong Kong from operators having inadequate access to spectrum which highlights the real risk of a loss in quality of service should any operator lose access to some of its spectrum in the period ahead when mobile data demand is growing rapidly.

84. Despite strong price competition, there appears to be evidence of capacity issues in Hong Kong. J.P. Morgan recently stated that download speeds for LTE services in Hong Kong lag other developed nations surveyed (see Figure 12). The loss of spectrum to a further new entrant and investment being deterred in the lead-up to the auction risks exacerbating this issue.

Figure 12: Average download speed: Country/technology – Mbps, 2016[45]



Source: OpenSignal, J.P. Morgan

International authorities have concluded that significant additional spectrum will be needed

85. Numerous international authorities have recognised that ongoing access to substantial spectrum will be critical to ensuring that operators can meet the rapidly growing demand for mobile services at reasonable quality of service. The World Bank has noted that:

> *"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" and*
>
> *"By 2020, around 2 GHz of total spectrum will be needed in major markets for cellular services. Spectrum availability and allocation is one of the factors determining the future wealth of nations, and governments will have a vital role in maximising the benefits from this resource."*[46]

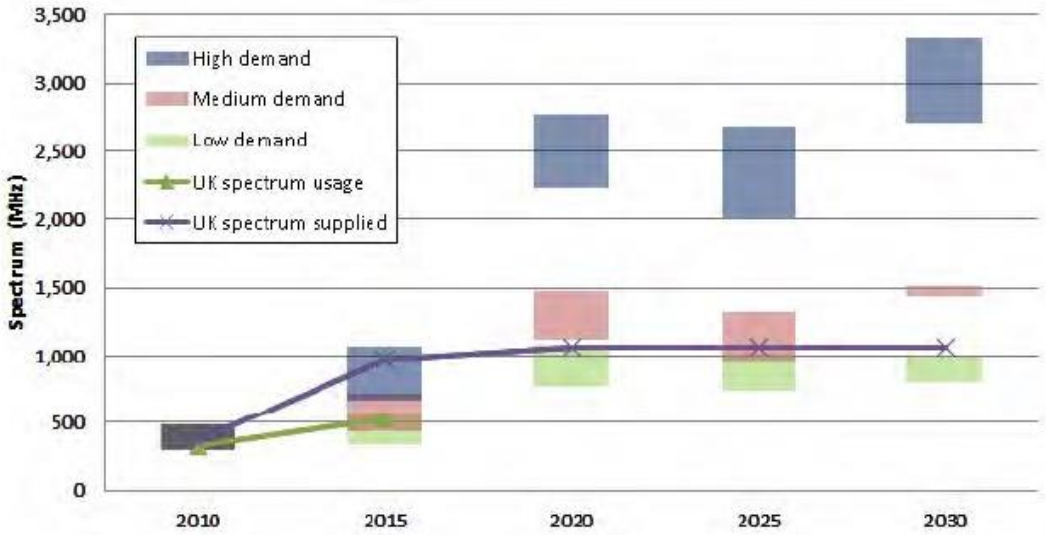
86. The UK Regulator, Ofcom, engaged the consultants Real Wireless to estimate spectrum required in the UK, based on the ITU-R spectrum methodology (ITU-R M. 1768-1). Real Wireless forecast a medium demand case of mobile spectrum

45 JP Morgan (2017) Telco Rules: US$100 capex = US$7 opex, Telco Conversation : Asian Telco Strategy, 1 March, p. 25.

46 World Bank, *Digital Dividends,* 2016, p.25 and p.214.

requirements in 2020 with a lower bound of 1,120 MHz (if all cell types share spectrum) and an upper bound of 1,475 MHz (if all cell types require dedicated spectrum). In the case of high demand, up to 2,770 MHz of spectrum may be required.

Figure 13: Real Wireless estimates of UK spectrum requirements



Spectrum(MHz)		2010	2015	2020	2025	2030
High demand	Shared	295	665	2,230	2,010	2,710
	Dedicated	490	1,070	2,770	2,675	3,325
Mid demand	Shared	295	440	1,120	950	1,445
	Dedicated	490	720	1,475	1,315	1,515
Low demand	Shared	295	340	775	740	805
	Dedicated	490	575	1,080	1,015	995

Source: Real Wireless, *Study on the future UK spectrum demand for terrestrial mobile broadband applications*, 11 April 2014, Figure 1.

87. Ofcom has stated that the trend of growing mobile data traffic will continue reflecting consumer enthusiasm for devices and applications that use mobile data, newer generations using mobile data more intensely, investments in better devices and applications, the Internet of Things based on mobile-connected devices and that, while new technologies provide greater capacity and quality of service, they also encourage mobile data use.[47] Ofcom finds that:

> *"Improving capacity by building additional sites presents some challenges, including costs and site availability. Spectrum is therefore a key enabler of growth and both low frequency and high frequency spectrum will be required to deliver improved capacity, quality of consumer experience and*

47 Ofcom, *Update on mobile data strategy*, 2016, §3.10.

coverage and ensure the availability of new applications and technologies to all UK citizen and consumers. Currently we have licenced a total of 741 MHz of spectrum which is or could be used for mobile…To meet a large increase in demand as described earlier, and to enable new services with very high speeds, a large increase in total bandwidth is likely to be required."[48]

88. In the US, it was estimated that the supply of licenced broadband spectrum would need to increase by 50% by 2020 to meet expected demand, even considering increased investment by operators in technology and networks.[49] The Federal Communications Commission (FCC) notes:

"In addition, increasing consumer demand for mobile broadband is increasing service providers' need for spectrum at an unprecedented rate and this is projected to grow further… To provide service providers with the opportunities to better meet the rising consumer demand discussed above, the Commission has made, and is continuing to make, substantially more spectrum available for the provision of mobile wireless services."[50]

89. Industry Canada set an objective of allocating a total of 750 MHz (new and existing holdings) of spectrum to commercial mobile services by the end of 2017.[51]

90. In contrast to the findings of international authorities, the Plum Report for the CA assumes that just 552 MHz (i.e. Hong Kong's existing allocation of spectrum to mobile services) will be generally adequate to meet demand in Hong Kong over the period of their study (2016 to 2023). This is a fraction of the spectrum expected to be required by the World Bank, Ofcom, the FCC and Industry Canada. Hong Kong, with one of the highest population densities in the world, a services-focused economy with Hong Kong customers having a reputation for early technology adoption, would be expected to require at least as much spectrum to meet demand as these other countries with their more dispersed populations. Compared with these international authorities, Hong Kong is also notable for the absence of a detailed assessment of what spectrum will be needed to support growing demand for mobile data and the lack of a clear roadmap as to when additional spectrum will be made available for mobile use.

91. Many of the key assumptions made by Plum have been redacted from the version of their report made available which limits stakeholders' ability to properly comment on the reasonableness of the conclusions and why they are in conflict with the conclusions of leading international authorities. Even key parts of Plum's assumed spectrum scenarios are not made public despite this not clearly raising any

48 Ofcom, *Update on mobile data strategy*, 2016, §3.19-3.20 and 3.35.
49 CTIA, Substantial Licenced Spectrum Deficit (2015-2019): Updating the FCC's Mobile Data Demand Projections, 2015
50 FCC, Nineteenth Mobile Wireless Competition Report, 2016, §49 and §54.
51 Industry Canada, Commercial Mobile Spectrum Outlook, 7 March 2013.

operator's confidential information. We have the following comments on the assumptions that have been made public.

4.1.1 The Plum Report's traffic forecasts are much lower than forecasts relied on by international regulators

92. The Plum Report (p.35-36) assumes that mobile data traffic in Hong Kong will grow on average by 26% per annum between 2016 and 2023 to reach 9 GB per month per subscriber. Plum notes (p.34) that they have cross checked their forecasts against forecasts by Cisco for Japan and Korea. However, Cisco forecasts for Japan a compound annual growth rate for mobile data traffic of 33% from 2016 to 2021 to reach 18.5 GB per month per user by 2021.[52] Cisco forecasts for South Korea that mobile data will grow at a compound annual growth rate of 37% from 2016 to 2021 to reach 23 GB per month per user by 2021.[53] Cisco's forecast for the "Rest of Asia Pacific" (which includes Hong Kong) is even higher at 51% compound annual growth. Plum's forecast of data traffic per subscriber in 2023 is thus 49% of Cisco's forecast for Japan for 2021 and 39% of Cisco's forecast for Korea of 2021 (and would be an even smaller share of expected traffic in 2023). While Ericsson does not provide specific forecasts for high income countries in Asia, Ericsson's forecasts for Western Europe of 22 GB per month per smartphone by 2022 and for North America of 25 GB per month per smartphone are broadly similar to Cisco's and are likely to reflect a reasonable forecast for Hong Kong given similar income levels.[54] It would be a substantial policy failure, if Hong Kong operators are constrained from supporting similar mobile data traffic per capita as that achieved in comparable, high income countries.

93. Plum's forecast annual growth rate for Hong Kong is also lower than Cisco's forecasts for Japan and Korea despite Japan having declining population (at a rate of -0.1% in 2015) and Korea less than half of Hong Kong's population growth (i.e. Korea's population growth of 0.4% in 2015 compares with Hong Kong's growth of 0.9%[55]). Plum has provided no explanation as to why its forecasts are so much lower than those of Cisco.

94. As noted at the start of this section, international regulators are forecasting substantial growth in mobile data over the next five to 10 years. The growth in data associated with the Internet of Things is still in its infancy. While the Plum report discusses Hong Kong as "a mature market", the FCC notes:

> *"Many research firms forecast that the overall trends for M2M [machine to machine] will become more significant as new and existing network service providers continue to deliver connectivity between devices, sensors,*

52 Cisco VNI forecasts highlights mobile 2016-2021.
53 Cisco VNI forecasts highlights mobile 2016-2021.
54 Ericsson Mobility Report, November 2016
55 World Bank population growth data.

monitors, etc., and their networks. Fifth Generation (5G) networks and services are expected to usher in an era of explosive growth for M2M."[56]

4.1.2 The assumed ability to mitigate the loss of spectrum is overstated and the costs of doing so have been ignored

95. Hong Kong operators have already implemented measures to meet growing capacity needs out of their limited spectrum holdings. This includes investment in new sites, migration of customer devices to 3G and 4G and WiFi offload. PCCW has been implementing WiFi offloading since 2007.[57] However, there is limited scope going forward for operators to invest their way out of capacity crunches and this would be exacerbated were they to lose any of their current spectrum. Obtaining new sites in central Hong Kong is difficult and expensive.

96. For example, HKT has told us that in many cases, building owners are concerned about radiation and have refused HKT access to install base stations. HKT provided examples where they have been trying to install base stations for some time but, as of April 2017, are still awaiting permission (see Table 3).

Table 3: Evidence of difficulties by HKT in acquiring sites

Date of request	*Location*
[CONFIDENTIAL]	
[CONFIDENTIAL]	
[CONFIDENTIAL]	

Source: HKT.

97. In addition, trying to expand capacity with more sites while retaining a fixed amount of spectrum leads to diminishing returns. Ofcom's technical advisor noted: "*In practice, sector overlap and real world channel conditions and antenna designs do result in adjacent sector or cross layer interference, and the returns for increasing numbers of antennas are diminishing*."[58] At some point the cost of such investments exceed the limited additional benefit they provide. Such investments would then not make commercial sense for operators.

98. There are also practical limits to the other mitigation measures put forward by Plum including:

56 FCC, *Wireless competition report – Nineteenth Report,* 2016, §13.

57 Cisco (2012), *PCCW mobile becomes World's first operator to Successfully complete Commercial Next Generation Wi-Fi Hotspot*.

58 Real Wireless, Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030.

- Limits on refarming to 4G by the need to provide service to 2G and 3G devices well into the future; and
- cell sectoring is limited by whether there is space available for the additional antennas at the sites concerned and the need to manage interference issues.

99. HKT's technical experts have also advised why the assumptions of the Plum Report are invalid. They have advised that HKT would not be able to mitigate the service degradation should it be unable to retain its 900MHz holding and unreserved 1800MHz spectrum. The rapid growth in data will imply congestion and a deterioration in service quality.

100. HKT's 900MHz spectrum is used for:

- Indoor penetration to allow customer to have a good VoLTE / CS voice experience indoor; and
- Serving additional LTE cells in MTR underground to provide additional capacity to try and alleviate the current congestion.

101. Should HKT be unable to retain any 900MHz, HKT's technical experts consider that there is no practical alternative to avoid a significant deterioration in indoor quality of service and to overcome congestion in the MTR.

102. Should HKT not retain the bulk of its 1800MHz spectrum, quality of service for customers will be harmed in two key ways:

- While HKT will be able to divert the LTE traffic onto the L2600 layers at outdoor locations (and selected indoor locations), HKT will no longer be able to deliver the same customer experience in downlink throughput, both average speed and peak speed of 450Mbps.
- HKT customers will experience unacceptable congestion in the MTR underground (for stations not yet upgraded with L2600) where HKT's LTE capacity will be reduced to one third of its original capacity (or below if it is assumed that HKT is unable to retain any 900MHz spectrum).

103. Plum finds (p.8) that "*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*." Plum also finds no impact on 2G services and an impact, requiring mitigation, on 3G services for only one operator and an impact on 4G services, requiring mitigation, for only two operators. These findings are surprising. The loss of spectrum from existing operators to, say, a new entrant would be expected to require significant investment by existing operators to maintain capacity and quality of service. Plum's finding seems to imply that operators' current investments are excessive creating capacity that they would not need if they were to retain their access to spectrum.

104. Further, Plum does not consider whether such investment (including new sites) is practical to achieve or what the cost of it would imply for efficiency and service pricing. Indeed, the Plum Report states (p.45) that "*It should be noted that assessing the cost of mitigating measures is outside the scope of the Study*". The cost of additional investment and mitigating measures is nonetheless something that is required for the CA to be able to properly weigh up the costs and benefits created by re-auctioning some or all the spectrum compared to renewal. Further, where an operator cannot justify incurring the costs of mitigation in a specific case, operators (and their customers) may need to accept a loss in quality of service, notwithstanding that mitigation might be theoretically possible.

105. HKT has provided evidence where the site rental costs have risen significantly upon renewal of the lease (see Table 4). High site costs limit the level of mitigation that would be practical to implement.

Table 4: Examples of increases in site rental costs following lease renewal

Location	HK$ per Month (each contract for 2 years)
[CONFIDENTIAL]	
[CONFIDENTIAL]	
[CONFIDENTIAL]	

Source: HKT.

106. We believe that the findings of the Plum report cannot be relied upon. The analysis should be undertaken again based on reasonable traffic forecasts in line with independent forecasts and considering the cost and practicality issues that constrain the ability to increase capacity from limited spectrum. Further analysis should also consider how service continuity can be protected by providing for rights of first refusal over spectrum proportionate to each operator's needs (as reflected in their subscriber or traffic shares). To instead provide for a right of first refusal in relation to the same amount of spectrum per operator would fail to recognise: (i) the significant differences in needed capacity between operators as reflected in their market shares and (ii) as shown in the CA's First Consultation (Table 1). HKT's service continuity is at greater risk as it has access to 46% of its total spectrum expiring compared with 38% for SmarTone, 31% for Hutchison and 23% for China Mobile Hong Kong (CMHK).

4.1.3 The CA have previously expressed concerns regarding service continuity of reduced spectrum allocations for existing operators

107. The Plum Report's findings are also surprising in light of the CA's earlier assessment. The 2014 merger to create HKT was approved following a competition assessment by the CA. The approval was given subject to a number of conditions including some spectrum divestment as well as preventing the merged entity from participating in any subsequent 3G auctions for 5 years.[59] In making its decision, the CA stated that any further divestment of spectrum of the merged entity would threaten the viability of meeting long term demand and could therefore jeopardise its ability to provide a service of good quality to its subscribers, to compete effectively in the market, and to fulfil its commitment to honour all pre-existing agreements such as wholesale access agreements and network sharing agreements.[60]

108. The practical impact of the spectrum reassignment proposals mean that HKT could face the loss (in a worst-case scenario) of up to 80-90MHz of spectrum (depending on whether it takes up the offer of 2*10MHz of 1800MHz RFR spectrum). Even the loss of a significant proportion of this spectrum at risk would threaten HKT's ability to compete for new customers and to maintain quality of service, i.e. the very risks that the CA recognised in its 2014 merger decision and that have become even more serious with the growth in mobile data demand.

4.2 Efficient spectrum utilisation

109. The approach to relicensing spectrum can affect the efficient use of spectrum in multiple ways.

110. First, it needs to be recognised that the choice to re-auction spectrum rather than provide for automatic renewal will be likely to lead to inefficiencies in the use of spectrum until future access to spectrum is certain. This is evident from considering an example of the effect uncertainty as to whether spectrum will be renewed has on the incentive to minimise costs (i.e., on productive/technical efficiency).

111. Imagine, for example, an operator that can make an investment in a cost saving process that has an expected payback period of 5 years. In the early part of a hypothetical 15-year licence term the operator will have an incentive to invest in the

59 Part of the remedies required by CA in approving the merger included the two parties to the merger (HKT and CSL) being directed to divest a total of 29.6 MHz of the 3G Spectrum, by not seeking to renew the assignment of and not acquiring spectrum in the frequency ranges of 1920.3 – 1935.1 MHz paired with 2110.3 – 2125.1 MHz, when the assignment of these ranges of 3G Spectrum expires on 21 October 2016 and that that parties to the merger be directed that they shall not participate in any 3G Spectrum auction in Hong Kong for a period of five years from the effective date of the Direction.

60 CA (2014) Final Decision of the Communications Authority – Application for prior consent under Section 7P of the Telecommunications Ordinance in respect of the proposed acquisition of CSL New World Mobility by HKT Limited, paragraph 120, April.

cost saving process as it is expected to pay itself back. However, toward the end of the licence term an operator will need to factor in some prospect that its spectrum will not be renewed (and its investment in the cost saving process will be lost/stranded). Where the expected period required to earn revenues to payback the investment exceeds the remaining life of the licence, the incentive to invest in the cost saving processes will be lower the lower the probability of the licence being renewed.

112. Similarly, operators will be deterred from growing their customer base and using their spectrum more intensely in a period in which they are unsure of whether they will shortly lose their access to that spectrum and hence their ability to provide reasonable quality of service to customers.

113. In this way, allocative and dynamic efficiency are also likely to be harmed. In the case of allocative efficiency, renewal uncertainty distorts investment choices in favour of assets that would not be stranded by spectrum not being renewed. Renewals uncertainty would also distort the timing of decisions to invest in assets (so-called dynamic efficiency). These issues are elaborated on in section 4.4 below.

114. As such, a choice to re-auction some or all of the spectrum will only promote the efficient use of spectrum where it can be expected to lead to a more efficient allocation of spectrum compared with alternative approaches. However, there is no reason to expect re-auctioning to lead to a more efficient allocation of spectrum compared with spectrum trading which provides operators with the ability to trade spectrum if and when they attach different values to acquiring spectrum at the margin.

115. There is also no clear reason to believe that re-auctioning some spectrum would produce gains in efficiency that would offset the loss in efficient use of spectrum in the period until future access is determined. All operators have the incentive to use their existing spectrum holdings efficiently to reduce their network costs and maintain high service quality. While the CA discusses the opportunity to de-fragment spectrum, this does not require an auction but can be implemented administratively. As is noted in the Plum report (p.15), the CA has approved previous applications by MNOs to swap frequencies. As discussed elsewhere in this report, facilitating these types of trade, and the transferability of spectrum more generally, is likely to lead to significantly greater efficiency gains in the long term compared to a presumption of an auction to reassign spectrum (which will distort efficiency).

116. The CA argues that re-auctioning will put the spectrum into the hands of the MNOs or new entrants which value the spectrum the most and hence will put it to the most efficient use. However, as shown in Table 5, the operator that would be likely to value additional spectrum the most (i.e. that has a much highest number of subscribers per MHz than the other operators) is HKT. HKT will be prevented from acquiring additional spectrum in the auction because of the spectrum cap. In other

words, the auction would carry a risk of HKT inefficiently losing some of its spectrum but not provide it with the opportunity to efficiently acquire more spectrum. In this regard, the auction carries risks of harming, not promoting the efficient allocation of spectrum.

Table 5: Spectrum and subscriber shares of Hong Kong operators

	HKT	SmarTone	H3G	CMHK
Ratio of subscriber share to spectrum share	1.53	0.80	0.76	0.96

Source: Based on network operator subscriber shares from Telegeograhy (with MVNO subscribers allocated to the relevant host network) and spectrum shares from Consultation.

117. While there is the potential for the spectrum holdings of the other operators to change hands, it is not clear that this would bring any significant gain in the efficient use of spectrum or would be more likely to promote rather than harm competition. As shown in the table, the spectrum holdings of the other operators are more in line with their subscriber shares. A change in spectrum holdings between operators would risk significant costs in modifying their networks. Operators' site locations are the product of years of effort trying to locate the best locations given their spectrum holdings. Obtaining new sites is costly and can take years including negotiating leases, planning restrictions and the fact that the best site locations are already taken.

118. It may be observed that CMHK does not presently hold sub-1 GHz spectrum. This does not imply that current spectrum allocations are inefficient or otherwise constrain CMHK from competing as it holds proportionally greater allocations of above 1 GHz spectrum. As has been observed in other jurisdictions, operators do not need sub-1 GHz spectrum to compete, particularly in high tele-density areas such as Hong Kong.[61] Therefore the gains from re-allocation of 900 MHz spectrum in favour of CMHK may not be significant. Further, if CMHK were to outbid SmarTone (as is possible given their ratio of spectrum to subscribers), competition may be harmed as the competitiveness of SmarTone would be undermined.

119. The CA has argued that one of the benefits of auctioning two thirds of the re-assigned spectrum is the possibility of new entry. However, as we discuss further in the next section, it is highly unlikely that new entry into the Hong Kong would create a viable long-term competitor. Should spectrum be acquired by an entrant but be poorly utilised then the efficient use of spectrum will be harmed by re-auctioning. As noted in Section 3, Belgium provides a recent example of spectrum being acquired and held by an entrant but without services being launched. Years passed before the spectrum was able to be utilised by the existing operators. It appears that

[61] We discuss Ofcom's statements on this matter in the next section.

a similar situation may be emerging in Hong Kong with the spectrum acquired by 21 ViaNet in 2012. As noted in Appendix E of HKT's submission to the first consultation, the spectrum acquired by ViaNet has not been used to meet critically needed capacity for mobile services in Hong Kong. In 2015, 3 years after the auction, the CA amended the coverage obligations on ViaNet to only provide coverage to 3,000 village houses by 29 March 2017 and 4,000 houses by 29 March 2018. In 21 ViaNet Form 20-F Filing of 21 April 2017, ViaNet notes "*Currently, we plan to incur a small amount of capital expenditure to build the infrastructures in rural areas in Hong Kong by ourselves. However, we may not be able to successfully rollout our network in rural villages in time to meet the requirements of the Hong Kong Communications Authority and the performance bond may be withheld if we fail to successfully fulfill the revised requirements for the fixed wireless license by ourselves.*" Even if ViaNet is able to meet the coverage requirements (which ViaNet acknowledges is unclear), it would still mean that the valuable spectrum is not being used in the densely populated areas of Hong Kong.

120. Finally, the CA could achieve much stronger gains in the efficient use of spectrum through releasing additional spectrum for mobile services, particularly the digital dividend spectrum in the 700 MHz range. As is demonstrated in Table 6, Hong Kong is significantly lagging advanced economies in bringing digital dividend spectrum to market. We understand that the Analogue Switch Off date has already been delayed twice from the original target set in 2004 for 2012 to a 2015 (set in 2011) and in 2014 switchover was further postponed to 2020.

121. It is important to note that this delay has potential harmful ramifications for the reassignment plans for the 900/1800 MHz spectrum. Specifically, the withholding of the digital dividend spectrum creates 'artificial scarcity' for spectrum in Hong Kong (most importantly in the sub-1 GHz spectrum band). This is likely to drive up the cost of spectrum in any auction of the 900/1800 MHz spectrum because operators will be uncertain as to the release of the digital dividend spectrum. In addition, the withholding of that spectrum risks operators making inefficient decision to acquire 900/1800 MHz spectrum when it would be lower cost/more productive to use 700 MHz spectrum.

Table 6: Release of digital dividend spectrum

Country	Spectrum	Auction
North America		
USA	700 MHz	Jan 2003 – Feb 2012
Canada	700 MHz	Jan 2014 – Feb 2014
Mexico	700 MHz	2017 (planned)
Jamaica	700 MHz	Apr 2014
Europe		
France	800 MHz	Jan 2012
Germany	800 MHz, 1.8 GHz, 2.6 GHz	May 2010
Sweden	800 MHz	Mar 2011
Spain	800 MHz, 900 MHz, 2.6 GHz	May 2012
Italy	800 MHz, 1.8 GHz, 2.0 GHz, 2.6 GHz	May 2011
Switzerland	800 MHz, 900 MHz, 1.8 GHz, 2.1 GHz 2.6 GHz	May 2012
United Kingdom	800 MHz, 2.6 GHz	Feb 2013
Denmark	800 MHz	Jun 2012
Poland	800 MHz, 2.6 GHz	Nov 2014
Asia Pacific		
Australia	700 MHz, 2.5 GHz	May 2013
Japan	700 MHz	Jun 2012
Singapore	700 MHz	Early 2017

Source: ITU, various sources

4.3 Promoting effective competition

4.3.1 The evidence shows that Hong Kong's mobile market is already highly competitive

122. Assessing the licensing approach which would best promote competition requires first considering the current level of competition. In a market which is already effectively competitive, there is little scope for further gains in competition. On the other hand, an approach that has the potential to alter the existing competitive dynamics could end up harming the very factors that underlie the competition prevailing in the market.

123. In relation to the CA's objective of promoting effective competition, the CA has stated at the start of its first consultation that "*Hong Kong has one of the most*

*competitive mobile telecommunications markets in the world, with four mobile network operators ("MNOs") serving a population of 7.3 millio*n…" (§1). CA has also previously noted that the Hong Kong retail telecommunications market "*is characterized by the rapid introduction of new products and new and innovative service offerings*."[62]

124. As already discussed, Hong Kong has one of the lowest HHI of any mobile market internationally (see Figure 3).

125. The strength of competition is supported by the 2016 World Economic Forum survey of Digital Readiness which used a range of independent publicly available data sources to rank 139 countries according to several social and economic Digital Readiness Pillars.[63] Table 7 summarises Hong Kong's individual rankings according to a selection of parameters and shows Hong Kong as a leading market in key areas typically associated with effective competition.

Table 7: WEF Digital Readiness, Hong Kong, selected parameters, 2016

Parameter	WEF Hong Kong Ranking (out of 139 countries)
Mobile Network coverage (% of pop)	#1
Affordability – Prepaid mobile cellular tariffs (PPP $/min)	#1
Level of Internet and Telephony competition	#1
Mobile phone subscriptions per 100 pop	#1
Mobile broadband subscriptions per 100 pop	#13

Source: WEF, ITU ICT Indicators Database, ITU World Telecommunication Regulatory Database, World Bank Development Indicators.

4.3.2 There is no evidence that existing spectrum allocations have adversely impacted competition

126. The CA argues that spectrum reassignment will strengthen the competitiveness of more efficient MNOs through spectrum re-distribution.[64] However, there is no

62 CA (2014) *Final Decision of the Communications Authority – Application for prior consent under Section 7P of the Telecommunications Ordinance in respect of the proposed acquisition of CSL New World Mobility by HKT Limited*, April, paragraph 59.

63 World Economic Forum (2016) The Global Information Technology Report 2016 - Innovating in the Digital Economy, p. 107.

64 CA (2017) *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 – Summary of Submission to the First Consultation Paper and responses of the CA and the SCED*, Annex paragraph 19, p. 9.

evidence that the current mix of spectrum allocations is having a detrimental impact on the competitiveness of the market.

127. Differential spectrum allocations across the 4-mobile operators have been a feature of the Hong Kong market for many years. However, this does not appear to have restricted the ability of mobile operators to compete strongly for customers. For example, HKT lost market share between 2014 and 2016 while CMHK gained market share despite the difference in spectrum holdings between the operators (see Table 8). SmarTone continues to have significantly fewer subscribers than CMHK although these operators have similar shares of total spectrum.

Table 8 – Spectrum and subscriber shares for HK operators

	Share of total spectrum	Subscriber share 2014	Subscriber share June 2016
SmarTone	20%	14%	14%
CMHK	21%	18%	20%
Hutchison	23%	23%	22%
HKT	35%	33%	31%

Source: spectrum shares from CA, *Second Consultation,* Table 1 and retail subscriber shares from DBS Research, *Hong Kong Telecom Sector,* 26 January 2016 (p.4) and 25 April 2017 (p.20). MVNO subscriber share not shown.

128. Ofcom in the UK has also noted that across a significant range differences in spectrum holdings do not harm competition. Ofcom state with reference to the UK market where there are 4 credible MNOs that they were comfortable with asymmetric spectrum holdings among MNOs provided no one player holds more than 40% of the total spectrum available and the other players have at least 10-15% of the total spectrum available each (the minimum requirements in Ofcom's view for an MNO to be credible).[65]

129. In relation to its competition assessment and auction rules for the forthcoming allocation of 2.3 GHz and 3.4 GHz spectrum in the UK, Ofcom stated that:

> *"… operators do not need to have the same, or close to the same, shares of spectrum in order for there to be strong competition. This is because:*
>
> - *There is no reason to expect rivals in any market to need the same capacity for competition to be strong. MNOs can have different market shares, may have compensating strengths in other areas (e.g. customer service), or may*

65 Ofcom, *Award of the 2.3 and 3.4 GHz spectrum bands: Competition issues and auction regulations*, November 2016, p. 26-27.

still be able to deliver services to many consumers by choosing commercial strategies that make best use of their capacity.

- *Spectrum is not the only way of adding capacity…*
- *A certain degree of asymmetry in spectrum holdings may reflect differences in operators' commercial strategies and expectations about the future. Such asymmetries may give rise to consumer benefits. For example, an operator that already has a high share of spectrum may use additional spectrum in an innovative way, and an operator that has a lower share of spectrum may find innovative ways of attracting consumers to compensate for its lower share of spectrum e.g. targeting particular consumer or business segments, or offering higher quality in other aspects of service."*[66]

130. In the Hong Kong context, there are 4 credible MNOs and the existing spectrum allocations are within the parameters considered by Ofcom as not raising competition concerns (i.e. between 10-15% and 40%).[67]

131. We also noted that despite CMHK having a smaller spectrum share than HKT, its network is being used to supply low price mobile services. For example, JP Morgan recently highlighted that a fixed broadband provider (HKBN) has partnered with CMHK to provide mobile services:

> *"… a 21Mbps mobile plan in collaboration with CMHK, which is HK$18 cheaper than similar offerings in the market."*[68]

132. There is also no evidence of CMHK's lack of 900 MHz spectrum impairing its ability to offer competitive quality of service. Credit Suisse found that CMHK performed better than most of its rivals in terms of its 4G coverage and equal to HKT in terms of 4G speed.[69]

4.3.3 Efficient entry is unlikely

133. The CA has indicated that one of the benefits of using an auction to allocate reassigned spectrum is the potential for a new entrant and that this would promote greater investment and innovation. However, there is unlikely to be a strong business case for a new entrant into the Hong Kong mobile market.

134. There appears to be no evidence that the current structure of the Hong Kong market has been deficient in offering innovative services to consumers and businesses or

66 Ofcom, *Award of the 2.3 and 3.4 GHz spectrum bands: Competition issues and auction regulations*, November 2016, p.25-26.

67 In particular, in the CA's 2nd consultation paper, the MNO with the highest spectrum allocation is HKT with 35% of total spectrum compared to SmarTone with the lowest (at 20%).

68 JP Morgan (2017) *Telco Rules: US$100 capex = US$7 opex, Telco Conversation : Asian Telco Strategy,* 1 March, p. 26.

69 Credit Suisse report, *SmarTone is the best, Chana Mobile and CSL Tie*, 2013

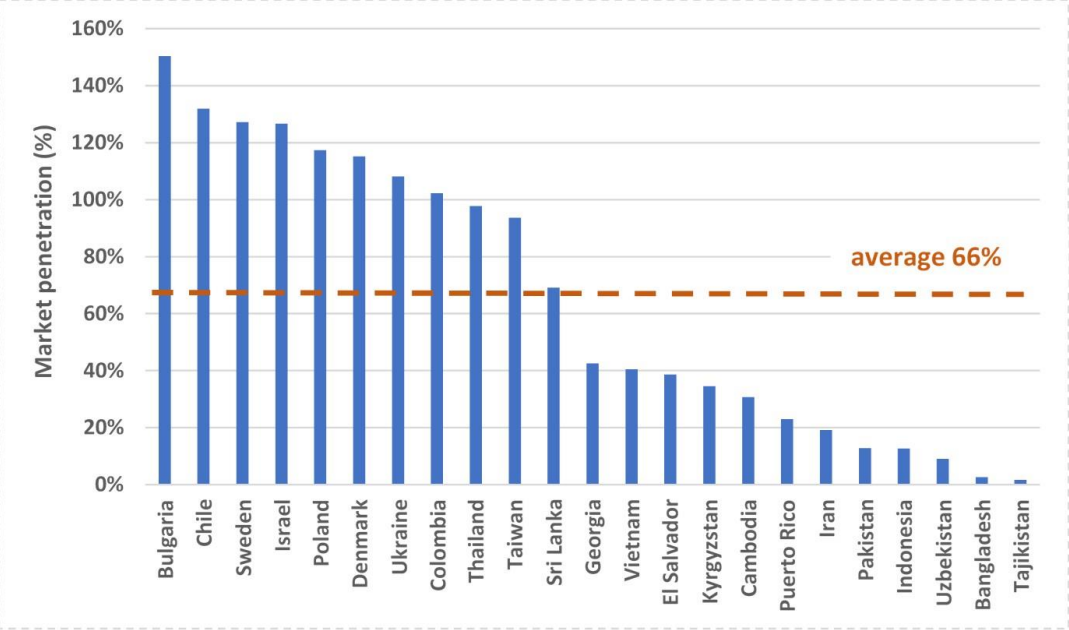
that new entry would usher in improvements in this respect. Moreover, technological innovation in mobile services are increasingly been driven by international equipment suppliers and OTT service providers rather than individual operators, i.e., it typically originates from different parts of the supply chain.

135. In these circumstances, efficient new entry seems highly unlikely. The incumbent players with their existing (sunk) networks are likely to value re-assigned spectrum more highly than any potential new entrant. Entry carries the costs of the need to roll-out a new network and supply a customer base with compatible devices, and appears to offer little opportunity for additional competitive benefits. If entry were to occur, concerns would inevitably arise about the long-term viability of the new firm. The 3G auctions in Europe led to several bidders acquiring licences, who were subsequently unable to develop a viable business case and exited the market. The cost of such failed entry in terms of the under-utilisation of spectrum until it is re-assigned is likely to be greater in the current Hong Kong given the pressing need for spectrum to meet existing and forecast demand.

136. There are few if any precedents for successful new entry of a fifth player into highly penetrated and effectively competitive mobile markets. See Figure 14 which plots the timing of the entry of a fifth mobile player against the penetration rate at the time of entry. As can be seen from the data, where there has been the entry of a fifth mobile player, the average market penetration rate has been below 66%. There are no precedents for the entry of a fifth mobile player at markets as mature as Hong Kong where mobile penetration is over 230%.[70]

[70] CA states in their 2nd Consultation documents that mobile market penetration in Hong Kong currently stands at 230% (see paragraph 66 of the consultation paper).

Figure 14: Market penetration levels at the time of entry of a 5th mobile player.



Source: CEG based on GlobalComms Database

137. In all countries where a fifth operator entered when penetration was above 100%, the fifth operator has now merged with an existing operator or ceased operations. We also note that in no OECD country are there five independent national operators remaining, with the exception of Denmark where a niche operator using 450 MHz spectrum has a market share of 0.2%.[71] This evidence indicates that it would be highly unlikely for a fifth operator to establish itself as a significant competitor in a market as mature as that of Hong Kong. Rather, fifth operators appear to exist in a transition phase in growing markets where players compete strongly for new customers in a bid to become one of the smaller number of operators that remain viable in the longer run.

138. The economics of the 4G and potentially 5G is also likely to mean an increase in the minimum efficient scale for network deployment. For example, 4G/5G networks are likely to require a significant expansion in the number of cell sites to cater for demand. In this scenario, it is more likely that existing operators will be looking to share network infrastructure (including spectrum) and the business case for a new network will be even more difficult to justify.

[71] In Poland, two of the five operators are under shared ownership. In Israel, two operators are in the process of merging. In Canada and the US, there are some operators present in particular regions but only 3 and 4 national operators respectively.

4.3.4 Re-auctioning spectrum actually creates serious risks to competition

139. The proposed re-auctioning of spectrum carries serious risks of undermining the current strong competition in the market.

140. Incumbents may compete and invest less in the run up to the auction due to the uncertainty over future spectrum access. Subscriber acquisition and retention costs are a substantial component of overall operator costs with HKT incurring customer acquisition costs of HK$2.9 billion in 2016 (when HKT's total profit before tax was HK$5.7 billion).[72] Operators will be deterred from competing to acquire additional customers if they cannot be certain that they will be able to supply services to these customers at adequate quality because of the risk of losing access to significant spectrum. Operators may also delay network upgrades because network planning (e.g. site location and the choice of macro, micro and pico cells) is heavily dependent on the nature of an operator's future spectrum holdings. Competition will be harmed to the extent that operators refrain from launching competitive new retail offers to attract customers or compete less strongly on quality of service by postponing investments.

141. In addition, given the large amount of spectrum that will be available at auction (somewhere between 160 MHz and 200 MHz), there is the danger that the auction results in a re-arrangement of spectrum holdings which undermines the existing vigorous competition in the market. Critical to an operator's ability to make competitive offers are the costs faced by the operator in acquiring new customers and supplying additional services. If an operator is deprived of spectrum when it is already constrained by spectrum holdings that are small relative to its existing customer base, then it will face higher costs in supplying additional volumes and may have to withdraw existing offers from the market, increase prices or compete less vigorously in other ways.

142. Although the operator that acquires additional spectrum from its competitors would see its costs go down, it need not pass-through cost reductions into its prices. In particular, with less competitive pressure from the operators which face higher costs after the loss of their spectrum, an operator gaining spectrum may choose to retain lower costs as higher profits or only marginally undercut the prices of its rivals.

143. The risks to service continuity discussed in the earlier section may also alter the competitive dynamics in the market by potentially threatening operator's reputation. A deterioration in an operator's quality of service can have long lasting impact on its brand and weaken the competitive constraint it imposes on rival operators.

144. A further way in which an auction may undermine the existing competitive dynamics is through the price paid for the spectrum at auction. The European 3G

[72] HKT Annual Report 2016, p.123.

auctions resulted in operators being saddled with high debt levels which ultimately led to consolidation. Further, high debt levels can reduce operators' ability to fund investment or raise the cost of raising additional funds which itself acts to curtail investment.

145. Hong Kong's mobile market is already highly competitive. The CA's proposals have a real risk of undermining the market structure and market factors including current pricing, quality of service and investment levels that support the current vigorous competition.

4.3.5 Releasing more spectrum to the market and allowing trading would be superior to Option 3 (the hybrid approach) in supporting effective competition

146. Even if the CA believes that the market could support additional competition, releasing additional spectrum for mobile services would make additional spectrum available to existing and any potential new operators without creating the costs to service continuity, efficiency and investment of re-auctioning some of the spectrum.

147. Additional spectrum would help address capacity issues in the market as well as provide existing operators with the ability to optimise their spectrum holdings and compete more effectively in the market in delivering new and existing services to end-users. We note that analogue TV spectrum is likely to be available from end 2020 (Plum p.17). Plum Consulting assumes spectrum re-assignment would occur in 2021 so 700MHz would be available around the same time as the auction for re-assigned spectrum.

148. Plans for the allocation of this spectrum could be developed and announced prior to the finalisation of the auction of re-assigned spectrum. This would help promote effective competition by providing operators with greater certainty of future spectrum allocations. Greater certainty on spectrum release will also allow operators to plan more effectively for new infrastructure investment. This is crucially important in a market such as Hong Kong which is spectrum constrained on the supply side but with anticipated strong growth.

149. The publication of forward guidance about the medium-term plans for spectrum release should also be pursued. This is now a common practice by regulators such as Ofcom.[73] Forward guidance provides the industry with information on the plans for future spectrum release even in areas where time is needed to clear the band. There are several clear benefits to issuing forward guidance including providing the industry with greater information to plan for future network investment and the development of its technology roadmap.

73 See for example, Ofcom's recent publication: *Mobile Data Strategy*, 2016

150. In parallel, we see value in introducing measures to allow spectrum trading. This will have several economic benefits (as previously discussed). From a competition perspective, it will allow operators to buy and sell existing allocated spectrum when the need arises. Operators which face growing demand would have a relatively high value for additional spectrum and thus could offer to acquire the spectrum from operators that obtain less value from the spectrum. In this way, the competitive dynamics in the market could be enhanced.

151. An alternative to trading that also facilitates mutually beneficial exchanges of spectrum is a dual-sided auction. The FCC recently undertook a dual-sided incentive auction (see Box below). In essence, the FCC created a market place for spectrum that would result in voluntary exchanges of spectrum where the willingness to pay for spectrum exceeded the value to existing users. The auction process involved the FCC conducting a reverse auction to determine the willingness of existing users to give up their spectrum, followed by a forward auction to determine the willingness of operators to pay for that spectrum. The process run through iterations until the market cleared. The processes also included measures to deal with spectrum fragmentation and a final auction phase to assign specific spectrum blocks to those operators who valued them most highly. Such auctions are relatively complex to run and would seem to have an advantage over trading mainly where the auction would overcome coordination issues that would otherwise make it difficult for potential acquirers of spectrum to be confident of obtaining sufficient spectrum to viably offer services, even where they have the highest value for the spectrum.

Box 1: The FCC dual-sided incentive auction

Secondary market auction

In the US, the Federal Communications Commission (FCC) completed in March 2017 an innovative dual-sided incentive auction to reallocate spectrum away from the broadcast TV industry for mobile broadband. The former FCC chief commented: "*We were charged with creating a marketplace and that marketplace successfully performed to produce the second largest amount of spectrum ever auctioned; and to do so by reallocating spectrum to its highest and best usage as determined by the market.*"[74]

In addition, the FCC noted that allowing TV broadcasters to sell their unused spectrum licences would also benefit consumers:[75]

74 FierceWireless 22 March 2017 (Available at: http://www.fiercewireless.com/wireless/former-fcc-chairman-wheeler-has-a-huge-smile-for-600-mhz-incentive-auction-results).

75 FCC, Broadcast Incentive Auction, April 2017. Available at: https://www.fcc.gov/about-fcc/fcc-initiatives/incentive-auctions

> *"The auction preserves a robust broadcast TV industry while enabling stations to generate additional revenues that they can invest into programming and services to the communities they serve. And by making valuable "low-band" airwaves available for wireless broadband, the incentive auction will benefit consumers by easing congestion on wireless networks, laying the groundwork for "fifth generation" (5G) wireless services and applications, and spurring job creation and economic growth."*

The auction raised $19.8 billion, of which $10.05 billion was allocated to winning broadcast bidders in the reverse auction, $1.75 billion was allocated for reimbursing involuntarily repacked broadcasters, and the remaining >$7 billion was provided to the US Treasury. In total, 84 MHz of spectrum was repurposed, with 70 MHz being diverted to licenced use and another 14 MHz to wireless microphones and unlicensed use.

Reverse and forward auctions

The FCC's broadcast incentive auction featured two "separate but interdependent" auctions that are analogous to the market process of matching demand with supply.[76] The process involves iterating through the following three steps: reverse auction; forward auction; and repacking.

In the reverse auction, broadcasters bid to voluntarily relinquish their spectrum usage rights by underbidding one another with lower prices, which is analogous to establishing the "supply" of spectrum available.

In the forward auction, mobile broadband providers bid for flexible use wireless licences by outbidding one another with increasing prices, which is analogous to establishing the "demand" or willingness to pay for the licences.

The auctions are then paired with a "repacking" process in which channels are reorganised and assigned in order to create contiguous blocks of cleared spectrum that are suitable for flexible use.

The process is initialised in the first iteration by running a reverse auction with a spectrum clearing target that is set at the highest level possible (up to 126 MHz). The reverse auction determines the total amount of payments that must be paid to broadcasters in order for that amount of spectrum to be cleared. This is followed by the forward auction, which determines the corresponding total amount that mobile operators are willing to pay when that level of spectrum is available.

The "final stage rule" is used to determine the end of the incentive auction. The rule consists of two components that must both be met:

i. Either:

[76] FCC, How It Works: The Incentive Auction Explained, February 2017. Available at: https://www.fcc.gov/about-fcc/fcc-initiatives/incentive-auctions/how-it-works

a. Average price for low impairment licences in the forward auction is greater than or equal to $1.25/MHz-pop at a 70 MHz cleared benchmark; or

b. spectrum clearing target at the stage exceeds 70 MHz and total proceeds of the forward auction exceeds $1.25/MHz-pop × 70 MHz × total pops for high-demand Partial Economic Areas with at least one category 1 block.

ii. The total proceeds from the forward auction is sufficient to meet the mandatory expenses set out in the Spectrum Act.

If the "final stage rule" is satisfied at any point, then the incentive auction will close at the end of the forward auction in that iteration. Otherwise, the incentive auction will continue with a further iteration of bidding, but with lower spectrum targets and lower spectrum available in the reverse and forward auctions respectively. An assignment stage was then used with the winners from the incentive auctions bidding for specific blocks equal to the number of blocks that they had won in the incentive bidding auction.[77]

4.4 Encouraging investment and promoting innovative services

152. The CA is also tasked with encouraging investment and promoting innovation. However, it is important to clarify that satisfying this objective is not simply a matter of supporting spectrum management decisions that maximise absolute levels of investment. The welfare of Hong Kong citizens is maximised when investment decisions, including the investment mix, the timing of investment and the magnitude of investment are 'efficient'.

153. The CA states:

> *"If part of the re-assigned spectrum is taken up by new entrants, they will need to make investment to build networks from scratch and put the spectrum to use in a timely manner."*

154. However, investment in new networks will be inefficient if it duplicates existing investment without yielding benefits to consumers such as in product differentiation or lower prices.[78] Given that no additional spectrum is planned to be

[77] See: FCC, Incentive Auction Dashboard – Assignment Phase – Bids. Available at: https://auctiondata.fcc.gov/public/projects/1000/reports/assignment-bids

[78] See. Mankiw, G.N. and Whinston M.D., (1986) "Free Entry and Social Inefficiency" *The RAND Journal of Economics*, Vol. 17, No. 1 (Spring, 1986)

released into the market in the short-to-medium term, there is even stronger arguments to favour investments focused on improving customer experience. Instead, the CA risks future finite investment resources being spent on mitigating the loss of spectrum and/or stranded assets rather than delivering higher quality of service to customers.

155. At present, existing networks will have been deployed to make maximum use of existing spectrum holdings, with site locations selected to provide the competitive levels of indoor and outdoor coverage and sufficient radio resources to meet demand. Operators will optimally locate base stations and configure antenna to provide required capacity and coverage at minimum costs given their specific spectrum assignments. There is a risk that with a different spectrum allocation their existing site locations may be sub-optimal and operators may be left with coverage gaps. To the extent that operators' investment budgets are redirected towards adapting their network to different spectrum holdings, this is potential capital expenditure on improving network quality that is lost.

156. The problems created by the proposals can be illustrated by considering investments in site locations. To cost effectively meet service quality requirements, operators must optimise existing site locations to provide the competitive levels of indoor and outdoor coverage and sufficient radio resources to meet demand. Operators will optimally locate base stations and configure antennae on the basis of their specific spectrum assignments. Operators aim to provide required capacity and coverage (with minimal coverage gaps) at lowest cost. This is particularly complex in relation to 3G because of:

- cell breathing in which the effective coverage of a cell decreases the greater the traffic load carried by that cell; and
- rapidly growing demand, which is also uneven across the network as new services increase demand for capacity amongst particular customer segments and at particular times.

157. In this context, uncertainty over whether an operator will retain a significant portion of its existing 900/1800MHz spectrum does not simply impact on investments in marginal capacity expansions but also on fundamental network planning. If an operator were to invest on the expectation of retaining a similar amount of spectrum currently held, only to subsequently fail to do so, it would be forced to decide whether to:

- incur large coverage gaps for excessive site numbers compared with the optimal site location for that spectrum assignment; or
- to incur the cost of decommissioning its existing sites, negotiating new site rental agreements and physically re-locating its sites.

158. Faced with these risks, operators are likely to:

- hold back on new network investments for as long as possible (with adverse consequences in terms of reduced service quality) and avoid reducing prices so as not to stimulate additional demand; and
- limit its capital expenditure to critically needed investments, which may turn out to be sub-optimal once final spectrum assignments are known with the consequence of higher ongoing costs of service provision.

159. CA's proposals would have adverse impacts on the objective of encouraging efficient investment. In particular, as a result of CA's proposals, no existing operator can now be confident over what amount of 900/1800 MHz spectrum they will have after the allocation of reassigned spectrum is complete. Nor will they know the spectrum of rival operators. This regulatory uncertainty will continue until the outcome of the allocation of RFR and auctioned spectrum is known, several years from now. This is at a time when rapidly growing demand can be expected to require significant new network investment as well as pressure on operators to continue to upgrade existing technology to achieve faster data rates.

160. We note that the CA does recognise, as a "beside", that new entrants may "potentially" offer more innovative services, but this would be far from probable in an already highly competitive environment. The table below shows the history of innovation in the Hong Kong market over the past 15 years. It demonstrates there has been rapid deployment of the latest technologies in Hong Kong following the 2001 award of 3G licences to four successful bidders: Hong Kong CSL Limited, Hutchison 3G HK Limited (H3G), SmarTone 3G Limited and SUNDAY 3G (HKT) Limited.

Table 9: Technology launch history in Hong Kong

Year	HKT	CSL	Other MNOs (H3G, SmarTone and China Mobile)
2004		3G service	H3G and SmarTone 3G service
2005	3G service		
2006	HSDPA 3.6Mbps Mobile Broadcast Service	Launch of HSDPA 3.6Mbps	H3G and SmarTone HSDPA 3.6Mbps
2007	HSPA (U/D) 7.2/2Mbps		H3G and SmarTone HSPA (U/D) 7.2/2Mbps
2008			SmarTone HSPA (D/U) 14.4/5.76 Mbps
2009	HSPA 21Mbps 1st 3G FemtoCell Deployment	HSDPA 21Mbps HSUPA 5.76Mbps U900	H3G and SmarTone HSDPA 21Mbps
2010	HSPA DC-42Mbps	DC-HSDPA 42Mbps	SmarTone DC-HSPA 28.8Mbps
2011	L2600 service using MOCN Shared eRAN of GBL	LTE 100Mbps HD voice on 3G LTE roaming trial with Telstra	SmarTone DC-HSPA 42Mbps
2012		LTE roaming with SK Telecom	H3G DC-HSPA 42Mbps H3G and SmarTone LTE1800 China Mobile LTE2600 (FDD) and LTE2300 (TDD)
2013	3G Network Sharing to China Mobile using MOCN eUTRAN 20MHz BW at L2600	VoLTE LTE Roaming with Telstra LTE2600 (20MHz) 150Mbps	
2014	20MHz BW at LTE1800 3MHz BW at LTE900 VoLTE Service eSRVCC Multi Operator Core Network (MOCN) LTE-A 2CC Carrier Aggregation 300Mbps		
2015	LTE-A 3CC Carrier Aggregation Demo LTE 1Gbps Demo		China Mobile LTE-A 2CC CA (TDD+TDD) SmarTone LTE-A 3CC CA H3G LTE-A 2CC CA (FDD+TDD)
2016	LTE-A 3CC Carrier Aggregation 450Mbps LTE 1Gbps Network Ready (4x4MIMO, 256QAM, 3CC CA)		China Mobile LTE-A 3CC CA (FDD+TDD+TDD) H3G launched LTE-A 3CC CA (FDD+FDD+TDD)
2017	VoWiFi		

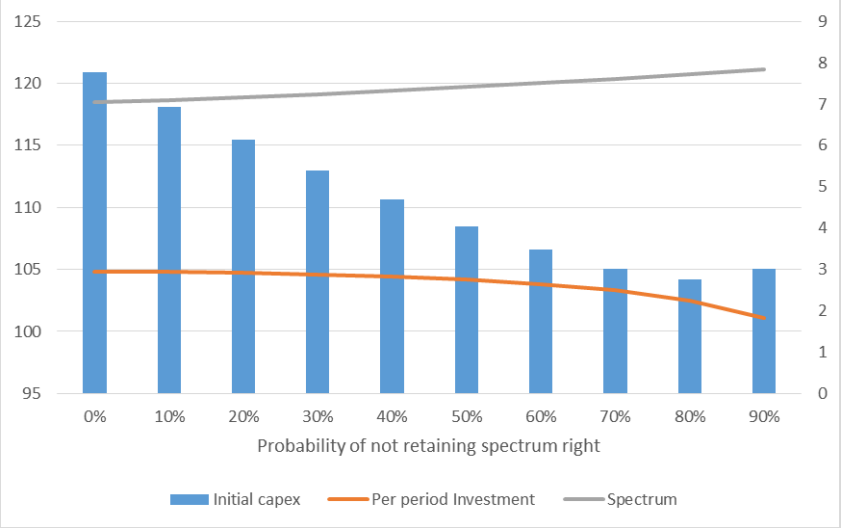
Source: HKT (accuracy subject to other operators' confirmation)

4.4.1 Relationship between uncertainty and investment

161. As shown in section 3, international evidence indicates that the uncertainty created by re-auctioning risks investment being delayed until future access to spectrum is clear. We have developed a stylised model, detailed in Annex A to demonstrate this relationship between an operator's choice of the quantity of spectrum to lease versus investment in infrastructure when the firm faces a probability of losing the spectrum in the future.

162. Within the model, the hypothetical operator chooses the optimal level of spectrum to lease and capital expenditure each period to maximize the net present value of its expected future profit. As shown in Figure 15, as the probability of losing access to spectrum increases, the operator substitutes away from infrastructure investment and towards spectrum acquisition, thereby reducing their potential for stranded assets.

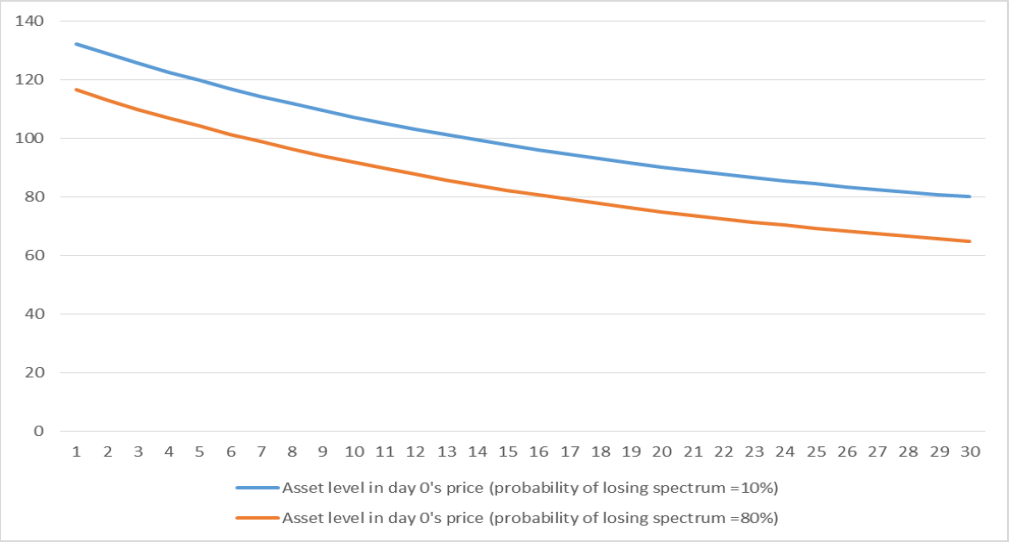
Figure 15: Trend in firm choices as probability of losing access to spectrum increases



Source: CEG Analysis. Assumptions: each contract lasts 15 periods. Inflation is 2%. Depreciation is 5%. Discount factor is 3%. γ is 20%. α is 200. β is 30000. TFP is 100.

163. On average, our model finds that the spectrum quantity purchased increases by 1.21% for every 10 percentage point increase in the probability of losing access to spectrum. In addition, the initial capex decreases by 1.59% and investment per period decreases by 5.1% for every 10 percentage points increase in the probability of losing access to spectrum. This implies that firms are relying on spectrum quantity as a replacement for lower levels of infrastructure to ensure service continuity. As shown in Figure 16, this lower investment, both initially and per period results in a reduced volume of network infrastructure in all model periods.

Figure 16: Asset level under different probabilities of losing spectrum



Source: CEG Analysis. Assumptions: each contract lasts 15 periods. Inflation is 2%. Depreciation is 5%. Discount factor is 3%. γ is 20%. α is 200. β is 30000. TFP is 100

4.4.2 Relationship between high prices and investment

164. High upfront costs in the form of spectrum prices may also impact investment:

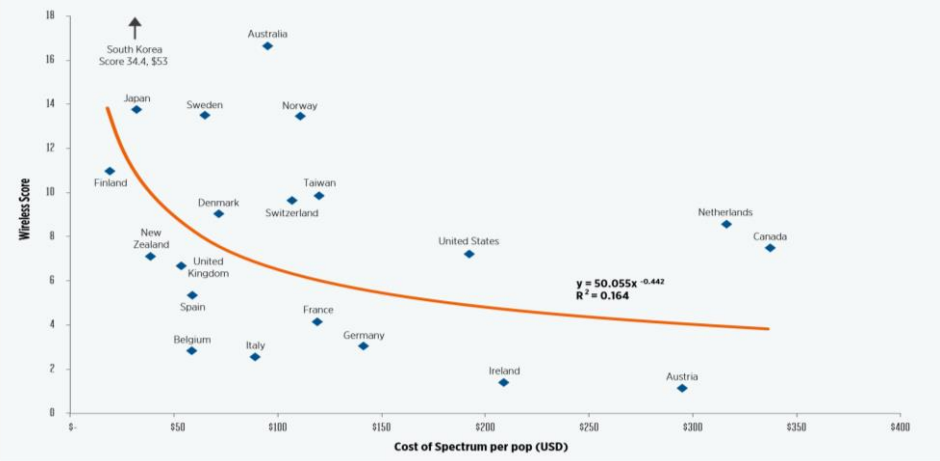
- Given the repeated nature of spectrum awards, the risk of future high spectrum prices will reduce the operator's expected return on investment, resulting in lower investment.
- The more debt or other capital that an operator needs to raise, the higher the cost of capital which will further curtail investment levels.

165. A GSMA study[79] found evidence that supports the relationship between high spectrum prices and reduced investment in mobile networks. As shown in Figure 17, they found a correlation between low spectrum costs and a high wireless score, a proxy for investment parameter.[80]

79 GSMA (2017), *Effective Spectrum Pricing: Supporting better quality and more affordable mobile services*

80 GSMA's wireless score is a proxy for an investment parameter calculated using data on 3G/4G coverage, 4G subscribers and average network speeds.

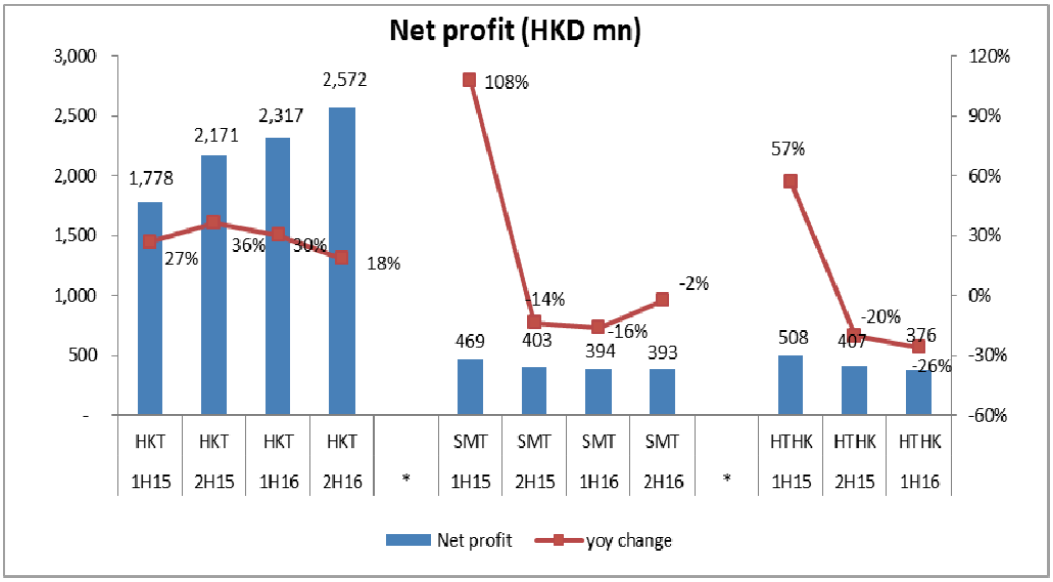
Figure 17: Relationship between spectrum costs and wireless score in high income countries as identified by GSMA



Source: GSMA (2017), Effective Spectrum Pricing: Supporting better quality and more affordable mobile services

166. Therefore, the risk of elevated spectrum prices resulting from an adoption of an auction approach to spectrum renewal, as occurred in Germany and India, may supress investment in the Hong Kong mobile market. The risk to investment is exacerbated by the low profitability of the Hong Kong operators. J.P. Morgan, in a recent note, have highlighted concerns about recent variable (and falling) profitability (see Figure 18).

Figure 18: HK operators Net Profit, 2015-2016[81]



Source: JP Morgan and Companies

4.5 The importance of a rigorous Regulatory Impact Analysis

167. Leading international authorities recognise that sound policy-making requires a rigorous identification and evaluation of the likely effects of significant regulatory proposals.

168. The European Commission requires that all Commission initiatives that are likely to have significant economic, environmental or social impacts be subject to a thorough Impact Assessment. The EC's Guidelines note that:

> *"Good regulation starts with good planning…An impact assessment must identify and describe the problem to be tackled, establish objectives, formulate policy options and assess the impacts of these options… An impact assessment should be comprehensive, proportionate, evidence-based, open to stakeholders' views, unbiased, prepared collectively with relevant Commission services, embedded in the policy cycle, transparent and of a high quality."*[82]

169. The UK regulator, Ofcom, also recognises that Impact Assessments are a key part of best practice policy-making. Ofcom states:

81 JP Morgan (2017) *SmarTone (315 HK) - The pain goes on in a tough mobile market,* 16 February, p. 2.

82 European Commission, Best Practice Guidelines, 2015, pages 6, 10 and 18 (http://ec.europa.eu/smart-regulation/guidelines/docs/swd_br_guidelines_en.pdf).

"In developing policy proposals, our aim will be to think widely about the possible impacts, taking account of the whole value chain and knock-on effects across the communications sector. By doing so, we will seek to minimise any unintended consequences.

An Impact Assessment is an essential part of considering different options for regulation, including alternatives to formal regulation, and then, using objective criteria, selecting the best option. Subject to the principle of proportionality, an Impact Assessment will generally:

• identify the impacts of each option on the interests of particular groups of stakeholders;

• identify any impacts which each option would have on competition;

• identify and, where possible, quantify the costs and benefits flowing from the impacts which each option would have;

• assess the key risks associated with each option."[83]

170. We believe that the analysis put forward to support the CA's proposals fall short of the requirements of an Impact Assessment set out in the guidelines of the European Commission and Ofcom. Following are key deficiencies:

- The CA's proposals to take-back and re-auction most of the spectrum are not based on a rigorous identification of any problem in the market. Hong Kong's mobile market is already highly competitive. It is also doubtful that the proposals could lead to a more efficient allocation of spectrum. The operator that currently has little spectrum relative to the size of its customer base is HKT and HKT is prevented from acquiring additional spectrum in the auction (although it is vulnerable to losing some of its spectrum).
- The analysis of likely effects of the proposals is incomplete with important effects ignored while weight is given to other effects which are unlikely to be relevant given the market context. Plum states in its analysis of service continuity that it has not considered the cost of mitigation and its conclusions are at odds with other evidence including the analysis of international spectrum authorities of additional spectrum required, of current evidence of capacity issues in HK affecting quality of service and the CA's earlier statement of HKT's spectrum needs. Little consideration has been given to the harm to the efficient use of spectrum, competition and investment in the period before future usage is clarified. New entry in Hong Kong's market is unlikely nor would it be sustainable. The analysis of investment focuses on the amount of

83 Ofcom, Better Policy Making – Ofcom's approach to Impact Assessment, 2005.

investment rather than whether investment created by a change in spectrum use would be efficient and bring benefits to consumers.

- The CA has not identified the range of alternative options to meet its objectives including administrative re-assignment of some spectrum to address current fragmentation nor does the CA give proper consideration to the introduction of trading as an alternative to its proposals.
- The failure to present all key effects and key alternative options in the Consultation is likely to limit the responses received on the consultation by stakeholders. Even relatively informed stakeholders cannot properly comment on the analysis of the Plum report given the level of redactions.
- The CA has not shown that any benefits from its proposals would outweigh the real costs and risks they give rise to.

5 Concluding remarks

171. In this paper, we have examined the likely outcomes of proposals to reassign 900 MHz and 1800 MHz spectrum upon expiry of existing assignments Our analysis indicates that there is an overwhelming case against using an auction process to allocate this spectrum.

172. We find that CA's preferred option is more likely to harm competition, investment and innovation, since:

- As the CA has acknowledged, the market is already highly competitive;
- there is no reason to expect that any new entry will be efficient or would deliver better consumer outcomes; and
- consolidation of spectrum by one or two operators would weaken the competitive constraint imposed by other operators and be likely to lead to higher prices than would have occurred had existing spectrum assignments been retained.

173. Significant service degradation is likely to occur and there are also clear risks of deterring investment and/or causing inefficient investment.

174. Against these significant costs and risks, potential benefits from re-auctioning spectrum are speculative and, even were they to occur, they are likely to be of much smaller magnitude than the costs. For example, although it is theoretically possible that auctioning may result in increased spectral efficiency, this is unlikely in practice given that:

- More spectrum for one player means less for another;
- the operator which has little spectrum relative to its customer base is HKT and HKT is prevented from acquiring additional spectrum; and
- international experience suggests that larger spectrum allocations do not outweigh the impact of a loss of competition in terms of consumer outcomes.

175. The Second Consultation appears to rely on its proposals delivering benefits because they are 'market based'. The proposed approach is, however, more akin to a 'command and control' regime. There are few actual markets in which a critical input is forcibly removed from existing market players. Such extreme market intervention is likely to only be justified in exceptional circumstances where there is a dominant player that has prevented the development of competition and where there exists no less disruptive alternative to achieve competition. The benefits of a market-based approach would actually be achieved by enabling spectrum trading.

176. There are several reasons as to why the proposed auction cannot be relied upon to achieve greater efficiency or competition:

- One clear risk is that spectrum bidding and the auction outcomes are driven by an expected diminution of competition from spectrum consolidation. Such an outcome could result in less competition and higher prices to consumers.
- All auctions carry the risk of flaws in the auction design and/or bidding behaviour which would give rise to inefficient outcomes.

177. The Hong Kong mobile market is currently working well with consumer outcomes amongst the best in the world. The CA's proposals offer little realistic prospect of benefits while they carry serious risks to investment, service quality and competition. We recommend that the CA should instead provide for the full renewal of the licences of the relevant spectrum to the existing spectrum holders. The CA should also support the efficient use of spectrum through releasing more spectrum to the market, allowing for trading and publishing forward guidance on medium-term plans for spectrum release.

Appendix A Investment modelling

178. This appendix describes CEG's model of the behaviour of a hypothetical telecom operator in determining the quantity of spectrum to lease versus investment in infrastructure when the operator faces a probability of losing the spectrum in the future (renewals uncertainty).

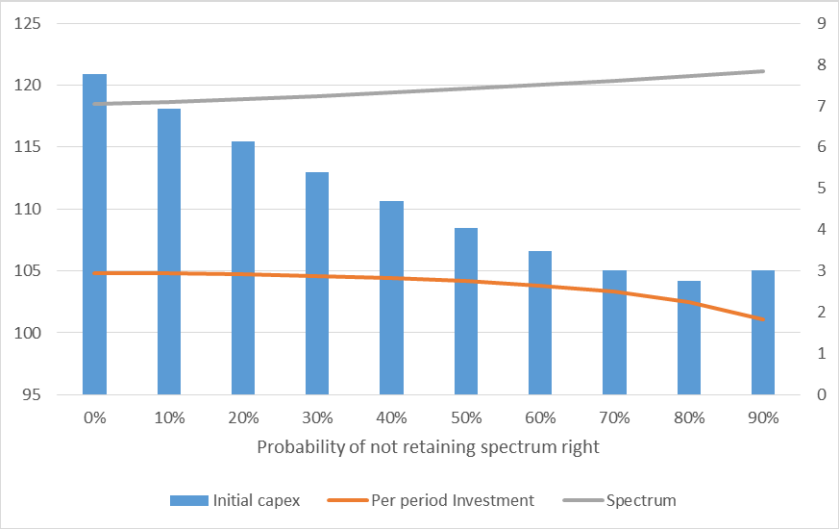
179. Within the model, the operator chooses the optimal level of spectrum to lease and its capital expenditure in each model period in order to maximize the net present value of its expected future profit. The operator may substitute between the quantity of spectrum it acquires and capex in order to achieve maximum efficiency. However, the operator risks losing access to the spectrum when the current licence period ends, in which case its physical assets may become partially stranded.

180. Whilst stylised, the model demonstrates the real-world trade-offs that mobile operators face in light of uncertainty regarding the renewal of spectrum. If spectrum is not renewed a portion of the value of existing assets will be stranded due to those assets needing to be reconfigured to use alternative spectrum. The direct cost of reconfiguring assets and any reduction in revenues from those assets represents a form of asset stranding.

A.1 Model results

181. The result, illustrated in Figure 19, shows that as the probability of losing access to the spectrum increases, the operator is likely to acquire more spectrum as a substitute for expenditure on physical assets. This is a consequence of the expected loss from stranded physical asset increasing as the probability of losing spectrum increases, thereby increasing the marginal cost of investing in physical assets compared to leasing additional spectrum.

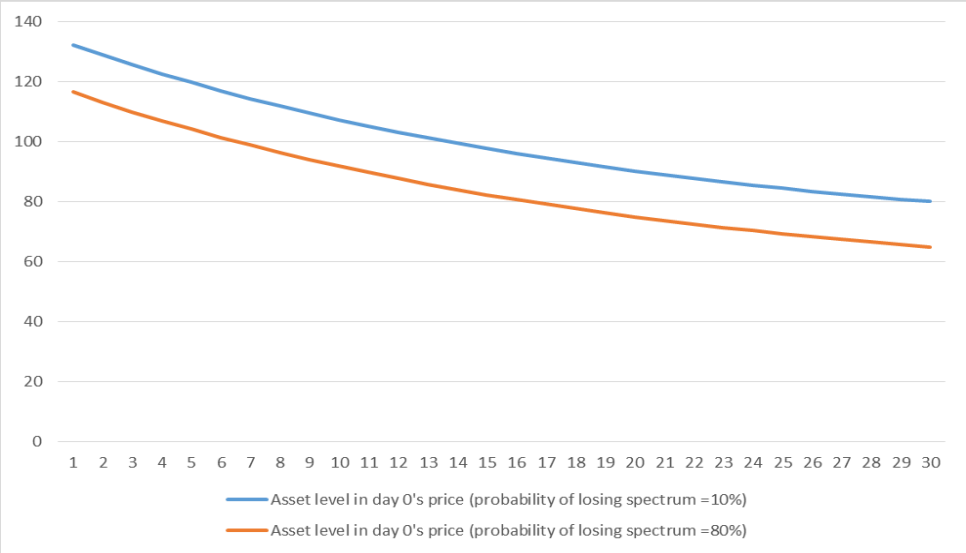
Figure 19: Trend in firm choices as probability of losing access to spectrum increases



Source: CEG Analysis. Assumptions: each contract lasts 15 periods. Inflation is 2%. Depreciation is 5%. Discount factor is 3%. γ is 20%. α is 200. β is 30000. TFP is 100

182. On average, the model shows that the quantity of spectrum purchased increases by 1.21% for every 10 percentage point increase in the probability of losing spectrum at renewal, while the operator's initial capex decreases by 1.59% and investment in physical assets per period decreases by 5.1%. This implies that the operator is relying on spectrum quantity as a substitute for lower levels of infrastructure to ensure service continuity for its customers. As shown in Figure 20, the reduction in both initial investment and investment per period indicates a lower level of infrastructure in all model periods.

Figure 20: Asset level under different probability of losing spectrum



Source: CEG Analysis. Assumptions: each contract lasts 15 periods. Inflation is 2%. Depreciation is 5%. Discount factor is 3%. γ is 20%. α is 200. β is 30000. TFP is 100

A.2 Modelling approach

183. The model covers two spectrum licence contract periods, with each licence period lasting n years. At the beginning of the first licence period, the hypothetical operator chooses how much $Spectrum$ it wants to acquire and its capital expenditure in each modelled year. After the end of the first licence period, the operator has a probability of not renewing its spectrum. If it loses the spectrum, it will dispose its remaining assets at a discount. If it does not lose the spectrum, it will continue to invest and receive income until the end of the second licence period.

184. When an operator is acquiring spectrum, its revenue is dependent on the amount of spectrum and its asset level in that period. Its cost per licence period is the investment capex plus the cost of spectrum licence. Hence, its profit can be written as follows.

$$Profit_t = Rev_t(Spectrum, Asset_t) - Investment_t - Spectrum\ Fee_t$$

In the initial period, at date 0, the initial investment is labelled as initial capex, therefore the profit function is:

$$Profit_0 = Rev_0(Spectrum, Asset_0) - Initial\ Capex - Spectrum\ Fee_0$$

A.2.1 Spectrum choice

185. The operator chooses the optimal quantity of spectrum at the beginning of the first licence period. This quantity remains fixed until the end of the second licence period unless the firm loses the spectrum licence. The continued use of the spectrum requires a payment each year. The amount paid varies according to the spectrum bandwidth and is adjusted according to inflation.

$$Spectrum\ Fee_t = Spectrum \times (1 + inflation)^t$$

A.2.2 Assets and investment choice

186. In the initial period, period 0, the operator chooses its initial capital expenditure:

$$Asset_0 = initial\ capex$$

For every modelled year thereafter, the assets depreciate based on a perpetual depreciation approach. The operator additionally has scope to invest further in its network in every modelled year, increasing the network asset value.

$$Asset_t = Asset_{t-1}(1 - Dep)(1 + \text{Inflation}) + Investment_t \text{ for } t > 0$$

187. We have made the simplifying assumption that the operator chooses a single investment level for every modelled year, denoted as $Invest$, allowing actual investment to increase at the rate of inflation.[84]

$$Investment_t = Invest \times (1 + inflation)^t$$

A.2.3 Revenue

188. The revenue function[85] depicts the operator's earnings in a period as a function of the size of its asset and the quantity of spectrum leased, again this varies in line with inflation.

$$Rev_t(Spectrum, Asset_t) = Rev(Spectrum, Asset_t) \times (1 + inflation)^t$$

189. In order for the revenue function to reflect the nature of the telecommunication industry, the following assumptions have been made:

- The operator may opt to serve the market by increasing spectrum bandwidth and reducing infrastructure levels; or increasing infrastructure while reducing spectrum bandwidth. However, the two inputs are not perfect substitutes and spectrum cannot perfectly replace infrastructure or vice-versa.

84 Only applies to $t > 0$, since the investment in the first period, to $t = 0$, is the initial capex.

85 Alternatively, this can be treated as the net revenue function after operating expenses.

- When the quantity of spectrum bandwidth and network assets is low, the revenue function is convex. In order for the firm to begin generating revenue it needs to reach a minimum scale of operation. This reflects the behaviour of the industry in which an operator with limited spectrum or infrastructure finds it difficult to attract customers and generate revenues.
- When the quantity of bandwidth and network assets is high, the revenue function is concave, ensuring that an optimal spectrum and asset level exists. Without this condition, the profit level is strictly increasing on the level of spectrum and asset. This condition additionally reflects market behaviour in which the operator's revenue growth rate decreases as its size increases.

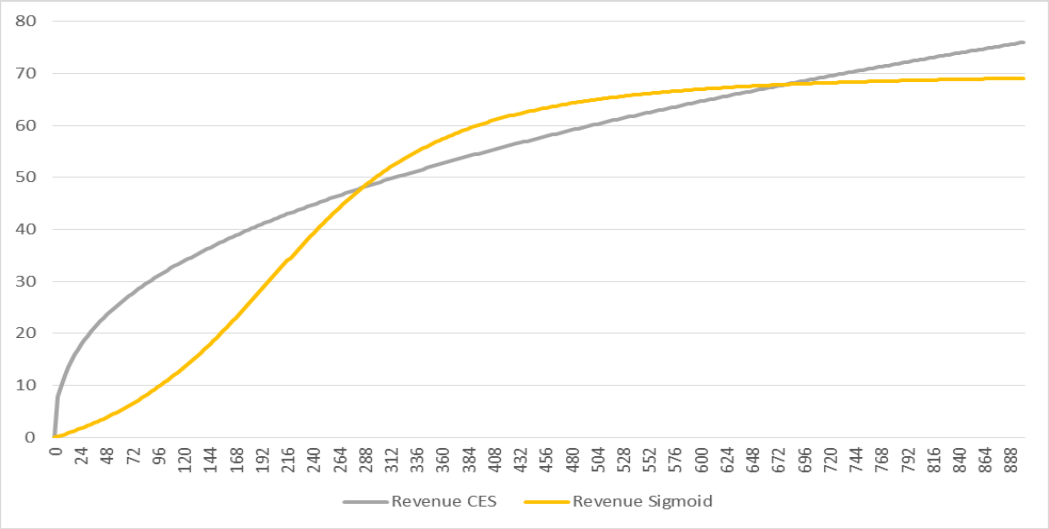
190. Due to the assumptions made in modelling the revenue function, a sigmoid function form is used to represent the revenue curve. The function is:

$$Rev(Spectrum, Asset_t) = \text{TFP}\left(\frac{\left(\frac{Asset_t \times Spectrum}{(1+inflation)^t} - \alpha\right)}{\sqrt{\beta + \left(\frac{Asset_t \times Spectrum}{(1+inflation)^t} - \alpha\right)^2}} + \frac{\alpha}{\sqrt{\beta + \alpha^2}}\right)$$

191. $\frac{Asset_t}{(1+inflation)^t}$ is deflated to remove the price impact on the size of the operator's infrastructure. α and β are parameters that affect the shape of the revenue function.

192. Figure 21 below compares a sigmoid curve against a curve for Constant Elasticity of Substitution (CES). It shows that, with the modelled approach, the fastest rate of revenue growth does not necessarily have to occur at 0 level of infrastructure or spectrum . The use of a CES curve would restrict the fastest rate of revenue growth to occur at the lowest level of infrastructure or spectrum. This does not reflect the telecommunication market due to the operator's requirement to achieve a minimum level of scale in order to attract a large group of customers.

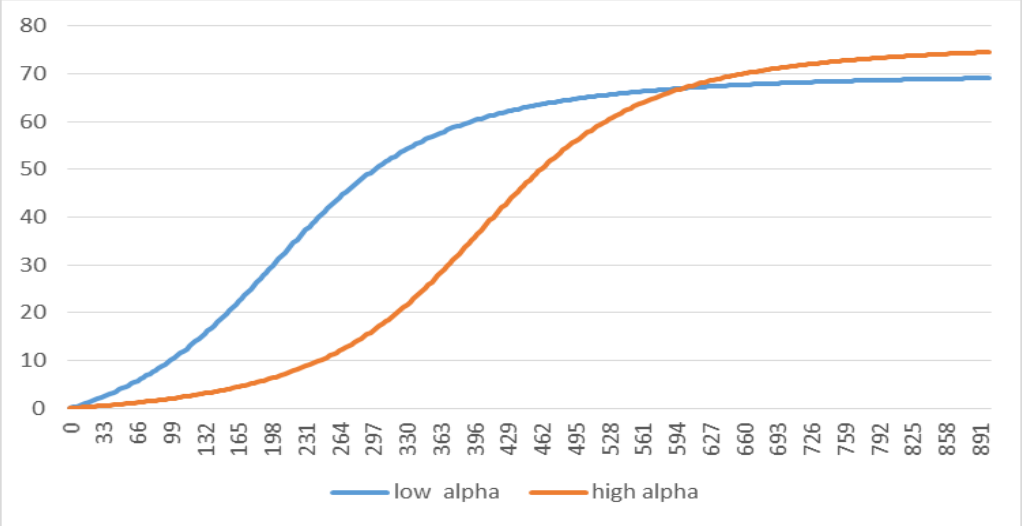
Figure 21: Comparison of a sigmoid curve and CES curve



Source: CEG Analysis

193. The sigmoid curve is very flexible in terms of its parameters. As shown in Figure 22, the choice of α controls the location of the inflection point.

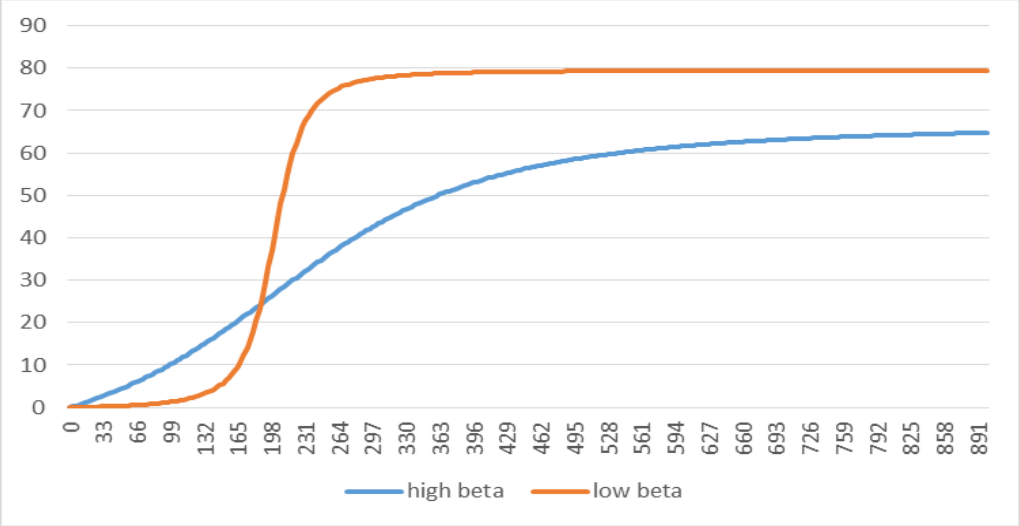
Figure 22: Impact of α on the revenue function



Source: CEG Analysis.

194. As shown in Figure 23, β controls the gradient of the curve.

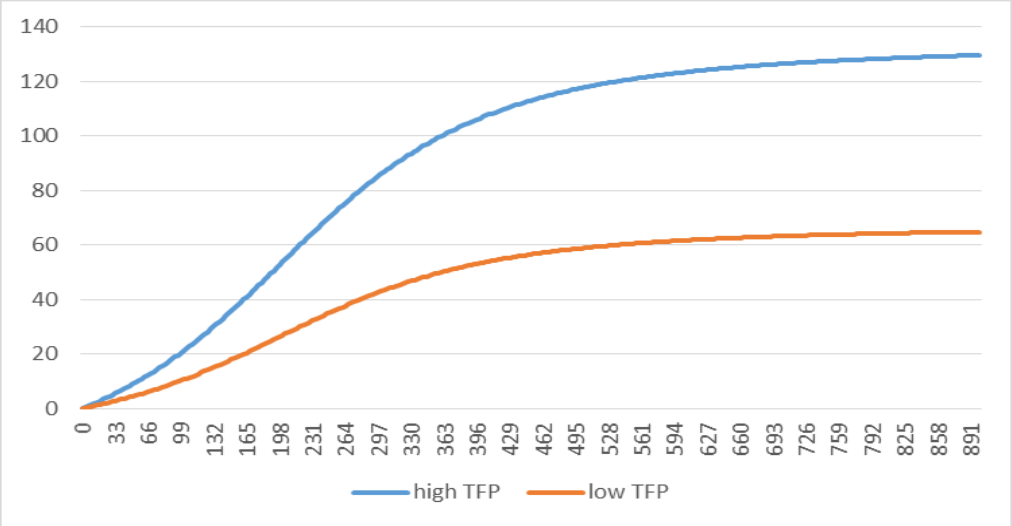
Figure 23: Impact of β on the revenue function



Source: CEG Analysis.

195. As shown in Figure 24, the TFP controls the vertical scale of the sigmoid.

Figure 24: Impact of TFP on the revenue function



Source: CEG analysis

A.2.4 Operator objective

196. The modelled hypothetical operator chooses the optimal initial capital expenditure, *initial capex*, investment per period expressed in day 0's price, *Invest*, and quantity

of spectrum, *Spectrum*, to maximize the net present value of its expected future profit.

197. In the first contract period, the operator owns the spectrum, so it knows the net present value of the profit from the first contract period. The discounted profit from the first contract period is $\sum_{t=0}^{n-1} \frac{Profit_t}{(1-discount)^t}$. However, the operator does not know if it will retain the spectrum access in the second contract period, therefore its discounted profit from the second contract period is:

$$Prob(retaining\ the\ spectrum\ access) \sum_{t=15}^{2n-1} \frac{Profit_t}{(1-discount)^t}.$$

198. The operator also has the option of selling its remaining assets, at a discounted value, at either the end of the first licence period if it loses the spectrum access or at the end of the second licence period if it does not lose the spectrum access. Its objective function is therefore:

$$\sum_{t=0}^{n-1} \frac{Profit_t}{(1-discount)^t} + (1 - Prob(retaining\ the\ spectrum\ access)) \frac{Asset_{n-1}}{(1-discount)^{n-1}} \gamma + Prob(retaining\ the\ spectrum\ access) \left(\sum_{t=15}^{2n-1} \frac{Profit_t}{(1-discount)^t} + \frac{Asset_{2n-1}}{(1-discount)^{2n-1}} \gamma \right).$$

Where γ is the percentage of the asset value that it can retain when its remaining assets are sold.

A.3 Sensitivity Analysis

199. This section investigates the impact on the model outputs under different economic and modelling parameters.

Table 10: % change in operator choices as probability of losing spectrum access increases

	Number of years per contract period		Depreciation		Inflation		Discount Rate		Asset Disposal Value	
Range	10	20	2.5%	10%	1%	4%	2.5%	4%	10%	40%
Initial capex % Change	-2.81%	-0.98%	-3.64%	-0.50%	-1.48%	-1.77%	-1.87%	-1.16%	-1.80%	-1.16%
Investment per year % Change	-7.77%	-3.76%	NA[86]!	-2.08%	-4.86%	-5.76%	-5.03%	-5.10%	-5.43%	-4.26%
Spectrum Quantity % Change	1.48%	1.07%	1.75%	0.79%	1.10%	1.40%	1.26%	1.11%	1.29%	1.01%

Source: CEG Analysis.

200. Table 10 investigates how the operator's optimal choices vary as the probability of losing spectrum access increases under different economic variables. It sets out two different scenarios for these key parameters away from their base case levels of:

- The number of years per contract period, set in the base case as 15 years;
- depreciation rate for assets, set in the base case as 5%;
- inflation rate, set in the base case as 2%;
- discount rate, set in the base case as 3%; and
- percentage of asset value the operator can recoup when disposing of its assets, set in the base case as 20%.

201. In all the sensitivities, initial capex falls and spectrum quantity purchased rises as the probability of losing spectrum access increases.

202. In all but one scenario, the per period investment also decreases. In the case where depreciation is very low compared to the total model period, the trend in investment per period shows a hump shape. It is zero for both a very low and very high probability of losing spectrum access, but slightly positive when the probability of losing spectrum access is 50%. However, compared to the initial capex, the investment per period is very small at 0.2% of initial capex.

86 The per period investment is 0 for very low and very high probability of losing spectrum access. When the probability of losing spectrum access is 50%, the per period investment is marginally above 0.

Table 11: % change in operator choices as probability of losing spectrums access increases for modelling variables

	α (the location of the inflection point)		. β (steepness of the curve)		TFP	
Range	100	300	10000	60000	50	200
Initial capex % Change	-1.62%	-1.56%	-1.56%	-1.60%	-1.55%	-1.61%
Investment per period % Change	-6.31%	-4.39%	-4.23%	-5.74%	-5.12%	-5.23%
Spectrum Quantity % Change	1.19%	1.21%	1.22%	1.20%	1.20%	1.21%

Source: CEG Analysis.

203. Table 11 shows the sensitivity of the result to changes in the parameters driving the revenue function from their base case levels of:

- α of 200;
- β of 30,000;
- TFP of 100.

204. It shows little change in the operator response to changes in the probability of losing spectrum access to such model adjustments.