

Final report for HKT

# The value of mobile spectrum in Hong Kong

An empirical analysis

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## 0 Executive summary

Private firms must expect to pay a reasonable price for property rights for the use of a public resource such as spectrum. If sufficient spectrum is made available at a reasonable price then operators may minimise costs to produce retail services efficiently, continue to invest and develop innovative services and products, all of which promote social efficiency or consumer benefit. However consumer welfare will not be promoted if the price of spectrum is in excess of its true market value, as market distortions will likely occur, driven largely by the impact of high prices on firms' investment. Restrictions on spectrum availability may result in a detrimental impact upon consumers, either through reduced investment in new services, service quality or price.

With the expiry of existing spectrum assignments in Hong Kong for 900MHz and 1800MHz spectrum over the period from November 2020 to September 2021, the Communications Authority (CA) proposes to base the spectrum utilisation fee (SUF) for renewal spectrum licences with reference to prices paid in three previous Hong Kong auctions. This data will inform either a fixed price (if the spectrum is not auctioned) or a reserve price (if the spectrum is auctioned).

Setting the optimal price for spectrum in a re-assignment process presents major challenges. In accord with the Telecommunications Ordinance, the Hong Kong Government aims to achieve the efficient allocation and use of spectrum, and the most economically, socially and technically efficient use of spectrum as specified in the Radio Spectrum Policy Framework. Auctions with no or few conditions typically promote allocative efficiency with in theory the winner putting the spectrum to its most efficient use. However re-assignment through administrative pricing may be more conducive to ensuring technical efficiency than auctioning. Technical efficiency may be compromised if existing operators' spectrum holdings reduce in a reassignment process. Moreover there is the risk that both fixed and

variable costs may increase as investment is undertaken to preserve existing service levels. As a result potentially the market may become less competitive.

Regardless of the choice of allocation method, there is compelling evidence that the sole pursuit of Government revenue maximisation in spectrum assignment processes does not promote consumer welfare. Given the extent of utility derived by consumers from mobile services and applications, large public licence revenues do not adequately compensate society for delayed investment in new mobile services or declining service levels. Empirical evidence suggests that this is particularly applicable in service-based economies such as Hong Kong where the service sector represents over 90% of GDP. The key drivers of social efficiency in mobile markets are the extent of market competition and the quantum of allocated spectrum.

A detailed examination of the three reference auctions proposed by the CA for the SUF re-assignment process indicates that prices based on these auctions may not reflect appropriate benchmarks. In comparison with international benchmarks the reference prices are very high. Moreover since these auctions key structural changes have occurred within the industry, such as market consolidation, spectrum sharing arrangements and potential removal of supply-side inefficiencies all of which are likely to have a material effect on the true market value. Use of these reference prices for setting reserve or fixed prices may lead to artificially high SUFs which may have a distortionary effect on the market to the detriment of consumers.

Assuming a low relative weight is assigned to maximising Government revenue, this implies that achieving an optimal outcome involves setting a relatively low auction reserve price or alternatively a fixed price that accurately reflects true market value. This implies that the two prices may need to be decoupled if a hybrid process is adopted, in which a portion of the spectrum is auctioned with the remainder assigned administratively. A relatively low auction reserve price may also be essential if the Government wishes to promote competition through new market entry in the forthcoming spectrum reassignment.

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# 1 Introduction

With the expiry of existing spectrum assignments in Hong Kong for 900MHz and 1800MHz spectrum over the period from November 2020 to September 2021, it is timely to explore some of the potential effects of the proposed reassignment of these bands by the Communications Authority (CA). Spectrum in these bands was originally used by the Mobile Network Operators (MNOs) to deliver 2G mobile services, however part of the 900MHz spectrum is now used for 3G and 4G services while a substantial portion of the 1800MHz band is used for 4G services.

The CA proposes to base the spectrum utilisation fee (SUF) for renewal spectrum licences with reference to prices paid in three previous Hong Kong auctions. In its February 2016 consultation paper<sup>1</sup> the CA proposed using as a base the results from the March 2011 auction for the 900MHz band, and for the 1800MHz band the results from the December 2014 auction for 1.9-2.2GHz spectrum and the March 2013 auction of 2.5/2.6GHz spectrum. This data will inform either a fixed price (if the spectrum is not auctioned) or a reserve price (if the spectrum is auctioned).

HKT has requested that we examine:

- whether these reference prices are indicative of the value of 900MHz and 1800MHz spectrum for the next 15-year term of spectrum assignment
- the potential effect of inefficiently set spectrum prices for Hong Kong and its consumers.

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<sup>1</sup> Communications Authority (2016), *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*, consultation paper, 3 February 2016.

Following this introduction this report includes:

- an overview of the mobile market in Hong Kong (Section 2)
- a review of the three auctions proposed for use in setting prices (Section 3)
- an analysis of optimal spectrum pricing based on a theoretical review and case study evidence (Section 4)
- our concluding remarks (Section 5).

Although this report has been commissioned by HKT the views expressed here are entirely our own.



## 2 Hong Kong and the market for spectrum

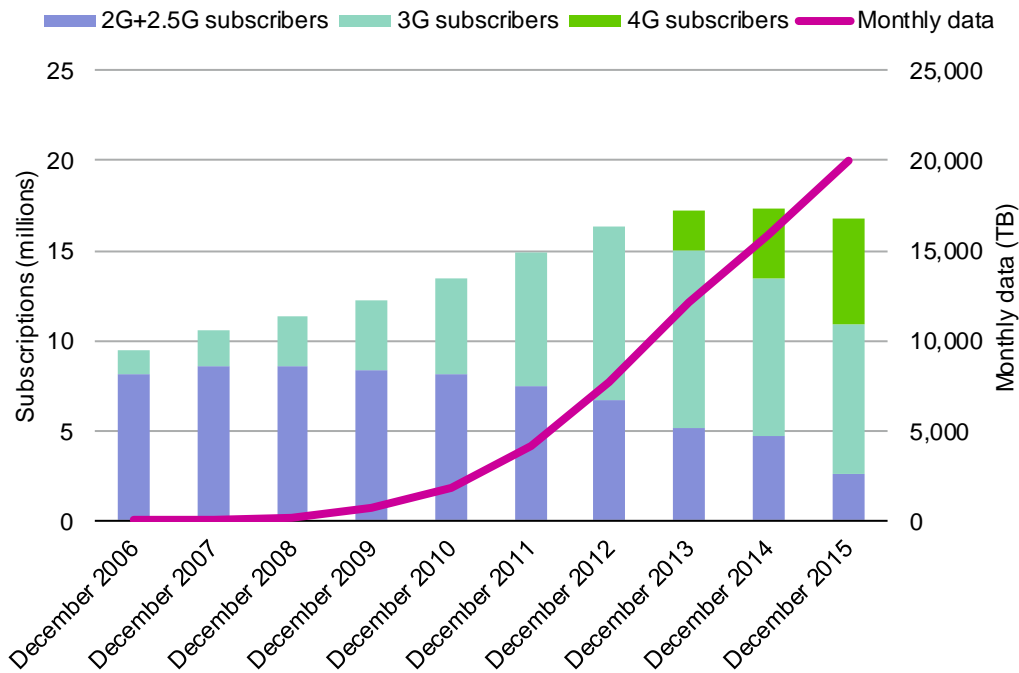
### 2.1 Scoping the mobile market

The mobile market in Hong Kong is highly competitive, with four MNOs – China Mobile Hong Kong Company Limited (CMHK), Hong Kong Telecommunications Limited (HKT), Hutchison Telephone Company Limited (HTCL) and SmarTone Mobile Communications Limited – plus a number of mobile virtual network operators (MVNOs) and resellers.

Over the past twelve years the market has undergone some acquisition and merger activity:

- in 2004 the MNO Sunday was acquired by PCCW
- in 2006 the MNO Peoples was acquired by CMHK
- also in 2006 the MNO New World merged with CSL
- in 2014 CSL was purchased by HKT.

All MNOs offer 2G, 3G and 4G (LTE) services. With the launch of LTE in late 2010, monthly data traffic has dramatically increased (Exhibit 2.1), and as at August 2016 over 40% of all subscriptions were for 4G services.



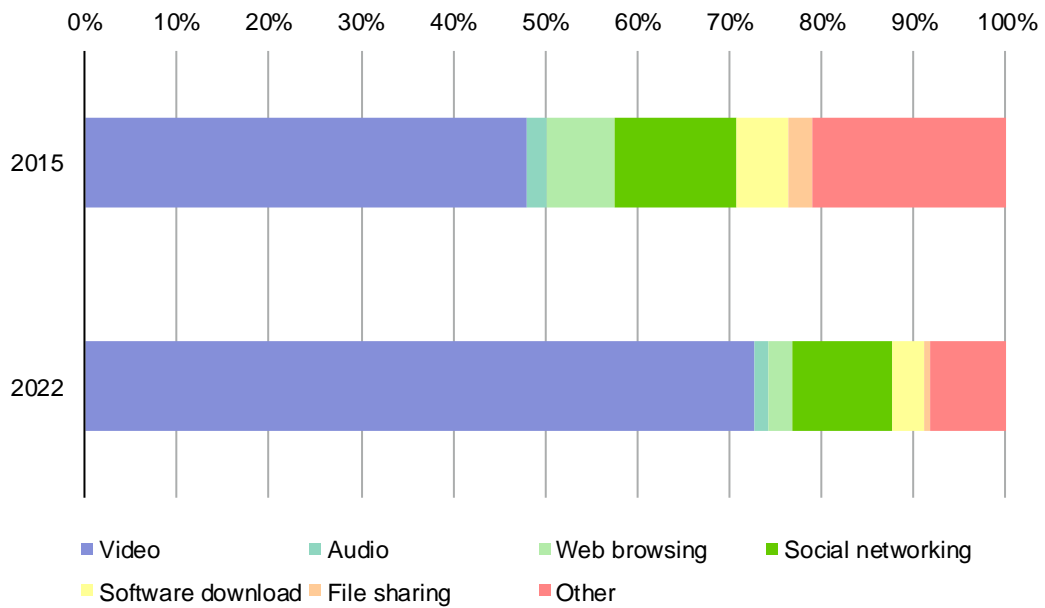
Note: Prior to 2013 data on 3G and 4G subscriptions is not available separately – the 3G subscriptions include 4G.

**Exhibit 2.1:** *Hong Kong mobile subscriptions and monthly data volumes, December 2006 to December 2015 [Source: OFCA]*

As in most other developed markets, mobile traffic is being driven by data, which is putting increasing pressure on MNOs worldwide to increase capacity. Cisco predicts that global mobile traffic will increase eight-fold from 2015 to 2020, representing a compound annual growth rate of 53%, with mobile traffic per user increasing 47% per year.<sup>2</sup> Data traffic is dominated by video – Ericsson estimates that video comprised 35% of global mobile data traffic in 2015, and forecasts that this will increase to over 70% by 2022 (Exhibit 2.2)<sup>3</sup>.

<sup>2</sup> Cisco (2016), *VNI mobile forecast highlights 2015–2020*. Available at [http://www.cisco.com/c/dam/assets/sol/sp/vni/forecast\\_highlights\\_mobile/index.html](http://www.cisco.com/c/dam/assets/sol/sp/vni/forecast_highlights_mobile/index.html).

<sup>3</sup> Ericsson (2016), *Ericsson Mobility Report*, November 2016.

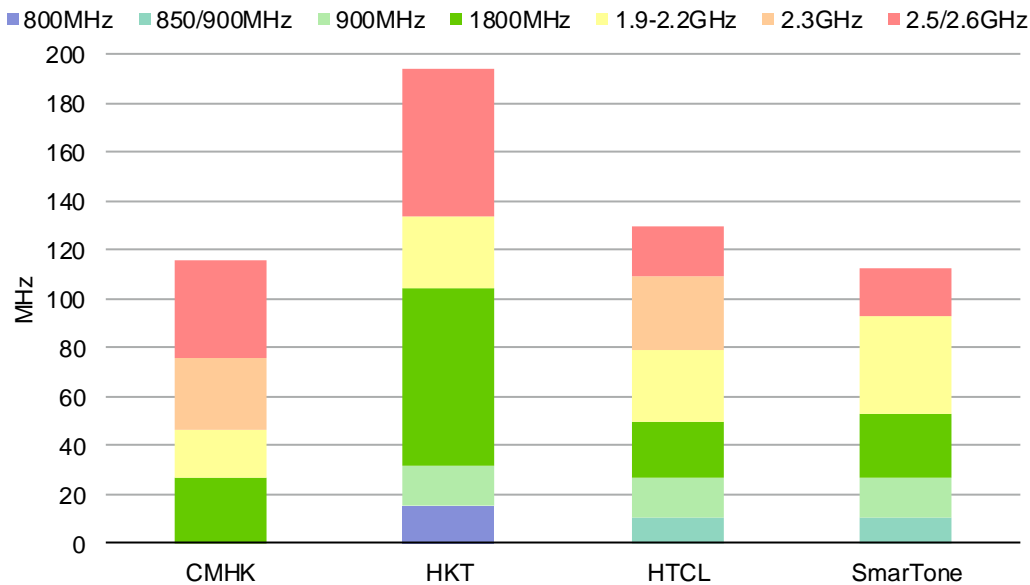


**Exhibit 2.2:** Global data traffic by application, 2015 and forecast 2022 [Source: Ericsson]

## 2.2 Spectrum supply and the spectrum crunch

Hong Kong MNOs are currently using spectrum across a range of different bands to provide services to their customers. The CA recently noted<sup>4</sup> that all spectrum available for mobile service provision has already been assigned to the four MNOs (Exhibit 2.3).

<sup>4</sup> Office of the Communications Authority (2016), *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*, 3 February 2016.



**Exhibit 2.3:** Hong Kong spectrum assigned to MNOs, 2016 [Source: Network Strategies]

According to the most recent Spectrum Release Plan<sup>5</sup> no new spectrum is due for release in Hong Kong from 2016 to 2018. Nevertheless a significant spectrum re-assignment will occur in 2020–2021 following the expiry of existing spectrum assignments of 49.8MHz in the 900MHz and 148.8MHz in the 1800MHz bands. A consultation process is already underway to assist in determining the optimal approach for re-assignment.

Additional mobile spectrum may become available with the cessation of analogue television broadcasting, which has a target date of 2020 (delayed from the original target of 2015<sup>6</sup>).

In the United States, the Federal Communications Commission (FCC) noted that despite network investment and technology delivering increased efficiency, demand will outstrip spectrum capacity in the near-term – the so-called ‘spectrum crunch’.<sup>7</sup> Without additional

<sup>5</sup> Office of the Communications Authority (2013), *Spectrum Release Plan for 2016-2018*, [http://www.ofca.gov.hk/filemanager/ofca/common/Industry/broadcasting/spectrum\\_plan2016\\_en.pdf](http://www.ofca.gov.hk/filemanager/ofca/common/Industry/broadcasting/spectrum_plan2016_en.pdf)

<sup>6</sup> Government of Hong Kong (2014), *Working target for analogue switch-off changed to 2020*, press release, 9 December 2014.

<sup>7</sup> Federal Communications Commission (2010), *Mobile broadband: the benefits of additional spectrum*, FCC staff technical paper, October 2010.

spectrum bands becoming available, the FCC anticipated an impact on service quality and retail prices. To address this issue, in 2011 the FCC was directed to release 500MHz of new spectrum for mobile services over the forthcoming decade.<sup>8</sup>

Also acknowledging a situation in which demand is projected to outstrip supply, the European Commission announced that all member states were to make the bands 900–1800MHz, 2.5–2.69GHz and 3.4–3.8GHz available for mobile services by the end of 2012, with the 800MHz band to follow in 2013 (or by the end of 2015 under special circumstances).<sup>9</sup> It should be noted that several other bands, such as 2.1GHz, are also used for mobile services in Europe.

Although the pressure on spectrum capacity may not have been as severe as originally projected – due to the availability of various mitigating factors such as WiFi offloading and more technically efficient use of spectrum – spectrum remains a limited resource while demand for high-bandwidth applications continues to increase.

A key outcome of the World Radiocommunications Conference 2015 (WRC-15) was the allocation of several new spectrum bands for mobile broadband services, including L-band (1427–1518MHz) and the lower part of C-band (3.4–3.6GHz). Some countries are already preparing for the release of these bands. For example in Australia, the Australian Communications and Media Authority (ACMA) is currently investigating the use of these bands for mobile broadband services.<sup>10</sup> If one of these bands was to progress to the next stage for consideration, the ACMA's indicative timeline suggests that re-farming would commence in Q4 2017.

The lack of confirmed new spectrum capacity in Hong Kong over the next two years is likely to inflate spectrum prices as MNOs seek to acquire any spectrum made available through the renewal process.

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<sup>8</sup> The White House (2011), *President Obama Details Plan to Win the Future through Expanded Wireless Access*, 10 February 2011.

<sup>9</sup> European Commission (2012), *Decision No 243/2012/EU of the European Parliament and of the Council of 14 March 2012 establishing a multiannual radio spectrum policy programme*, 14 March 2012.

<sup>10</sup> Australian Communications and Media Authority (2016), *Future use of the 1.5 GHz and 3.6 GHz bands: Initial investigation of the 1427–1518 MHz and 3575–3700 MHz bands for mobile broadband services discussion paper*, October 2016.

In contrast to OFCA’s Spectrum Release Plan which encompasses simply a listing of potential spectrum releases over a three-year period, the ACMA’s annual publicly released Five Year Spectrum Outlook (FYSO)<sup>11</sup> is a detailed outline of the regulator’s spectrum management plans and priorities over the next five years, which includes a band-by-band work programme. This time span is more compatible with the long lead times typically required for planning – by both regulators and operators – for new spectrum releases.

Failure to release additional mobile spectrum in a timely manner may have an adverse outcome for Hong Kong consumers and the local economy. In many countries digital dividend spectrum is already being used for mobile services, and the identification and planning for the release of other bands is well underway.

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<sup>11</sup> Australian Communications and Media Authority (2016), *Five year spectrum outlook 2016-20: the ACMA’s spectrum management work plan*, October 2016.

### 3 Auctions in Hong Kong: why is spectrum so expensive?

The CA proposes to use prices from three past Hong Kong auctions as a guide for the renewal assignment, either as fixed prices or as reserve prices (if the spectrum is to be auctioned). Hence it is crucial to examine these auctions to determine if there was any factor that could affect the price paid, relative to prices from other auctions or indeed in comparison with a renewal of existing licences. These auctions, in chronological order, were:

- March 2011 auction for 850 and 900MHz (Section 3.1)
- March 2013 auction of 2.5/2.6GHz spectrum (Section 3.2)
- December 2014 auction for 1.9–2.2GHz spectrum (Section 3.3).

It is also informative to compare the price of spectrum in Hong Kong with that in other countries, with the data standardised to take into account differing lot sizes, licence durations and market sizes (population)<sup>12</sup>. Over more than 20 years, auctions for mobile spectrum provide a wealth of information on the market value of that spectrum. Note however that older data reflects a time when technologies and market characteristics were very different and thus the corresponding value of spectrum may not be applicable to a time span encompassing the next 10-15 years. Auctions from 2010 onwards would thus be more indicative of current market value than earlier data.

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<sup>12</sup> A description of our methodology is in Annex A.

### 3.1 850MHz and 900MHz auction

The Hong Kong March 2011 auction for spectrum in the 850MHz and 900MHz bands offered just two lots of previously unassigned paired spectrum, namely:

- Frequency Band A – 832.5–837.5MHz paired with 877.5–882.5MHz (2×5MHz)
- Frequency Band B – 885–890MHz paired with 930–935MHz (2×5MHz).

There were no spectrum caps limiting participation in the auction and no ownership rules or bidder association rules to restrict participation of connected or associated bidders.<sup>13</sup> Network rollout targets would apply for the successful bidders for which a performance bond of HKD50 million was also required as a guarantee for those targets.

Prior to the auction the three MNOs CSL, HTCL and SmarTone each held 2×8.3MHz in the 900MHz band and PCCW-HKT held 2×7.5MHz in the 850MHz band. Note that CMHK had no spectrum in either of these two bands.

The winning bidders were SmarTone and HTCL, both of which paid significantly more than the minimum (Exhibit 3.1). The unsuccessful bidders were CMHK, CSL, PCCW-HKT and the fibre network operator Hong Kong Broadband Network.

<i>Winning bidder</i>	<i>Lot</i>	<i>Price paid</i>	<i>Minimum price</i>
SmarTone	Frequency Band A	HKD875 million	HKD30 million
HTCL	Frequency Band B	HKD1077 million	HKD30 million

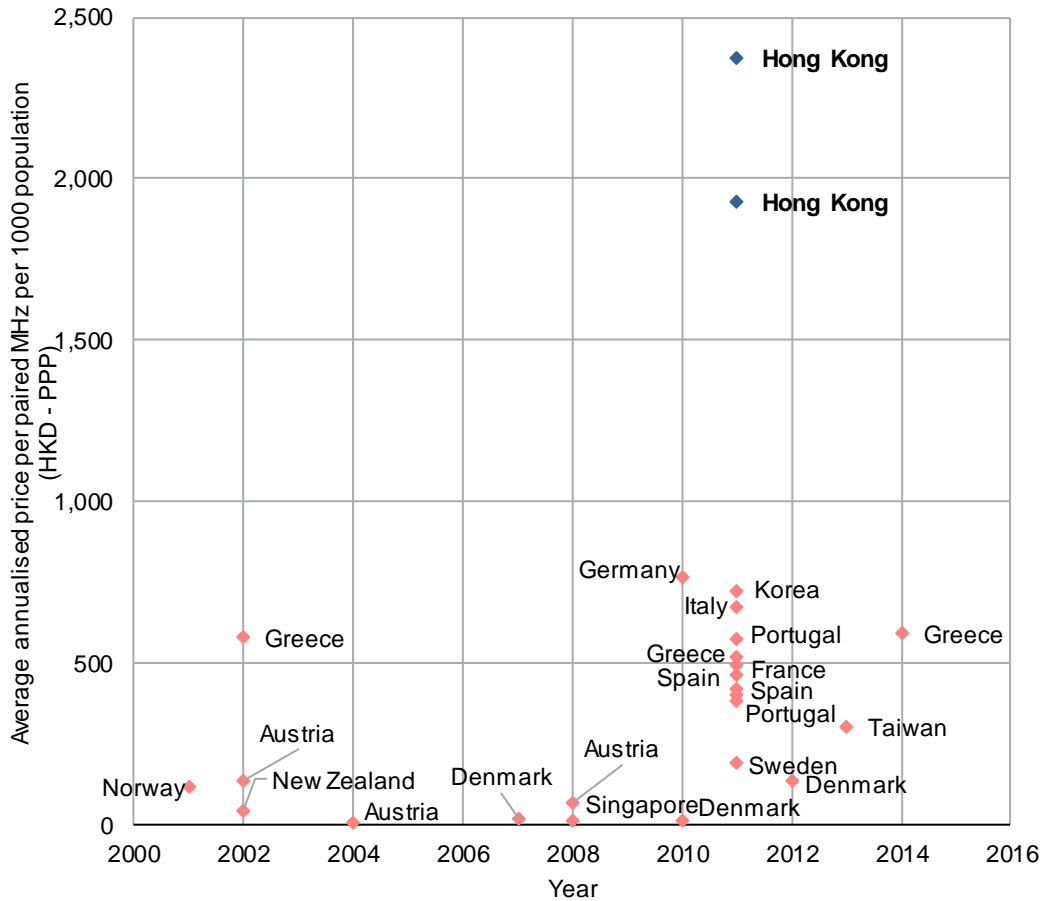
**Exhibit 3.1:** Results of the March 2011 auction for 850 and 900MHz spectrum [Source: OFCA]

The auction was clearly very competitive, and the standardised results (on an annualised per-MHz-population basis) were significantly higher than those achieved in other 800MHz and 900MHz auctions (Exhibit 3.2). Other than the Hong Kong auction, the uplift on the reserve for these sample auctions was relatively low – most uplifts were considerably less than 40% (rather than in excess of 2800%). Such high prices could give rise to the so-called winner’s

<sup>13</sup> Office of the Telecommunications Authority (2010), *Auction of radio spectrum in the 850 MHz, 900 MHz and 2 GHz bands for provision of public mobile telecommunications services*, information memorandum, 10 December 2010.



course, whereby the successful bidder pays more for the spectrum than its value. This is discussed in more detail in Section 4.



**Exhibit 3.2:** Average winning bids for 800MHz and 900MHz spectrum, 2001 to 2014 (real HKD using PPP rates) [Source: Network Strategies]

Examining the results from 2010 onwards, the annualised price per paired MHz-population ranged from HKD10 to HKD2373, with a midpoint of HKD490 (Exhibit 3.3). Note that these prices have been adjusted for inflation and are in 2015 HKD.

	<i>Annualised price per paired MHz-population (2015 HKD PPP)</i>	<i>Country</i>	<i>Band</i>	<i>Year of auction</i>
Maximum	2,373	Hong Kong	900MHz	2011
Upper quartile	672	Italy	800MHz	2011
Median	490	France	800MHz	2011
Lower quartile	382	Portugal	900MHz	2011
Minimum	10	Denmark	800MHz	2010

**Exhibit 3.3:** Summary of benchmark prices for 800/900MHz band auctions from 2010 onwards (annualised price per paired MHz-population in 2015 HKD) [Source: Network Strategies]

If these results were scaled to Hong Kong's 2015 population, the upfront price<sup>14</sup> per MHz for a 15 year term is between HKD1 million and HKD130 million, the midpoint of HKD27 million being significantly lower than the outcome of the 2011 900MHz auction, which achieved HKD107.7 million for the 900MHz lot and HKD87.5 million for the 850MHz lot, unadjusted for inflation (Exhibit 3.4).

	<i>Upfront price per MHz for 15 year term (2015 HKD PPP, millions)</i>	<b>Exhibit 3.4:</b> <i>Summary results for 900MHz re-scaled by Hong Kong population [Source: Network Strategies]</i>
Maximum	130	
Upper quartile	37	
Median	27	
Lower quartile	21	
Minimum	1	

So why were prices in this Hong Kong auction so high? We believe that supply-side factors played a significant role.

<sup>14</sup> Based on a simplified annualisation calculation.

*Demand greater than supply*

There were six bidders in the auction, which lasted for 41 rounds over four days.<sup>15</sup> Clearly, with fewer lots than bidders, demand exceeded supply, and thus a competitive auction would be expected to generate high prices.

Yet Hong Kong is not unusual in this regard. Other recent examples of auctions (also shown in Exhibit 3.2) in which there were more bidders than lots include:

- France – the 2013 auction for 800MHz spectrum had four bidders for three lots
- Germany – in the 2010 multiband auction there were four bidders for three lots within the 800MHz band.

There have also been instances in which there were more lots than bidders but some bidders were unsuccessful, such as the 2011 Swedish auction for 800MHz which had five bidders competing for six lots, however only three of the bidders won spectrum.

*Inefficiencies associated with existing 900MHz allocations*

At the time of the auction the 900MHz spectrum holdings of the three existing licensees – CSL, Hutchison and SmarTone – were fragmented into non-contiguous blocks, with Hutchison having the most fragmented holding<sup>16</sup>. The most efficient configuration for any MNO is to have contiguous spectrum, and thus the auctioned lots would be particularly attractive if they were adjacent to an MNO's existing spectrum holding.<sup>17</sup> While this was not the case for the winning bidders, it may well have been a factor increasing the competitiveness of the auction, and in any case a contiguous lot of 2×5MHz would have

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<sup>15</sup> Office of the Telecommunications Authority (2011), *Auction of Radio Spectrum for the Provision of Public Mobile Telecommunications Services Successfully Concluded*, press release, 3 March 2011.

<sup>16</sup> Hutchison had three separate blocks in the 900MHz band, consisting of 2×4.8MHz, 2×0.9MHz and 2×2.6MHz. CSL and SmarTone both had two blocks: 2×7.5MHz and 2×0.8MHz.

<sup>17</sup> Carrier aggregation available with LTE-Advanced technology enables better use of non-contiguous spectrum blocks, however there are still some overheads associated with non-contiguous spectrum.

been of interest to each one of the MNOs. Nonetheless, the winner of the more expensive of the two lots was Hutchison – the MNO with the most fragmented 900MHz holding.

Fragmented assignments in the 900MHz band have become less common as regulators seek more technically efficient ways to package spectrum for assignment. Assignment of 900MHz spectrum in countries such as Australia, New Zealand, Singapore and Sweden ensures that each operator has a contiguous allocation in this band.

Since the term or duration of spectrum licences or usage rights tends to be relatively long, users' requirements may evolve over time, particularly with changes in market conditions. This means that the opportunity cost of spectrum may change over time. As such, secondary trading has been introduced in a number of jurisdictions as a market-based mechanism to facilitate ready transfer of usage rights to firms or parties that place the highest economic value on the spectrum. Countries that have introduced secondary trading in spectrum include Australia, Austria<sup>18</sup>, Denmark, India, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States, but not as yet Hong Kong, although we understand that over the past decade it has been considered. The ability for firms to respond quickly to shifts in demand and technology supports dynamic efficiency gains and arguably increases possibilities for new market entry and innovation.

### 3.2 2.5/2.6GHz auction

The second of the three reference auctions was held in March 2013. There were five lots of previously unassigned paired spectrum offered in the 2.5/2.6GHz band, namely:

- A1 – 2515–2520MHz paired with 2635–2640MHz (2×5MHz)
- A2 – 2520–2525MHz paired with 2640–2645MHz (2×5MHz)
- A3 – 2525–2530MHz paired with 2645–2650MHz (2×5MHz)
- A4 – 2530–2535MHz paired with 2650–2655MHz (2×5MHz).

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<sup>18</sup> All European Union member states are required to permit trading and leasing of spectrum rights in harmonised bands used for wireless communications services. See European Commission (2012), *Decision No 243/2012/EU of the European Parliament and of the Council of 14 March 2012 establishing a multiannual radio spectrum policy programme*, 14 March 2012.

- A5 – 2535–2540MHz paired with 2655–2660MHz (2×5MHz).

There were no spectrum caps limiting participation in the auction and no ownership rules or bidder association rules to restrict participation of connected or associated bidders.<sup>19</sup>

Four existing MNOs plus one new entrant participated in the auction, which consisted of 18 rounds over two days. While HKT and Hutchison did not participate in their own right, Genius Brand Limited is a 50:50 joint venture of the two MNOs, enabling sharing of the acquired spectrum. The winning bids across the five lots exhibited only a slight variation in price and were all approximately double the reserve (Exhibit 3.5).

<i>Winning bidder</i>	<i>Lot</i>	<i>Lot size</i>	<i>Price paid</i>	<i>Minimum price</i>
Genius Brand Limited	A1	2×5MHz	HKD290 million	HKD150 million
SmarTone	A2	2×5MHz	HKD330 million	HKD150 million
SmarTone	A3	2×5MHz	HKD310 million	HKD150 million
CMHK	A4	2×5MHz	HKD300 million	HKD150 million
CSL	A5	2×5MHz	HKD310 million	HKD150 million

**Exhibit 3.5:** Results of the March 2013 auction for 2.5/2.6GHz spectrum [Source: OFCA]

Genius Brand, CMHK and CSL each increased their holding to 2×20MHz, having originally been assigned 2×15MHz that was awarded in the 2009 auction for this band. SmarTone won two blocks giving it half the allocation of these other three assignees (Exhibit 3.6).

	<i>Spectrum allocation</i>	
	<i>Prior to 2013 auction</i>	<i>After 2013 auction</i>
CMHK	2×15MHz	2×20MHz
CSL	2×15MHz	2×20MHz
Genius Brand	2×15MHz	2×20MHz
SmarTone	–	2×10MHz

**Exhibit 3.6:** Spectrum allocation in the 2.5/2.6GHz band [Source: OFCA]

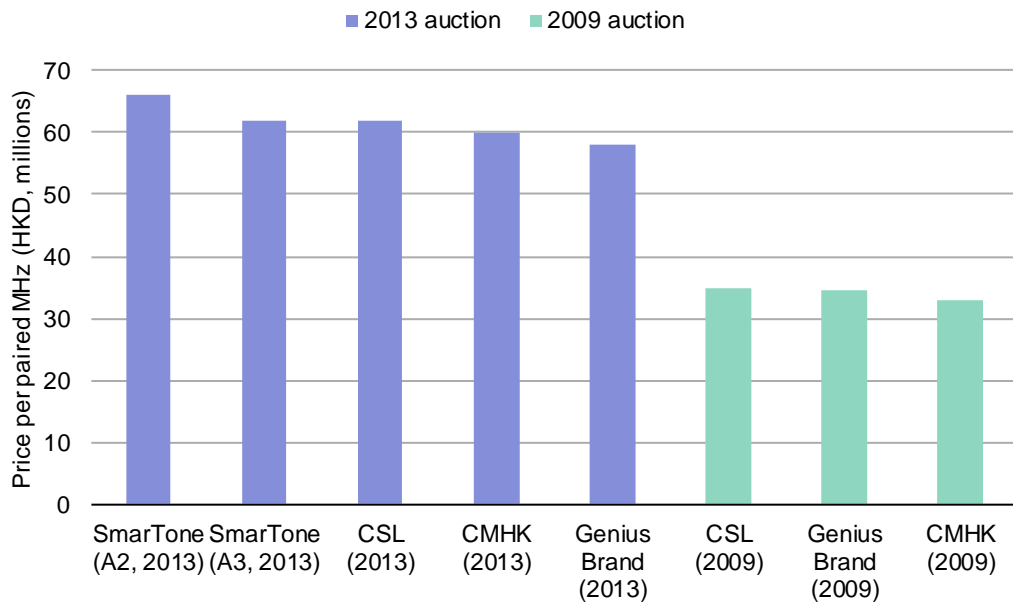
<sup>19</sup> Office of the Communications Authority (2012), *Auction of radio spectrum in the 2.5/2.6 GHz band for the provision of wireless broadband services*, information memorandum, 12 December 2012.

*Attractiveness of specific lots varied by MNO*

Given the existing assignments, particular lots would be more attractive to individual MNOs, who would seek to obtain these lots in preference to other less attractive lots. Lots A1 and A5 would have been of most interest to Genius Brand and CSL respectively, as the two lots were immediately adjacent to their existing holdings. None of the lots were adjacent to CMHK's prior assignment, and thus any new acquisition by CMHK would have resulted in a fragmented holding.

The highest price on per-MHz basis was paid by SmarTone. As the only MNO without access to 2.6GHz spectrum, it was strategically important for SmarTone to acquire a significant allocation in this auction, with its optimal outcome being to win adjacent lots. These factors may account for the slight premium paid for lots A2 and A3.

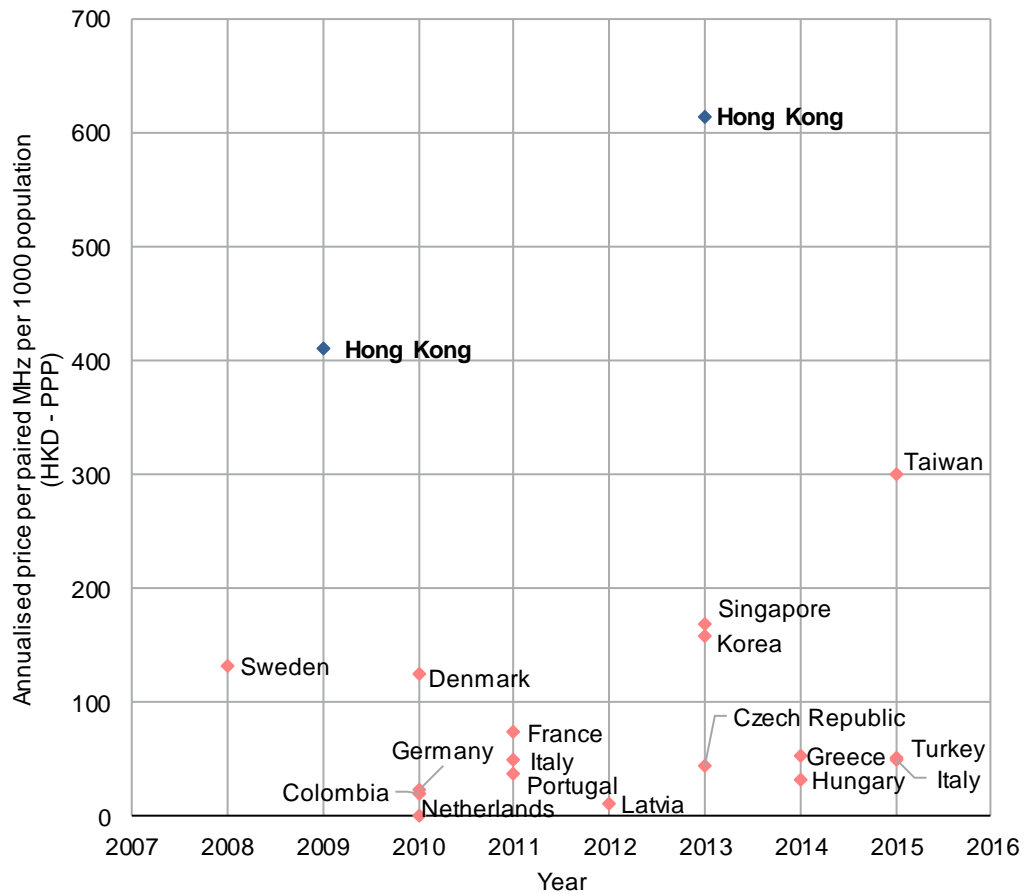
Note that the 2013 auction achieved prices that were almost double those from the earlier 2009 auction for the same band (Exhibit 3.7). Unlike the 2013 auction, the 2009 auction included spectrum caps, whereby the maximum amount of spectrum that could be assigned to any bidder was 30MHz (2×15MHz) – as noted above the three successful bidders were each awarded 2×15MHz.



**Exhibit 3.7:** Price per paired MHz for the Hong Kong 2.5/2.6GHz auctions in 2009 and 2013  
 [Source: Network Strategies]

*Spectrum expensive in comparison with international benchmarks*

In comparison with other auctions of 2.5/2.6GHz spectrum, both the 2009 and the 2013 Hong Kong results appear significantly more expensive (Exhibit 3.8).



**Exhibit 3.8:** Average winning bids for 2.5/2.6GHz spectrum, 2008 to 2015 (real HKD using PPP rates) [Source: Network Strategies]

### 3.3 1.9–2.2GHz auction

The most recent of the three proposed reference auctions is the December 2014 auction for the 1.9–2.2GHz band. Five lots of paired spectrum were auctioned, namely:

- Frequency Band A1 – 1920.3–1925.3MHz paired with 2110.3–2115.3MHz (2×5.0MHz)
- Frequency Band A2 – 1925.3–1930.2MHz paired with 2115.3–2120.2MHz (2×4.9MHz)
- Frequency Band A3 – 1930.2–1935.1MHz paired with 2120.2–2125.1MHz (2×4.9MHz)
- Frequency Band A4 – 1960.0–1964.9MHz paired with 2150.0–2154.9MHz (2×4.9MHz)
- Frequency Band A5 – 1964.9–1969.8MHz paired with 2154.9–2159.8MHz (2×4.9MHz)



This auction formed a component of the CA's hybrid approach for re-assignment of the original 1.9–2.2GHz spectrum assignments which were due to expire in October 2016. It was originally proposed that the four incumbent operators – CSL, HKT, Hutchison and SmarTone – would be offered the right of first refusal (RFR) to a portion (2×9.9MHz) of their original allocation with the remaining portion (2×4.9MHz) to be auctioned. However as a condition for the acquisition of CSL by HKT, 2×14.8MHz of the merged entity's spectrum would be auctioned, and HKT would not be permitted to participate in any auction for spectrum in this band for a period of five years.<sup>20</sup>

The auction spanned six rounds over a single day. Three bidders competed for the five lots, with both CMHK and SmarTone winning two lots and the remaining lot being acquired by HTCL. Only two lots achieved a price higher than the reserve (Exhibit 3.9).

<i>Winning bidder</i>	<i>Lot</i>	<i>Lot size</i>	<i>Price paid</i>	<i>Minimum price</i>
SmarTone	A1	2×5.0MHz	HKD510 million	HKD480 million
CMHK	A2	2×4.9MHz	HKD470.4 million	HKD470.4 million
CMHK	A3	2×4.9MHz	HKD500 million	HKD470.4 million
SmarTone	A4	2×4.9MHz	HKD470.4 million	HKD470.4 million
HTCL	A5	2×4.9MHz	HKD470.4 million	HKD470.4 million

**Exhibit 3.9:** Results of the December 2014 auction for 1.9–2.2GHz spectrum [Source: OFCA]

Lots A4 and A5 would have been of most interest to SmarTone and HTCL respectively, as these lots adjoined the spectrum the MNOs had retained in this band. None of the remaining three lots were adjacent to bidders' existing spectrum assignments. China Mobile – which previously had no spectrum in this band, and thus would be expected to aim for more than one lot – acquired two adjacent lots, while the largest of the five lots – which achieved the highest price – went to SmarTone.

With only two of the five lots exceeding the minimum price, this suggests that the reserve may have been set too high and was thus not a reflection of the true market value of this

<sup>20</sup> Office of the Communications Authority (2014), *Auction of radio spectrum in the 1.9 – 2.2 GHz band for the provision of public telecommunications services*, information memorandum, 9 September 2014.

spectrum. In contrast to previous auctions, market consolidation and competition concerns had reduced the number of bidders so that there were more lots available than bidders.

### **3.4 Lack of other options for unsuccessful bidders**

One factor common to the three reference auctions is that OFCA's Spectrum Release Plan applicable at each auction listed no other new releases of mobile spectrum over the forthcoming three-year period. MNOs thus had no assurance that any new bands would become available over the short- to medium-term. This artificial scarcity – generated by the lack of new spectrum releases and the inability to make more efficient use of spectrum through secondary trading – would put pressure on MNOs to acquire spectrum at each auction in order to ensure capacity for projected growth in demand. In addition the SUFs determined via auction would not represent a true market value due to the information asymmetry imposed upon the MNOs. This appears inconsistent with a market-based approach seeking to deliver maximum benefits to consumers.

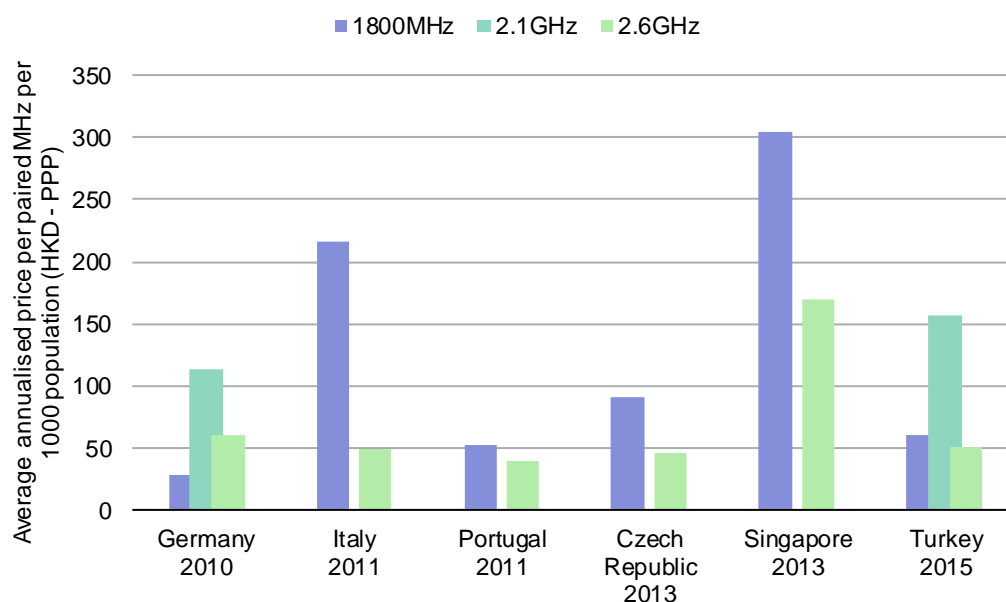
Failure to win spectrum at these auctions would mean that without any option in the short- to medium-term to acquire lots in alternative mobile bands an unsuccessful MNO would have no alternative other than technical mitigation strategies to increase capacity. Such an approach would involve increased capital and operating expenses which conceivably may have implications for retail pricing.

### **3.5 Using other bands for 1800MHz price benchmarks**

Without any recent Hong Kong auctions in the 1800MHz band, the CA proposes to use as a reference the prices from the 1.9–2.2GHz and 2.5/2.6GHz auctions. It is therefore important to establish whether these bands form a suitable benchmark for 1800MHz spectrum prices.

As we have seen in the above analysis there can be considerable variation in prices achieved in spectrum auctions – even within the same band in differing years. Technologies, markets, competition, licence terms and conditions, existing spectrum assignments and band plans all influence auction prices.

We have examined a sample of multiband auctions to establish whether it is reasonable to use prices from these higher frequency bands to set prices for 1800MHz spectrum. By using multiband auctions, environmental and auction conditions would be similar for the various bands and thus, in theory, it should be easier to identify a relationship between the prices of the various bands. However, within our sample of recent multiband auctions<sup>21</sup>, there does not appear to be any consistent relationship between the price of 1800MHz and that of 2.1GHz and 2.6GHz spectrum (Exhibit 3.10). The 2011 Korean multiband auction, which we did not include in this graph due to scaling issues, achieved an extremely high price for 1800MHz (Exhibit 3.11) which was more than double the price achieved for the 2.1GHz lot offered at the same auction<sup>22</sup>. This is in contrast to the German and Turkish auctions in which the price of 1800MHz spectrum was lower than that for 2.1GHz.



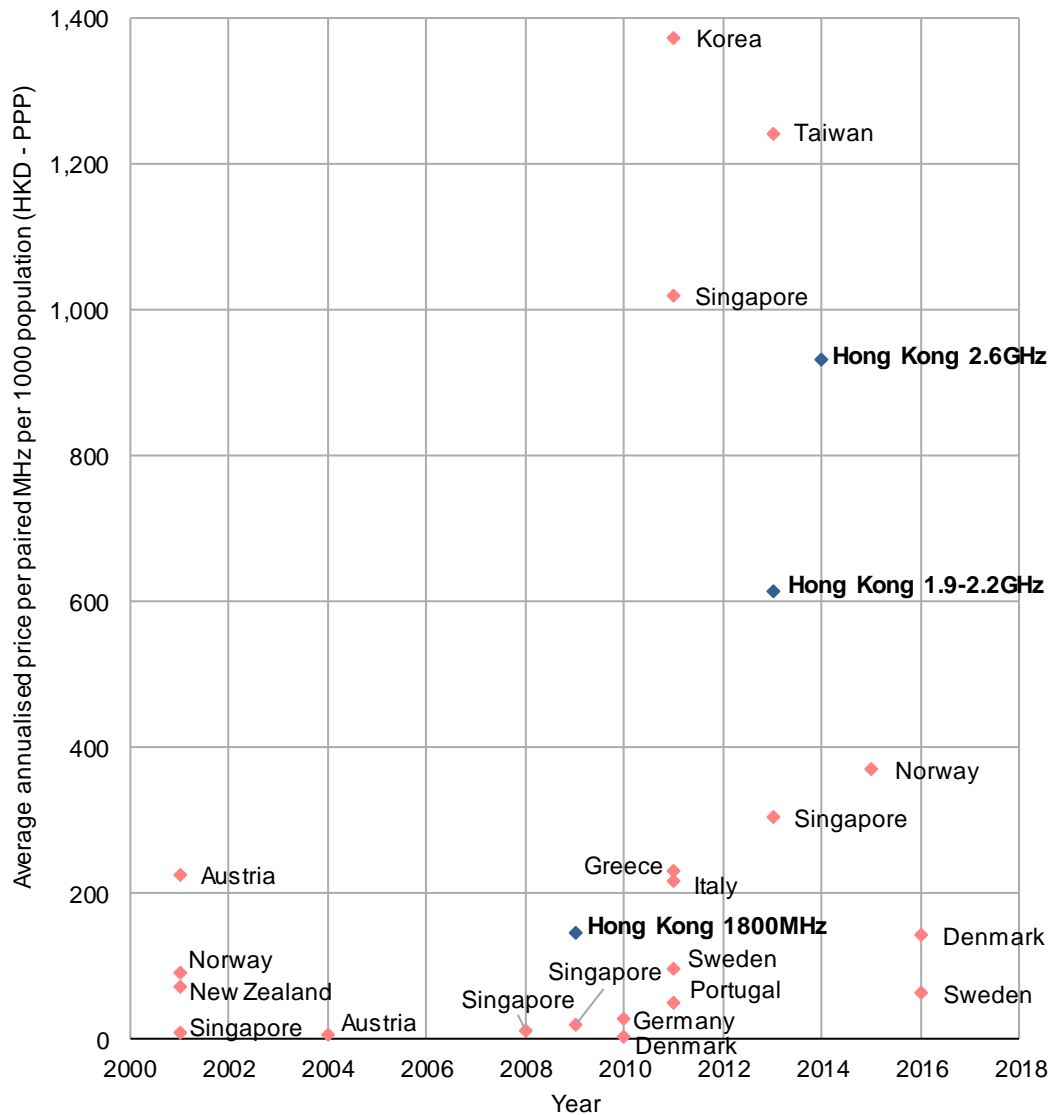
**Exhibit 3.10:** Average winning bids for 1800MHz, 2.1GHz and 2.6GHz spectrum in a sample of multiband auctions [Source: Network Strategies]

<sup>21</sup> Our sample includes only those auctions in which prices for each band are available. A number of multiband auctions only report the winning bids for the combination of lots across all the bands offered and thus it is difficult to infer the price for individual bands.

<sup>22</sup> Note that the 2.1GHz lot was sold at the reserve price. There was only a single bidder (LG Uplus) as the two largest Korean MNOs, SK Telecom and KT, were excluded from bidding for this lot due to competition concerns.

This suggests that there are local factors which influence the relative attractiveness of these bands. Such factors are likely to include the existing assignments of the MNOs as well as traffic densities and other market characteristics.

Our next step is to compare the results of the two proposed Hong Kong reference auctions (1.9–2.2GHz and 2.5/2.6GHz) with prices of 1800MHz spectrum. Only three auctions – Korea and Singapore in 2011, and Taiwan in 2013 – achieved higher prices (Exhibit 3.11), but as we note below these were all special cases with circumstances unlike those applicable for re-assignment of Hong Kong 1800MHz spectrum. The Hong Kong reference auctions are also significantly higher than the Hong Kong 1800MHz auction in 2009. This suggests that as in the case of 900MHz, the CA’s proposed reference prices would deliver an SUF for 1800MHz that would be significantly higher than the market values achieved in most other countries, or indeed than that previously set in Hong Kong.



**Exhibit 3.11:** Average winning bids for 1800MHz spectrum, 2001 to 2016, compared with results from Hong Kong 1.9–2.2GHz and 2.5/2.6GHz auctions (real HKD using PPP rates) [Source: Network Strategies]

Excluding the three special cases, annualised price per paired MHz-population achieved at recent 1800MHz auctions (from 2010 onwards) range from HKD3 to HKD370, with a midpoint of HKD120 (Exhibit 3.12). Note that these prices have been adjusted for inflation and are in 2015 HKD.

	<i>Annualised price per paired MHz-population (2015 HKD PPP)</i>	<i>Country</i>	<i>Band</i>	<i>Year of auction</i>
Maximum	370	Norway	1800MHz	2015
Upper quartile	321	–		
Median	120	–		
Lower quartile	60	–		
Minimum	3	Denmark	1800MHz	2010

Note: The median and quartiles do not correspond to specific prices – they are estimates midway between two sequential datapoints.

**Exhibit 3.12:** *Summary of benchmark prices for 1800MHz band auctions from 2010 onwards (annualised price per paired MHz-population) [Source: Network Strategies]*

Adjusted these results to a market with population equivalent to Hong Kong in 2015, the upfront price per MHz for a 15 year term ranges from HKD0.2 million to HKD75 million, with a midpoint of HKD12 million. In comparison, the average price per MHz paid in 2013 for 2.6GHz spectrum was HKD30.8 million, while in 2014 the average price for the 1.9–2.2GHz spectrum was 49.2 million (both are unadjusted for inflation) – well in excess of the maximum from the benchmark sample (Exhibit 3.13).

	<i>Upfront price per MHz for 15 year term (2015 HKD PPP, millions)</i>
Maximum	20
Upper quartile	18
Median	7
Lower quartile	3
Minimum	0.2

**Exhibit 3.13:**  
*Summary results for 1800MHz re-scaled by Hong Kong population [Source: Network Strategies]*

Although the reference prices appear to be relatively comparable with the three auctions in Korea, Taiwan and Singapore, we have established that for each of these auctions there were any special circumstances which may have affected the price paid. Such special cases are not relevant or appropriate to the re-assignment of spectrum in Hong Kong and thus these

prices are not be suitable benchmark comparators for the re-assignment of 1800MHz spectrum in Hong Kong.

#### *Korea – record price for 1800MHz spectrum*

The 2011 multiband auction – the first spectrum auction in Korea – included a single lot in each of the 800MHz, 1800MHz and 2.1GHz bands. The two largest Korean MNOs – SK Telecom and KT – were competing for the single 2×10MHz lot. These two MNOs were not permitted to bid for the 2×10MHz lot in the 2.1GHz band due to competition concerns, while the 800MHz lot was only 2×5MHz.

Competition for the new lot in the 1800MHz band was fierce. KT already had an 1800MHz LTE network and acquiring more spectrum in that band was viewed as preferable to implementing 800MHz, especially given the relatively small lot size for that band. The 1800MHz lot would deliver far more capacity than the 800MHz lot. On the other hand, SK Telecom had an existing 800MHz LTE network and was seeking to complement this with LTE in the 1800MHz band.

The eventual winner of the 1800MHz lot was SK Telecom, paying more than twice the reserve price. KT purchased the 800MHz lot at its reserve price.

In this particular case, local circumstances were key to the auction result: the MNOs existing spectrum holdings and network deployments, coupled with only one available lot that was desired by both bidders, were strong influences on the resultant market valuation. These circumstances were unique to that particular Korean auction and markedly different to the situation of re-assignment in Hong Kong's 1800MHz band.

#### *Taiwan*

The 2013 Taiwanese 4G spectrum auction included the 700MHz, 900MHz and 1800MHz bands:

- 700MHz – one lot of 2×15MHz and three lots of 2×10MHz

- 900MHz – three lots of 2×10MHz
- 1800MHz – two lots of 2×15MHz and three lots of 2×10MHz.

All four of the country's 3G operators participated in the auction, together with three new entrants – many more players than in recent Hong Kong auctions.

The 1800MHz band was hotly contested, and achieved prices significantly higher than the sub-1GHz bands. The expectation – as indicated by the reserve prices – was that these lower frequency bands would be more expensive (which is typically the case in other markets) however prices paid for the 1800MHz lots were more than six times their reserve.

The 900MHz and 1800MHz lots were previously licensed for 2G services and due to expire in 2012 and 2013. However as there were still a large number of 2G subscribers, the Taiwanese Government decided to extend the 2G licence term until June 2017. Therefore any MNOs acquiring 1800MHz that had previously belonged to another operator would not be able to use that spectrum until it was vacated in 2017.

The winning bidders were also subject to a spectrum cap of 2×35MHz for the total amount of spectrum across all three lots.

In the 1800MHz band FarEasTone won two adjacent 2×10MHz lots – it was the incumbent for one, but the other was held by Chunghwa Telecom. Taiwan Mobile won a 2×15MHz lot, but again the existing licensee was Chunghwa Telecom. The two lots won by Chunghwa Telecom were both part of its existing assignment.

If the 1800MHz price was typical of Taiwanese market value, then similarly inflated prices should have also been the outcome of the 2015 auction of 2.6GHz spectrum. This was not the case – the average price paid for 2.6GHz spectrum in 2013 was less than a quarter of that paid for 1800MHz spectrum in 2013. While the Taiwanese 2.6GHz price was still relatively high in comparison to that in many other countries, the gap was much reduced in comparison with that of 1800MHz (Exhibit 3.8 and Exhibit 3.11).

This suggests that the 2013 Taiwanese auction may not be a suitable benchmark for the re-assignment price of 1800MHz spectrum in Hong Kong.



### *Singapore*

The 2011 auction for 1800MHz spectrum in Singapore achieved a significantly higher price than those in the 2008, 2009 and 2013 auctions (Exhibit 3.11).

In 2011 there was only a single lot of 2×5MHz offered, not previously assigned, which was contested by three bidders – the MNOs SingTel, StarHub and M1 (the successful bidder). The 2009 auction was also for just a single previously unassigned 2×5MHz lot, with only two bidders – SingTel and StarHub. In contrast, the 2013 auction offered 15 2×5MHz lots (as well as 12 2×5MHz lots in the 2.5GHz band), and was again contested by the same three bidders as in 2011. The 2008 auction, another multiband auction which also included the EGSM and 900MHz bands, offered 12 2×5MHz lots in the 1800MHz band. Both the 2008 and 2013 auctions were held as a result of the expiry of the existing licences.

Prices for 1800MHz spectrum have been relatively consistent in Singapore, with the sole exception of the 2011 auction. This suggests that another key element in the bidding strategy may also have been to prevent a bidder obtaining a competitive advantage from additional spectrum capacity – SingTel had previously been assigned 2×25MHz in the 1800MHz band while the other two MNOs had 2×20MHz.

The unusual circumstances of the 2011 auction, in relation to those for re-assignment of Hong Kong spectrum, suggests that this particular result should not be used as a benchmark comparator. The 2013 Singapore auction would be a preferable benchmark.

### **3.6 Should the proposed reference auctions be used for setting prices?**

We have seen that in comparison with international benchmark data, spectrum prices in Hong Kong are very high, so the question is whether the three proposed reference auctions are appropriate for setting the SUF for the re-assignment of 900MHz and 1800MHz spectrum.

We have identified a range of factors that would have some influence on these reference auction results, and which may not apply for the re-assignment, for example:

- demand greater than supply

- bidders' pre-existing spectrum assignments across all bands
- inefficiencies associated with existing spectrum assignments
- uncertainty over future spectrum releases, resulting in an artificial scarcity
- lack of spectrum trading
- setting high minimum prices for the 2014 1.9–2.2GHz auction
- number of market players.

MNOs clearly have much to gain via spectrum sharing and spectrum trading arrangements, such as the joint venture between HKT and Hutchison as they promote both efficiency and flexibility.

Our main concern is that basing 900MHz and 1800MHz SUFs on these past Hong Kong auction results will not take into account key structural changes that may have occurred within the industry, such as market consolidation, spectrum sharing arrangements and removal of supply-side inefficiencies all of which are likely to have a material effect on market-based spectrum prices. Furthermore, by fostering an artificial scarcity through the lack of releases of additional bands the outcome may well be overly aggressive bidding.

If these issues are not considered in setting the SUFs for re-assignment, the outcome will be artificially high SUFs which may have a distortionary effect on the market.

The approach used by Ofcom in the United Kingdom for setting annual licence fees for 900MHz and 1800MHz spectrum<sup>23</sup> was informed by a combination of UK auction results in other bands (800MHz and 2.6GHz) together with a selection of European auction prices for 800MHz, 900MHz, 1800MHz and 2.6GHz. This sample was based on an assessment of a wider sample of European awards, in which Ofcom determined whether the results reflected the market value in the country and whether the market value in that country would also reflect the true market value within the UK. Ofcom also assigned different weightings to the sample auctions, indicating relative importance.

We suggest that OFCA adopt a similar approach – namely to identify a suitable sample of benchmark auctions that would better reflect the true market value for Hong Kong's spectrum re-assignment. Past Hong Kong auctions could also be included within this sample,

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<sup>23</sup> Ofcom (2015), *Annual licence fees for 900 MHz and 1800MHz spectrum*, statement, 24 September 2015.

however we recommend some adjustments are necessary to allow for changing circumstances.



## 4 Spectrum re-assignment: the quest for efficiency

The Telecommunications Ordinance (Chapter 106)<sup>24</sup> encompasses an obligation to promote the efficient allocation and use of the radio spectrum in Hong Kong. This is reflected in the key objectives of the Spectrum Policy Framework<sup>25</sup> which include:

- to facilitate the most **economically** and **socially** efficient use of spectrum in order to achieve maximum benefit for the community
- to achieve **technically** efficient use of spectrum to facilitate the introduction of advanced and innovative communications services and strengthen Hong Kong's position as a telecommunications and broadcasting hub.

As Hong Kong Government policy aims to achieve economically, socially and technically efficient use of the spectrum resource, the spectrum manager is immediately presented with trade-offs in selecting the most appropriate method of reassigning existing assignments upon expiry.

In this Section we provide a short survey of the literature to assist in identifying the optimal pricing approach in the light of Government objectives. It is important to note at the outset that most of the literature on this topic does not directly address the issue of the reassignment or renewal of existing spectrum holdings.

We include:

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<sup>24</sup> Available at: [http://www.legislation.gov.hk/blis\\_pdf.nsf/CurAllEngDoc/65248D243340F9BD482575EE0039F763?OpenDocument](http://www.legislation.gov.hk/blis_pdf.nsf/CurAllEngDoc/65248D243340F9BD482575EE0039F763?OpenDocument).

<sup>25</sup> Commerce and Economic Development Bureau (2007), *Radio spectrum policy framework*, April 2007. Available at <http://www.cedb.gov.hk/ccib/eng/legco/pdf/spectrum.pdf>.

- a discussion of different efficiency concepts (Section 4.1)
- a review of the relationship between social efficiency and revenues from spectrum assignment (Section 4.2)
- an investigation of key issues in promoting market competitiveness (Section 4.3)
- a consideration of efficiency in administrative pricing approaches (Section 4.4)
- the differing perspectives on the impact of spectrum fees on consumers (Section 4.5)
- concluding remarks (Section 4.6).

## 4.1 What is efficiency?

As economic efficiency is a broad concept the first step in policy implementation involves decisions on its meaning in the context of spectrum assignment. In general economists typically identify three forms of economic efficiency which all bear a relationship with the price of the factors of production:

- **allocative** – producing the optimal quantity of goods or services demanded by consumers
- **productive** – producing a given output at minimum cost
- **dynamic** – innovation and investment to promote efficient resource usage over a long-run time horizon.

Technical efficiency delivers maximum output for a given quantum of input. In regard to mobile service delivery, spectrum is the (finite or limited) input and technical efficiency would imply that it is employed as intensively as possible. Arguably technical efficiency is a necessary condition for economic efficiency but not sufficient.

Social efficiency encompasses all costs and benefits associated with an economic activity or transaction. Thus social efficiency accounts for considerations that may not be captured in the price mechanism which reflects private costs and benefits.

### *Auction versus administrative approaches*

Much of the literature investigates the comparative efficiency of alternative methods of allocating new spectrum. Auctions may facilitate allocative efficiency in that the winning bidder places the greatest value on the spectrum and as such should be capable of using it more efficiently than losing competitors. In the case of reassigning existing spectrum holdings through auction, incumbent operators with existing network investment are likely to value the spectrum more highly than newcomers.

Auction outcomes do not guarantee technical efficiency (for example, if the spectrum's value to the winner lies in depriving rivals of it), while administrative pricing methods may support productive efficiency at the expense of allocative efficiency. As noted by Freyens and Yerokhin these trade-offs, together with a lack of policy guidance as to priorities, can lead to significant practical challenges in policy implementation.

When competitively auctioned, spectrum property rights provide ideal pathways to achieving allocative efficiency but they are not necessarily technically efficient, in the sense that the spectrum may remain largely unused. Therefore, property rights and auctions may help channel the spectrum to where it is valued most, but they offer no guarantee of efficient use (or any use at all). Conversely, administrative licensing arrangements that facilitate the productive use of a specific frequency band will usually not be allocatively efficient because the deployed service or the adopted technology are typically prescribed with no regard for market forces. Hence, efficiency objectives can diverge significantly from one another in practice and the type of licensing regime adopted can itself be a source of divergence through the transaction costs they impose and the incentives they generate.<sup>26</sup>

A related issue for spectrum auction outcomes, sometimes described as the winner's curse, is the market distortion caused if the winning bid does not reflect the true value of the spectrum or if the true value is in fact less than expected by the winner. Furthermore, in practice if at the time of a spectrum auction some firms are financially constrained the most efficient firm may not be the winning bidder. As noted by Burguet and McAfee:

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<sup>26</sup> Freyens, B. P. & Yerokhin, O. (2011). "Allocative vs. technical spectrum efficiency". *Telecommunications Policy* 35 (4), 291-300.

... auctions could have a perverse effect if the most efficient firms face relatively tighter financing constraints, because auctions favor both the efficiency and large budgets.<sup>27</sup>

*Case study: United Kingdom – budget constraints prevent efficient auction outcome*

In the United Kingdom 250MHz in the 800MHz and 2.6GHz bands was made available to the market through auction in 2013. The stated aims of the auction were:

- to achieve a market structure with at least four national mobile operators, each with adequate spectrum holdings to remain viable in the medium term
- subject to that objective, to achieve an economically efficient allocation of the auctioned spectrum, so that spectrum was assigned to the operators able to make best use of it.

The auction was designed with spectrum caps and with packages set aside for the smallest operator or new entrants to the market. Reserve prices were based on benchmarks from previous European auctions.

The UK Audit Office subsequently considered whether the auction achieved the stated objectives. It concluded that a competitive market structure had been retained as the four incumbent national operators had secured sufficient spectrum to remain viable in the medium term, and a new entrant had secured spectrum. It noted, however, that only two operators had secured sufficient adjacent spectrum to offer advanced 4G services with higher download speeds.

As regards the second objective the Audit Office could not confirm that an economically efficient allocation had been achieved as it was apparent that all participating firms did not bid the full value of the spectrum to their businesses. In particular two firms were identified as budget constrained:

In this auction, our analysis indicated that at least two bidders appeared to be subject to budget constraints which meant that they sought to limit the amount they would be required

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<sup>27</sup> Burguet, R. and McAfee, R. P. (2009), "License prices for financially constrained firms", *Journal of Regulatory Economics* 36, 28 March 2009. Page 194.



to pay for spectrum in the auction. These budget constraints meant that they were not necessarily bidding the full value of the spectrum to their businesses. This may have prevented them from achieving all their objectives in the auction.<sup>28</sup>

In addition, the UK Audit Office noted that any judgement on whether spectrum was actually assigned to those able to make best use of it cannot truly be made until evidence is available from post-auction spectrum usage.

## 4.2 Social efficiency and the revenue from spectrum assignment

Private firms must expect to pay a reasonable price to acquire property rights for the use of a public resource such as spectrum. In doing so spectrum revenues accrue to the public whether the spectrum is allocated by administrative assignment, by auction or any other means. So is social efficiency best served by attempts to maximise Government revenue from spectrum fees?

There is compelling empirical evidence to suggest that the **most** important determinants of social welfare in mobile service markets are the extent of market competition and the quantum of allocated spectrum. For example, Hazlett and Muñoz provide an empirical model<sup>29</sup>, using time-series and cross-sectional data, which illustrates that these two factors play a key role in influencing retail market outcomes.

Our empirical analysis focuses on wireless telephone service in twenty-eight countries, of which nineteen employ auctions to assign licenses. After adjusting for cross-sectional differences in demand and supply, we find that larger quantities of spectrum, as well as more intense competitiveness (measured by the Herfindahl Hirschman Index), are strongly associated with lower prices. We then use the coefficient estimates from our model to perform simulations quantifying retail market effects associated with various policy changes. In general, auction rules intended to increase license rent extraction by restricting spectrum

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<sup>28</sup> National Audit Office (2014), *4G radio spectrum auction: lessons learned*, 6 March 2014. Page 23.

<sup>29</sup> Hazlett, T.W. and Muñoz, R.E. (2008), *A welfare analysis of spectrum allocation policies*, 1 December 2008.

access are not welfare-enhancing. Restricting the use of spectrum inputs is a relatively expensive way to raise public funds.

This finding suggests that in order to maximise social efficiency (or consumer benefits) it is crucial to focus on ensuring market competitiveness and spectrum supply rather than maximising rents from spectrum allocation techniques. As Hazlett et al conclude:

To maximize consumer welfare, spectrum allocators should avoid being distracted by side issues like government license revenues. By focusing on wireless market efficiency, getting abundant spectrum resources into a competitive marketplace, policy makers can pave the way for low prices, high outputs, and robust innovation. The economic forces unleashed will produce the highest social gains.<sup>30</sup>

Underlying these conclusions is the significant value or utility that consumers and businesses obtain from mobile services and applications. Since 2000 there have been many attempts to estimate this value to consumers<sup>31</sup>. Consumer surplus is a traditional economic measure that captures the difference between what a consumer would be willing to pay and the price actually paid. Using very conservative assumptions a minimum estimate of the ratio of consumer surplus to spectrum value (as reflected by historical spectrum prices) is 10-to-1<sup>32</sup>. Indeed, the magnitude of consumer surplus estimates is so great that even a minuscule contraction in output or price increase at the retail level is likely to have a significant impact on consumer welfare. As noted by Hazlett et al:

Delicate adjustments that seek to juice auction receipts but also alter competitive forces in wireless operating markets are inherently risky. A policy that has an enormous impact in increasing license revenues need impose only tiny proportional costs in output markets to undermine its social utility. So, for example, a new auction design that (heroically) doubled

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<sup>30</sup> Hazlett, T.W., Muñoz, R.E. and Avancini, D.B. (2012), "What really matters in spectrum allocation design", *Northwestern Journal of Technology and Intellectual Property*, Winter 2012.

<sup>31</sup> See, for example, Bazelon and McHenry (2015), *Mobile Broadband Spectrum: A Vital Resource for the American Economy*, 11 May 2015.

<sup>32</sup> *Ibid*, page 17.

auction revenues would, if it reduced consumer surplus by just one-half of one percent, produce costs in excess of benefits.<sup>33</sup>

Acceptance that consumers may be harmed should Government pursue revenue maximising strategies in auction design is now widespread in the literature. As an example, Martin Cave reflecting on lessons learnt in the last decade states:

An auction also captures some of the investors' profits for the government, which benefits consumers as taxpayers – as long as governments are not tempted to use the auction primarily to raise revenues. If spectrum is withheld or the auction otherwise designed to artificially increase auction revenues, the harm done to users through higher prices and less innovation invariably far outweighs the short-term finance ministry gain.<sup>34</sup>

In this regard it is important to note that recent empirical research has indicated that the highest economic benefits from both fixed and mobile broadband are observed in the service sector<sup>35</sup>. As the service sector – particularly financial services, tourism, trading and professional services<sup>36</sup> – dominates the Hong Kong economy, accounting for over 90% of GDP in 2015, future economic growth and productivity depend more on long-term investment in communications infrastructure than short-term fiscal returns.

### 4.3 Ensuring market competitiveness

Although we have identified a broad consensus in the literature that market competition rather than the size of auction revenues is key to social efficiency, we should also consider whether mechanisms that maximise revenue will in any event lead to pro-competitive market

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<sup>33</sup> Hazlett, T.W., Muñoz, R.E. and Avancini, D.B. (2012), "What really matters in spectrum allocation design", *Northwestern Journal of Technology and Intellectual Property*, Winter 2012.

<sup>34</sup> Cave, M. (2014), *Lessons of a decade of spectrum management reform: 'Don't mess with input prices'*, The Public Policy Series No. 15. August 2015.

<sup>35</sup> Bertschek, I., Briglauer, W., Hüschelrath, K., Kauf, B., and Niebel, T. (2016), *The Economic Impacts of Telecommunications Networks and Broadband Internet: A Survey*. Centre for European Research, Discussion Paper No. 16-056, August 2016.

<sup>36</sup> See, Hong Kong Monthly Digest of Statistics (2016), *The Four Key Industries and Other Selected Industries in the Hong Kong Economy*, 3 March 2016.

expansion. For example, reducing the size of existing spectrum assignments might simultaneously maximise overall Government revenue and permit new market entry.

In theory with a more concentrated market structure we would anticipate less intense price competition than in a less concentrated market. However in practice the nature of mobile service provision is such that economies of scale and scope are typically very significant – to the extent that this characteristic represents a major barrier to new market entry. Hence price competition can be very intense with relatively few firms in the market producing efficient outputs, assuming there are no large asymmetries in spectrum holdings. This suggests that in mobile services markets it is not necessarily the case that competition would be best served if the number of market participants is increased by reducing the size of spectrum allocations. This point is acknowledged in the literature as an important consideration for competition policy.

... competition policy needs to consider the potential for higher social value from concentrated ownership of spectrum: incumbents may be able to leverage existing infrastructure to provide services more efficiently and some aggregation of spectrum may be necessary to develop a new generation of services (for example, a high-speed wireless data service).<sup>37</sup>

If existing relatively efficient operators emerge from a spectrum re-assignment process with less spectrum than previously then to maintain existing service levels and preserve market position it may be necessary to undertake mitigation strategies such as deploying additional infrastructure. This is likely to entail increases in both fixed and variable costs, and if it is not possible to internalise all of these costs then there may be price implications at the retail level.

Given the above risks, the implication is that the spectrum manager in selecting appropriate mechanisms for spectrum re-assignment should have a reasonable expectation that welfare-enhancing new market entry is indeed feasible. In fact in most developed markets we observe a trend towards greater mobile market consolidation and mergers, rather than successful new

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<sup>37</sup> Cramton, Kwerel, Rosston, and Skrzypacz (2011), *Using Spectrum Auctions to Enhance Competition in Wireless Services*, February 2011. Page 3.

entry. Indeed in Hong Kong market consolidation occurred in 2014 with the acquisition of CSL by HKT. It should be noted that new market entry is also possible through acquisition.

The CA characterises the Hong Kong mobile market as ‘one of the most competitive mobile telecommunications markets in the world, with four mobile network operators (MNOs) serving a population of 7.3 million’<sup>38</sup>. It also considers ‘that the optimal number of MNOs to meet demand for mobile telecommunications services in Hong Kong should be determined by market forces’<sup>39</sup>. The desire to provide an opportunity for new market entry appears to drive its preference in re-assigning existing arrangements in the 900MHz and 1800MHz bands to maximise the amount of spectrum available for acquisition with a market-based mechanism (auction).

Should the spectrum manager decide in favour of promoting new market entry in the spectrum assignment or re-assignment process then appropriate mechanisms should be considered.

... to create new entry in the provision of wireless services it is often necessary to first encourage entry into auctions; the expectation that incumbents are likely to have some synergy value for new spectrum and have additional incentives to bid aggressively in the auction to deter entry is often a strong deterrent for potential new bidders.<sup>40</sup>

A high reserve price may represent a significant barrier to entry for potential newcomers, and may discourage auction participation. When Ofcom was recently setting reserve prices for 2.3GHz and 3.4GHz spectrum – based on a range of market values derived from benchmarks – its focus was on the low end of this range as “reserve prices set at this level would provide room for relevant price discovery”.<sup>41</sup>

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<sup>38</sup> Office of the Communications Authority (2016), *Arrangements for the frequency spectrum in the 900MHz and 1800MHz bands upon expiry of the existing assignments for public mobile telecommunications services and the Spectrum Utilisation Fee*, Consultation Paper, 3 February 2016. Page 3.

<sup>39</sup> *Ibid*, page 12.

<sup>40</sup> *Ibid*.

<sup>41</sup> Ofcom (2015), *Public Sector Spectrum Release: Award of the 2.3 and 3.4 GHz spectrum bands*, 26 May 2015, paragraph 4.93.

The level of the reserve price implied in the CA's initial consultation paper for the 900MHz and 1800MHz bands would appear to be inconsistent with conventional wisdom that relatively low reserve prices encourage market entry. In addition, as a result of capital constraints, high reserve prices could have unintended consequences such as market exit or further consolidation which would increase market concentration, creating upward pressure on retail prices.

#### 4.4 Setting an efficient renewal price via administrative methods

In circumstances where dynamic efficiencies are a key consideration for policy-makers, and / or there is a strong presumption of licence renewal, re-assignment of existing spectrum rights is often undertaken through administrative means rather than auctions. Typically this involves the use of opportunity cost approaches to estimate an appropriate market value. Benchmarks from other jurisdictions or other relevant local auctions are often used as a cross-check of estimates from opportunity cost modelling. Countries that have employed such approaches include Australia, New Zealand and the United Kingdom.

It is important to note that an efficient outcome from such a process is not necessarily achieved through attempting to maximise revenue, as highlighted recently by Poort and Kerste:

... charging an operator his own maximum value for [licence] extension ... would punish the incumbent for its success and specific investments by extracting the rents associated with these. Moreover it would not equal the theoretical market price, because in general an efficient incumbent would not have to pay his own maximum value to win the auction but that of his contestant to outbid him.<sup>42</sup>

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<sup>42</sup> Poort, J. and M. Kerste (2014), "Setting licence fees for renewing telecommunication spectrum based on an auction", *Telecommunications Policy* 2014.

## 4.5 To what extent do spectrum costs affect consumers?

In 2005 the World Bank suggested that:

... high license fees would result in a substantial tax on consumers to the extent that the fees are passed on to them. Higher than reasonable licensing fees levied on operators may, in practice, translate into rent-extracting behaviour, or constitute a barrier to competition.<sup>43</sup>

This view is disputed by some theorists who consider that auction fees are one-off sunk costs that do not affect retail pricing or future investment decisions<sup>44</sup>.

However, other commentators suggest that sunk costs cannot be dismissed in this way, given the level of fees paid in relation to total firm resources, and the particular characteristics of the mobile sector. For example, Bohlin et al note:

... this line of reasoning holds only if stringent assumptions as to the competitiveness of the mobile market, the working of capital markets, and the dynamics of sector adjustment hold. If these assumptions are modified to better reflect the institutional and economic features of the mobile industry, licence fees may have less benign effects on sector evolution. The potential distortion of pricing and investment decisions is higher for fees that are fixed upfront, as they lock in the sector outlook at one moment in time without opportunities to adjust once more information on the true market conditions is revealed.<sup>45</sup>

As implied above the reaction of capital markets may be important in the event that high spectrum charges affect the firms' level of debt, cash flow and its cost of capital. Corporate finance theory suggests that increased capital requirements may lead to an increase in the firm's cost of capital and consequently this may affect the firm's future investment<sup>46</sup>.

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<sup>43</sup> The World Bank (2005), *Mobile license renewal: what are the issues? What is at stake?*, June 2005, page 12.

<sup>44</sup> See, for example, Binmore, K. and Klemperer, P. (2002), "The biggest auction ever: the sale of the British 3G telecom licences", *Economic Journal*, 112, March 2002.

<sup>45</sup> Bohlin, E, Madden, G. and Morey, A. (2010), *An econometric analysis of 3G auction spectrum valuations*, EUI Working Paper 2010/55, July 2010. Page 2.

<sup>46</sup> See, for example, Whited, T. M. (1992), "Debt, Liquidity Constraints, and Corporate Investment: Evidence from Panel Data", *the Journal of Finance* Vol. XLVII, No. 4 September 1992.

Moreover there is evidence of such effects in the early 2000s when extremely high fees paid in 3G spectrum auctions in the United Kingdom and Europe precipitated a debt crunch in the sector.

As a direct consequence of the 3G licensing processes, substantial value was extracted from the mobile sector, both directly through high license fees in certain Member States, and indirectly through deflating stock prices and worsening debt ratings to which 3G substantially contributed. This has resulted in significant funding problems for several operators, and in a number of Member States has already led to delays in planned 3G network rollouts and application.<sup>47</sup>

Given the evidence that telecommunications firms are subject to financing constraints, Burguet and McAfee examine the implications for consumers of high spectrum prices with a theoretical model<sup>48</sup>. The model indicates an inverse relationship between licence prices and service deployment (or service quality) in circumstances where spectrum prices exceed hard budgets (reflecting the so-called winner's curse), although the effect on consumers depends on the characteristics of demand elasticity. If consumer demand is sufficiently elastic then auction revenues may be sufficient to compensate for delays on service deployment.

Both experience with telecommunications companies and corporate finance research indicates that financing constraints are a fact of life in many bidding contexts. In principle, frequent company complaints that high auction prices prevented the rapid rollout of services could have merit. The effect of financing constraints on the deployment of services was examined in the context of a model of hard budgets. Evaluation of the effect of auction prices hinges on relatively inelastic demand, and auctions are optimal even when the firms are financially constrained, provided the auction price is not too large a fraction of the firms' resources<sup>49</sup>.

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<sup>47</sup> European Commission (2002), *Comparative assessment of the Licensing Regimes for 3G Mobile Communications in the European Union and their Impact on the Mobile Communications Sector*, 25 June 2002.

<sup>48</sup> Burguet, R. and McAfee, R. P. (2009), "License prices for financially constrained firms", *Journal of Regulatory Economics* 36, 28 March 2009.

<sup>49</sup> *Ibid*, page 193.



It should be noted that this model includes Government licence revenue in the objective function. This explains the finding that under some demand elasticity assumptions licence revenue is sufficient to compensate consumers for slower deployment (or lower quality services). Given the extensive social and economic benefits of mobile services discussed in Section 4.2 this treatment of Government revenue is questionable.

So in practice is there any direct relationship observable between high spectrum fees and retail prices, service quality, innovation and investment? As retail prices are driven by many factors including market structure and these differ from one market to the next, it is understandably difficult to identify causal relationships. Nevertheless, although causality may be difficult to establish in all cases, some empirical studies illustrate that firms do attempt to recover high auction fees through mark-up pricing strategies, both in the short and long term<sup>50</sup>.

#### *Case study: Hong Kong*

When the original assignments of 1.9–2.2GHz spectrum were approaching expiry, the Communications Authority determined that a hybrid approach would be used to re-assign this spectrum. Each of the four incumbent operators would be offered the right of first refusal (RFR) to a portion (2×9.9MHz) of their original allocation with the remaining portion (2×4.9MHz) to be auctioned.

With the acquisition of CSL by HKT, conditions were imposed upon the new entity, with HKT required to divest 2×14.8MHz of spectrum in the 1.9–2.2GHz band – which would be assigned via the auction – and would not seek to obtain additional spectrum in that auction.

The SUF applicable for the auctioned spectrum would be determined by the market as an outcome for the auction, however the SUF per MHz for the RFR spectrum was set to be the maximum of HKD66 million and the SUF determined in the auction, with a cap of HKD86 million. The figure of HKD66 million was determined from the 2015/16 royalty payment for 3G spectrum multiplied by 15 (representing a 15-year licence term). By

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<sup>50</sup> See, for example, Offerman, T. and Potters, J. (2000), *Does auctioning of entry licenses affect consumer prices? An experimental study*, May 2000.

referring to this term as the “Lower Limit” the evident assumption was that this would be a lower bound for the SUF.<sup>51</sup>

However, the SUF from the auction proved to be significantly lower than HKD66 million – the auction results ranged between HKD48 and HKD51 million per MHz.

In their statement regarding the setting of the RFR SUF the CA and the Secretary for Commerce and Economic Development (SCED) noted:

Frequency spectrum is a scarce public resource. It is incumbent upon the Government to ensure that the SUF of spectrum is set to reflect as close as possible its full market value so that spectrum assignees, which run their commercial operations in a fully liberalised market, would put the spectrum so acquired to its most efficient use.<sup>52</sup>

It is clear that with regard to the SUF for the RFR spectrum the Government did not meet this objective. As the set price for the RFR spectrum exceeded the auction price, operators paid more than the market value for the RFR spectrum. As the price did not reflect the market value the implication is that additional costs have been imposed on market players. This inefficient result could distort investment behaviour and decisions and explain the observed need to passthrough a part of the additional costs at retail level. All MNOs in Hong Kong now include a monthly flat rate “administration fee” or levy in consumers’ mobile bills which contributes to spectrum fees and other charges payable by MNOs (such as MTR and tunnel charges).

## 4.6 Conclusion: what is the optimal pricing approach for spectrum?

The optimal approach for pricing spectrum in a re-assignment process depends entirely on the policy-maker’s objectives.

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<sup>51</sup> Communications Authority and the Secretary for Commerce and Economic Development (2013), *Arrangements for the Frequency Spectrum in the 1.9 – 2.2 GHz Band upon Expiry of the Existing Frequency Assignments for the Provision of 3G Mobile Services and the Spectrum Utilisation Fee*, statement, 15 November 2013.

<sup>52</sup> *Ibid*, paragraph 49.

<i>Maximising social efficiency</i>	Evidence from the literature demonstrates that, given the extent of utility derived by consumers from mobile services and applications, setting high SUFs in pursuit of revenue maximisation strategies in selecting spectrum assignment or re-assignment mechanisms is not a socially efficient approach and may actually harm consumers. The key drivers of social efficiency in mobile markets are the extent of market competition and the quantum of allocated spectrum.
<i>Maximising technical efficiency</i>	Technical efficiency may be compromised if existing operators' spectrum holdings reduce in a reassignment process. Moreover there is the risk that both fixed and variable costs may increase as investment is undertaken to preserve existing service levels. As a result potentially the market may become less competitive. Re-assignment through administrative pricing may be more conducive to ensuring technical efficiency than auctioning.
<i>Encouraging new market entry</i>	In theory allowing for new market entry in a re-assignment process may increase competition and drive innovation. As a newcomer will incur considerable capital costs in establishing a new network, high spectrum prices will represent a further entry barrier. As such a relatively low auction reserve price may be essential if the Government wishes to promote competition through new market entry in the forthcoming spectrum reassignment.
<i>Promoting investment</i>	Spectrum auctions are widely viewed as promoting allocative efficiency, yet the literature identifies circumstances in which there are mismatches between the price paid or the winning bid and the true value of the spectrum. In these cases dynamic efficiency may be impeded. If the investment decisions of incumbent operators are distorted then potentially new service deployment may slow and / or service quality will degrade, to the detriment of consumers. Assuming a low relative weight is assigned to maximising Government revenue, this implies that achieving an optimal outcome

involves setting a relatively low auction reserve price or alternatively a fixed price that accurately reflects true market value.

## 5 Concluding remarks

Our examination of the CA's proposed reference auctions suggests that these results may not be appropriate for setting SUFs for re-assignment of 900MHz and 1800MHz spectrum. With structural changes in the market and supply-side factors, there is a strong risk that these reference auctions would not now reflect true market values in Hong Kong. Use of these reference prices for setting reserve or fixed prices may lead to artificially high SUFs which may have a distortionary effect on the market. Real harm to consumers and the economy may occur.

We recommend that the CA bases the SUFs on a sample of suitable benchmark auction results from other jurisdictions. Previous Hong Kong auction results could be included within this sample, but it will be necessary to make appropriate adjustments to reflect the effect of those structural changes.

Our review of the economic literature revealed that optimal consumer outcomes occur where true market value is reflected in spectrum prices. With efficient spectrum pricing and sufficient spectrum allocation incumbent operators may minimise costs to produce retail services efficiently, continue to invest and develop innovative services and products.

SUFs that reflect the true market value would ensure that Government's key objectives – whether those be maximising social and technical efficiency, encouraging new market entry, or promoting investment – can be achieved.



# Annex A: Benchmark methodology

## A.1 Overview

Benchmarking techniques seek to establish a price for spectrum based on market prices in other jurisdictions, or from other spectrum bands. Every country is unique, which makes direct comparisons difficult. Furthermore mobile networks typically reflect the characteristics of the local environment, which in turn influence the valuation of the spectrum. These characteristics include:

- subscriber distribution and traffic density
- mix of urban, suburban and rural areas
- coverage area
- terrain
- traffic levels
- the amount of spectrum available.

Ideally benchmark data should be recent and obtained from countries or bands ‘similar’ to the spectrum bands being considered; the underlying assumption being that prices will be comparable where the price drivers – cost drivers of the service requiring the spectrum, market drivers and spectrum licence conditions – are similar.

In practice however, there may be various uncertainties associated with the benchmarking estimate:

- few suitable datapoints may be publicly available

- current market conditions may differ substantially from the period for which the data applies
- available data may be from countries or alternative spectrum bands with very different characteristics and markets
- there may be terms and conditions associated with the benchmark spectrum licences or the corresponding auction process which could affect the price paid.

Any straightforward comparison – as well as for a benchmark modelling approach – of spectrum prices needs to apply sequentially some basic adjustments to ensure the prices have a similar basis:

- convert to a common currency (discussed in more detail below)
- adjust for differing lot sizes – divide by the (paired) lot size to obtain a price per (paired) MHz
- adjust for differing licence durations – divide by the licence term to obtain an annualised price per MHz
- adjust for differing market sizes – divide by population (expressed in thousands<sup>53</sup>) to obtain an annualised price per MHz per 1000 persons.

The result is referred to as the “price per MHz-population”.

As auctions may encompass several lots, our analysis is based on the average price across all winning bids, rather than the maximum or minimum winning bid.

Due to the irregularity of spectrum awards over time, caution should be taken if attempting to infer any overall trends in prices as the characteristics of countries awarding spectrum may vary dramatically from year to year.

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<sup>53</sup> The population is expressed in thousands simply for the purpose of using a convenient scale for presentation of the values.



## A.2 Prices and currency conversion

Our benchmarking analysis requires that all prices be converted to a common currency, and adjusted for inflation as well as the relative price differences between countries.

The original spectrum prices were reported in nominal local currency units (LCUs). Firstly we converted these to real 2015 LCU prices by applying the CPI for that country, thus adjusting for inflation. These prices were then converted to HKD using the 2015 purchasing power parity (PPP) rates from the World Bank World Development Indicators.

PPP is used widely by international and national telecommunications (and non-telecommunications) bodies which undertake international price comparisons. It is the ratio of the costs of a basket of goods in two countries each calculated in their own currency units. These costs reflect labour and other input costs, profit margins, indirect taxes and also, indirectly, capital costs. The use of PPP enables us to convert prices to a common currency unit, and at the same, adjusts for average cost differences between countries.