

Spectrum Limits and Auction Revenue: the European Experience

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July 29, 2013

Summary of the main points

- Sub-1 GHz spectrum has attractive propagation characteristics, enabling a degree of coverage that would be difficult to replicate without it. Accordingly, a wireless operator without proper access to such spectrum will be weakened, and possibly severely weakened.
- There is evidence that robust competition among wireless operators benefits both customers and the wider economy by spurring innovation and lowering prices.
- In recognition of this, governments and regulators in Europe have worked to design auctions in ways which maintain competitive pressures. This effort has led them in many cases to impose spectrum-aggregation limits on the amount of sub-1 GHz spectrum which any operator can acquire.
- The regulators' common goal has been to ensure that a sufficient number of operators have enough spectrum of the right kind to generate effective infrastructure competition. The resulting auctions have not excluded the largest operators from bidding, but have been designed to ensure smaller operators' access to some of the spectrum being auctioned.
- Auction designers must balance their desire to promote competition and maximise the economic impact of the use of spectrum with the need to raise revenues for important public purposes. The limited available evidence from European auctions is consistent with spectrum limits *not* having reduced revenues.
- The wireless market in the USA is structured in a manner which would probably lead European regulators to give careful consideration to the imposition of sub-1 GHz limits. However, any such limitation should be calibrated to achieve the desired outcomes at the minimum level of intervention.

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² The views expressed belong to the authors alone.

1. Introduction

The question of spectrum-aggregation limits in auctions has attracted a lot of predictable controversy – predictable because larger incumbents have an interest in opposing them, while smaller operators or entrants take the opposite view.

Onlookers also disagree on the merits of spectrum-aggregation limits. This disagreement is illustrated in the present case by the interchange between the Department of Justice (DoJ), which has favoured some form of spectrum-aggregation limits in its *ex parte* submission to the FCC Notice of Proposed Rulemaking,³ and direct responses to this by AT&T's General Counsel⁴ and a group of senior Congressional House Republicans.⁵

In essence, the DoJ argues that imposing a limit on the amount of spectrum which AT&T and Verizon can acquire in the forthcoming forward auction of reclaimed broadcast spectrum in the 600 MHz band will ensure that the smaller nationwide networks can acquire the low frequency spectrum that they need, and that this will improve the competitive dynamic among nationwide carriers and benefit consumers. The Republican House Members and AT&T counter that taking this step will both diminish and distort competition in wireless markets, and will jeopardise one of the goals expressed in the underlying legislation – that of maximising revenue from the auction, to be used for several purposes including construction of a public safety wireless broadband network. The interpretation of the legislation offered by the Republican House Members is itself contested by Democratic House Members.⁶

It is our impression that both sides in this debate recognise that the final decision in this matter involves balancing a number of imponderables, such as how wireless markets will develop with or without a spectrum-aggregation limit, and how such limits might affect revenues, for instance, by altering the number of parties that participate in the forthcoming auction.

It is our goal to address the question from the standpoint of participants in parallel debates on the role of spectrum-aggregation restrictions in Europe, where limitations on spectrum acquisition were present in the 3G spectrum auctions which took place in 2000/01, and also, in most countries, in the so-called 4G or 'digital dividend' auctions which have taken place in the past three years.

We attempt to explain some of the thinking which has underpinned regulators' decisions, and we also comment on the evidence of the impact of aggregation limits in Europe, recognising that the available data is only capable of providing indicative, rather than definitive, answers to this question.

Accordingly, we first set out briefly in section 2 the history of the adoption (or non-adoption) of aggregation limits in Europe; we then describe in section 3 the reasoning adopted in making decisions about aggregation limits, based upon the expected impact of such rules on competition in the wireless sector, and briefly the resulting consequences for economic growth. Section 4 contains

³ US Department of Justice, *Ex parte Submission of the United States Department of Justice*, Docket No. 12-269 (filed April 11, 2013).

⁴ Letter from W Watts to Chairman Genachowski and others, dated April 24, 2013.

⁵ Letter from the Honorable Fred Upton and others to Chairman Julius Genachowski and others, dated April 19 2013.

⁶ Letter from Honorable Henry Waxman and others to the Honorable Julius Genachowski, dated May 16, 2013.

some case studies of the impact of individual firms which auction design has encouraged to challenge the market leaders in the wireless sector. Section 5 discusses the apparent impact of aggregation restrictions on auction revenues, as illustrated by the results of recent European auctions. Section 6 summarizes our findings.

2. Spectrum-aggregation limits in Europe

2.1 Introduction

Prior to 2000, the standard method of licensing wireless operators in Europe was to issue a predetermined number of wireless communications licences, each associated with a licence to use a specified component of the chosen frequency band. This method was used to issue national GSM licences in the 1980s, and the method of assignment was a comparative evaluation of applicants against a predetermined set of criteria, or “beauty contest.” Initially, only one or two licences were issued, but in the 1990s more spectrum was identified for commercial use and assigned in the same fashion to additional operators. The spectrum was tied to a particular use and a particular technology and was not tradable. Each licensee was thus subject to a spectrum limit. If one licensee merged with another, the combined entity would typically be required to hand back some of the assigned spectrum.

This rigorous form of control of operators’ spectrum was carried forward into the 3G licensing process which was accomplished in Europe in 2000/1.⁷ The government typically chose the number of licences to be made available, and associated an assignment of spectrum with each. The method of assignment was now an auction, typically a simultaneous ascending auction, for the specified number of licences. In Germany and Austria, six blocks of spectrum were made available and the auction was designed to ensure that they went to at least four operators. These designs permitted new entrants in several markets.

By the time the next major round of spectrum auctions occurred, often known as the digital dividend because of its association with the switch-off of analogue terrestrial television, European licensees typically held portfolios of spectrum holdings, acquired at various rounds of awards going back up to twenty years, at 900 MHz, 1800 MHz, 2.1 GHz, 2.3 GHz and more. In many countries, earlier licences had been renewed or retendered. Several countries chose to conduct simultaneous auctions of spectrum at multiple frequencies, most of them using combinatorial clock auction techniques. For this purpose, spectrum at the various frequencies was divided into blocks, and bidders made bids for combinations of blocks at different frequencies. In other words, bidders could choose the combination of licences which they wanted, rather than having them predetermined by the auction designer.

This required governments or regulators expressly to decide whether to impose spectrum-aggregation limits. We discuss below how these decisions were made, but note here that in imposing such limits, governments took into careful consideration the differences in the attributes of different frequency bands.

⁷ See Paul Klemperer, *Auctions: Theory and Practice*, Princeton University Press, 2004, Ch. 5.

Radio frequencies have differing properties. In particular, lower frequencies have greater range and an associated ability to penetrate buildings more effectively. The actual range achieved depends on many factors including base station height, power, topography, handset efficiency and much more, but Table 1 gives some approximations as to the range that might be achieved in different mobile bands.

Frequency band	Exemplar range (km)	Comments
600 MHz	7.7	US incentive auction band (expected)
700 MHz	6.9	US recent auction
800 MHz	6.2	European recent auctions
900 MHz	5.8	2G band in Europe
1.8 GHz	3.5	Additional 2G band
2.1 GHz	3.1	3G band
2.6 GHz	2.6	Used by Clearwire

Table 1: Frequency range with frequency based on Hata model with 20 m base station height and 160 dB allowed path loss

For a system built to maximise coverage, the range has a major impact on deployment costs. A base station coverage area is related to the square of the range. Hence, for example, a 1.8 GHz network would need 4.8 times as many cells as a 600 MHz network for equivalent coverage.⁸ As the cost of a network is roughly proportional to the number of base stations, operators with lower-frequency spectrum can have a major cost advantage over those without. As can be seen from the table, there is a large gap between 600-900 MHz and 1.8 GHz, with no intervening frequencies currently being used for cellular. Hence, simplistically, spectrum splits into sub-1 GHz and above-1 GHz, with material range advantages to the sub-1 GHz bands. This is why regulators and policymakers have paid particular attention to the distribution of this spectrum.

For example, Ofcom⁹ has noted:

“Particular importance of sub-1 GHz spectrum

5.40 Sub-1 GHz spectrum gives advantages over higher frequencies in terms of coverage. It allows a significantly greater geographical area to be served than higher frequency bands

⁸ There is an important caveat here. Some networks are “capacity limited” rather than “coverage limited”. This means that the cell range has been deliberately reduced in order to increase network capacity by allowing the introduction of additional cells. Networks tend to be capacity limited in urban areas but coverage limited in rural areas. In capacity-limited situations, the advantage of greater range is diminished or even removed completely; however, low-frequency spectrum *can* serve the capacity functions more typically associated with high-frequency spectrum (for example, by lowering power, increasing antenna downtilt, etc.), but the physical properties of high-frequency spectrum make it much more costly and much less practical to serve the coverage functions associated with low-frequency spectrum. See, .e.g., Jonathan B. Baker, “Spectrum Auction Rules that Foster Mobile Wireless Competition,” at 15, Exhibit B, Reply Comments of T-Mobile USA Inc., Docket No. 12-268 (filed March 12, 2013).

⁹ Ofcom, Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues, 22 March 2011. In its 2013 auction design which incorporated a spectrum floor for a fourth bidder, Ofcom effectively guaranteed that bidder a choice among several spectrum bands. From those available, the fourth bidder elected to acquire 800 MHz spectrum; see section 4.1 below.

would, for the same number of sites (because signals travel further at lower frequencies). It also tends to provide substantially better signal quality and higher download speeds (throughput) within buildings than higher frequencies since lower frequency signals are better at penetrating solid objects.

5.41 These advantages could mean that national wholesalers with a large amount of sub-1 GHz spectrum would have an unmatched competitive advantage over those without any sub-1 GHz spectrum. By an unmatched competitive advantage we mean that the national wholesalers without sub-1 GHz spectrum suffer a material competitive disadvantage because they are unable to develop their networks to offer services sufficiently similar to national wholesalers with sub-1 GHz spectrum. This would depend partly on technical differences between wholesalers with different spectrum portfolios and partly on how sensitive consumers are to any such technical differences, such as the quality of deep indoor coverage.

5.42 In our technical analysis we have explored the technical scale of these advantages. This analysis is set out in Annex 7. Our preliminary conclusion is that national wholesalers with a large amount of sub-1 GHz spectrum may have an unmatched technical advantage compared to national wholesalers without any sub-1 GHz spectrum.”

The Irish regulator, Comreg, has commented:¹⁰

- “the inclusion of the 800 MHz band would almost double the amount of spectrum in the competition;
- while there may be short-run differences (e.g. due to equipment availability) between the 800 MHz and 900 MHz bands, ComReg did not believe these to be sufficient to prevent the use of a single cap for the sub-1GHz spectrum; and
- while perfect symmetry in sub-1GHz spectrum distribution between competitors is not necessary to facilitate competition, highly asymmetric distributions of sub-1GHz spectrum could be detrimental to competition downstream.”

This has led most European regulators to adopt mechanisms to ensure that holdings of sub-1 GHz spectrum do not become concentrated across a subset of operators as discussed below.

2.2 Spectrum-aggregation limits in Europe

The use of spectrum-aggregation limits is widespread around the world and appears to be becoming an increasing feature of spectrum auctions. In this section, we concentrate on the use of aggregation limits in spectrum auctions below 1 GHz. These are predominantly at 800 MHz in Europe. This practice is an ever changing area as regulators review and change plans and as more auctions are held. Nevertheless, in aggregate, the data paint a picture of limits as a widely employed feature of the spectrum auction process.

Many of these auctions are complex, with unique features or national idiosyncrasies. We have done our best to categorise them appropriately. We have made some assumptions in treating the data – for example the simplification that coverage obligations do not have materially different impacts on

¹⁰ Source: “Multi band spectrum release”, doc 11/60a, 24 Aug 2011, Comreg.

auction revenues in different countries. As a result, we do not expect that our analysis is perfect in all respect, or that flaws cannot be found. However, we believe that the results presented here provide useful pointers.

Specific cases

In Germany's auction of the 800 MHz, 1800 MHz, 2.1 GHz and 2.6 GHz bands, the regulator imposed spectrum-aggregation limits¹¹ which effectively limited two MNOs (T-Mobile and Vodafone) to 2x22.4 MHz and all other potential bidders to 2x20 MHz of sub-1 GHz spectrum. In contrast, it did not impose any limits on the higher frequency spectrum in the auction, indicating their greater concerns regarding excessive concentration in the sub-1 GHz bands and their relative lack of concern with concentration in the higher frequency bands which were more plentiful and conferred less competitive advantage. The outcome¹² was that T-Mobile and Vodafone acquired spectrum up to their cap¹³ (which was 2x10 MHz in the 800 MHz band).

Sweden's regulator cited the sub-1 GHz spectrum as being "well suited for area coverage and indoor coverage" and imposed 2x10 MHz caps¹⁴ in its 800 MHz auction which resulted in the three incumbents gaining spectrum.

In Ireland's November 2012 auction of the 800 MHz, 900 MHz and 1800 MHz bands, the regulator proposed a sub-1 GHz cap of 2x20 MHz. It identified sub-1 GHz spectrum as "particularly important for competition in a service market such as this" and cited a technical study which identified the significantly smaller number of sites needed for a 900 MHz network to achieve the same service level as a network using higher frequency spectrum.¹⁵ The outcome was that three of the four operators each purchased 2x10 MHz of the spectrum.

In its 2012 auction of all mobile spectrum bands Switzerland's regulator proposed a sub-1 GHz cap of 2x30 MHz (subsequently revised down to 2x25 MHz¹⁶), highlighting its relative importance by citing the bands' "good propagation characteristics". The 800 MHz band is the only new spectrum band that has caps imposed on it, with the 2.6 GHz band having no cap.¹⁷ There is a total overall cap of 2x135 MHz per operator. The outcome was that Orange gained 2x10 MHz at 800 MHz and 2x5 MHz at 900 MHz, Swisscom gained 2x10 MHz at 800 MHz and 2x15 MHz at 900 MHz, and Sunrise gained 2x10 MHz at 800 MHz and 2x15 MHz at 900 MHz.¹⁸

Spain's regulator proposed a 2x20 MHz sub-1 GHz cap for its September 2011 auction of all mobile spectrum bands. Three incumbent operators acquired 2x10 MHz of spectrum at 800 MHz. There

¹¹ Source: Ofcom: Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues, published 22 March 2011, see Annex 6, Section 5.

¹² All auction outcome data is sourced from the PolicyTracker Global Spectrum Database, see <http://www.policytracker.com/global-spectrum-database>

¹³ See <http://www.tolaga.com/pdfReports/GermanyMegaAuction.pdf> where Exhibit 3 shows T-Mobile and Vodafone both had 2x12.4 MHz at 900 MHz prior to the auction.

¹⁴ Source: Ofcom, as above.

¹⁵ Source: Ofcom, as above.

¹⁶ See <http://www.ofcom.admin.ch/themen/frequenzen/03569/03901/index.html?lang=en>

¹⁷ Source: Ofcom, as above.

¹⁸ See <http://www.telegeography.com/products/commsupdate/articles/2012/02/23/trio-snap-up-swiss-spectrum/>

were some indications that the caps may have had an impact in some regions in a complex multi-band auction implemented in multiple phases. In particular, caps may have had an impact on the subsequent 900 MHz auction that followed from the 800 MHz auction.

Portugal put in place a 2x10 MHz cap at 800 MHz. Three incumbents all gained 2x10 MHz.

Slovakia decided that no one operator will be allowed to acquire more than 2x10 MHz in the 800 MHz band or more than 2 x 15 MHz in the 1800 MHz band. There are three current operators and the auction is structured to enable a new entrant.

Iceland auctioned 2x30 MHz at 800 MHz in March 2013. A cap of 2x20 MHz was used. In addition 3G licence holders had a maximum gain on their spectrum holdings across all bands of 2x20 MHz. Four bidders all gained spectrum at 800 MHz, although little further information is available about this auction at present.

The Czech Republic will auction 2x30 MHz at 800 MHz and has proposed a cap of 2x15 MHz and obligatory roaming onto the 800 MHz networks for those without 800 MHz spectrum. There are three incumbent operators. The regulator controversially cancelled the first auction attempt, on the ground that bids had reached too high a level, as a result of what appears to be an error in auction design.¹⁹

The UK held an auction with a complex set of floors and coverage obligations. There was an overall cap of 2x105 MHz per operator and a sub-1 GHz cap of 2x27.5 MHz. To be competitive in a minimum four player wholesale market, Ofcom stipulated that the operators must hold one of the following spectrum portfolios once the auction is over:

- 2 x 5 MHz of sub-1 GHz spectrum plus 2 x 20 MHz or more of 2.6 GHz,
- 2 x 5 MHz of sub-1 GHz spectrum plus 2 x 15 MHz or more of 1800 MHz,
- 2 x 10 MHz of sub-1GHz spectrum plus 2 x 15 MHz or more of 2.6 GHz,
- 2 x 10 MHz of sub-1 GHz spectrum plus 2 x 10 MHz or more of 1800 MHz,
- 2 x 15 MHz or more of sub-1 GHz.

Of the four existing operators, two got 2x5 MHz and two 2x10 MHz at 800 MHz. The sub-1 GHz cap was met for both Vodafone and O2 who had previous holdings of 2x17 MHz at 900 MHz.

Italy has a cap of 2x25 MHz for sub-1 GHz spectrum. Three incumbents all gained 2x10 MHz. These all had between 2x10 MHz and 2x12 MHz previously²⁰ so two of the three operators were effectively at the caps.

Norway will auction 2x30 MHz at 800 MHz. A cap of 2x10 MHz will apply.

France auctioned its 800 MHz spectrum with a cap of 2x15 MHz. Three of the four incumbents acquired 800 MHz spectrum, the relatively new entrant Free did not (but there are roaming obligations on 800 MHz licenses to allow Free access to their networks).

¹⁹ <https://www.policytracker.com/headlines/czech-regulator-cancels-4g-auction>

²⁰ PolicyTracker, op. cit. in footnote 12.

In the Netherlands two 2x5 MHz blocks at 800 MHz were set aside for new entrants. Two incumbents and one new entrant (Tele2) won spectrum at 800 MHz, the other incumbent acquired spectrum at 900 MHz. Tele2 acquired both 2x5 MHz blocks set aside.

Denmark held an auction in mid-2012. There were three bidders of which two were successful (TDC and TT-Networks which was a consortium of Telia and Telenor). A coverage obligation was imposed on one of the blocks.

Table 2 below summarises specific measures regarding sub-1 GHz in recent and upcoming European auctions. Notably, all of the regulators concerned have put in place measures that at least maintain the current number of sub-1 GHz MNOs, whilst in the case of Ireland and Spain efforts have been made to ensure sub-1 GHz spectrum will be available to all national wholesalers.

	Number of national MNOs	Aggregation limit in auction	Sub-1 GHz limit	Outcome
Germany	4	2x20 MHz (2x22.4 MHz Vodafone and T-Mobile) below 1 GHz	Yes	2x10 MHz (O2) 2x10 MHz (T-Mobile) 2x10 MHz (Vodafone)
Ireland	4	2x20 MHz	Yes	2x10 MHz (Meteor) 2x10 MHz (Vodafone) 2x10MHz (O2)
Switzerland	3	2x25 MHz on combined 800 MHz and 900MHz	Yes	2x10 MHz (Orange) 2x10 MHz (Sunrise) 2x10 M Hz (Swisscom)
Sweden	4	2x10 MHz	Yes	2x10MHz (3) 2x10 MHz (Telenor) 2x10 MHz (Sulab)
Spain	4	2x20 MHz	Yes	2x5 MHz (Telefonica) 2x5 MHz (Vodafone) 2x20 MHz (Orange)
Portugal	3	2x10 MHz	Yes	2x10 MHz (Optimus) 2x10 MHz (TMN) 2x10 MHz (Vodafone)
Slovakia	3	2X10 MHz	Yes	Auction due 2H 2013
Iceland	6	2X20 MHz	Yes	Winners were Nova, Vodafone, Simmin and 365 (amounts unknown)
Czech Republic	3	2x15 MHz with roaming provision	Yes	Bidding halted because prices considered too high
UK	4	2X27 MHz below 1GHz plus floor and coverage obligation	Yes	2x5 MHz (EE) 2x5 MHz (3) 2x10 MHz (Vodafone) 2x10 MHz (Telefonica)
Italy	4	2X25 MHz below 1 GHz	Yes	2x10 MHz (TIM) 2x10 MHz (Vodafone) 2x10 MHz (Wind)
Norway	6	2X10 MHz	Yes	Auction expected late 2013
France	4	2X15 MHz with roaming provision	Yes (plus roaming obligations on low-band incumbents)	2x10 MHz (Bouygues) 2x10 MHz (Orange) 2x10 MHz (SFR)
Netherlands	5	N/A (blocks set aside for new entrants)	Yes (via set-asides)	2x10 MHz (Tele2)
Denmark	6	2x20MHz	Yes	2x20 MHz (TDC) 2x10 MHz (TT)

Table 2: Summary of caps in European auctions and outcomes

In summary, the use of spectrum-aggregation limits in auctions is widespread, especially for sub-1 GHz spectrum which is often considered especially valuable and yet has the most supply constraints.

Almost all European countries have implemented some form of spectrum-aggregation limit. In a few countries provision was made for new entrants, but this was relatively rare. Coverage obligations were also used in a few countries, although typically only on a sub-set of the available licenses. The regulators' common underlying goal has been to ensure that a sufficient number of operators have enough spectrum to generate effective network infrastructure competition.

Where auctions have been held, the results are often a near-even distribution of the spectrum across the incumbent operators, sometimes below the level of the limits in place.

2.3 Summary

As the mobile sector has become more complex, restrictions on access to spectrum in Europe have switched from the 'one licence assignment per company' procedure which characterised 3G licensing, to more complex arrangements affecting portfolios of spectrum holdings, but focussed on sub-1 GHz bands. This gives regulators extended opportunities to flex their interventions to achieve particular goals, as the description above shows. In the next section, we discuss further the logic behind decisions to impose caps in recent awards on the acquisition of sub-1 GHz spectrum.

3. Features of mobile markets which may require spectrum-aggregation limits

The diffusion of wireless services was relatively speedy in Europe, and the sector received considerable attention as an attractor of investment and employment, a source of growth, and (for equipment manufacturers) an opportunity for exports. The benefits of an effectively competitive market place were also recognised, and this was evident in governmental decisions to structure spectrum awards to encourage entry.

Given the common view that economies of scale and entry barriers in the wireless industry have produced a tendency towards the concentration of market power in the sector, regulators and competition authorities paid close attention to its evolution. Thus from 2002 to 2007, regulators in European Union Member States had to examine wholesale mobile markets for the presence of significant market power or dominance, and take action when they found it.²¹

Within the European competition law and regulatory frameworks, dominance can be exercised either by a single firm or jointly and collectively by several firms.²² The presence in mobile markets of substantial regulatory and other barriers to entry create the risk of adverse outcomes for consumers resulting either from the unilateral conduct of a single firm or from tacitly co-ordinated behaviour by several firms, which could harm consumers by raising prices and stifling innovation.

²¹ COMMISSION RECOMMENDATION of 11 February 2003 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communication networks and services (2003/311/EC).

²² In addition, there are prohibitions on explicit price-fixing agreements. Mobile operators in France were convicted of this in 2005. See the press release issued at the time by the French Competition Authority, available at http://www.autoritedelaconurrence.fr/user/standard.php?id_rub=160&id_article=502

In particular, the necessary conditions for tacit co-ordination which are suggested by economic theory seem to be present in mobile markets.²³

- pricing is a possible focal point for co-ordination, and is transparent to all;
- if one operator departs from a tacitly agreed price point, others can detect the deviation and punish it;
- if market shares are asymmetric and barriers to entry are high, there is limited external competitive constraint on the co-ordinating group.

European merger policy also recognised the importance of keeping competition alive, especially in the form of operators, which are capable of breaking the constraints of existing modes of competition.²⁴ The departure of such an operator can have an effect on subsequent prospects for co-ordination, and it can also have non co-ordinated effects. These issues came up in the European Commission's decision over whether to allow T-Mobile in Austria to take over a smaller Austrian operator, tele.ring.²⁵ As a European Commission Competition Directorate official later explained, the Commission's Horizontal [Merger] Guidelines expressly state that "some firms have more of an influence on the competitive process than their market shares would suggest. A merger involving such a firm could change the competitive dynamics in a significant anti-competitive way, in particular when the market is very complicated."²⁶

These concerns about mobile competition do not expressly concern spectrum aggregation, but it is easy to see how spectrum-aggregation limits can be employed to deal with them. Allowing the largest operators to acquire the predominant proportion or even all the highest value spectrum available at a major spectrum award risks triggering several effects:

- weakening the competitive constraint provided by smaller operators;
- creating more fertile conditions for the exercise of single firm dominance or co-ordination between a small group of the larger operators.

These motives may lead operators in that small group to use their deep pockets to acquire all the spectrum, even if it has for a time to be 'warehoused', on the footing that the benefits of depriving rivals of the spectrum outweigh the costs of acquiring the additional investment ahead of need.

These issues are alluded to in two of the documents which we referred to at the start of this paper. Thus the DoJ argues that "carriers do have the ability and, in some cases, the incentive to exercise at least some degree of market power, particularly given that there is already significant nationwide concentration in the wireless industry". The Department also refers to the 'foreclosure value' of additional spectrum to large operators, which arises because their acquisition of extra spectrum prevents rivals from improving their services and thus eroding the rents available to the larger

²³ See L Cabral, Introduction to Industrial Organisation, 2000, Ch. 8. Note that these are necessary, not sufficient, conditions.

²⁴ See section 4 below for some case studies.

²⁵ For more details, see section 4.3 below.

²⁶ J Luebking, 'T-Mobile Austria/tele.ring: remedying the loss of a maverick', Competition Policy Newsletter, 2, 2006, p.49.

operators.²⁷ Conversely, the House Republicans argue that “creating unbridled competition in an open and fair auction is the only way to maximize auction revenues and ensure that spectrum is put to its highest and best use.”²⁸

We understand that the approximate market shares of wireless subscribers in the USA are currently:²⁹

	Market share
AT&T	32.3%
Verizon	34.3%
Sprint	15.8%
T-Mobile	9.7%
Others	8%

Table 3: Current US wireless market shares

In our view, this configuration would be likely to cause European regulators to give serious consideration to imposing spectrum-aggregation limits, for the following reasons. A small ‘leading group’ of two operators has emerged, accounting between them for 67% of subscribers, followed by two much smaller operators, and a ‘tail’ of other operators. Each of the larger operators might be able to exercise some unilateral market power. In addition, the shares of AT&T and Verizon are similar, and such symmetry is often (but not invariably) said to facilitate co-ordination.

Finally, competition issues in wireless acquire particular salience in Europe because of the impact which the spread of wireless voice is said to have exercised on economic growth, and because of the effect which the spread of wireless data services is expected to have.³⁰ Cisco forecasts that mobile data traffic in Europe (as elsewhere) will increase 20-fold between 2012 and 2017.³¹ It is widely believed that this will have both a direct effect on investment and employment in the wireless sector, and that it will have a spill-over effect in the rest of the economy. It is also widely recognised that a competitive market structure which keeps prices low and encourages innovation provides a better platform for investment, employment and growth than a market structure characterised by limited competition, higher prices and lower output levels. Ensuring that the mobile market will function competitively is thus a regulatory priority.

4. Case studies of competitive effects in mobile markets

We pointed out in section 2 that there have been two ‘waves’ of the use in Europe of restrictions in auctions on spectrum aggregation. The first occurred in 2000/01, and took the form of the identification of a set number of licences, with the restriction that a firm could hold one licence only. The second wave of restrictions, which mostly take the form of limits on the sub-1 GHz spectrum

²⁷ Op. cit. in footnote 3, pp. 8 and 11.

²⁸ Op. cit. In footnote 5, p. 3.

²⁹ Source: FCC, “Sixteenth Report”, FCC 13-34, 21 March 2013:

http://transition.fcc.gov/Daily_Releases/Daily_Business/2013/db0321/FCC-13-34A1.pdf

³⁰ See for example C Qiang et al. ‘The economic impact of broadband’, Information and Communication for Development, World Bank, 2009, pp. 43-69.

³¹ Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012–2017.

which each firm may acquire, possibly combined with an overall cap on any firm's aggregate spectrum holdings, came into effect in the 'digital dividend' auctions from 2010 onwards.

In our view, the period of time which has elapsed since implementation of this second set of pro-competitive rules is not extensive enough for their effects (or absence of effects) to be clearly visible. This is because there is a relatively large timing lag affecting use of the new spectrum at 800 MHz in Europe, resulting from the fact that the band is being used almost exclusively by operators for the deployment of new 4G networks. New wireless technologies take some time to have market impact because the following stages are needed:

1. The technology needs to become sufficiently mature to deploy in large scale (this can include standards-setting work within international standards bodies such as the 3rd Generation Partnership Project (3GPP)).
2. Networks need to be built with sufficient coverage to be useful.
3. Consumer devices need to be manufactured and introduced into the market.
4. A significant percentage of customers need to acquire these devices such that they can benefit from the new technology.

It took some five years from the 3G auctions of 2000 before 3G networks were having a significant effect on the mobile market. Although some of the above-noted conditions are by now fulfilled for 4G, they have only recently fallen into place, and the diffusion process has a long way to go. In light of these considerations, our three case studies come from the world of 3G rather than 4G. Two of the case studies thus focus on the effects of 3G entrants. To the degree that such effects are reversible by exit, they also speak to the likely consequences of the exit or weakening of a smaller player unprotected by appropriate spectrum-aggregation limits. The third case study shows how a European competition authority responded to the likely exit of a smaller operator through acquisition by expressly ensuring that spectrum holdings were not tilted by the merger in favour of one of the two larger players.

4.1. The impact of "3" in the UK

The 2000 auction of the 2.1 GHz 3G spectrum in the UK marked a clear policy intent to introduce a fifth mobile operator into the market, to add to the two operators originally awarded 900 MHz licences in the 1980s and the two further operators subsequently awarded 1800 MHz licences in the 1990s. (By 2000, the market shares of these four operators were approximately equal.) The 2000 auction was thus structured such that some frequencies were reserved for new entrants. The result was that the existing four operators and H3G, known as "3", all gained 3G spectrum.

Ever since the auction, "3" has been a disruptive influence on the UK market. It was first to roll out 3G services, launching a network in March 2003 and by December 2003 covering over 70% of the UK population – the fastest rollout in European telecoms at the time. From the start they pioneered video telephony and video download over their network. In September 2003 they delivered music videos to mobiles for the first time in Europe and in 2006 they launched the "3 Music Store" giving customers access to 500,000 tracks at 99p per track, at a time when other mobile operators were charging consumers £3 for one track. At one point their music downloads were second only to iTunes.

In 2005 they launched a service called SeeMeTV that was a precursor to YouTube. For every “3” customers that watched a clip, the customer who made the video was paid 1p. By March 2006, SeeMeTV had over 4 million downloads and had earned customers over £100,000.

In March 2006, “3” made a landmark agreement with Skype, which allowed customers to use Skype on their mobiles. This ran counter to the approach of other operators who were blocking access to the service. By December 2006 “3” was offering international Skype calls and in April 2009 “3” launched unlimited free Skype-to-Skype calls and instant messages. In February 2010 the billionth minute of Skype calls was made across the “3” network.

By 2006, “3” had gained more 3G subscribers than the other four networks combined. In 2007 they sought to revolutionise roaming by offering “3 at home” that allowed users roaming onto “3” networks in other countries to pay the same for their calls and data as when at home (this was discontinued in 2009). Its mobile data tariffs were the first ones offering unlimited data (in 2010), and they have constantly been less expensive per gigabyte (GB) than their competitors. For example, when other mobile networks at launch were charging £50 for 1 GB, “3” offered 1 GB for £10. This caused a rapid reduction in the prices offered by other operators.

“3” was also the first UK operator to offer “MiFi” capability where the handset becomes a local Wi-Fi hotspot, using the 3G connection as the backhaul at a time many other operators were banning this usage. They have also lobbied regulators often in a contrary manner to other operators – in the UK pushing for lower termination rates for calls from fixed lines to mobiles and in Europe working with the Commission to reduce mobile data roaming charges.

This is not to say that all of “3”’s interventions were successful. It seems highly likely, however, that the presence of “3” has made the UK mobile market much more competitive and has hastened the deployment of new technologies, services and customer propositions. In particular, prior to “3”, the market was evenly distributed across four operators. It could be argued there was little incentive for any of these to upset the status quo with disruptive policies. However, “3” needed to gain market share as a new entrant and believed it could only do so if it could differentiate itself via its services. It clearly had the role of a maverick.

It is this which convinced Ofcom to incorporate in its design of the 2013 ‘digital dividend’ auction certain features which ensured the continuation of competition, which had already been reduced from five to four players by a merger between T-Mobile and Orange in 2011. Ofcom argued that:³²

“UK consumers will be likely to benefit from better services at lower prices in future if following the Auction there continue to be at least four credible national wholesalers of mobile services, Therefore, we would be concerned if as a result of the Auction fewer operators had access to sufficient spectrum to compete credibly at the wholesale level in the future than is currently the case in the UK;

It is likely that this would be the case if neither Hutchison 3G UK (H3G) nor a new entrant acquires at least a minimum amount of spectrum in the Auction. Absent intervention, there is

³² Ofcom, Assessment of future mobile competition and award of 800 MHz and 2.6 GHz, July 2012, pp. 2-3.

a material risk that neither H3G nor a new entrant would acquire this minimum amount of spectrum in the Auction.”

Ofcom went on to examine the question of whether it was likely that a fourth operator which placed a higher intrinsic value on spectrum than other operators might nonetheless be outbid because those other operators would bid strategically to exclude the fourth operator. Ofcom concluded that this was a realistic risk.³³

Accordingly, Ofcom introduced a procedure which had the effect of favouring the bids of a fourth operator competing for a minimum package of spectrum, including a sub-1 GHz package.³⁴ In short, absent intervention, there was a material risk that neither “3” nor a new entrant would have acquired the minimum amount of spectrum which it needed to be an effective competitor, ensuring that consumers continued to enjoy lower prices and better, more innovative services.

4.2 Free in France

Our second example is in some respects a time-delayed but accelerated version of the first. France chose to assign its planned four 3G licences by a hybrid process, involving a set fee and a beauty contest. Two licences were issued in 2000 (to France Telecom and SFR), and a third in 2002 (to Bouygues). Many observers have claimed that these three did not compete vigorously, and prices were higher than in Germany and the UK.³⁵

In 2009, the fourth licence was assigned to Iliad, a fixed entrant which traded as an ISP under the name of Free. It was the first company in France to offer a fixed ‘triple play’ product for €30 (\$39) per month, and had had a deliberately disruptive effect on the fixed market.³⁶

Free Mobile did not start operations until the beginning of 2012, allowing the other three operators time to prepare what they hoped were matching low cost offers. However, Free trumped these by a launch offering of a €20 (\$27) a month subscription, including unlimited national calls and calls to 40 countries, unlimited messaging and 3GB per month of internet service. Subscribers to Free’s fixed services got a discount. It also offered access to millions of home Wi-Fi nodes for its mobile subscribers through its triple-play home product offering and emerging standards that enable automatic roaming of handsets onto selected Wi-Fi nodes.

Subscriber numbers grew as shown in Table 4.³⁷

³³ Ibid. P. 64.

³⁴ For details see op. cit. in footnote 30.

³⁵ http://www.telco2research.com/articles/EB_Free-mobile-disruption-model_Summary

³⁶ Free also made a temporary roaming agreement with Orange to launch a nationwide service. The French Competition Authority has recommended that, in the interest of encouraging infrastructure competition, the agreement should not be extended. In the same report, the authority refers to the ongoing risk of collusion in the sector. http://www.autoritedelaconcurrence.fr/user/standard.php?id_rub=483&id_article=2062

³⁷ http://en.wikipedia.org/wiki/Free_Mobile

Date (end of quarter)	Subscribers
Q1 2012	2,610,000
Q2 2012	3,600,000
Q3 2012	4,405,000
Q4 2012	5,205,000
Q1 2013	6,075,000

Table 4: Free Mobile subscriber numbers

The last figure amounts to a market share of about 10%. By this stage overall mobile prices across all operators were down by 16%, and the incumbent operators had lost a considerable share of their subscribers, the largest losing the smallest proportion and the smallest the highest proportion.³⁸

There was substantial reaction from all the existing operators to both the prospect of Free and the actual emergence of the operator. Late in 2011, they had all anticipated the Free Mobile launch by starting second brands³⁹ aimed at the low-cost end of the market. These brands were based on simplified offerings combining SIM-only plans and online activation and support. However, as mentioned above, Free surprised the existing operators with lower than anticipated launch prices. All operators modified their low cost offerings rapidly after Free's launch with 30% to 40% price reductions – although even these reductions were not sufficient to match Free's tariff.⁴⁰

Beyond adding additional brands, the established operators started to make SIM-only promotions available to compete with Free's strategy of not subsidising handsets. They have also begun to trim down their cost structures to adjust to lower revenues - both SFR and Bouygues announced significant cost reduction plans in 2011. Finally, the three established mobile operators have announced they will accelerate their LTE rollout plans with an explicit objective of selling higher quality data connectivity services at premium rates. Conversely, Free's LTE plans are less clear as it will rely on roaming agreements to access LTE networks. It is predicted that the emergence of Free "could also make France a fertile experimentation ground for new carrier business and operational models geared for a post-voice and commoditized-data era."⁴¹

This example shows the galvanising effect on a market which a new entrant can have. It has to be said that third and fourth entrants in European markets have not always prospered. In France, Free's progress seems to have been helped by its arrival in a market which was rather uncompetitive, allowing it to gain considerable attention and customers. Juxtaposing the British "3" and the French "Free" cases, we see how additional competitive pressure, and the associated consumer benefits, can be generated both by new entry and by securing the supply of spectrum to an existing smaller operator or operators.

³⁸ <http://www.globalpost.com/dispatch/news/afp/130515/french-telecom-iliad-sees-sales-soar-mobile-entry>

³⁹ Sosh for Orange, Red for SFR, B&You for Bouygues.

⁴⁰ Sosh from Orange did offer two cheaper plans that include a €9.90 plan with unlimited Facebook and Twitter usage through a dedicated application and a €14.90 plan with 1GB 3G data allowance and throttled speed beyond this allowance. It has also recently added unlimited SMS from any EU country and French Overseas Territories to its €24.90 unlimited plan that directly competes with Free.

⁴¹ <http://upnextmobile.com/post/26500503382/how-french-operators-are-adjusting-to-the-new-normal>

4.3 tele.ring

The previous examples concern the effects of entry. This final example concerns the effects of exit. In 2005, the second largest Austrian operator (T-Mobile) sought to take over the fourth largest, tele.ring. The market shares pre- and post-merger, reported as ranges by the competition authority, were:

Operator	Market share pre-merger	Market share post-merger
Mobilkom	35%-45%	35%-45%
T-Mobile	20%-30%	
T-Mobile & tele.ring		30%-40%
tele.ring	10%-20%	
One	15%-25%	15%-25%
H3G	<5%	<5%

Table 5: Austrian market shares [Source: European Commission, Case No COMP/M.3916 – T-Mobile Austria/telearning 26/04/2006]

tele.ring operated in the lower end of the market and T-Mobile and Mobilkom in the upper end. The authority concluded from switching and price comparison data that in the period 2002-05, “tele.ring was the most active player in the market, and that it exerts considerable competitive pressure on T-Mobile and Mobilkom in particular and plays a crucial role in restricting their freedom on pricing. The price analysis therefore suggests that tele.ring’s role in the market has been that of a maverick.”⁴²

In the absence of tele.ring, the merger authority, the European Commission, expressed concern that “with the elimination of a maverick and the simultaneous emergence of a market structure with two leading, symmetrical network operators, it is probable that the proposed merger will have a tangible effect on prices in the market. Even if prices do not rise in the short term, the weakening of competitive pressure as a result of tele.ring’s elimination from the market makes it unlikely that prices will continue to fall significantly as in the past.”⁴³

It noted that the creation of two symmetrical operators with a combined market share of 60-80% might lead to a weakening of competitive pressures as a result of co-ordination, but did not conclude on this point.⁴⁴

The measure which it took to deal with his problem was to accept commitments by the merging parties to sell one block of spectrum to H3G and another to another operator, which could be H3G or an operator with a small market share.⁴⁵

⁴² European Commission. Case No COMP/M.3916 – T-Mobile Austria/Telering 26/04/2006, para 72. It is noteworthy that in opposing the merger between AT&T and T-Mobile USA, the Department of Justice characterised T-Mobile USA as an ‘aggressive competitor’ or a ‘challenger brand’ – terms broadly equivalent to a maverick. See <http://www.justice.gov/opa/documents/Justice-ATT-TMobile-Complaint.pdf>

⁴³ Op. cit. In footnote 38, para 125.

⁴⁴ Ibid. paras. 127-9.

⁴⁵ Ibid. para. 132.

In the present context, part of the interest of this episode is that the competition authority is expressly concerned about the elimination of a competitor, and responds to this eventuality by ensuring that other smaller operators are not starved of spectrum. In the context of a merger, this is designed expressly to prevent a loss of competitive constraint. The more general proposition is that it is necessary to ensure that competitors have adequate access to the spectrum resources without which they cannot compete and exert pricing and innovation pressure on the market.

4.4 Conclusions

For the reasons given above, our three examples relate not to the effects of spectrum assignment for 4G, but to the effects of the rather more historic 3G assignments. Two of them also concern entry. The arrival of “3” in the UK in 2003 led to a decade of path-breaking innovations, most of which the larger operators were able quickly to follow. This limited “3”’s commercial success, but Ofcom was sufficiently persuaded of the consumer benefits it is still capable of bringing to design its ‘digital dividend’ auction expressly to ensure the continuation of the ‘four operator’ market structure. Free’s success in France is more recent and spectacular.

It is natural to ask how much we can infer from ‘disruptive’ entry episodes about the ‘dysfunctional’ or ‘conforming’ effects of market exit. Ofcom’s views in 2012/13 on this matter are clear. Their concerns were also prefigured by the European competition authority when it intervened in a proposed merger to demand concessions precisely intended to ensure that smaller players in the market would continue to have adequate spectrum holdings to compete.

5. Effects on revenues

An important issue in the evaluation of aggregation limits at auctions is their impact on revenues. Legislatures, governments and regulators (whichever sets the auction goals and rules) almost invariably have ambivalent feelings about the level of auction revenues. On one hand, they recognise that high auction revenues reflect bidders’ expectations about the prices they can charge and the profits they can make from selling the spectrum-using service. High revenues may therefore foretell high prices and high profits in the sector, which are bad for customers. On the other hand, in the fiscal circumstances in which many governments find themselves, higher revenue from auctions is welcome.

In European spectrum auctions, the motives of enhancing revenue and enhancing consumer welfare by lower prices can both be observed. Although it would be unlawful for a Member State of the EU to design an auction solely to maximise proceeds, there are quite a few things it could do to enhance them.

Chief among these is to increase participation by the greatest number of potential bidders. It was a feature of the 3G auctions in 2000/01 that as the auctions took place one after another around Europe, the number of bidders diminished.⁴⁶ As a result a downward trend can be observed in the standardised prices realised (Euros per pop per MHz).

⁴⁶ Paul Klemperer, *Auctions: Theory and Practice*, Princeton University Press, 2004, p. 164.

A more problematic response to the revenue imperative is to design the auction in a way which permits the successful bidder(s) a degree of market power which can be converted into excess profits, some or all of which is transferred to the state in the course of a competitive auction. This aspect of tendering for exclusive rights has a long history in the hands of absolutist monarchs in Europe, who tendered the right to supply staples such as salt or tobacco at a monopoly price to the population; the high price of salt being one of the causes of, for example, the French Revolution.

The revenue maximising outcome would be for many bidders to compete for a spectrum monopoly. It would be unthinkable for a modern state to sell spectrum monopolies in this fashion. However, for reasons discussed in section 3 above, governments or regulators often have a choice over how far they are prepared to go when setting auction rules to protect against the risk of future use of market power.

This choice will rationally depend upon an empirical estimate of how far aggregation limits will affect revenues. More generally, an optimal spectrum-aggregation limit will seek to balance incremental revenues against the incremental loss of consumer benefits.

Opponents of spectrum-aggregation limits often suggest that any limit will inevitably reduce revenues, on the ground that it reduces the effective demand which is applied in the bidding process and reducing demand will lead to lower revenues. However, the first proposition is not necessarily true. A limit reduces the demand of the affected operators, in the region beyond where the limit operates. But it may also increase the number of bidders, the aggregation of whose demand curves determines total demand. As has widely been noted, the overall effect is the sum of these two effects – an individual bidders' effect and a participation effect.

How might the absence of aggregation limits on large players discourage participation? In a market for spectrum-using services which combines a small number of large players and other smaller players, the latter will easily figure out that the value of spectrum to the large players is greater than its value to them, because those larger players are not only increasing their capacity to supply the market, but also increasing their present and/or future market power. In other words, the smaller operators are aware of the 'foreclosure motive,' and thus conjecture that the larger ones, which are also likely to have the deeper pockets, will outbid them. Accordingly the smaller operators choose not to incur the often quite significant upfront costs of taking part in the auction.⁴⁷ This may even enable the larger operators to acquire all of the available spectrum at the reserve price, below the price at which they would have won the licences in the presence of other bidders.

We cannot see how any participant in this discussion can claim on an *a priori* basis that one effect – unrestricted bidding by larger operators – must dominate the other - reduced participation by smaller operators. In any given auction in any country, either may dominate. The auction designer therefore has to take a decision, guided by its statutory duties and the evidence at its disposal.

In such circumstances, it is natural to seek lessons from past auctions. This is difficult in present circumstances for at least two reasons. First, the number of past auctions is limited, and cannot

⁴⁷ The smaller players might consider strategies to bid up prices paid by the larger players, but this might be expensive and, depending on auction design, even dangerous. There is also a free rider problem: each small operator will hope that another will do it instead.

support established methods of statistical inference. Second, the process involves a willingness to read across from one country's experience to another's.

However, examination of past experience may furnish some limited help, and we now bring together the experience of recent auctions in Europe, associated with awarding the digital dividend spectrum (790-862 MHz) since 2010.

We use as a source a paper by the consultancy Dot.econ prepared for Ofcom⁴⁸ which *inter alia* covers the value of 800 MHz bands auctioned in Europe up until about the end of 2011. Their analysis appears comprehensive, taking into account factors such as the differing length of the licences. However, it does not consider auctions where the 800 MHz was awarded as part of a multi-band auction, so that its value cannot be definitively extracted. The values derived by Dot.econ are shown in Table 6.

Country	Price (\$/MHz/pop)
Denmark	0.195
France	0.78
Germany	1.065
Italy	1.02
Portugal	0.765
Sweden	0.375
Spain	0.69

Table 6: Auction values derived by Dot.econ

For each auction, we sought to establish a) whether an aggregation limit on sub-1 GHz spectrum was in operation, and b) whether the limit in question had an impact on the outcome because it was "binding", meaning that but for the presence of the aggregation limit, the bidder in question would have acquired additional spectrum. Neither of these judgements is straightforward. To take the latter first: if an operator subject only to a sub-1 GHz limit buys less than the permitted amount, then it is clear that the limit is not binding. But if it buys exactly the limited amount, then either the limit is binding or the operator's best choice happens coincidentally to be the level of the limit.⁴⁹ In the former case the limit is binding; in the latter, it is not. In some auctions, 800 MHz acquisition is coupled with some 900 MHz divestment to stay below sub-1 GHz limit levels; again it is not clear here whether the limit has had an impact on the 800 MHz auction.

The other problem is that of multiple limits. An operator may be subject both to a limit on total holdings and a limit on acquisition in the auction of sub-1 GHz spectrum. It may be restricted by the former limit in bidding up to the latter limit. In that case we would regard it as (indirectly) subject to the sub-1 GHz limit.

⁴⁸ <http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/spectrum-value.pdf>

⁴⁹ Since caps tend to be set in round numbers (eg 2x10 MHz) corresponding to technical convenience, such a coincidence is quite likely.

As an example, consider the case of the UK where multiple complex rules applied. One was a limit on sub-1 GHz spectrum of 2x27 MHz. Since Vodafone and O2 already held 2x17 MHz of 900MHz spectrum this effectively applied a limit of 2x10 MHz on their 800 MHz acquisition (unless they chose to divest some 900 MHz spectrum). Spain had a similar situation, made even more complex due some mandatory 900 MHz divestments and a 900 MHz auction that followed on from the 800 MHz auction.

We present in Figures 1 and 2 scatter charts of the prices realised against population and GDP⁵⁰ per head. The motivation behind the first association is to see if larger countries appear to show different results than smaller ones. The motivation behind the second association is to see if prices appear to be correlated with national prosperity. Thus if there were no variation with population in the first graph, we would expect to see the same value in terms of \$/pop/MHz for all countries, so all points would lie on a horizontal line. Then, if there were a difference between auctions where the bids were below the limit, the “below limit” marker would not be on this line. If a bid which was below limits (so that the limit did not influence bid) resulted in higher auction fees, as some have postulated, then the below limit marker would be above the line of the “at limit” markers.

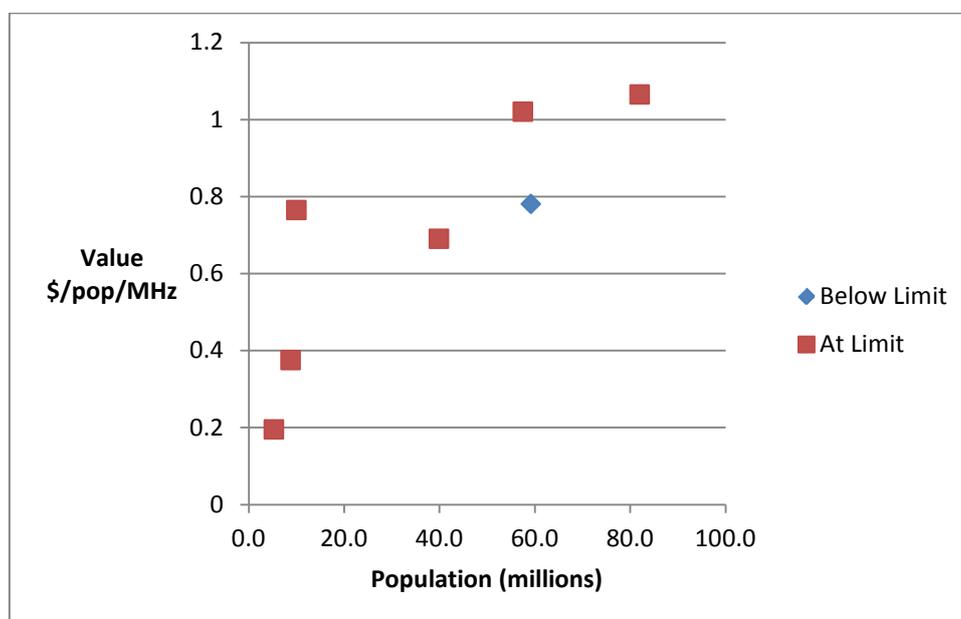


Figure 1: Spectrum award values versus population (Dot.econ)

Inspection of Figure 1 suggests that there is an apparent correlation between population and bid value, with larger countries having a higher auction fee after normalisation. The “below limit” point (where the bidder was unconstrained by limits) appears to sit on or slightly below the trend line, suggesting that in this auction bids were broadly the same as would be expected for a country of its size.

⁵⁰ GDP data is sourced from the World Bank – see <http://data.worldbank.org/indicator/NY.GDP.MKTP.CD> and is based on single year exchange rates.

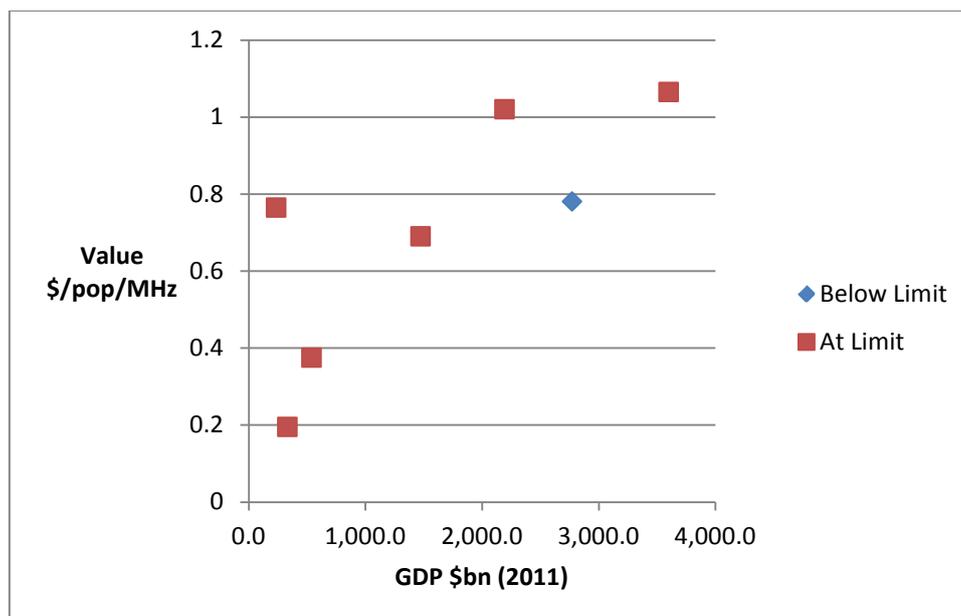


Figure 2: Spectrum award values versus GDP/pop (Dot.econ)

Figure 2 shows that there appears to be a correlation between GDP and normalised bid value. Here again the “below limit” marker appears to be on or even below trend.

How do we interpret these data? First recall the caveats – on the accuracy of the prices, and on whether the limit is actually binding. Then be aware of the small sample. Can anything then be said? The case where the limits were above the actual bids (and so, arguably, did not affect auction revenue) did not result in revenues that show up as materially different from those where the restrictions limited bids.

In these circumstances it seems sensible for the regulator to give careful consideration to proposing a well designed set of limits which balance the benefit of unrestricted bidding by large operators against the benefit of the higher participation by all operators, combined with the competitive advantages which limits are likely to bring.

6. Summary

Radio spectrum is a requirement for providing mobile communication services, but it is a limited resource and for this reason access to spectrum can change the dynamics of the marketplace. Spectrum is managed by legislatures or governments through regulators, and the manner in which it is provided needs to meet multiple objectives. These can include raising revenue from any sale, indirectly raising revenue from downstream taxable activities, promoting competition and innovation, and maximising the economic benefit to the country. Inevitably there can be tension among these objectives.

The European experience suggests that high-revenue spectrum auctions are compatible with limits on spectrum-aggregation. In Europe there have been auctions of approximately equivalent spectrum at 800 MHz over the last three years. Almost all European regulators have balanced the requirements to raise revenue with those to maintain competition through the use of spectrum-aggregation limits. It is important to note that these have not excluded the largest operators from

bidding, but have been designed to ensure smaller operators' access to some of the spectrum being auctioned. In this paper we ask whether the lessons learned from Europe indicate that limits should be applied in the US auction.

In the case of the forthcoming 600 MHz US incentive auction, there is a clear underlying motive to raise revenue to fund a public safety network and also to reduce the budget deficit. However, few would wish to see these objectives met at the expense of substantial reductions in competition and innovation. This is particularly pertinent in the US auction because (1) the frequencies in question have favourable propagation properties making them generally more advantageous than other frequencies; (2) there is an increasing trend towards consolidation in the mobile voice and data services marketplace; and (3) at present, two dominant carriers hold the majority of the competitively advantageous sub-1 GHz spectrum.

The main concern expressed in the US with the use of spectrum-aggregation limits is that they will reduce auction revenue and so prevent some of the key objectives of the auction being met. We have analysed the results of the European auctions to try to assess whether these might inform this issue. We caution that no two auctions are the same, that interpreting the results of any auction is often complex and that differences in auction rules across Europe mean that comparisons require some judgement which are open to debate. On the limited evidence available, we found no difference between auctions where limits were hit and the case where the limit was not. We judge the evidence insufficient to conclude that limits do not affect revenues, but equally there is no evidence that they do materially reduce revenue. But they do appear to have been effective at maintaining the number of mobile operators in the marketplace.

We also cite three case studies that show that increased competition, particularly where one of the competitors applies different strategies, can lead to innovative new services or tariffs. For example, in the UK it seems likely that Skype was introduced to mobile phones years ahead of what might have transpired in the absence of maverick operator.

On the basis of our knowledge of other markets and jurisdictions, we would recommend that serious consideration be given by the FCC to the use of a cautiously and carefully designed spectrum-aggregation limit, to achieve the desired goal of maintaining competition by use of the minimum effective intervention. Thus in relation to the two views of the matter described in the Introduction of this paper - those of the DoJ and those of AT&T and the House Republicans - this conclusion places us, respectfully, closer to the former than to the latter.

Annex - Biographies

Martin Cave

Martin Cave is a visiting Professor at Imperial College Business School and a Deputy Chair of the UK Competition Commission. In 2010/11 he was BP Centennial Professor at the London School of Economics, and from 2002 to 2010 he was a professor at Warwick Business School. He is a regulatory economist specialising in competition law and regulation, especially of the communications sector. He holds bachelor's and master's degree and a D Phil in economics from Oxford University. He has written in the journal literature on spectrum management. He is the co-author of *Understanding Regulation* (Oxford University Press, 2011) and *Essentials of Modern Spectrum Management* (Cambridge University Press, 2007), and co-editor of the *Handbook of Telecommunications Economics* (Elsevier, 2002, 2005) and the *Oxford Handbook on Regulation* (2010).

Cave has conducted two reviews for the UK government on spectrum matters (*Review of Radio Spectrum Management*, 2002, and *Independent Audit of Major Public Holdings*, 2006). He has taken part in independent reviews of spectrum strategy for the Australian and Canadian governments. He has also advised several regulators on spectrum matters, in countries including Georgia, Germany, Ireland, Moldova and Singapore. He also participated in the FCC's 2002 Spectrum Policy Task Force activities.

William Webb

William has published 12 books and over 100 papers. He is a Visiting Professor at Surrey University, a member of Ofcom's Spectrum Advisory Board (OSAB), other oversight Boards and a Fellow of the Royal Academy of Engineering, the IEEE and the IET (the Institution of Engineering and Technology) where he is a Deputy President. His biography is included in multiple "Who's Who" publications around the world. William has a first class honours degree in electronics, a PhD and an MBA.

William is one of the founding directors of Neul, a company developing machine-to-machine technologies and networks, which was formed at the start of 2011. Prior to this William was a Director at Ofcom, the independent communications and spectrum regulator in the United Kingdom, where he managed a team providing technical advice and performing research across all areas of Ofcom's regulatory remit. He also led some of the major reviews conducted by Ofcom including the Spectrum Framework Review, the development of Spectrum Usage Rights and most recently cognitive or white space policy. He consulted with US regulators on numerous occasions, and participated in multiple Aspen Institute roundtable events on spectrum issues in the US. Previously, William worked for a range of communications consultancies in the UK in the fields of hardware design, computer simulation, propagation modelling, spectrum management and strategy development. William also spent three years providing strategic management across Motorola's entire communications portfolio, based in Chicago.