Three's response to Ofcom's Annual Licence Fees for 900MHz and 1800MHz spectrum further consultation.

Non-confidential

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Executive Summary.

Hutchison 3G UK Ltd (Three) welcomes the opportunity to respond to Ofcom's Annual licence fees (ALFs) for 900MHz and 1800MHz spectrum further consultation[1].

Ofcom's consultation sets out revised proposals for implementing the Government's Direction to Ofcom to set ALFs for 900MHz and 1800MHz spectrum to reflect full market value (having particular regard for the sums bid in the UK 4G auction), namely:

- for 900MHz, a new base ALF for 900MHz at £1.57m per MHz (rather than £1.99m per MHz in Ofcom's initial consultation[2]); and
- for 1800MHz, a new base ALF of £0.96m per MHz (rather than £1.19m per MHz).

Three strongly agrees with many aspects of Ofcom's revised ALF proposals, in particular that:

- Ofcom should set ALFs more conservatively than in its previous consultation, in order more appropriately to take account of the asymmetry of risk and availability of future spectrum bands;
- Ofcom's international benchmark evidence should focus primarily on the relative values of 900MHz and 1800MHz to the values of 800MHz and 2.6GHz in each benchmark country, rather than absolute values of 900MHz and 1800MHz spectrum;
- Ofcom should use the "distance-method" for determining the lump-sum value of 1800MHz spectrum;
- Ofcom should use a cost of debt for the discount rate to convert the lump-sum values of 900MHz and 1800MHz into ALFs, rather than weighted-average cost of capital (WACC);
- Ofcom is right that lump-sum spectrum should be treated as 100% debt financed, rather than equity financed;
- Ofcom should use the consumer price index (CPI) inflation measure for setting future ALFs, rather than the retail price index (RPI); and
- Ofcom should set the same common effective date (CED) for all licensees and should phase in the new ALF rates.

However, Three strongly disagrees with some other major aspects of Ofcom's revised proposals.

First, Three disagrees with Ofcom's estimated market value of 800MHz and 2.6GHz spectrum in the UK.

[1] Annual licence fees for 900MHz and 1800MHz spectrum: Further consultation, Ofcom, 1 August 2014.
[2] Annual licence fees for 900 MHz and 1800 MHz spectrum: Consultation, Ofcom, 10 October 2013.

Ofcom now proposes that the market value of 800MHz and 2.6GHz spectrum in the UK should be based on an analysis of bids by the marginal bidders in the auction, rather than the linear reference price (LRP) method, as in Ofcom's first consultation.

In principle, Ofcom could use either method for determining the UK 800MHz and 2.6GHz values – and they should lead to similar results.

However, Three considers that Ofcom has wrongly analysed the bids made by marginal bidders in the auction, having the effect of over-estimating the market value of 800MHz and 2.6GHz in the UK auction. In particular, Ofcom's approach is far from conservative.

In contrast, Three's application of the LRP method leads to an estimate of the market value of 800MHz of £25.0m per MHz (compared to Ofcom's value of £32.6m) and market value of 2.6GHz of £3.6m per MHz (compared to Ofcom's value of £5.5m).

These are the values recommended in our expert report by Power Auctions, appended at Annex A.

Second, Three disagrees with Ofcom's interpretation of international benchmark evidence for determining the relative values of 900MHz and 1800MHz to 800MHz and 2600MHz spectrum.

Specifically, Three considers that Ofcom has been conservative with its 900MHz lump-sum value but, in contrast, very aggressive with its 1800MHz estimate. This is due to what appears to be a highly subjective categorisation of very few data points.

For instance, Ofcom's 1800MHz lump-sum value is significantly higher, and its 900MHz value is significantly lower, than their respective simple averages. This asymmetry is surprising given that Ofcom's own analysis suggests that it is very uncertain about the quality of its benchmarks.

In particular, Three considers that Ofcom's proposed UK 1800MHz lump-sum value of £14m per MHz is too high (on the basis of Ofcom's proposed UK 800MHz and 2600MHz values), both in absolute terms and in relation to the 900MHz value (61%).

In contrast, Three's benchmarking approach leads to a UK 1800MHz lump-sum value of £7.7m per MHz for 1800MHz, and £21.3m per MHz for 900MHz spectrum (on the basis of Three's proposed UK 800MHz and 2600MHz values).

If a discount were also applied to reflect Ofcom's conservative approach, then the resulting values would £6.5m per MHz and £19.0m per MHz respectively. These are the values recommended in our expert report by Analysys Mason and Aetha report, appended at Annex B.

Third, Three disagrees with Ofcom's rejection of technical and economic evidence as to the relative value of 900MHz and 800MHz spectrum.

In its previous consultation, Ofcom proposed to take technical and commercial evidence into account as well, but has now decided against this.

We disagree with this, as a comparison of technical characteristics and commercial opportunities of 800MHz and 900MHz shows that they are of almost identical value.

Three therefore suggests that for 900MHz, international benchmarking evidence and technical/commercial evidence should be given equal weight, namely:

– international benchmarking evidence implies a lump-sum value of £21.3m per MHz; and
– technical/ commercial evidence implies a lump-sum value of £25.0m per MHz, i.e. the same as 800MHz.

Hence, we consider that £23.2m per MHz is the most appropriate lump-sum value of 900MHz spectrum.

Fourth, Three disagrees with Ofcom's cost of debt for converting lump-sum values to ALFs.

The cost of debt discount rate for converting lump-sum values to ALFs should reflect the relevant risks to the Government of the ALF payments, which Three considers the corporate cost of debt does not.

In Three's analysis, the relevant risks to the Government of the ALF payments are near risk-free. Three estimates that the relevant discount rate should be at a premium at most of 0.2% over the risk-free rate, implying a pre-tax real CPI discount rate of 2.7%.

This value is recommended in our expert report by Economic Insight, appended at Annex C.

Fifth, Three disagrees that Ofcom has made an adequate impact assessment of its proposals for revising ALFs.

Accordingly, overall, Three considers that Ofcom has not implemented the Government's Direction to Ofcom to set ALFs for 900MHz and 1800MHz spectrum to reflect full market value nor that Ofcom has been conservative in its approach.

The effect of this is that Ofcom's revised proposals continue to overstate the ALF for 1800MHz, which Three considers should be £0.49m per MHz per year. Three believes that Ofcom's proposals for the ALF for 900MHz are also overstated and should be £1.48m per MHz per year.

Table 1 below summarises Ofcom and Three's proposed ALFs, highlighting the underlying proposed UK 800MHz and 2600MHz values, 900MHz and 1800MHz lump-sum values, relevant discount rate and overall proposed ALFs.

Table 1: Ofcom and Three's proposed ALFs.

	900MHz calculation		**1800MHz calculation**	
	Ofcom	Three	Ofcom	Three
800MHz value (per MHz)	£32.6m	£25.0m	£32.6	£25.0m
2600MHz value (per MHz)	£5.5m	£3.6m	£5.5m	£3.6m
900/1800MHz value (per MHz)	£23.0m	£23.2m	£14.0m	£7.7m
Discount rate (pre-tax real CPI)	3.8%	2.7%	3.8%	2.7%
ALF (per MHz per year)	£1.57m	£1.48m	£0.96m	£0.49m

Source: Ofcom, Three.

The remainder of Three's response to Ofcom's consultation explains our position in further detail, including supporting reports by Power Auctions, Analysys Mason and Aetha Consulting, and Economic Insight.

Contents.

1. Three disagrees with Ofcom's market value of 800MHz and 2600MHz spectrum in the UK.

Ofcom's revised proposal is to set ALFs more conservatively than in its previous consultation, in order more appropriately to take account of the asymmetry of risk and availability of future spectrum bands. Three strongly agrees with this approach.

Ofcom also now proposes that the market value of 800MHz and 2.6GHz spectrum in the UK should be based on an analysis of bids by the marginal bidders in the auction, rather than the linear reference price (LRP) method, as in Ofcom's first consultation.

In principle, Ofcom could use either method for determining the UK 800MHz and 2.6GHz values – and they should lead to similar results.

However, Three considers that Ofcom has wrongly analysed the bids made by marginal bidders in the auction, having the effect of over-estimating the market value of 800MHz and 2.6GHz in the UK auction. In particular, Ofcom's approach is far from conservative.

In contrast, Three's application of the LRP method leads to an estimate of the market value of 800MHz of £25.0m per MHz (compared to Ofcom's value of £32.6m) and market value of 2.6GHz of £3.6m per MHz (compared to Ofcom's value of £5.5m).

Three has commissioned Power Auctions to review and evaluate Ofcom's marginal bidder analysis. Power Auctions' report is provided in Annex A to this submission. In the remainder of this section, we summarise its main points.

Three accepts that the marginal bidder approach could be used to estimate the market value of 800MHz and 2.6GHz in principle. However, Three strongly disagrees with the way Ofcom has implemented the marginal bidder approach. In particular:

– Ofcom's implementation of the marginal bidder approach violates the Revenue Equivalence Theorem; and
– without the spectrum reservation, UK auction revenue would have been lower, not higher, as claimed by Ofcom.

Furthermore, Three considers that Ofcom has wrongly analysed the bids made by EE in the auction, thereby has significantly over-estimated the market value of 800MHz and 2.6GHz in the UK auction. More specifically:

– EE's bid for 2x20MHz of 800 MHz should not be interpreted as an expression of EE's true value, but an attempt to increase opponents' costs and, therefore, should not be relied upon in the marginal bidder analysis;

– Ofcom's implementation of the marginal bidder approach included many arbitrary and subjective decisions. For example, Ofcom omitted EE's bids for (2xA1, 9xE) and (4xA1, 9xE) from its analysis. If these bids are also included, then the corrected full market value of 800 MHz spectrum becomes £23.68m/ MHz – significantly lower than £32.63m/ MHz estimated by Ofcom.

Accordingly, Ofcom's approach is neither conservative nor has particular regard for the sums bid in the UK 4G auction, as required by the Government Direction.

Power Auctions develops an alternative approach to estimating the "full market value" of 800 MHz and 2.6GHz. We utilise Linear Reference Prices (LRPs) without a revenue constraint and adjust those to reflect lower revenue that would have been raised in an auction without the spectrum reservation (to reflect the full market value). Our estimated values are presented in Table 1 below (alongside Ofcom's estimates):

Table 2: Estimated values of 800MHz and 2.6GHz per MHz

Band	Ofcom's estimate (1st consultation)	Ofcom's estimate (2nd consultation)	Three's estimate
800MHz (without coverage obligation, net of DTT costs)	£26.85m	£32.63m	**£25.04m**
800MHz (with coverage obligation, net of DTT costs)	£25.30m	£31.08m	**£23.49m**
2.6 GHz	£4.95m	£5.50m	**£3.57m**

Source: Ofcom, Three.

Below, we discuss the above points in more detail.

Ofcom's implementation of the marginal bidder approach violates the Revenue Equivalence Theorem.

In its implementation of the marginal bidder approach, Ofcom effectively simulates a uniform-price auction, i.e. the competitive bidding process that yields values for 800MHz and 2.6GHz based on the highest losing bid. Ofcom takes the bids from the actual auction (with a Vickrey pricing rule) and substitutes them into the pricing rule of a uniform-price auction. The resulting values of 800MHz and 2.6GHz, when aggregated, produce higher revenue than was actually achieved in the UK 4G auction.

Ofcom's analysis runs contrary to the accepted principle that a change in the auction format causes bidding behaviour to change. In particular, Ofcom cannot expect to raise higher revenue by simply changing the pricing rule – bidders would respond to the change by reducing their bids. According to the Revenue Equivalence Theorem, bidding behaviour would change in a way that fully offsets the higher pricing rule of the uniform-price auction, rendering the change revenue-neutral (as long as both auction formats assign the same items to the same bidders).

It is not straightforward to generalise this result if the allocation of licences change with a change in the auction format. However, Ausubel et al. (2014)[3] demonstrate that in a class of environments, in which bidders have multi-unit demands and exhibit linear marginal values, the ex-post revenue of the Vickrey auction is greater than that of the uniform-price auction. There do not exist any results in the literature establishing the reverse ranking in any class of environments (see Section 2 of Annex A for more details).

Therefore, the estimates of 800 MHz and 2.6 GHz values should be bounded by actual 4G auction revenue (irrespective of whether Ofcom uses the marginal bidder or the LRP approach).

Without the spectrum reservation, UK auction revenue would have been lower, not higher as claimed by Ofcom.

In the Second ALF Consultation, Ofcom argues that the UK auction revenue potentially understates the spectrum's full market value because of the spectrum reservation:

[3] Ausubel, L. M., P. Cramton, M. Pycia, M. Rostek and M. Weretka (2014), "Demand Reduction and Inefficiency in Multi-Unit Auctions," *Review of Economic Studies*, forthcoming, at Section 5, http://restud.oxfordjournals.org/content/early/2014/07/27/restud.rdu023.full.pdf?keytype=ref&ijkey=jGg1ddzGeMl0NpK.

> *"… the auction revenue from the prices paid by H3G and EE for 800 MHz spectrum at the reserve price is below market value for the purpose of ALF, due respectively to spectrum reservation for H3G and EE being the only losing bidder for additional 800 MHz spectrum".*[4]

Ofcom simulates an alternative auction result by removing the spectrum reservation, but keeping all bids as in the actual auction.

We strongly disagree with Ofcom's assumptions underlying this approach. In particular, Three would certainly not have placed all the same bids if it had not been an opt-in bidder. In an equivalent auction without spectrum reservation, Three would have only bid for 800 MHz spectrum at the reserve price or would not have bid for 800 MHz spectrum at all (knowing we had no chance of winning it). This would have had significant implications for the auction revenue reducing it by 12-15% (Scenarios 2 and 3 in Section 3.2 of Annex A).

This is entirely consistent with the general principles of auction theory: subsidising designated bidders (i.e. reserving spectrum for small operators) is likely to create extra competition and induce the unsubsidised incumbents to bid more aggressively, potentially improving auction revenue.

Our analysis of the UK auction without spectrum reservation is supported by evidence from the Canadian 700 MHz auction[5]. In the Canadian auction, as in the UK auction, a removal of the spectrum reservation would have reduced revenue significantly – by 19%-34% (Section 3.3 of Annex A).

Our analysis is further corroborated by a comparison of auction prices in Europe. Auctions in countries with effective spectrum reservations (Ireland, the Netherlands, Romania) raised higher revenue per MHz/pop than auctions without spectrum reservations (Spain, Portugal, Germany). (Section 3.4 of Annex A).

Overall, without the spectrum reservation, the UK auction revenue would have been lower, not higher as claimed by Ofcom. In order to replicate a "competitive" market outcome without the spectrum reservation, Ofcom should reduce the UK auction revenue by 12-15% and use this figure as the revenue constraint when estimating the value of 800 MHz spectrum.

[4] Second ALF Consultation, [2.18]
[5] The Canadian 700 MHz auction was chosen because of its similar auction format and publicly available bid data.

EE's bid for 2x20MHz of 800 MHz was not an expression of its value, but an attempt to increase opponents' costs and, therefore, should not be relied upon.

Ofcom's marginal bidder analysis relies to a large extent on a difference between two bids: EE's bids for package of (2xA1, 4xC) and (4xA1; 4xC). We can easily demonstrate that EE's bid for (4xA1; 4xC) had virtually no chance of winning and that therefore there is no reason to think that this bid is reflective of EE's true value.

It is also worth noting that EE submitted a supplementary bid for (2xA1,5xC), which was very competitive, fit with the other bidders' final clock bids and therefore formed a feasible allocation for the winner determination problem. The (4xA1; 4xC) bid, on the other hand, did not fit with the opponents' bids and was less competitive. The value gap between these two bids permitted EE to overstate its true valuation of (4xA1, 4xC) in order to attempt to increase its opponents' costs. Indeed, while the (4xA1, 4xC) bid had no chance of winning, it was very close to setting price for Vodafone and Telefonica (see Section 4 of Annex A for more details).

Three would therefore caution Ofcom against using EE's bid for (4xA1, 4xC) to assess its intrinsic incremental value of 2x10 MHz of 800 MHz spectrum. Instead, it should be treated as a price setting bid, which was submitted with no intention of winning. This bid should not be relied upon in Ofcom's marginal bidder analysis.

Ofcom's implementation of the marginal bidder approach included many arbitrary and subjective decisions.

It appears that in its implementation of the marginal bidder approach, Ofcom has omitted some of EE's bids. More specifically, the bid for (9xE), which was EE's final clock bid, as well as bids for (2xA1, 9xE) and (4xA1, 9xE) were omitted from the marginal bidder analysis. We add the Incremental Bid Values based on those bids to Ofcom's table 2.5 (see Table 3 below).

Table 3: Ofcom omitted some EE bids in its marginal bidder analysis (Ofcom's expanded Table 2.5)

Packages with	First 2x5 MHz (1xA1)	Second 2x5 MHz (2xA1)	Third 2x5 MHz (3xA1)	Fourth 2x5 MHz (4xA1)
No 2.6 GHz (0xC)	£23.0m	£42.0m	£26.33m	
2x5 MHz of 2.6 GHz (1xC)	dnb	dnb	dnb	dnb
2x10 MHz of 2.6 GHz (2xC)	£23.0m	£60.5m	£29.02m	
2x15 MHz of 2.6 GHz (3xC)	£23.0m	£55.59m	£26.65m	
1x45 MHz of 2.6 GHz (9xE)	**£25.49m**	**£61.0m**	**£23.68m**	
2x20 MHz of 2.6 GHz (4xC)	£23.0m	£50.55m	£32.63m	
2x25 MHz of 2.6 GHz (5xC)	£23.0m	£49.12m	dnb	np
2x30 MHz of 2.6 GHz (6xC)	£27.5m	£46.1m	np	np
2x35 MHz of 2.6 GHz (7xC)	£35.3m	np	np	np

Source: Ofcom, Three.

Using the difference between EE's bids for (4xA1, 9xE) and (2xA1, 9xE), while otherwise adopting exactly Ofcom's methodology, produces a "full market value" of £23.68m/ MHz for 800 MHz spectrum. The fact that the identical methodology applied to an equally plausible row of Table 2.5 produces such a different result highlights the arbitrary and subjective nature of Ofcom's implementation of the marginal bidder approach.

Three's estimate of 800 MHz value is based on LRPs with revenue adjusted to reflect no spectrum reservation.

Given Ofcom's implementation of the marginal bidder approach is not satisfactory, we develop our alternative estimates of the "full market value" of 800 MHz and 2.6 GHz licences. We utilise LRP without a

revenue constraint and adjust Three's bids in the absence of a spectrum reservation (based on Scenario 3 of Section 3, Annex A).

We then prorate the prices to a simulated revenue target of £2002m (the auction revenues in the absence of a spectrum reservation), maintaining proportional mark-ups from the reserve prices and maintaining the value relationship between A1 and A2 blocks. Our recommended value estimates are:

– 800 MHz band (no coverage obligation, no DTT costs): £25.04m/ MHz; and
– 2.6 GHz band: £3.57m/ MHz

The details of our calculations are presented in Section 6, Annex A.

Note that, while the 800 MHz value estimate is substantially lower than Ofcom's estimated value of £32.63m/ MHz, it is actually slightly higher than the value obtained from utilising EE's omitted bids while otherwise adopting exactly Ofcom's methodology (£23.68m/ MHz). Therefore, we have substantial confidence that this reduction is justified.

2. Three disagrees with Ofcom's interpretation of international benchmark evidence.

Ofcom's revised proposal is that international benchmark evidence should focus primarily on the relative values of 900MHz and 1800MHz to the values of 800MHz and 2.6GHz in each benchmark country – rather than absolute values of 900MHz and 1800MHz spectrum – and that Ofcom should use the "distance-method" for determining the lump-sum value of 1800MHz spectrum. Three strongly agrees with this.

However, Three disagrees with Ofcom's interpretation of international benchmark evidence.

Specifically, Three considers that Ofcom has been conservative with its 900MHz lump-sum value but, in contrast, very aggressive with its 1800MHz estimate. This is due to what appears to be a highly subjective categorisation of very few data points.

For instance, Ofcom's 1800MHz lump-sum value is significantly higher, and its 900MHz value is significantly lower, than their respective simple averages. This asymmetry is surprising given that Ofcom's own analysis suggests that it is very uncertain about the quality of its benchmarks.

In particular, Three considers that Ofcom's proposed UK 1800MHz lump-sum value of £14m per MHz is too high (on the basis of Ofcom's proposed UK 800MHz and 2600MHz values), both in absolute terms and in relation to the 900MHz value (61%).

In contrast, Three's benchmarking approach leads to a UK 1800MHz lump-sum value of £7.7m per MHz for 1800MHz, and £21.3m per MHz for 900MHz spectrum (on the basis of Three's proposed UK 800MHz and 2600MHz values).

If a discount were also applied to reflect Ofcom's conservative approach, then the resulting values would £6.5m per MHz and £19.0m per MHz respectively. These are the values recommended in our expert report by Analysys Mason and Aetha report, appended at Annex B.

Three has identified what we consider are significant problems with Ofcom's assessment, namely:

- Ofcom's 900MHz and 1800MHz values are highly sensitive to the Tiers and weights used;
- Ofcom ignores its Tier 3 benchmarks and relies on too few data points;
- Ofcom omits key criteria in the classification of its benchmarks;
- Ofcom uses ad hoc criteria instead of applying objective principles to categorise all benchmark values; and

– Ofcom is much more conservative in its determination of the 900MHz lump-sum value than in respect of 1800MHz spectrum.

Three considers that a better approach would be to incorporate as much evidence as possible in the analysis and apply clear and consistent principles to classify all benchmarks. Three has applied this approach to estimating the UK lump-sum values of 1800MHz and 900MHz spectrum, which we discuss further below and in the Analysys Mason and Aetha report.

Three has serious reservations about Ofcom's proposed 900MHz and 1800MHz lump-sum values.

Ofcom has addressed many of our concerns with its previous lump-sum values. In particular, Ofcom no longer uses absolute measures (other than as a cross-check) to arrive at its lump-sum estimates. Instead, it has adopted our proposed distance method for 1800MHz. Ofcom also presents a clearer explanation of the framework used to classify benchmarks and of its determination of lump-sum values.

Nevertheless, Three continues to have serious reservations about Ofcom's revised values. Table 4shows Ofcom's estimates of full market value for 900MHz and 1800MHz spectrum in the UK, together with its 800MHz and 2.6GHz prices based on the marginal bidder method.

Table 4: Ofcom's lump-sum estimates of UK spectrum value

Band	800MHz	900MHz	1800MHz	2.6GHz
£m per MHz	£35.6m[6]	£23.0m	£14.0m	£5.5m
Value relative to 900MHz	155%	100%	61%	24%

Source: Ofcom.

In Three's view, Ofcom's proposed 1800MHz value is too high, both in absolute terms (£14m per MHz) and in relation to the 900MHz value (61%). We consider that this is due to a highly subjective categorisation of a very small number of benchmarks: Ofcom's 900MHz value is conservative while its 1800MHz figure is very aggressive. This is

[6] This is Ofcom's estimate for an 800MHz licence without coverage obligation and gross of coexistence costs.

supported by our expert report from Analysys Mason and Aetha appended at Annex B.

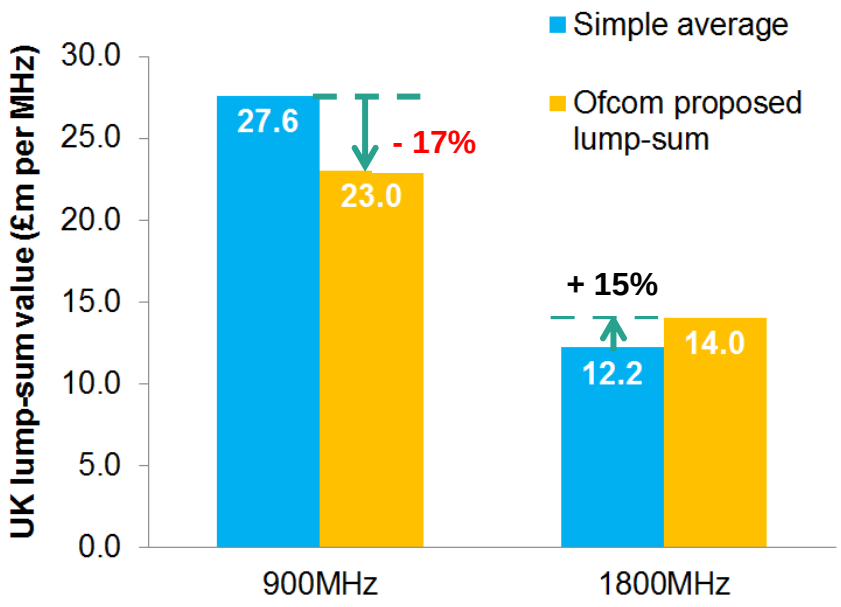
Ofcom's 1800 lump-sum value is significantly higher, while the 900MHz value is significantly lower, than their simple averages.

There are inherent limitations to any benchmarking approach for estimating the value of 900MHz and 1800MHz spectrum in the UK. The sample of recent EU auctions provides relatively few data points, and it is not possible to control for every factor that could possibly influence relative values between countries.

In light of those limitations, it is very important that the benchmarking approach is inclusive and tries to use as many data points as possible. The starting point should therefore be to attach the same weight to all observations and set a simple average value for 900MHz and 1800MHz, unless evidence clearly suggests that significant differences in the quality of benchmarks will not even out in the aggregate.

However, Ofcom's proposed 1800MHz lump-sum value is 15% higher than the 1800MHz simple average, while its 900MHz value is 17% lower than the 900MHz average value.

Figure 1: Ofcom's 1800MHz UK lump-sum value is at the top end of all possible values.[7]



Source: Ofcom, Three.

This asymmetry is surprising given that Ofcom is not confident that its 900MHz and 1800MHz benchmarks reflect market value in the UK (see section 3.3 of the Analysys Mason/Aetha report).

Ofcom's proposed lump-sum values are highly sensitive to the Tiers and weights used.

Ofcom classifies its benchmark values in three Tiers, or excludes them entirely, based on the extent to which they are informative of UK value. This is a change from its previous 2-Tier classification of more important/less important (and excluded) that has not been adequately justified.

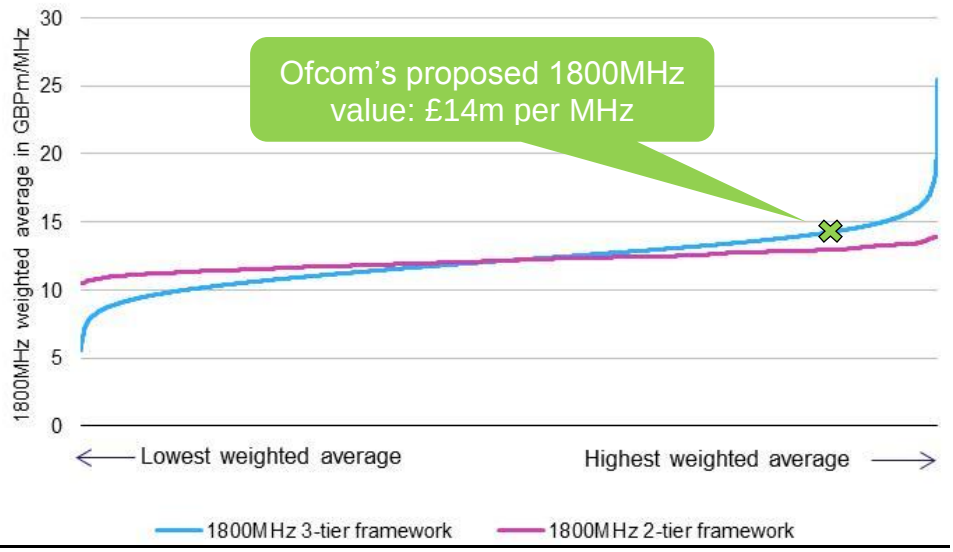
Three agrees with Ofcom that it is necessary to group benchmarks into Tiers and attach greater weight to the more important Tiers, to reflect key differences in the quality of the evidence where they exist. But by increasing the number of Tiers Ofcom has greatly widened the range of

[7] The 900MHz simple average excludes the Denmark value, which in our view is not at all informative given that the three main incumbents were not allowed to participate in the award. The 900MHz average is £24m per MHz if Denmark is included.

possible values. This makes the lump-sum determination highly sensitive to the Tiers and weights used.

For instance, Figure 2 shows (in blue) the weighted-average 1800MHz values associated with each possible combination of Ofcom's nine 1800MHz benchmarks and three Tiers, assuming weights of 2, 1 and 0 used in Ofcom's cross check. The pink curve shows the corresponding 1800MHz average if only two Tiers are used (assuming weights of 2 and 1).

Figure 2: Ofcom's 1800MHz UK lump-sum value is at the top end of all possible values.



Source: Three.

Ofcom's three-Tier framework produces a much wider range of possible 1800MHz lump-sum values (£5.6m to £25.5m per MHz) than its previous two-Tier framework (£10.5m to £13.9m per MHz).

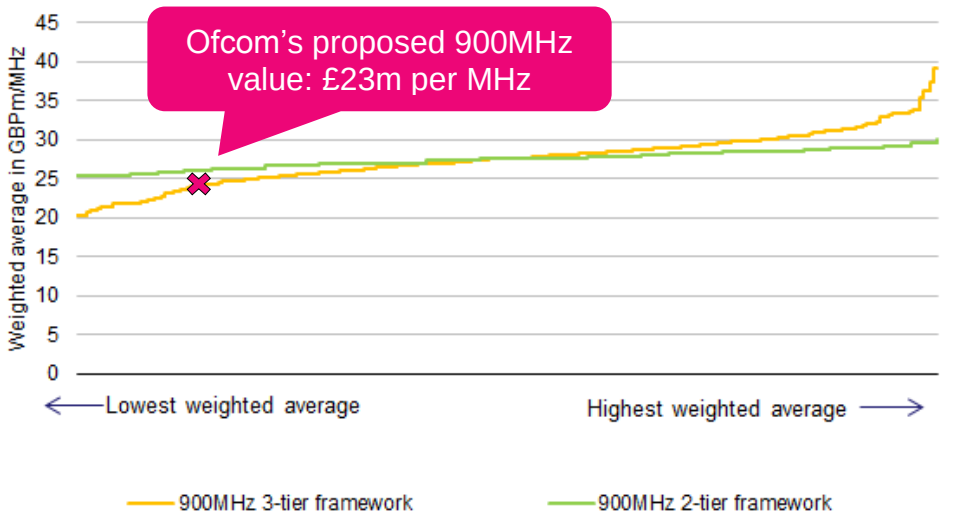
Moreover, Ofcom's proposed 1800MHz value is towards the top end of all possible results, given that very few tiering combinations would lead to a weighted average value of £15m per MHz:

– a two-Tier framework could not produce an 1800MHz value as high as £14m per MHz (if weights of 1 or 2 are assumed); and
– a three-Tier framework can only arrive at £14m per MHz by ignoring or giving minimal weight to low price 1800MHz benchmarks, and

assigning most weight to high price auctions (given weights of 2, and 0). This is precisely what Ofcom has done.

In the case of 900MHz, the opposite is true. Ofcom's three Tiers also widen the range of possible values, from £25.4m-£30.1m per MHz to £20.3m-39.2m per MHz. But in this case, Ofcom's £23m per MHz value is towards the bottom end of all possible 900MHz weighted average values. In fact, Ofcom could not have set such a low 900MHz value based on a mechanistic application of its previous two-Tier framework.

Figure 3: Ofcom's 900MHz UK lump-sum value is towards the bottom of all possible values.



Source: Three.

This shows that Ofcom has been conservative with the (implicit) weights given to the 900MHz benchmarks, but very aggressive with its 1800MHz weights. The sensitivity of both values to the Tiers and weights used highlights the importance of using objective criteria to classify benchmarks and then giving appropriate weight to them.

We have three main concerns with Ofcom's benchmark classification: the weight given to the Tier 3 values, the omission of key principles and the inclusion of ad hoc criteria.

Our main concerns with Ofcom's benchmark classification are:

– Ofcom ignores the Tier 3 benchmarks and relies on too few data points;
– Ofcom omits key criteria in the classification of its benchmarks;
– Ofcom uses ad hoc criteria instead of applying clear and consistent principles across all benchmarks.

We propose three sets of changes to address each of those concerns in Table **5**. These are colour-coded in red, yellow and blue respectively, and discussed in the following three sections.

Table 5: Three's proposed changes to Ofcom's classification.[8]

	1800MHz			900MHz		
Country	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**
Austria	25.5			39.2		
Ireland	14.3			20.3		
Italy	13.5					
Germany		5.6				
Sweden		~~17.5~~ 5.5				
Czech Rep			7.5			
Portugal			6.1		21.8	
Romania			12.0			33.5
Slovakia			7.5			
Spain					23.2	
Denmark						~~6.1~~

Source: Three.

Ofcom ignores its Tier 3 benchmarks and relies on too few data points.

Our first concern relates to the newly created Tier 3 category and the weight Ofcom attaches to it. This is discussed in Section 3.4.1 of the AM&A report.

[8] As discussed below, we propose a different 1800MHz value from Sweden and consider that Ofcom should remove the Danish 900MHz value from its data set, as incumbents were not allowed to participate in that award.

In effect, Ofcom gives the same weight to the Tier 3 values and the excluded benchmarks – zero. Ofcom does not consider those values in its non-mechanistic approach, and it attaches zero weight to them in its mechanistic cross-check. As a result, Ofcom relies on very few data points to arrive at its lump-sum values.

Ofcom should not adopt two separate categories and then give them equal (ie zero) weight. By differentiating between Excluded and Tier 3 benchmarks, Ofcom recognises that Tier 3 values are more informative of UK market value. There are two ways to assign proper weight to the Tier 3 benchmarks:

– by reverting to Ofcom's previous 2-Tier framework of more important and less important values (together with the excluded category) – for instance, by moving the Tier 3 900MHz and 1800MHz benchmarks to Tier 2; or
– by retaining the 3-Tiers (plus excluded) but assigning a positive weight to Tier 3.

We prefer the first option, as it reflects a more inclusive approach. That option reduces the range of possible values, minimising the scope for subjectivity to unduly influence values while still recognising key differences in the quality of individual benchmarks. This is reflected in the changes proposed in Table **5** (in red). Our proposed treatment of Denmark is discussed in the next section.

Ofcom omits two key criteria in the classification of benchmarks

Our second concern relates to the omission of certain criteria in Ofcom's framework. Sections 3.1 and 3.4.4 of the Analysys Mason and Aetha report explain this. Table 6 compares Three's and Ofcom's criteria for classifying benchmark values from other countries.

Table 6: Ofcom vs Three's classification of evidence points.

Price represents market value in country	Ofcom	Three
No lots sold at reserve	●	●
No unsold spectrum	●	●
No bidder precluded from bidding	●	Exclude
Band-specific prices can be directly inferred	●	●
All relevant bands have been auctioned (ie no need to use proxy values for 2.6GHz)	●	●
No obvious contenders for spectrum due to packaging/non-contiguous lots	●	●
Auction took place after late 2011 (post emergence of LTE1800 ecosystem)	●	●
Same number of bidders in each band	●	●
Price is relevant to UK value	**Ofcom**	**Three**
EU award from 2010 onwards	●	●
All prices from single multi-band auction (ie no large time gap between awards)	●	●
All band available for sale	●	●
Other (e.g. 2G is as important as in the UK, etc)	●	●

Source: Three, Ofcom.

Our framework includes two key criteria that Ofcom omits in assessing whether a benchmark represents market value in a country:

– **Whether band-specific prices can be directly inferred** – Ofcom defines market value as the market-clearing price in a well-functioning market.[9] For all CCA awards except Austria, Ofcom lacks the bid data needed to determine whether its estimates adequately explain auction outcomes or reflect market value. In the case of Austria, strictly speaking Ofcom's linear prices do not reflect market value, because bands would not have cleared and winners would not have

[9] Paragraph 2.9 of the Consultation.

chosen the same packages at those prices.[10] In practice, different methods to disaggregate package prices can generate very different estimates. Due to informational limitations, Ofcom applies Austrian prices based on its LRP method and Irish values reflecting final clock prices to UK values that are based on a marginal bidder approach. For these reasons, benchmarks from CCA awards should be Tier 2 at best;

– **Whether all relevant bands have been auctioned (ie. no need to use proxy values)** – 1800MHz distance estimates require benchmark countries to have auctioned 800MHz, 1800MHz and 2.6GHz. If some bands have not been auctioned (e.g. Ireland's 2.6GHz) the resulting 1800MHz UK estimates will rely on a mix of actual and proxy values. Different assumptions about the proxy value can then generate very different estimates. For these reasons, benchmarks that rely on proxy values should at best be Tier 2.

Ireland's CCA auction illustrates why the first criterion is needed. Ofcom relies on the ratio of final clock prices to estimate band prices for 800MHz and 1800MHz. In its report for Ofcom, Dotecon uses a simple linear fit instead.[11] We add Ofcom's proxy value for 2.6GHz, which has not yet been auctioned in Ireland, in both cases.[12] This yields two very different 1800MHz distance parameters from Ireland: 32% (Ofcom's) and 13% (Dotecon's).

Table 7: Different methods to estimate band prices in CCA auctions can produce very different values.

	800MHz	1800MHz	2.6GHz	D
Ofcom final clock prices (£m per MHz)	63.5	25.2	6.8	**32%**
Dotecon simple linear fit (€m per MHz)	60.0	13.1	6.4	**13%**

Source: Ofcom, Dotecon.

[10] Ofcom uses use the Austrian LRP (calculated without revenue constraint) for the Austrian A2, B2 and C1 lot categories as inputs. Ofcom's Update on European auctions shows that this method generates maximum excursions of €65.7m across bidders. This is the maximum amount that Austrian bidders would have to be compensated with in order to choose their winning packages at the linear reference prices proposed.

[11] Section 4 of Dotecon's 800MHz and 2.6GHz linear reference prices and additional spectrum methodology. Report prepared for Ofcom, September 2013

[12] Ofcom's 2.6GHZ proxy is based on the 2.6/800 ratio of 10.7%,the average (geometric mean) of the ratio in ten EU countries where the 800MHz value is net of co-existence costs.

Ofcom's treatment of Sweden provides a good example of why the second criterion is required. Sweden auctioned 2.6GHz spectrum in 2008, two years before Ofcom's 2010 cut-off date. Instead of using an actual price, Ofcom prefers a 2.6GHz proxy based on the average 800/2.6 ratio in other EU countries. This has a large upward impact on the UK 1800MHz estimate from Sweden, as shown in Table 8.[13]

Table 8: Ofcom uses an inflated 1800MHz distance estimate from Sweden

£m/MHz UK equivalent	800	1800	2.6	D	UK 1800
Ofcom	21.2	9.7	2.0	**40%**	**17.5**
Three	21.2	9.7	9.7	**0%**	**5.5**

Source: Ofcom, Three.

For these reasons, we invite Ofcom to adopt our proposed criteria and classify prices from CCA awards and benchmarks that rely on proxies as Tier 2 at best. This would downgrade the 900MHz and 1800MHz Austrian and Irish benchmarks to Tier 2. We have reflected these changes in Table **5** (in yellow).

In our view, Ofcom should also use our proposed 1800MHz UK value from Sweden and exclude the Danish 900MHz benchmark from its data set. That auction precluded incumbents from participating, so the resulting price provides no useful information about market value in that country.

Ofcom uses ad hoc criteria instead of applying clear and consistent principles across all benchmarks.

Finally, our third concern relates to the inclusion of certain criteria in Ofcom's framework. As shown in Table 8 above, we do not agree with several of Ofcom's criteria. Instead of adopting clear principles and applying them consistently to all benchmarks, Ofcom appears to use some ad hoc reasons to rationalise certain values and fit Ofcom's pre-

[13] See sections 5.1-5.2 of the Analysys Mason and Aetha report. To assist comparability the table uses Ofcom's 1800MHz estimate of £9.7m per MHz, instead of the value of £9.3m per MHz proposed in the report.

conceived view of their reliability. This is discussed in Sections 3.4.2 and 3.4.3 of the Analysys Mason and Aetha report.

To illustrate this point, Table 9 compares the reasons provided by Ofcom to categorise certain 900MHz and 1800MHz benchmarks.

Table 9: **Ofcom's benchmark classification is highly subjective.**

	1800MHz			900MHz		
Ofcom Tier	**1**	**1**	**2**	**2**	**2**	**3**
Price reflects market value in country	**AU**	**IE**	**DE**	**PT**	**ES**	**RO**
No lots sold at reserve	✓	✓	✓	✗	✗	✗
No unsold spectrum	✓	✓	✓	✗	✓	✗
No excluded bidder	✓	✓	✓	✓	✓	✓
Auction post 2011	✓	✓	✗	n/a		
No obvious contenders	✓	✓	✗	✗	✗	✓
Band prices can be directly inferred	✗	✗	✓	✓	✓	✗
All relevant bands auctioned (no proxy)	✓	✗	✓	n/a		
Price is relevant to UK value						
EU award from 2010 onwards	✓	✓	✓	✓	✓	✓
All prices from single auction (no large gap)	✗	✓	✓	✓	✗	✓
All band available for sale	✓	✓	✗	✗	✗	✓
Other (e.g. 2G is as important as in the UK)	✓	✓	✓	✗	✓	✗

Source: Ofcom, Three

Like Austria and Ireland, Germany's 1800MHz price meets Ofcom's main criterion for Tier 1 status. The price was determined by bidding. All lots sold above reserve, with no excluded bidders and no unsold lots. Ofcom

even cites an academic article concluding that bidding was competitive and revenue was close to expectations.[14]

Nevertheless, Ofcom assigns the German 1800MHz value to Tier 2 on the basis that i) there were 'obvious contenders' due to existing allocations; ii) the auction took place before development of the LTE 1800 ecosystem; iii) only 2x25MHz of spectrum was available. As discussed in the Analysys Mason and Aetha report, these reasons are not particularly convincing.

In any event, Three does not understand why Ofcom should be more concerned about these factors than about the following problems with its Austrian and Irish 1800MHz benchmarks:

– Austria: many possible band values depending on the method used to disaggregate CCA package prices, and a 3-year gap between the 800MHz/900MHz/1800MHz auction and the 2.6GHz award;

– Ireland: many possible band prices depending on the method used to disaggregate package prices and the 2.6GHz proxy value used, and the fact that 1800MHz is more valuable in Ireland than in the UK because 2.6GHz spectrum has not yet been auctioned.

Similarly, Ofcom classifies Romania's 900MHz benchmark as Tier 3 – less informative than the 900MHz Tier 2 values from Spain and Portugal. This is on the basis that the Romanian values reflect reserve prices set by the regulator. But this is also true of Spain and Portugal, where 900MHz sold at reserve and prices were not determined by bidding.[15]

The other reason provided for Romania's Tier is that 2G is much more important in that country than in the UK. It is unclear why this relegates Romania to Tier 3 while the following do not impact Portugal or Spain's status as Tier 2 benchmarks:

– 2G is also much more important in Portugal than in the UK - Ofcom has not presented any statistics (e.g. the proportion of 2G traffic across countries) to justify its decision, so there is no way to tell whether Romania is indeed an outlier;
– Ofcom ignores the existence of 'obvious contenders' for 900MHz in both Portugal and Spain;[16] and

[14] Paragraph A8.115 cite P. Cramton & A. Ockenfels, The German 4G Spectrum Auction: Design and Behaviour (June 2014), p. 4. Available at http://www.cramton.umd.edu/papers2010-2014/cramton-ockenfels-german-4g-auction.pdf
[15] In Portugal, 800MHz and 900MHz sold at reserve (and one sub-1GHz lot went unsold). In Spain, the lowest 800MHz block and all 900MHz spectrum sold at reserve.
[16] In Portugal, due to pre-existing allocations and the sub-1GHz cap, only Vodafone could buy a 900MHz lot that was contiguous with its existing frequencies, which it won. The lack of bids from Optimus and TMN for the other (unsold) lot indicates that their valuation for non-contiguous spectrum was below reserve. The Spanish Nov 2011 auction made available

– the amount of spectrum available – two 900MHz blocks in Portugal and one in Spain vs the entire band in Romania – and the fact that the 800MHz and 900MHz Spain prices used by Ofcom are from different auctions.

In our view, Ofcom is not in a position to draw these distinctions because the impact of these factors on market value is essentially unknown. Ofcom is also very uncertain about the extent to which its benchmarks reflect market value (as show in Tables A8.1 and A8.2 of the consultation).

We continue to believe that Germany 1800MHz should be in Tier 1. In our view, Romania 900MHz does not deserve that status (as spectrum sold at reserve, there was unsold spectrum and package prices need to be disaggregated), but it should certainly be accorded the same status as Portugal and Spain and more weight than Denmark and the excluded benchmarks. Table **5** reflects these changes (in blue).

Ofcom is more conservative in its determination of 900MHz value than the 1800MHz value.

Our final concern is that Ofcom has not been equally conservative in its determination of the 900MHz and 1800MHz lump-sum values. In the case of 900MHz Ofcom is conservative in two respects:

– Ofcom sets an initial value of £25m per MHz, towards the lower end of the Tier 1 benchmarks – which in its view would be appropriate if only those values were considered; and
– It then reduces the value further to £23m per MHz, to take account of the Tier 2 benchmarks (Portugal's £21.8m per MHz and Spain's 23.2m per MHz).

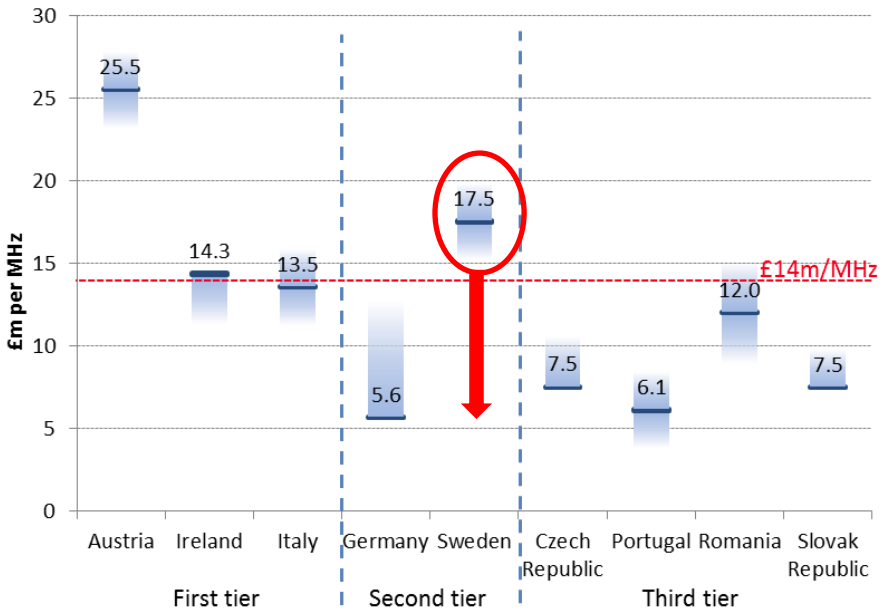
In the case of 1800MHz, Ofcom also sets an initial lump-sum (£14m per MHz) in the bottom half of its Tier 1 values But the figure is not then reduced to take account of the Tier 2 benchmarks on the basis that those values (Germany's £5.6m per MHz and Sweden's £17.5m per MHz) are less consistent – one is above and one below the initial value of £14m per MHz.

However, as shown in Table 8 above the reason for the very different 1800MHz Tier 2 benchmarks is that Ofcom uses of a proxy value instead of the actual value from Sweden's 2008 2.6GHz auction. If the correct

a single 900MHz lot released by Telefonica (who eventually won it), which was adjacent to Telefonica's and Vodafone's 900MHz existing holdings.

value from Sweden is used, the resulting UK 1800MHz estimate from Sweden would be £5.5m per MHz, almost the same as Germany's £5.6m per MHz.

Figure 4: Ofcom should have been more conservative with its 1800MHz UK value.



Source: Figure 3.3 of the Consultation

Following the same logic applied to 900MHz, Ofcom should then have reduced its initial 1800MHz lump-sum value of £14m per MHz to take account of its Tier 2 benchmarks. This would have ensured a consistent application of its conservative approach.

A more inclusive benchmarking approach produces an 1800MHz UK lump-sum value of £7.6m per MHz, and a 900MHz lump-sum value of £21.4m per MHz.

A key difficulty with the benchmarking exercise is that there are not many recent EU awards. We have adopted the following principles to address this problem:

– the overall approach should be inclusive and make use of as many data points as possible;
– the classification of benchmarks into Tiers should be based on clear and objective criteria; and
– a two-Tier framework reduces the range of possible values, minimising the scope for subjectivity while still recognising key differences in the quality of individual benchmarks.

Table 10 summarizes our classification of individual benchmarks based on these principles. This is discussed in further detail in Section 4 of the Analysys Mason and Aetha report.

Table 10: Three's proposed classification of evidence points.

1800MHz						
Country	**Price can't be inferred**	**Use of proxy**	**Unsold spectrum**	**Large gap between auctions**	**Spectrum sold at reserve**	**Tier**
Austria	✓			✓		2
Czech Rep			✓		✓	2
Germany						1
Ireland	✓	✓				2
Italy						1
Portugal			✓		✓	2
Romania	✓		✓		✓	2
Slovakia	✓				✓	2
Sweden				✓		2
900MHz						
Austria	✓					2
Ireland	✓					2
Portugal			✓		✓	2
Romania	✓		✓		✓	2
Spain					✓	2

Source: Section 4.1 of the Analysys Mason/Aetha Report.

Our framework recognises Tier 1 status to recent benchmarks from multi-band SMRA auctions in the EU where all relevant bands sold above reserve. Only the German 2010 and Italian 2011 1800MHz benchmarks meet that test. All other 900MHz and 1800MHz benchmarks are Tier 2. This reflects the fact that there is significant uncertainty about them, and no sound basis for drawing distinctions about the extent to which they are informative of UK value.

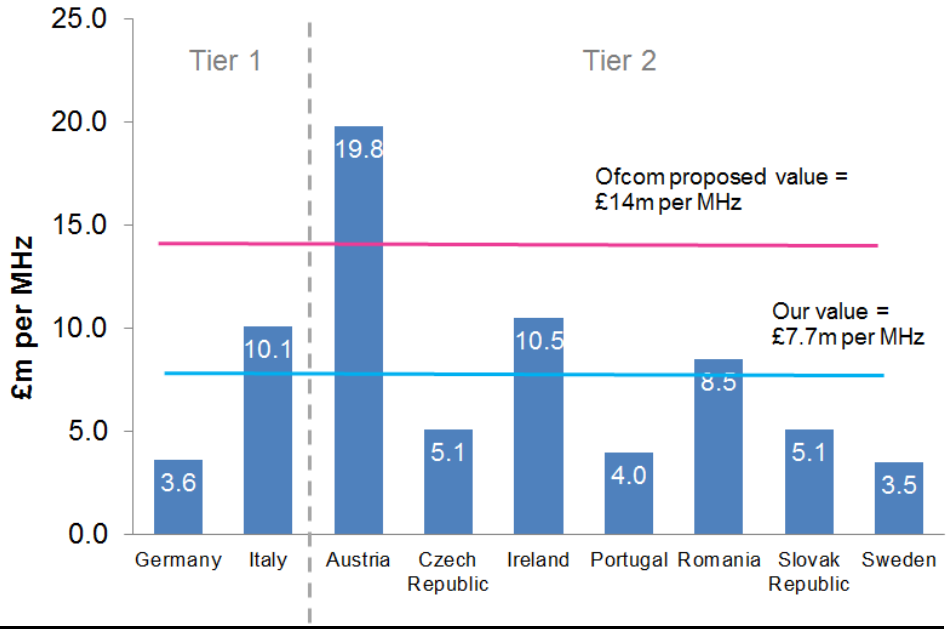
Our previous response invited Ofcom to assign explicit weights to its evidence and use a weighted average as its proposed lump-sum value. Ofcom continues to prefer a 'non-mechanistic' approach, with weighted average values used as cross-checks. We have no particular objection to this. Both approaches should produce similar values if consistently applied.

Annex D presents the data inputs we have used to calculate our proposed lump-sum values, namely:

– Our UK 800MHz values (with and without coverage obligation, gross and net of co-existence costs) and 2.6GHz values, set out in Table 2;
– Three's corrected input values from recent EU auctions, and the resulting UK 900MHz and 1800MHz estimates; and
– Our proposed two Tiers and weights (2 for Tier 1 and 1 for Tier 2) and the classification set out in Table 10.

As shown in Figure 5, our proposed 1800MHz lump-sum value is £7.7m per MHz. Our value is very close to the simple average value of all 1800MHz data points (£7.8m per MHz), reflecting an inclusive approach to the benchmarking exercise. Our proposed value should be an upper bound because it is based on the weighted average value of our 1800MHz distance estimates, and includes no discount to reflect Ofcom's conservative approach. If a small discount is applied (as is proposed in the Analysys Mason and Aetha report), then the resulting lump-sum value for 1800MHz is £6.5m per MHz.

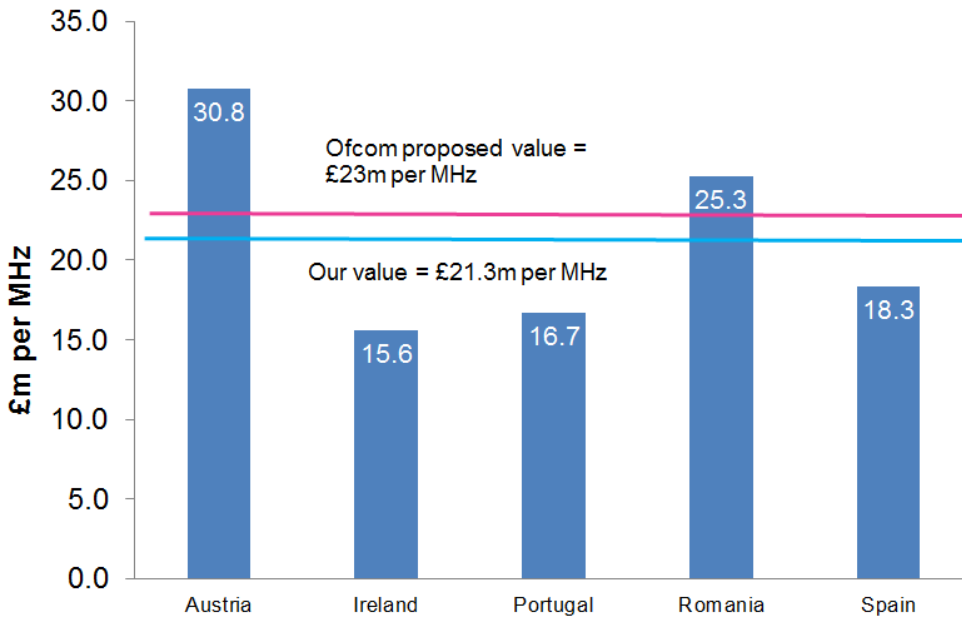
Figure 5: Three's proposed 1800MHz UK lump-sum value.



Source: Three.

Our proposed 900MHz lump-sum value is £21.3m per MHz. Given that all of our 900MHz benchmarks carry the same weight, the lump-sum value is the same as the simple average 900MHz value, and slightly lower than Ofcom's proposed £23m per MHz. If a small discount is applied to reflect a conservative approach (as is proposed in the Analysys Mason and Aetha report), then the resulting lump-sum value for 900MHz would be £19m per MHz

Figure 6: Three's proposed 900MHz UK lump-sum value



Source: Three.

Section 7 of the Analysys Mason and Aetha report criticise Ofcom's 1800/900 cross-check, which is solely based on Austria and Ireland. The ratio of our proposed lump-sum values (36%) is much closer to the geometric mean of the benchmark ratios, suggesting that our proposed lump-sum values are much more robust than Ofcom's.

Table 11: Our proposed 1800/900 ratio is much lower than Ofcom's

	900MHz	1800MHz	1800/900 ratio
Ireland	39.6	25.2	64%
Ofcom UK	23.0	14.0	61%
Austria	79.4	48.6	61%
Greece	32.8	14.5	44%
Denmark	2.9	1.2	43%
Romania	47.3	19	40%
Three UK	21.3	7.7	36%
Portugal	24.9	3.2	13%
Geometric mean			**40%**

Source: Section 7, Analysys Mason and Aetha report.

3. Three disagrees with Ofcom's rejection of technical evidence as to the value of 900MHz spectrum.

Ofcom's updated approach to estimating the value of 900MHz spectrum in the UK relies on:

– estimating the value of 800MHz spectrum in the UK; and
– adjusting it for a 900MHz/ 800MHz price ratio, based on the evidence from international benchmarking evidence.

In its previous consultation, Ofcom proposed to take technical and commercial evidence into account as well, but has now decided against this.

We disagree with this, as a comparison of technical characteristics and commercial opportunities of 800MHz and 900MHz shows that they are of almost identical value.

Three therefore suggests that for 900MHz, international benchmarking evidence and technical/commercial evidence should be given equal weight, namely:

– international benchmarking evidence implies a lump-sum value of £21.3m per MHz; and
– technical/ commercial evidence implies a lump-sum value of £25.0m per MHz, i.e. the same as 800MHz.

Hence, we consider that £23.2m per MHz is the most appropriate lump-sum value of 900MHz spectrum.

In contrast, we agree with Ofcom that technical or commercial evidence is unsuitable for estimating the value of 1800MHz spectrum, owing to its lack of technical proximity to either to 800MHz or 2600MHz spectrum.

Ofcom states that the model it used to value 700MHz spectrum is not fit to estimate the relative values of 800MHz and 900MHz:

> *"The model as currently designed and specified does not distinguish between 800 MHz and 900 MHz spectrum. In principle it would be possible to introduce additional assumptions to attempt to capture the difference in device ecosystems and other factors.*
>
> *However, there is considerable uncertainty about the relevant assumptions to make and the results would be highly sensitive to the input assumptions. In addition, the model's focus on network cost savings may not fully capture the difference in commercial value between the two bands."*[17].

[17] Ofcom's Consultation, [A9.23-[A9.24]], page 6

The 900 MHz band is currently widely used to serve the 3G customers (the largest part of the customer base) and the remaining 2G customer. It is also liberalised for 4G in the UK (i.e. MNOs are able to refarm it for 4G when they chose to do so) and being rapidly deployed now for 4G across the in other European and global markets[18].

In the UK, 900MHz also enjoys a higher transmission power limit than the 800MHz band, further increasing its value (owing to incrementally better coverage and capacity). All these factors suggest that the technical and commercial value of 900MHz spectrum is no less than the value of 800MHz spectrum (and possibly higher)[19].

Turning to the evidence from the European auction, we identify two factors that could cause prices of 900MHz and 800MHz to diverge in the short run. These are:

1 **Relative abundance of 900MHz spectrum**: there was 2x35 MHz of 900 MHz available vs. 2x30 MHz of 800 MHz.
2 **Differences in auction design:** differences in spectrum caps help to explain why 900MHz spectrum was relatively cheap in some countries (compared with 800MHz spectrum).

We consider that these factors have caused the prices of 900MHz spectrum to deviate from the prices of 800MHz spectrum in the short run. This, however, does not mean that 900MHz spectrum is less valuable than 800MHz spectrum in the long run. Three made previous submissions and continues to maintain that 900MHz and 800MHz spectrum are equally valuable. Ofcom should take technical evidence into account and set the ALF for 900MHz spectrum based on both the benchmarking evidence and technical evidence.

Based on the benchmarking evidence (presented in Section 2), the lump-sum value of 900MHz is £21.3m per MHz. However, based on the technical evidence, 900MHz should be valued at £25.04m per MHz (i.e. equal to the 800MHz value). We propose to take the average between these two values and use £23.17m as the most appropriate lump-sum value of 900MHz spectrum.

Below, we explain each factor in turn, highlighting how it affected the relative prices of 900 vs. 800 in the short run.

[18] "For example, LTE in 900MHz spectrum (3GPP band 8) – market status", GSA, August 2014, highlights that 4G is currently deployed in the 900MHz band in five networks globally (compared to 55 in the 800MHz band) and available in 335 devices (compared to 467 in the 800MHz band). This excludes the recent launch of 4G 900MHz by T-Mobile in the Netherlands.
[19] For the avoidance of doubt, we are not advocating using technical modelling to gauge market value of 1800MHz spectrum because 1800MHz spectrum does not have a good comparator spectrum band that has recently been auctioned.

Relative abundance of 900MHz spectrum contributed to its lower price.

One factor that affected the relative price of 900MHz spectrum is its relative abundance – 2x35MHz vs 2x30MHz of 800MHz spectrum. Competition for 800MHz spectrum was particularly fierce in countries with four operators present (e.g. Italy, Ireland, Germany). Incumbent operators felt they needed to obtain 2x10MHz of 800MHz spectrum each in order to provide good coverage and to have enough capacity to serve their customer base. In most of these countries, the price of 800MHz spectrum was bid up high and the challenger operator was left with no 800MHz spectrum.

Auction dynamics tended to be different in bidding for 900 MHz spectrum (in countries where it was auctioned). Like 800MHz spectrum, 2x10MHz of 900MHz spectrum was considered sufficient by incumbents to serve their existing 2G/3G customer base. This left 2x5MHz spectrum for the fourth ("challenger") operators. While this amount (2x5MHz) may have been considered insufficient by a large operator, for a small operator, it was preferable to get some low frequency spectrum than none. Indeed, small operators were clearly not in a position to outbid incumbents and to win 2x10MHz of 900MHz spectrum as their valuation of spectrum was lower due to much smaller customer base, as recognised in Ofcom's competition assessment for the UK 800MHz and 2600MHz auction.

Therefore, less intense competition for 900MHz spectrum in some countries (e.g. Ireland) partly reflects differences in the amount of spectrum available (2x35MHz vs. 2x30MHz of 800MHz). This, however, does not mean that 900MHz spectrum is less valuable in the long run.

Specific features of auction design could affect relative prices of 800MHz and 900MHz.

It appears that differences in relative prices, at least to some extent, can be attributed to differences in auction design, specifically to spectrum caps. Very few spectrum auctions had no spectrum caps in place (the 2008 US 700MHz auction is one example where almost no restrictions were put in place). These auctions typically produced very concentrated spectrum holdings. For example, in the US, only two operators out of four national operators won significant 700MHz spectrum. In order to avoid such an extreme concentration of spectrum, regulators around the world tend to impose spectrum caps to restrict maximum amount of spectrum any one operator could hold.

If spectrum caps are not too high and genuinely constrain operators' behaviour, they tend to be binding, i.e. some operators win the amount of spectrum up to the cap. For example, in the UK, both Vodafone and Telefonica won 2x10MHz of 800MHz spectrum (equal to their sub-1 GHz cap), while EE won 2x105MHz in total – equal to its total spectrum cap.

Spectrum caps therefore clearly affect auction outcomes. In Ireland, for example, each operator could win no more than 2x20MHz of sub-1GHz spectrum (across both 800MHz and 900MHz spectrum bands). There was also a cap on 900MHz spectrum in time period 1 (up until July 2015) – 2x10MHz. These two caps effectively created a focal point for the bidders: each incumbent operator protected its 900MHz spectrum holdings, but did not try to expand them, as it would have reduced their ability to bid for 800MHz. As a result, Meteor, Telefonica and Vodafone won 2x10MHz of 900MHz and 2x10MHz of 800MHz spectrum each, while Three won the remaining 2x5MHz of 900MHz spectrum (a block which was not in use before the auction). A combination of the spectrum caps and relative scarcity of 800MHz spectrum (compared with 900MHz) contributed to higher relative prices of the 800MHz band in Ireland.

In Austria, there were three caps: the sub-1GHz spectrum cap was set at 2x35MHz; the 800MHz cap – at 2x20MHz and the 900MHz cap – at 2x30 MHz. Given that the band-specific caps exceeded the sub-1GHz cap, it was less straightforward for the bidders to converge to any pre-determined outcome (e.g. the incumbent protects its legacy spectrum holdings and bids up to the sub-1GHz cap on 800MHz). As a result of the caps' being high and non-additive, all operators gained or lost some of the legacy spectrum (900MHz or1800 MHz). Overall, the result in Austria – higher relative price of 900MHz – was arguably driven by the auction design (high non-additive spectrum caps).

These two examples demonstrate that auction design matters: the outcomes can be very different in countries with broadly similar characteristics, but different auction design (e.g. different spectrum caps).

The two factors discussed above caused the relative price of 900MHz and 800MHz spectrum to diverge in the short run. This, however, does not mean that 900MHz spectrum is less valuable than 800MHz spectrum in the long run. It has very similar propagation characteristics and it is expected to be a very close substitute to 800MHz in near future. Three made previous submissions and continues to maintain that 900MHz and 800MHz spectrum are equally valuable. Ofcom should take technical evidence into account and set the ALF for 900MHz spectrum based on both the benchmarking evidence and technical evidence.

Based on the benchmarking evidence (presented in Section 2), the lump-sum value of 900MHz is £21.3m per MHz. However, based on the technical evidence, 900MHz should be valued at £25.04m per MHz (i.e. equal to the 800MHz value). We propose to take the average between these two values and use £23.17m as the most appropriate lump-sum value of 900MHz spectrum.

4. Three disagrees with Ofcom's cost of debt for converting lump-sum values to ALFs.

Ofcom's revised proposals determine the appropriate discount rate for converting lump-sum values to ALFs Ofcom concludes by:

- using a cost of debt, rather than WACC, for the discount rate to convert the lump-sum values of 900MHz and 1800MHz into ALFs;
- treating lump-sum spectrum as 100% debt financed, rather than equity financed; and
- using the CPI inflation measure, rather than the RPI.

Three strongly agrees with this approach.

The cost of debt discount rate for converting lump-sum values to ALFs should reflect the relevant risks to the Government of the ALF payments, which Three considers the corporate cost of debt does not.

In Three's analysis, the relevant risks to the Government of the ALF payments are near risk-free. Three estimates that the relevant discount rate should be at a premium at most of 0.2% over the risk-free rate, implying a pre-tax real CPI discount rate of 2.7%.

This value is recommended in our expert report by Economic Insight, appended at Annex C.

Three disagrees that MNOs' WACC is a polar case for the relevant discount rate.

In determining the relevant discount rate for converting the lump-sum values of spectrum into ALFs, Ofcom suggests considering two polar cases, namely:

- if the ALF payment were the same as the risk of the future after-tax cash flows associated with the spectrum, then the discount rate may be approximated by the MNOs' WACC, of 5.1%;
- if the ALF payment were completely fixed, regardless of circumstances, then the ALF would be akin to some form of highly secured debt and the correct discount rate would correspond to the interest rate on such an instrument, which Ofcom suggests as 2.6% (4.13-4.15)

Ofcom then suggests that the ALF obligation appears to have a number of features which means that it is close to its suggested debt rate case rather than the WACC case, and that in taking a conservative approach, Ofcom therefore proposes to use the debt rate case discount rate, of 2.6% (real, after-tax) (4.17, 4.25).

Three nevertheless considers that neither of Ofcom's suggested "polar cases" can correctly be described as polar cases for setting the relevant discount rate.

First, Three disagrees that if the ALF payment were the same as the risk of the future after-tax cash flows associated with the spectrum, then the discount rate may be approximated by the MNOs' WACC. This is because MNOs' WACC reflects many additional business risks unrelated to and on top of the value of spectrum.

In particular, the business risks associated with spectrum, especially incremental higher frequency spectrum such as 1800MHz, are much narrower than MNOs' overall business risks reflected in the WACC. This is because the market value of 1800MHz, at the margin, is determined by the costs of technological substitutes for increasing network capacity, such as adding additional cell sites or cell-splitting.

In comparison, overall business risks, as reflected in MNOs' WACC, include a much wider range of external factors, chiefly consumer demand and the intensity of competition.

Second, even if ALFs were revised annually to reflect full market value, they would still not reflect the same risk as the relevant spectrum cash flows. This is because market value reflects the present value of expected long-term forward-looking cash flows, i.e. a weighted-average of expected future cash flows, hence, should always be less variable than year-on-year annual cash flows.

Third, Three's (and we believe the industry's) reasonable expectation of Ofcom revising the current proposed ALFs within 20 years of them coming into force is nevertheless low, as:

– Ofcom has not committed to in what circumstances it will review future ALFs, except not for at least five years and only then if there were grounds to believe that a material misalignment had arisen between the level of these fees and the value of the spectrum (6.28);
– there is unlikely to be any significant new international European benchmark information on 900MHz or 1800MHz spectrum values within the next 20 years, given the recent auctions of these bands across Europe and associated licence terms of around 20 years or indefinite terms; and
– based on the experience of the current fees for 900MHz and 1800MHz (Administered Incentive Pricing, AIP), Ofcom has not

revised these since they were first introduced in 1998 (even for inflation).

It is also a legitimate fear among licensees that Ofcom is more likely to revise ALFs if there is evidence that ALFs are too low than too high, given Ofcom's discretion as to when it might consider to review ALFs and Government's interest in higher rather than lower fees. This creates an asymmetric risk in favour of the Government and against licensees, through the underlying regulatory option to revise fees upwards but not downwards.

Indeed, Three considers that the most likely situation in which ALFs would be revised downwards is in the event of a licensee handing back spectrum to the Government – owing to the ALF being above its value to the licensee (or to any other licensee who might be interested to acquire it).

Moreover, if the future revision of ALFs represented a sharing of risk between MNOs and the Government, then this should have the effect of lowering MNOs' WACC. There is nevertheless no analysis of this in Ofcom's recent reviews of MNOs' WACC[20] nor apparent expectation of this among independent industry analysts or commentators.

Hence, Three considers that the probability that the Government shares any meaningful risk of the overall licensee's cash flows is remote. Therefore is it both inaccurate and misleading for Ofcom to define the MNOs' WACC as (the upper-bound) polar case for the relevant discount rate.

Three disagrees that the corporate cost of debt is also a polar case for the relevant discount rate.

Ofcom proposes that a debt rate of 2.6% (pre-tax real CPI), reflecting MNOs' unsecured corporate bond rates, is a lower bound polar case for the relevant discount rate. Three disagrees with this.

First, Ofcom notes that, if the ALF payment were completely fixed, regardless of circumstances, and MNOs had no option but to pay this level of fee, the ALF would effectively be akin to a form of highly secured debt and the correct discount rate would be the corresponding interest rate for such a debt instrument. (4.13)

[20] Such as in Ofcom's current Mobile call termination market review.

This itself implies that the lower bound polar case should reflect the risk associated with the ALF payments, which in the situation where the MNOs had no option but to pay this level of fee, would by definition be risk-free to the Government. This suggests that the lower bound polar case should be the risk-free rate – and/or should reflect the extent that relevant risks to the Government of the ALF payments are not risk-free.

Second, Three considers that the risk to the Government of the ALF payments is effectively risk-free, as:

1 the underlying asset (the spectrum licence) is not merely highly secured, but remains in the Government's ultimate ownership in all circumstances and its use can be revoked by Ofcom for non-payment, for other non-performance of other licence conditions or for "spectrum management" reasons at any time at Ofcom or Government's decision;

2 spectrum is a non-depletable asset, meaning that Government will always be able to recover 100% of its market value in the event of being revoked or handed back;

3 provided that ALF is set at (conservative) market value, as required by the Government Direction, or less, then the underlying licences should always have a positive market value (net of future ALF payments) to at least one MNO in the market – hence if one licensee is unable or unwilling to continue making the ALF payments, then sale to another MNO should always be available rather than handing back the licence to Ofcom, meaning that there should be no loss of ALF to the Government of a "fallow period", even for a short period[21];

4 the only likelihood that a licence is handed back to Government is if the ALF is significantly above market value (implying a net negative value to the licence, net of ALF payments) – but in this situation, Government will already have been over-compensated and ALFs will be overdue for revising downwards; and

5 in the event that a licensee becomes bankrupt then Government should easily be able to recover any unpaid ALF from the licensee's assets, being the highest ranking creditor (along with any other unpaid taxes), and the licensee's liquidators should easily be able to sell the licence (as above) to raise further funds, again leading to no loss to the Government.

Hence, from the Government's perspective, ALF payments are for all relevant purposes risk free and the risk-free rate should therefore be the relevant discount rate for converting lump-sum values into the ALF rates.

[21] Ofcom's suggestion that the probability of default is likely to be higher than other forms of debt (4.18) is appears spurious. Indeed, Ofcom's first consultation recognised that handing back spectrum would have significant negative implications for MNOs, namely, of ceasing business or dramatically limiting the number of customers that it can serve. As above, an MNO would only rationally hand back spectrum if the ALF were above market value that it or any other MNO were willing to continue paying.

Three therefore considers that the relevant discount rate should be 2.5% in pre-tax real CPI terms. This also reflects Three's view that Ofcom has slightly over-estimated the underlying risk-free rate, as evidenced in Annex C below.

At most Ofcom should allow a small premium on top of the risk-free rate to allow for any small perceived risk of a fallow period and associated loss of ALF income during this period. We estimate at most this should be around 0.2%, based on a:

– maximum expected probability of default per year of [2.5%] (weighted across all the 900MHz and 1800MHz licences);
– an average expected fallow period of 18 months; and
– an expected recovery rate of the value of the spectrum licences of 93%.

We consider that these all extremely conservative assumptions and represent the correct upper bound on the relevant cost of debt for setting the discount rate. This would imply a pre-tax real CPI discount rate of 2.7% and corresponding post-tax real CPI rate of 1.7%.

Please refer to Economic Insight's expert report commissioned by Three on Ofcom's proposed discount rate for setting ALFs, appended at Annex C, for further evidence and analysis in support of Three's position.

Ofcom should not now need to make any tax adjustment for setting ALFs.

Ofcom concludes that, as the ALF is close to being of form of debt instrument, this implies that the ALF payments displace 100% debt capacity and therefore that Ofcom needs to capture the tax deduction of interest payments for such a lump sum payment (4.32). Three agrees with this.

Ofcom then states that the tax deduction for interest rates is embedded in the "after-tax" debt rate, so "it is not necessary to make an additional adjustment to the tax adjustment factor (TAF) to allow for this" (4.32).

Three is puzzled as to this approach and to Ofcom's non-standard concept of an "after-tax" debt rate. This is because interest payments on debt are normally tax deductible (unlike profits to equity holders), in which case the "pre-tax" and "post-tax" cost of debt should be identical. Accordingly, the relevant discount rate should simply be the cost of debt (namely, Ofcom's "pre-tax" cost of debt) and no further tax adjustment should be necessary. This would be a much simpler and more transparent approach than Ofcom's current method.

Indeed, Ofcom's apparent motivation for continuing with a tax adjustment approach is an erroneous assumption that licensees would not revalue their licences to reflect market value, even on a periodic basis. Financial reporting rules nevertheless require companies to conduct revaluation reviews of all assets on a periodic basis and to restate them accordingly.

Hence, Three considers that Ofcom should just use the standard (pre-tax) cost of debt, as proposed above, as the relevant discount rate for converting lump-sum spectrum values to ALFs.

5. Three disagrees that Ofcom has made an adequate impact assessment of its proposals.

At paragraph 1.42 of the Consultation, Ofcom notes that in response to Ofcom's October 2013 consultation a number of stakeholders have called for Ofcom to carry out a full impact assessment in relation to its proposals for revising ALFs. In particular, stakeholders complained that when revising ALFs, Ofcom needed to demonstrate that its approach to setting ALFs (and the specific levels of ALFs proposed):

> *"was necessary to promote efficient use of spectrum, and that the potential benefits in terms of spectrum efficiency would outweigh any potential adverse effects on consumer prices, investment in infrastructure, innovation and competition."*

At paragraphs 1.43 and 1.44, Ofcom disagrees with this view and makes reference to how it has implemented the Government Direction to date, including by way of carrying out certain impact assessment work (aspects of which have been updated in the current Consultation).

Three nevertheless remains of the view that Ofcom has not conducted an adequate impact assessment of its ALF proposals, as required by its statutory duties. In particular, Ofcom has not adequately considered the impact of ALFs on the wider mobile communications market, especially in terms of competition, future investment and consumer retail prices.

Ofcom has obligations to both act in accordance with the Government Directions and discharge their statutory duties when proposing new ALF fees. In Three's view, Ofcom needs to further show how such requirements have been met.

Annex A Power Auctions report.

ESTIMATING LICENCE VALUES BASED ON THE UK 4G AUCTION

PREPARED FOR HUTCHISON 3G UK BY POWER AUCTIONS LLC

24 September 2014

1. Introduction and Summary

Power Auctions welcomes the opportunity to comment, on behalf of Hutchison 3G UK, upon Ofcom's proposals to revise the annual fees payable for 900 MHz and 1800 MHz spectrum.

In this document, we primarily comment in detail on step 1, in which values for 800 MHz and 2.6 GHz licence values are estimated from the UK 4G Auction. Our main points are as follows:

- The overall methodology of the "marginal bidder analysis" proposed for step 1 appears to run afoul of the Revenue Equivalence Theorem, the most established principle in auction theory. The Condoc generally develops the view that the values of 800 MHz and 2.6 GHz licences should be estimated based upon a simulated uniform-price auction: this is the competitive process that yields values based upon the highest losing bid. However, the Condoc develops its value estimates by taking the bids from the actual auction (which had a Vickrey pricing rule) and merely substituting them into the pricing rule of a uniform-price auction. In doing this, the Condoc disregards the accepted principle that a change in the auction format causes bidding behaviour to change. Moreover, the Condoc repeatedly explains why Ofcom believes that prices in the UK 4G Auction understate the full market value of the licences. To a first approximation, auction theory holds that bidding behaviour should change in a way that fully offsets the higher pricing rule of the uniform-price auction and renders the change revenue-neutral. To a second approximation, auction theory allows somewhat different revenues from a uniform-price auction than from a Vickrey auction, to the extent that the equilibrium allocation of licences would be different. However, in the only known class of environments in which a ranking of revenues has been successfully made in the literature, the revenues from a uniform-price auction are less than the revenues from an auction with Vickrey pricing. In order for the marginal bidder analysis to conform with the Revenue Equivalence Theorem, the estimates of 800 MHz and 2.6 GHz licence values should be bounded by actual UK 4G Auction revenues.

- Regardless of whether Ofcom accepts the implications of the Revenue Equivalence Theorem, the Condoc appears to accept the principle that adjustments are potentially needed when using the auction results as a basis for valuing the ALF bands. The most important factor considered in the Condoc is the spectrum reservation—in the Condoc's view, full market value is supposed to be the highest losing bid for a marginal increment of spectrum in a (competitive) auction, whereas the presence of a spectrum reservation makes an auction non-competitive. We conclude that, in the absence of a spectrum reservation, the UK 4G Auction revenue actually would have decreased by 12–15%, rather than increasing. Our conclusion rests primarily on a detailed analysis of the UK bidding data. At the same time, we confirm our qualitative conclusion using: (1) the general principles of auction theory; (2) a replication of the exercise using data from Canada's 700 MHz auction; and (3) a comparison of the outcomes of other recent European spectrum auctions. Thus, a downward adjustment of 12–15% must be made

to the output of the "marginal bidder analysis", reflecting that a "competitive" market without a spectrum reservation would have attained lower prices.

- EE's bids for a third and fourth block are not *bona fide* expressions of value, but attempts to increase opponents' costs. The Condoc bases its marginal bidder analysis for 800 MHz blocks almost entirely on the difference between two bids: EE's bids for packages of (2-A1, 4-C) and (4-A1, 4-C). While Ofcom is directed to "have particular regard to the sums bid for licences in the auction", Ofcom must not take literally bids that cannot be taken literally. We demonstrate, particularly, that EE's bid for (4-A1, 4-C) had virtually no chance of winning and, so, there is no reason to think it is reflective of EE's true value. Note that EE submitted a supplementary bid for (2-A1, 5-C) at a price of £1233.5m. EE's bid for (2-A1, 5-C) fits with the other bidders' final clock bids and therefore forms a feasible allocation for the winner determination problem. Given this bid, EE would be able to view its supplementary bid for (4-A1, 4-C) at a price of £1798m, while large, as completely *out of the money*. Our calculations show that EE possessed sufficient information to know that (2-A1, 5-C) contributed £189.5m more to the winner determination problem than (4-A1, 4-C), an insurmountable disadvantage. This value gap assured that EE was free to overstate its value for (4-A1, 4-C) in order to attempt to increase its opponents' costs. While the (4-A1, 4-C) bid was uncompetitive for the purposes of the actual winner determination problem, it was quite competitive for the counterfactual winner determination problems that are used to set prices for Vodafone and Telefonica. The most likely intent of EE, in submitting the (4-A1, 4-C) bid, was to set prices for both Vodafone and Telefonica, while avoiding any risk of winning the (4-A1, 4-C) package itself. As such, there is no reason to think that the bid reflects EE's intrinsic, incremental value for two additional A1 lots.

- Ofcom's implementation of the marginal bidder approach included many arbitrary and subjective decisions. Our initial impression was that Ofcom's methodology had very much the appearance of computing a table of numbers (Table 2.5 of the Condoc) and then selecting with minimal justification the largest number in the Table. However, upon further inspection, Ofcom appears to have omitted an entire row of table 2.5. The omitted row includes some of EE's supplementary bids with greatest plausibility—the bid for (9-E), which was EE's final clock package and, hence, the only bid that EE was entitled to raise an unlimited amount. Moreover, using this row—in particular, using the difference between EE's bids for the packages of (2-A1, 9-E) and (4-A1, 9-E), while otherwise adopting exactly Ofcom's methodology—produces a "full market value" of £23.68m/MHz for 800 MHz spectrum. The fact that the identical methodology applied to an equally plausible row of Table 2.5 highlights the arbitrary and subjective nature of Ofcom's implementation of the marginal bidder approach. The fact that the equally plausible row was omitted from Table 2.5 raises still greater methodological concerns.

- Relying on our above analysis, we develop our alternative estimates of the "full market value" of 800 MHz and 2.6 GHz licences. We utilise LRP without a revenue constraint and we adjust H3G's bids in the absence of a spectrum reservation based on Scenario 3

of Section 3. We then prorate the prices to a simulated revenue target of £2002m (the auction revenues in the absence of a spectrum reservation), maintaining proportional markups from the reserve prices and maintaining the value relationship between A1 and A2 blocks. Our recommended values estimates are thus:

800 MHz band: £25.04m/MHz; and

2.6 GHz band: £3.57m/MHz.

Note that, while the 800 MHz value estimate is substantially lower than the Condoc's value estimate, it is actually slightly higher than the value obtained from utilising the "missing row" of Table 2.5 while otherwise adopting exactly Ofcom's methodology. Thus, we have substantial confidence that this reduction is justified.

We also make some minor points here (but we do not expand on these minor points in the main body of our report). Our minor points are as follows:

- The Condoc asserts that two other factors besides the spectrum reservation justify "full market values" that exceed the UK 4G Auction revenues. These factors are: "there only being a single losing bidder for the 800 MHz band"; and a "packing issue". We do not understand the reasoning that is being attempted here. The Condoc appears to take the view that the reserve price for A1 blocks was set correctly and the reason why the reserve prices determined the costs of some of the A1 blocks is that both EE and H3G omitted their bids. An alternative explanation is equally supported by the evidence: The reserve price for A1 blocks may have been set too high, and this is the reason why the reserve prices determined the costs of some of the A1 blocks. The high reserve price also explains why Three and EE did not place certain incremental bids—these bids would have been below the reserve prices, and so it was known that they would never win.

- In addition, these two other factors are indecipherable within the context of the simulations of the auction in the absence of a spectrum reservation. In our sensible simulations (Scenarios 2 and 3 of Section 3), EE wins 2 A1 blocks when the spectrum reservation is removed. When EE wins 2 A1 blocks, there is no longer any "packing issue". By the same token, there are two losing bidders, but H3G's value for A1 blocks is less than the reserve price.

- The Condoc's assertion that "LRPs may be below market value on a forward-looking basis due to the overall spectrum cap in the 4G auction" seems misguided. Indeed, Ofcom's attempts to renounce the spectrum caps for purposes of determining the ALF seem utterly wrong. First, the spectrum caps were cumulative, not just in-auction, and included prior holdings. Second, removing the spectrum caps puts one on the slippery slope of basing licence values on their foreclosure value. Economists fully understand that the way to maximise the auction proceeds from spectrum licences is to allow one bidder to purchase all of the spectrum—in that event, the auction prices will reflect monopoly profits. However, economists also understand that this is severely

detrimental to consumer welfare and the performance of the downstream market. As such, auction values were constrained by the spectrum caps that Ofcom correctly placed on bidders. By the same token, full market values of these licences are constrained by exactly these same spectrum caps, as these caps are enforced in order to maintain and advance competition in the downstream market.

In Section 2, we provide the detailed argument why, in order for the marginal bidder analysis to conform with the Revenue Equivalence Theorem, the estimates of 800 MHz and 2.6 GHz licence values should be bounded by actual UK 4G Auction revenues. In Section 3, we substantiate that spectrum reservations typically increase spectrum auction revenues, and we establish that a downward adjustment of 12–15% must be made to the output of the "marginal bidder analysis" reflecting that a "competitive" market without a spectrum reservation would have attained lower prices. In Section 4, we demonstrate that EE's bid for (4-A1, 4-C) had virtually no chance of winning, strongly suggesting that EE's bids for a third and fourth block are not *bona fide* expressions of value, but attempts to increase opponents' costs. In Section 5, we argue that Ofcom's implementation of the marginal bidder approach included many arbitrary and subjective decisions, and provide the "missing row" that was omitted from the Condoc's Table 2.5. In Section 6, we develop our alternative estimates of the "full market value" of 800 MHz and 2.6 GHz licences. Section 7 concludes.

2. All estimates of 800 MHz and 2.6 GHz licence values should be bounded by actual UK 4G Auction revenues

As Power Auctions understands the current Condoc, Ofcom proposes to determine lump-sum values for the liberalised licences in two steps. In step 1, values for 800 MHz and 2.6 GHz licence values would be estimated from the UK 4G Auction. Specifically, the estimation of values in step 1 would be based on "marginal bidder analysis", a counterfactual exercise *as if* the UK 4G Auction had utilised an auction format with uniform pricing for each spectrum band, such as an SMRA auction, a simple clock auction, or a sealed-bid uniform-price auction. Then, in step 2, 900 MHz and 1800 MHz licence values would be imputed from the 800 MHz and 2.6 GHz licence values derived in step 1.

In this section, we will show that the proposed methodology runs afoul of the Revenue Equivalence Theorem, the most established principle in auction theory. The actual UK 4G Auction had a pricing rule similar to that of the Vickrey auction,[1] in which self-interested bidders have incentive to bid their true values. However, the counterfactual exercise considers a uniform-price auction, in which it is understood that bidders optimally shade their bids. In short, Ofcom is taking bids from one auction format and substituting them into another auction format, disregarding that a change in the auction format changes bidding behaviour.

To a first approximation, auction theory holds that changes to the auction format are completely neutralised by offsetting changes in bids, leading to equal revenues. In particular, when the pricing rule is changed from Vickrey pricing to the higher pricing rule of uniform pricing, bidders respond with lower bids to offset the change. To a second approximation, auction theory allows somewhat different revenues from a uniform-price auction than from a Vickrey auction, to the extent that the equilibrium allocation of licences would be different. As a general proposition, it is ambiguous whether the revenues are lower or higher. However, in the only known class of environments in which a ranking of revenues has been successfully made, it is proven as a theorem that the expected revenues from the uniform-price auction are less than the expected revenues from the Vickrey auction.

Thus, Ofcom errs in proposing 800 MHz and 2.6 GHz values that exceed the UK 4G Auction revenues. Either Ofcom should take Revenue Equivalence literally and propose values that equal the auction revenues, or Ofcom should follow the class of environments in which a ranking has been established and propose values that are less than the auction revenues. In either case, the actual UK 4G Auction revenues must be treated as an upper bound on any estimates of 800 MHz and 2.6 GHz licence values; doing the opposite is counter to all that is known and accepted in auction theory.

[1] More precisely, the auction selected "core" prices that were nearest to the Vickrey prices. In practice, these prices would be expected to be very close or equal to the Vickrey prices and, in fact, the core adjustment was not required in the actual auction.

In this section, we will develop this argument step by step.

2.1 The marginal bidder analysis implies that licence value estimates should simulate the results of a uniform-price auction

Articles 6 (1) and (2) of the Direction[2] set out the following requirements:

(1) After completion of the auction Ofcom must revise the sums prescribed by regulations under section 12 of the Wireless Telegraphy Act for 900 MHz and 1800 MHz licences so that they reflect the full market value of the frequencies in those bands.

(2) In revising the sums prescribed Ofcom must have particular regard to the sums bid for licences in the auction.

Furthermore, in the Condoc, Ofcom introduces its revised approach by stating:

> As in the October 2013 consultation, we interpret full market value for the purpose of ALF to mean the market-clearing price in a well-functioning market, or the marginal opportunity cost of the spectrum. This is also the highest losing bid for the marginal increment of spectrum in a (competitive) auction.[3]

If each of the high bidders is to win licences and if each winner is to pay the amount of the highest losing bid, then the Condoc is interpreting full market value as simulating the outcome of a *uniform-price auction*—as this is precisely the auction format in which the high bidders win licences and each pays the amount of the highest losing bid. Moreover, following the Condoc's exact language, full market value for the purpose of ALF is not the highest losing bid in an impossible auction, but merely the highest losing bid in a well-functioning, uniform-price auction or in a competitive, uniform-price auction.

The uniform-price auction is well studied in the literature, and we will demonstrate in the following sections that the Condoc errs in the conclusion it reaches.

2.2 Bidding behaviour responds to changes in the auction format. Specifically, bids are lower in a uniform-price auction than in a Vickrey auction

One of the earliest observations in the academic literature is that bidding behaviour depends on the rules of the auction. For example, in the second-price auction for a single item, bidders bid their true values. Change the format to the first-price auction and, instead, bidders shade their bids. More particularly, when there are n bidders whose values, v, are independently drawn from the uniform distribution on [0,1], the equilibrium bid function in the second-price auction is $b(v) = v$, while in the first-price auction it is $b(v) = \left(\frac{n-1}{n}\right)v$.

[2] The Wireless Telegraphy Act 2006 (Directions to OFCOM) Order 2010 3024 of 20 December 2010.

[3] Condoc, at paragraph 2.9.

This reasoning extends directly to a comparison between the Vickrey auction and the uniform-price auction. In the Vickrey auction for multiple items, winners are determined by calculating the allocation of items that maximises value in relation to the bidders' expressed bids, while the price paid by a winner is based on the opportunity cost of allocating the items to him as opposed to his competitors. Since the price paid is independent of the bidder's own bids, incentives for truthful bidding are created, and it is a weakly dominant strategy for a bidder to bid its true value.[4] By contrast, in the uniform-price auction, a bidder's bid for a second unit has the possibility of setting the price paid for the bidder's first unit won, etc., so incentives for "demand reduction" are created. As a result, bids for a first unit are set equal to value, but bids for second and subsequent units are shaded relative to the bidder's true value. As a general proposition on equilibria, bids are weakly lower in the uniform-price auction than in the Vickrey auction, and bids for a second or subsequent unit are strictly lower.[5]

2.3 When making policy relating to auctions, a regulator is obliged to respect the Revenue Equivalence Theorem

The actual UK 4G Auction was a Combinatorial Clock Auction (CCA), which has a pricing rule similar to that of the Vickrey auction. Therefore, to a good approximation, self-interested bidders have the incentive to bid their true values.[6] However, as seen above, full market value for the purpose of ALF is the highest losing bid in a uniform-price auction, in which it is understood that bidders optimally shade their bids (i.e. bid less than their values).

In its implementation of the marginal bidder analysis, Ofcom is taking the bids from one auction format (the CCA) and merely substituting them into another auction format (the uniform-price auction). In doing this, the Condoc disregards the principle that a change in the auction format changes bidding behaviour. The Direction can be interpreted to instruct Ofcom to set the ALF by simulating the highest losing bid in a uniform-price auction. However, the Direction cannot be interpreted to require or permit Ofcom to violate the Revenue Equivalence Theorem by taking bids from a CCA and assuming that they will not change in a uniform-price auction. Assuming no change in behaviour is no better than assuming that the speed of light can be exceeded—or that a perpetual motion machine can be built. When making policy relating to auctions, a regulator is obliged to respect the Revenue Equivalence Theorem.

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[4] Vickrey (1961).

[5] Ausubel, L. M., P. Cramton, M. Pycia, M. Rostek and M. Weretka (2014), "Demand Reduction and Inefficiency in Multi-Unit Auctions," *Review of Economic Studies*, forthcoming, at Theorem 1, http://restud.oxfordjournals.org/content/early/2014/07/27/restud.rdu023.full.pdf?keytype=ref&ijkey=jGg1ddzGeMl0NpK.

[6] However, as we will see in Section 5 below, incentives may deviate from truthful bidding in the supplementary round of a CCA, for bids that have zero or near zero probability of winning. In that event, the bidder may overbid, in order to drive up its competitors' prices; or it may not submit the bid at all, out of indifference.

2.4 To a first approximation, the auction literature holds that revenues in the counterfactual exercise should equal the actual auction revenues

The Revenue Equivalence Theorem, the most established principle in auction theory, can be stated as follows:

> REVENUE EQUIVALENCE THEOREM: Assume that the random variables representing the bidders' valuations satisfy independence, and assume that bidders are risk neutral. Consider any two auction formats satisfying each of the following two properties:
>
> (i) Each auction format assigns the same item(s) to the same bidders, for every realization of the random variables; and
>
> (ii) Each auction format gives the same expected payoff to the lowest valuation type, $\underline{v}_i$, of each bidder *i*.
>
> Then each bidder earns the same expected payoff from each of the two auction formats, and consequently the seller earns the same expected revenues from each of the two auction formats.[7]

Applied to the case of a single-item auction with symmetric bidders, the Revenue Equivalence Theorem holds that any symmetric and increasing equilibrium of any standard auction (i.e. an auction procedure in which bidders submit bids and the highest bidder wins) such that the expected payment of a bidder with value zero is zero, yields the same expected revenue to the seller. For example, equilibrium bidding behaviour changes from a second-price auction to a first-price auction in exactly a way as to keep the seller's expected revenues fixed.

Applied to the case of multiple-item auctions, the Revenue Equivalence Theorem can only hold to a first approximation. Condition (i) above—"each auction format assigns the same item(s) to the same bidders, for every realization of the random variables"—is unlikely to be satisfied literally. In particular, suppose that one compares a Vickrey auction with a uniform-price auction. With multi-unit demands, only the Vickrey auction is generally efficient, while the uniform-price auction is generally inefficient.[8] Moreover, it is understood that no general ranking of the revenues can be obtained—depending on the environment, one or the other format may yield higher expected revenues.[9] Nonetheless, the direction of the behavioral

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[7] This classic result is due to Riley, J. and W. Samuelson (1981), "Optimal Auctions," *American Economic Review*, 71(3): 381–392 and Myerson, R. (1981), "Optimal Auction Design," *Mathematics of Operations Research*, 6(1): 58–73.

[8] Ausubel, L. M., P. Cramton, M. Pycia, M. Rostek and M. Weretka (2014), "Demand Reduction and Inefficiency in Multi-Unit Auctions," *Review of Economic Studies*, forthcoming, at Theorem 1, http://restud.oxfordjournals.org/content/early/2014/07/27/restud.rdu023.full.pdf?keytype=ref&ijkey=jGg1ddzGeMl0NpK.

[9] Ibid.

adjustment is known—bidders will bid systematically less in a uniform-price auction. And both in the stylized models that have been studied theoretically[10] and in the high stakes, multi-item auction formats that have been studied empirically, e.g. uniform-price v. pay-as-bid auctions for US Treasury notes,[11] revenue differences have been difficult to detect. In short, one's presumption in comparing the revenues from different auction formats in high stakes environment should be that revenue equivalence holds to a first approximation: a uniform-price auction will yield the same revenues as an auction with Vickrey pricing.

The Condoc completely misses the mark when it says: "However, in our view the 4G auction revenue understates the market value of the auction bands as a basis for ALF, especially 800 MHz, because of the specific circumstances of the auction."[12] As soon as Ofcom begins declaring that market values should exceed the auction revenue, it enters upon the dangerous terrain (or slippery slope) of violating the Revenue Equivalence Theorem.

2.5 To a second approximation, the auction literature holds that revenues in the counterfactual exercise should be less than the actual auction revenues

As described in the previous Subsection 2.4, revenue equivalence holds to a first approximation for the comparison between the uniform-price auction and the Vickrey auction, but it need not hold exactly. In the current Subsection 2.5, we will review the current state of knowledge in the literature and conclude that, if anything, revenues in the uniform-price auction should be presumed to be less than revenues in the Vickrey auction. As such, in inferring full market value from the simulated outcome of a uniform-price auction, the full market value should be presumed to be less than the actual revenues received in the UK 4G auction.

As reviewed above, the auction literature allows somewhat different expected revenues to arise from a uniform-price auction than from a Vickrey auction, to the extent that the equilibrium allocation of licences would be different. As a general proposition, it is ambiguous whether the revenues are lower or higher. However, in the only known class of environments to date in which a ranking of revenues has been successfully made, it is proven as a theorem that the expected revenues from the uniform-price auction are less than the expected revenues from the Vickrey auction.

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[10] Ibid, see Table 1.

[11] Malvey, P. F., Archibald, C. M. and Flynn, S. T. (1995), "Uniform-Price Auctions: Evaluation of the Treasury Experience", U.S. Department of the Treasury, Washington DC, http://www.treasury.gov/resource-center/fin-mkts/Documents/final.pdf. The authors write: "Our results show that the average spreads of auction yields to WI [when-issued] yields for uniform-price auctions are smaller than those for multiple-price auctions, but the difference is not statistically significant. On this basis, we are unable to conclude that there is a difference in expected revenue."

[12] Condoc, at paragraph 2.17.

This analysis occurs in the version of "Demand Reduction and Inefficiency in Multi-Unit Auctions" which is forthcoming in the *Review of Economic Studies* (2014).[13] The authors confront the large multiplicity of equilibria that are typically present in the uniform-price auction. (Multiplicity of equilibria is a challenge to obtaining revenue comparisons, since one needs to know which equilibrium of the uniform-price auction to compare with the truth-telling equilibrium of the Vickrey auction.) The authors consider a class of economic environments in which bidders, who have multi-unit demands, exhibit linear marginal values. In such environments, the authors are able to characterise a linear equilibrium, demonstrate that is unique within the class of linear equilibria, and establish the three-way revenue comparison between the uniform-price auction and the Vickrey auction (as well as the pay-as-bid auction).

The authors prove:

> THEOREM (EX POST REVENUE RANKING FOR LINEAR EQUILIBRIA): In the unique linear equilibrium, for any realization of v and Q ($v,Q > 0$), the seller's revenue satisfies $R^V > R^U$ (i.e. the ex post revenue of the Vickrey auction is greater than that of the uniform-price auction) whenever equilibria exist.[14]

Moreover, the focus on linear equilibria in this class of environments is entirely fair and non-misleading; it is generally believed that any non-linear equilibria of the uniform-price auction would be "low revenue" equilibria for which the revenue would be still lower than that earned from the linear equilibrium.

By way of contrast, there do not exist any results in the literature establishing the reverse ranking in any class of environments—the only known examples in which the uniform-price auction obtains greater revenues than the Vickrey auction are isolated, curious examples.

We conclude that, to the extent that Ofcom wishes to go beyond the first approximation given by revenue equivalence and to take account that a uniform-price auction would likely change the equilibrium allocation of licences, the only relevant guidance provided by the literature is that a uniform-price auction would generate lower revenues than an auction with Vickrey pricing.

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[13] Ausubel, L. M., P. Cramton, M. Pycia, M. Rostek and M. Weretka (2014), "Demand Reduction and Inefficiency in Multi-Unit Auctions," *Review of Economic Studies*, forthcoming, at Section 5, http://restud.oxfordjournals.org/content/early/2014/07/27/restud.rdu023.full.pdf?keytype=ref&ijkey=jGg1ddzGeMl0NpK.

[14] Ibid. The theorem as stated here is a special case of Theorem 3 and Proposition 8 (inequalities (13) and (14)) of the article.

2.6 Conclusion: the result of a legitimate marginal bidder analysis should yield the same or lower values than implied by UK 4G auction revenues

The conclusions of Section 2 are clear, but contrary to the numbers put forth by the Condoc. The marginal bidder analysis attempts to simulate the outcome of a competitive uniform-price auction, not the outcome of an impossible uniform-price auction. Merely taking the actual bids in the UK 4G Auction and substituting them into a uniform-price auction format runs afoul of the Revenue Equivalence Theorem, making this an impossible auction. For the exercise to be done correctly, it must take account that, as the auction format changes from Vickrey pricing to uniform pricing, bidders will optimally respond by shading their bids. The weight of all understanding in the literature is that a bona fide auction with uniform pricing would yield the same or lower revenues as an auction with Vickrey pricing. As such, the result of a legitimate marginal bidder analysis should yield the same or lower values than implied by actual UK 4G Auction revenues.

3. The spectrum reservation justifies a further reduction in value estimates—not an increase

The Condoc observes that the presence of a spectrum reservation *decreased* the price paid by H3G for 800 MHz spectrum. However, the Condoc fails to notice that the presence of a spectrum reservation also *increased* the prices paid in the auction by the dominant operators. Moreover, under the most plausible economic reasoning, as well as in the empirical analysis of the auction data, the magnitude of the increase was greater than the magnitude of the decrease—i.e. the spectrum reservation most likely increased, not decreased, the auction revenues. Consequently, the spectrum reservation justifies a further reduction in the estimated value of the licences—not the increase that the Condoc assumes.

Or to describe this slightly differently: regardless of whether Ofcom accepts the argument we made in Section 2, Ofcom appears to accept the principle that adjustments are potentially needed when using the auction results as a basis for valuing the ALF bands. In this Section 3, we demonstrate that auction prices were made artificially higher than "full market value" by the presence of the spectrum reservation. Consequently, one adjustment that needs to be made to the resulting value estimates is a downward adjustment to offset the positive revenue effect of the spectrum reservation in the auction.

In Section 3.1, we remind the reader that there is 30 years of literature showing that measures supporting entrants promote competition and are likely to increase revenues. In Section 3.2, we describe counterfactual exercises leading us to conclude that the UK auction revenues likely would have been 12 to 15% lower without the spectrum reservation. As a check on this reasoning, in Section 3.3, we replicate this analysis in the only other public data set comparable to the UK auction. We perform a similar counterfactual exercise using the data from Canada's recent 700 MHz Auction, and we conclude that Canadian auction revenues likely would have been 19 to 34% lower without the spectrum reservation. In Section 3.4, we cite additional evidence suggesting that spectrum reservations have increased revenues in other European spectrum auctions. In Section 3.5, we conclude.

3.1 There is 30 years of literature showing that measures supporting entrants promote competition and are likely to increase revenues

In a classic result of auction theory, Myerson (1981) proves that, when bidders are asymmetric, the revenue-maximizing auction is discriminatory, in the sense that there is a possibility that one bidder wins when another bidder has a higher valuation.[15] McAfee and McMillan (1987) interpret this directly in terms of giving preferential treatment to low-valuation bidders. "Which type of bidder receives preferential treatment? The answer depends upon the relative shapes of the valuation distribution functions F_1 and F_2. However, one special case is useful in aiding

[15] Myerson, Roger B. (1981), "Optimal Auction Design," *Mathematics of Operations Research*, 6:58–73.

understanding. If the distributions of valuations are identical except for their means, then the class of bidders with the lower average valuation are favoured in the optimal auction. … There is a trade-off. By favoring the low-valuation type of bidders, the seller raises the probability of awarding the item to someone other than the bidder who values it the most and receiving a relatively low payment. The benefit from this policy, however, is that the favoritism forces the bidders from the high-valuation class to bid higher than they otherwise would, driving up the price on average."[16]

The same reasoning can be reinterpreted in terms of giving preferences in procurement auctions. McAfee and McMillan (1989) argue that a government minimizes its procurement costs by operating a price-preference policy, not necessarily buying from the lowest bidder. "The procurement preferences can serve, by increasing bidding competition, to lower the expected price paid by the government for the item."[17] They conclude, in an international trade context: "If the aim of the government is to minimize its procurement costs, it should offer preferences to domestic firms when the industry has a comparative disadvantage; but when the domestic industry has a comparative advantage, the foreign bidders should be favored.[18]

McMillan (1994), in advising the US Federal Communications Commission on the design of its earliest spectrum auctions, wrote: "Theory offers an alternative way of aiding the designated bidders. … The government could allow any firm to bid on any license, but give the designated firms a price preference. With a preference of, say, 10 percent, a designated firm would win if its bid was no more than 10 percent less than the highest nondesignated-firm bid. This is a free-lunch policy. It would not only address the public-policy goal of increasing the number of licenses won by the designated firms, but it would also actually increase the government's revenue. Most of the designated bidders, presumably, have a lower willingness to pay for the licenses than the nondesignated firms (otherwise there would be little need for preferences). With level-playing-field bidding, they would therefore impose little competitive pressure on the nondesignated firms, who could get away with bidding relatively low. A price preference for the designated firms stimulates the bidding competition, forcing the nondesignated firms to bid higher. If the government sets the price preference at the right level, its revenue-raising effect (from the higher bids from the nondesignated firms) outweighs its revenue-lowering effect (from the chance that a designated firm win and pays a low price). The net effect of the price preference, therefore, is to increase the government's revenue."[19] Ayres and Cramton (1996)

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[16] R. Preston McAfee and John McMillan (1987), "Auctions and Bidding," *Journal of Economic Literature*, 25(2): 699–738, at p. 715.

[17] R. Preston McAfee and John McMillan (1989), "Government Procurement and International Trade," *Journal of International Economics*, 26: 291–308, at p. 292.

[18] Ibid, p. 304.

[19] McMillan, John (1994), "Selling Spectrum Rights," *Journal of Economic Perspectives*, 8(3): 145–162, at p. 158.

follow up on this reasoning, arguing that in auctions where incumbents have market power, subsidizing designated bidders or reserving spectrum for entrants may create extra competition and induce the unsubsidized incumbents to bid more aggressively, potentially improving auction revenues.[20]

3.2 A recalculation of the UK 4G Auction outcome, without the spectrum reservation, produces lower revenues

In this section, we provide our comparative revenue analysis for the UK 4G Spectrum Auction.

Our Approach

Similar to Ofcom, we start our analysis by removing spectrum floor protection from H3G by assuming that H3G decided to opt-out during the initial opt-in round.

Table 1 recounts the results of the primary stage of the actual UK 4G Auction.

Table 1: The outcome of the UK 4G Spectrum Auction

Bidder	A1	A2	C	E	Price
Vodafone	2		4	5	£790.761m
Telefonica		1			£550m
EE	1		7		£588.876m
H3G	1				£225m
Niche			3	4	£186.476m
Revenue					£2341m

We now consider three exercises which simulate the UK 4G Auction without a spectrum reservation, intending to shed light on the revenue effect of the spectrum reservation. In Scenario 1, we report the simulated auction outcome under the assumption that all bidders, including Hutchison 3G, would have submitted exactly the same bids as in the original auction. However, we consider this assumption to be implausible. Moreover, we note that the Condoc itself acknowledges the implausibility of Scenario 1's assumption: "We certainly expect H3G's bids to have been different, given that its bidding strategy was fundamentally based on spectrum reservation."[21] Therefore, in Scenarios 2 and 3, we assume instead that H3G would

[20] Ayres, Ian, and Peter Cramton. 1996. "Deficit Reduction Through Diversity: How Affirmative Action at the FCC Increased Auction Competition." *Stanford Law Review* 48(4): 761-815.

[21] Condoc, at paragraph 2.24, footnote 24.

have modified its bidding in either of two natural ways reflecting the removal of the spectrum reservation and we report the consequent auction revenues.

Simulation Results

Scenario 1: H3G does not opt in, but H3G's bids are NOT adjusted accordingly

Total Revenue: £2.500 billion (106.8% of the base revenue)

Scenario 1 provides a simulated auction outcome under two additional assumptions:

1. Hutchison 3G did not opt in for the spectrum reservation in the opt-in round.
2. All bidders, including H3G, would not have changed their bids after they had learnt that H3G did not opt in to the spectrum floor.

The simulated auction outcome is summarized in Table 2. Comparing to the actual outcome of the UK 4G spectrum auction, all bidders won the same packages. The lack of spectrum floor protection increased the payment of H3G by £159 million. The result is not surprising as H3G placed extremely competitive bid for its winning package, consisting of A1 lot, offering to pay £565.5 million (or £340.5 million higher than the reserve price).

Table 2: Scenario 1 – H3G does not opt-in for the spectrum floor

Bidder	A1	A2	C	E	Price
Vodafone	2		4	5	£790.761m
Telefonica		1			£550m
EE	1		7		£588.876m
H3G	1				£384m
Niche			3	4	£186.476m
Revenue					£2500m

While the assumption that bidders other than H3G would have bid the same might be believable enough, the Condoc acknowledges the implausibility of assuming that H3G would not have altered its bidding without the spectrum reservation, as noted above. In Scenarios 2 and 3, we will develop the logical conclusion of the explanation put forth by Geoffrey Myers (2013) and accepted by the Condoc. Myers (2013) concluded: "Perhaps the more likely explanation is that it was a bidding strategy by H3G which guaranteed that it would not pay

more than the reserve price for its winning spectrum floor."[22] The National Audit Office concurred: "Our evaluation of Three's bidding strategy suggests that it was designed to ensure that Three never paid more than the reserve price for the spectrum that had been reserved for it or new entrants to the market, and for which it knew early on in the auction that it was the only bidder." [23] Most importantly, the Condoc concluded: "The way that H3G chose to bid guaranteed it would win reserved spectrum at the reserve price (£22.5m/MHz), given the specific auction pricing rule."[24]

If Hutchison was never in danger of paying more that the reserve price for its reserved packages, then its bids for reserved packages were meaningless to the extent that they exceeded the reserve price. Note that the amount by which H3G's bids on reserved packages exceeded the reserve price was £340.5 million. Consequently, the most obvious adjustments to make to H3G's bids, in order to reflect the absence of the spectrum reservation, are: to subtract £340.5 million from each of H3G's bids that could have won under the spectrum reservation; and to delete each of H3G's "parking" bids, which were unlikely to be winning bids.[25] This is Scenario 2.

Scenario 2: H3G does not opt in and H3G's bids are adjusted downward to reflect the absence of the spectrum reservation.

Total Revenue: £2.082 billion (88.9% of the base revenue)

Scenario 2 provides a simulated auction outcome under three additional assumptions:

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[22] Myers, Geoffrey, "The innovative use of spectrum floors in the UK 4G auction to promote competition", Centre for the Analysis of Risk and Regulation, London School of Economics, Discussion Paper 74, November 2013, ISSN 2049-2718, http://www.lse.ac.uk/researchAndExpertise/units/CARR/pdf/DPs/DP74-Geoffrey-Myers.pdf .

[23] National Audit Office (2014), "4G radio spectrum auction: lessons learned", Report by the Comptroller and Auditor General, HC 968, Session 213-14, 12 March 2014, http://www.nao.org.uk/wp-content/uploads/2015/03/4G-radio-spectrum-auction-lessons-learned.pdf, at paragraph 2.21.

[24] Condoc, at paragraph 2.24, footnote 23.

[25] The NAO also characterised the first-round bids (but not the final-round bids) of both EE and H3G as non-serious bids: "During the first stage of bidding, the auction rules allowed bidders to make bids knowing that these were unlikely to be winning bids, helping to disguise their real intentions. Our analysis indicates both EE and Three did this during the first round of bidding (Figure 11), but not during the final round." National Audit Office (2014), "4G radio spectrum auction: lessons learned", Report by the Comptroller and Auditor General, HC 968, Session 213-14, 12 March 2014, http://www.nao.org.uk/wp-content/uploads/2015/03/4G-radio-spectrum-auction-lessons-learned.pdf, at paragraph 2.20. EE's bids that were characterised as unlikely to be winning bids were its bids for four 800 MHz blocks and four 2.6 GHz blocks.

1. H3G did not opt in for the spectrum reservation in the opt-in round.
2. All bidders, excluding H3G, would not have changed their bids after they had learnt that H3G did not opt in to the spectrum floor.
3. H3G bids according to Table 3. Parking bids (bids 1, 2, 3 and 4 in Table 3) from the clock stage are removed as there is no need to engage in parking.[26] All other bids are reduced by £340.5 million such that all bids for reserved spectrum are at the reserve prices.

Table 3: Final Bids of Hutchison 3G in Scenario 2

N	A1	A2	C	D1	D2	E	Original Bid Amount	Adjusted Bid Amount
1	3 - A1		10 - C		1 - D2	5 - E	1693095	removed
2	1 - A1	1 - A2	10 - C		1 - D2	5 - E	1601090	removed
3	2 - A1		10 - C		1 - D2	7 - E	1464424	removed
4		1 - A2	10 - C		1 - D2	7 - E	1299965	removed
5		1 - A2	2 - C				690500	350000
6	1 - A1		2 - C				665500	325000
7	1 - A1					9 - E	625500	285000
8	1 - A1					5 - E	595500	255000

[26] Each of H3G's "parking" bids were bids made in the clock rounds such that the same package was not bid in the supplementary round. According to the NAO's analysis, a bidder's submission of supplementary bids on all of the packages on which it had bid in the clock stage is an indicator of truthful bidding in the clock stage. (By the NAO's reasoning, not submitting a supplementary bid on these packages would be suggestive that these bids were not truthful.) The NAO wrote: "Our analysis shows Vodafone's bids during the clock stage and supplementary stage demonstrated an interest in 2.6 GHz if the price was low enough. It submitted supplementary bids on all the packages on which it had bid in the clock stage indicating it was truthful in the clock stage." National Audit Office (2014), "4G radio spectrum auction: lessons learned", Report by the Comptroller and Auditor General, HC 968, Session 213-14, 12 March 2014, http://www.nao.org.uk/wp-content/uploads/2015/03/4G-radio-spectrum-auction-lessons-learned.pdf, at paragraph 2.11.

9		1 - A2					590500	250000
10	1 - A1					4 - E	587500	247000
11	1 - A1						565500	225000
12			6 - C				500500	160000
13			4 - C			9 - E	460500	120000
14			5 - C				440500	100000
15			4 - C			5 - E	430500	90000
16			4 - C			4 - E	422500	82000
17			4 - C				400500	60000

The simulated auction outcome is summarized in Table 4. With Hutchison bids being uncompetitive, EE wins two A1 lots and six C lots. Relative to the actual outcome, Telefonica additionally wins two C lots (one from Niche and one from EE). Also, Vodafone concedes one of its E lots to Niche. The auction revenue drops to £2.082 billion, which is 11% less than the actual auction revenue.

Table 4: Scenario 2 – H3G bids adjusted downwards

Bidder	A1	A2	C	E	Price
Vodafone	2		4	4	£629.762m
Telefonica		1	2		£597.376m
EE	2		6		£740.377m
H3G					0
Niche			2	5	£114.176m
Revenue					£2082m

In order to opt in for the spectrum reservation, H3G was required to make bids at reserve prices for all three spectrum floor portfolios. It is possible that H3G had no interest in acquiring 800 MHz blocks at the reserve price, and only submitted those bids as the cost of qualifying for the 2.6 GHz spectrum reserve. Alternatively, without the spectrum floor, H3G might have

viewed bidding on 800 MHz spectrum as a fruitless exercise and placed bids only for C and E blocks.[27]

Scenario 3: H3G does not opt in. H3G's bids are adjusted downward to reflect the absence of the spectrum reservation, and H3G's 800 MHz bids are deleted.

Total Revenue: £ 2.002 billion (85.4% of the base revenue)

Scenario 3 provides a simulated auction outcome under three additional assumptions:

1. H3G did not opt in for the spectrum reservation in the opt-in round.
2. All bidders, excluding H3G, would not have changed their bids after they have learnt that Hutchison 3G did not opt-in for the spectrum floor.
3. H3G bids according to Table 5. Bids that include either A1 or A2 blocks are removed, as it is possible that H3G bid for sub-1-GHz spectrum just to qualify for the spectrum reservation of four C blocks. All other bids are reduced by 340.5 million so that the bid for the spectrum reservation (four C blocks) was at the reserve price. This automatically deletes the "parking" bids (bids 1, 2, 3 and 4 in Table 3), as they all included A1 or A2 blocks.

Table 5: Final Bids of Hutchison 3G in Scenario 3

N	A1	A2	C	D1	D2	E	Original Bid Amount	Adjusted Bid Amount
1	3 - A1		10 - C		1 - D2	5 - E	1693095	removed
2	1 - A1	1 - A2	10 - C		1 - D2	5 - E	1601090	removed
3	2 - A1		10 - C		1 - D2	7 - E	1464424	removed
4		1 - A2	10 - C		1 - D2	7 - E	1299965	removed
5		1 - A2	2 - C				690500	removed
6	1 - A1		2 - C				665500	removed
7	1 - A1					9 - E	625500	removed

[27] Declining to bid on 800 MHz blocks would have avoided hundreds of millions in bidding deposits.

8	1 - A1					5 - E	595500	removed
9		1 - A2					590500	removed
10	1 - A1					4 - E	587500	removed
11	1 - A1						565500	removed
12			6 - C				500500	160000
13			4 - C			9 - E	460500	120000
14			5 - C				440500	100000
15			4 - C			5 - E	430500	90000
16			4 - C			4 - E	422500	82000
17			4 - C				400500	60000

The simulated auction outcome is summarized in Table 6. Compared to Scenario 2, the allocation should not change as Hutchison was already losing. However, even less competitive bids by Hutchison 3G leads to another revenue drop of £80m for a total revenue of £2.002 billion, 14.5% less than the actual auction revenue.

Table 6: Scenario 3 – H3G bids adjusted downwards

Bidder	A1	A2	C	E	Price
Vodafone	2		4	4	£609.261m
Telefonica		1	2		£597.376m
EE	2		6		£681.656m
H3G					0
Niche			2	5	£114.176m
Revenue					£2002m

Conclusion

The Condoc's conclusion that the spectrum reservation had a negative impact on auction revenue is based on the assumption that H3G (and other bidders) would not alter their bidding

if the auction had no spectrum reservation. This assumption is most likely false, particularly if the protection provided by the spectrum reservation was a key element of the Hutchison bidding strategy. Replacing the false assumption with the much more reasonable assumption that H3G would fully adjust its bids to reflect the absence of a spectrum reservation, the auction revenue actually decreases by 12–15%, rather than increasing.

3.3 A recalculation of Canada's 700 MHz Auction outcome, without the spectrum reservation, produces lower revenues

In this section, we provide a comparative revenue analysis of the Canadian 700 MHz Spectrum auction held in early 2014. It allocated 97 out of 98 licenses to eight winners and raised $5.270 billion Canadian. There are at least three reasons why the Canadian 700 MHz Auction can be of significant interest in the context of this report:

1. The Canadian 700 MHz Auction followed essentially the same CCA format used in the UK 4G Auction.
2. Industry Canada followed the same desirable policy as Ofcom of making all bids from the auction publicly available.
3. The auction had a competition policy in place that effectively reserved one 2x5 MHz block of sub-1-GHz spectrum for smaller operators.

Auction Setup and Spectrum Reservations

The Canadian auction included both paired and unpaired spectrum in the 700 MHz band across 14 service areas. In each service area, five paired lots (A, B, C, C1 and C2) and two unpaired lots (D and E) were offered. Lots were organized into four categories (A, B/C, C1/C2 and D/E). Three large wireless service providers (Rogers, Bell and TELUS) were limited to acquiring in aggregate at most four paired lots. The spectrum reservation was implemented via standard spectrum caps. The only way for any large provider to win two paired blocks was to acquire the A+B combination. Large providers were not allowed to place bids on the other two-block combinations 2 B/C, B/C+C1/C2 and 2 C1/C2. Such spectrum limits ensured that one paired lot was reserved for the regional bidders. Furthermore, each large provider was protected against losing to the other large providers, since any two were not permitted to win in aggregate more than three paired lots.

Our Approach

In order to simulate the auction outcome under different spectrum reservation policies, we need to alter the auction setup in a way that would allow incumbents to win all five paired blocks. The most straightforward way of achieving this objective is to aggregate all paired blocks A, B, C, C1 and C2 into a single category. Effectively, the alternative setup comprises two categories, P (5 paired lots) and U (2 unpaired lots), in all 14 service areas.

Aggregating all paired lots leads to one data issue. Major bidders consistently expressed value differences between the "lower" band (A, B and C lots) and the "upper" band (C1 and C2 lots). When aggregating all paired lots into one category, we implicitly increase the intrinsic value of lots in the upper band to match the value of lots in the lower band, since a bid for a C1/C2 lot would be interpreted in exactly the same way as a bid for a B/C lot. To put it differently, the simulated auctions implicitly allocate 5 blocks of paired spectrum that all have the technical characteristics of the B/C lots. We adjust the base revenue of the Canadian auction to reflect this change in the underlying quality of the spectrum in Scenario 1 below.

Simulation Results

Scenario 1: Any pair of incumbents is limited to three paired lots (and each bidder is individually limited to two paired lots)

Total Revenue: $4.241 billion (CAD) (base revenue)

In this scenario, we calculate the revenue adjustment that is needed to compensate for the implicit improvement in the quality of C1/C2 paired lots. The winnings in this simulated auction are a perfect match to the actual winnings except for the YT area (Yukon and Northwest Territories & Nunavut—which received much lower bids than the other regions). However, an implicit improvement in quality of upper band reduced revenue by approximately $1 billion. The amount of the revenue drop is fully explained by the corresponding reduction in the opportunity costs of Bell and TELUS (each bidder received a package that is roughly $250 million more valuable than their original packages, due to the replacement of all C1/C2 lots with B/C lots). With the improved packages, the opportunity costs of both Bell and TELUS are reduced, resulting in a revenue drop of $1 billion in the following way: the price of Rogers is reduced by $500 million and the prices of both Bell and TELUS are reduced by $250 million.

Table 7: *Scenario 1— Any pair of incumbents is limited to three paired lots*

Winner	NL	NS	NB	EQC	SQC	EON	NQC	SON	NON	MB	SK	AB	BC	YT	Price
Rogers	PP	PP	PP	PP	PP	PP	P	PP	P	P	P	PP	PP		2803
Bell	PUU	PUU	PUU	P	P	P	PPUU	PUU	PPUU	P	P	P	P	PP	310
TELUS	P	P	P	PUU	PUU	PUU	P	P	P	PPUU	PPUU	PUU	PUU		874
Videotron				P	P	P	P	P				P	P		233
Bragg	P	P	P						P						13.9
MTS										P					3.2
SaskTel											P				2.8
Feenix														P	0.3
[Unsold]														PPUU	

Scenario 2: No spectrum reservation (but bidders are individually limited to two paired lots)

Total Revenue: $3.433 billion (CAD)

In this scenario, we completely remove spectrum reservation, allowing large providers to get all paired blocks. As can be seen from the Table 8, removing the spectrum reservation has an immediate effect on the winning allocation. Large providers win all five paired lots in 11 service areas, leaving one paired block for SaskTel and MTS in Saskatchewan and Manitoba service areas – strong regional bidders. At the same time, both Videotron and Bragg lose all paired lots. The total auction revenues drop by $808 million (a 19% drop in the base revenue).

Table 8: *Scenario 2— No Spectrum Reservation*

Winner	NL	NS	NB	EQC	SQC	EON	NQC	SON	NON	MB	SK	AB	BC	YT	Price
Rogers	PP	PP	PP	PP	PP	PP	P	PP	P	P	P	PP	PP		1274
Bell	PUU	PUU	PUU	P	P	P	PPUU	PPUU	PPUU	P	P	P	P	PPUU	1068
TELUS	PP	PP	PP	PPUU	PPUU	PPUU	P	P	PP	PPUU	PPUU	PPUU	PPU		1084
Videotron															0
Bragg															0
MTS										P					3.2
SaskTel											P				2.8
Feenix														P	0.3
[Unsold]							P							PP	

Scenario 3: No spectrum reservation + reduced bids for Videotron

Total Revenue: $2.743 billion (CAD)

With the spectrum reservation, Videotron was expecting to win paired spectrum in many service areas at the reserve price due to lack of regional competition. Judging from the bids of the other regional bidders, Videotron did not face any competition in five service areas, including the highly valuable Southern Ontario area. At the same time, several regional bidders showed some interest in paired spectrum in the Alberta and British Columbia service areas. Therefore, Videotron would have expected to pay the reserve price in areas without competition and a competitive price in Alberta and British Columbia. Using the final clock prices for C1/C2 category in Alberta and British Columbia, and the reserve price in other areas, the expected payment of Videotron for its final clock package would have been only $257 million.

Videotron was bidding 468 million in the end of the clock stage and further increased its bid to 490 million in the supplementary round. However, Videotron was not in any danger of actually paying this amount, as the rational expectation of the price would have been less than $257

million. It is very likely that Videotron would not bid as high without the knowledge that it would not be paying any more than $257 million.

In this scenario, all bids of Videotron are reduced by $230 million in order to remove the effects of the spectrum reservation. The auction revenues drop by a further $690 million (an additional 15% drop in the base revenue).

Table 9: ***Scenario 3— No spectrum reservation + reduced bids for Videotron***

Winner	NL	NS	NB	EQC	SQC	EON	NQC	SON	NON	MB	SK	AB	BC	YT	Price
Rogers	PP	PP	PP	PP	PP	PP	P	PP	P	P	P	PP	PP		1044
Bell	PUU	PUU	PUU	P	P	P	PPUU	PPUU	PPUU	P	P	P	P	PPUU	838
TELUS	PP	PP	PP	PPUU	PPUU	PPUU	P	P	PP	PPUU	PPUU	PPUU	PPU		854
Videotron															0
Bragg															0
MTS										P					3.2
SaskTel											P				2.8
Feenix														P	0.3
[Unsold]							P							PP	

It is impossible to estimate by how much Videotron would have reduced its bids if it was not protected by the spectrum reservation. Therefore, we expect a reduction in a [0%, 15%] range due to less aggressive bidding by Videotron.

Conclusion

To conclude, this exercise shows that the spectrum reservation in the Canadian auction actually led to a revenue increase of between 19% and 34% of the base price. Taking the actual revenue of $5.270 billion (CAD) in the Canadian 700 MHz auction, the revenue in the auction without spectrum reservation would have likely been reduced to somewhere between $3.478 billion and $4.269 billion.

3.4 Generally, European auctions with sub-1-GHz spectrum reservations raised higher £/MHz-pop than auctions without spectrum reservations

In this subsection 3.4, we compare European spectrum auction prices in countries that had sub-1-GHz spectrum reservations and in countries that did not. Of the countries we looked at, three reserved sub-1-GHz spectrum for a fourth operator in their auctions: Denmark, Ireland and the Netherlands. In Denmark, a separate auction, in which the three largest operators were not permitted to participate, was held for 2x5 MHz of 900 MHz spectrum and 2x10 MHz of 1800

MHz spectrum. In Ireland, spectrum caps limited each operator to 2x20 MHz of sub-1-GHz spectrum. Since 2x65 MHz of sub-1-GHz spectrum was available, this implicitly reserved 2x5 MHz for a fourth operator. The Netherlands explicitly reserved 2x10 MHz of 800 MHz spectrum for a fourth operator—and stunned telecoms analysts by raising £3,000m in its 4G auction (£11,406m, scaling up for the UK population—see Table 10). By creating scarcity of spectrum for the three strongest bidders, the spectrum reservation drove auction prices to more than double the prices in Switzerland, a country with 60% higher GDP per capita. Ireland also had higher prices than Switzerland. Ofcom classifies Ireland as a Tier 1 comparison country.

We constructed our sample of European countries by drawing data from the Condoc's Annexes, and from regulators' auction releases when additional information was needed. The significant differences with the countries considered in the Condoc are the Netherlands and Switzerland, which we consider to be serious omissions from the Condoc's analysis.

Table 10: ***Comparison of European auction overall price levels***

Country	Sub-1-GHz Spectrum Sold (MHz)	Above-1-GHz Spectrum Sold (MHz)	Total payment (£m scaled to UK population)	Price Index[28]
Austria	**140**	**150**	**11,978**	**260%**
Czech Republic	**60**	**138**	**1,507**	**62.8%**
Denmark*	**70**	**240**	**2,126**	**68.2%**
Germany	**90**	**269.2**	**2,740**	**71.2%**
Greece	**70**	**40**	**1,738**	**75.0%**
Ireland*	**130**	**150**	**5,285**	**115%**
Italy	**60**	**180**	**3,323**	**129%**
Netherlands*	**130**	**229.6**	**11,406**	**232%**
Norway	**90.2**	**80**	**2,098**	**67.7%**
Portugal	**70**	**229**	**1,792**	**58.3%**
Slovak Republic	**60**	**230.8**	**1,524**	**55.0%**
Slovenia	**130**	**340**	**3,639**	**67.8%**
Spain	**90**	**180**	**2,134**	**61.1%**
Sweden	**60**	**70**	**1,870**	**87.9%**
Switzerland	**130**	**445**	**5,150**	**89.0%**

*Country with a sub-1-GHz spectrum reservation for a fourth operator (either a set-aside of sub-1-GHz spectrum for a fourth operator or a spectrum cap which had the same effect)

[28] An OLS regression model, with country fixed effects, is estimated. The dependent variable (*y*) is the payment from each bidder in each country scaled to UK population. The independent variables are: the quantity of sub-1-GHz spectrum sold to each bidder in each country; the quantity of above-1-GHz spectrum sold to each bidder in each country; and a dummy variable for each country. The sub-1-GHz coefficient (α) is 7.7 times as large as the above-1-GHz coefficient (β). A price index amongst the fifteen countries is then constructed as follows:

Index = sum of *y* in country / [α(total sub-1-GHz sold) + β(total above-1-GHz sold)]

The index values are then scaled so that the unweighted average of all fifteen countries is 100%.

As can be seen in Table 10, amongst these fifteen countries, the price indices that stand out are: Austria (260%), Netherlands (232%), Italy (129%) and Ireland (115%). Two of these four were countries with sub-1-GHz reservations. Only Austria's prices were higher than the Netherlands—and Austria was unusual in establishing lax spectrum caps that permitted a single bidder to acquire more than half of the sub-1-GHz spectrum. As a group, Denmark, Ireland and the Netherlands averaged price indices of 138.2% versus 90.4% for the 12 countries (including Austria) with no sub-1-GHz spectrum reserved for a fourth winner.

Meanwhile, the Condoc selected seven countries to make comparisons of absolute values of 900 MHz prices. Of the six countries in the Condoc's Table 3.5 that are compared for the absolute value of the auction's 900 MHz prices, where revenue figures include non-reserved spectrum, the two countries with spectrum reservations, Ireland and Romania, were among the top three. In Romania, spectrum caps on the largest three operators left 2x5 MHz of sub-1-GHz spectrum reserved for a fourth operator. Ofcom's table is excerpted below in Table 11.[29]

Table 11: *900 MHz absolute values*

900 MHz	Portugal	Spain	Greece	Ireland*	Romania*	Austria
Absolute value (£m)	24.9	26.4	32.8	39.6	47.3	79.4

*Country with a sub-1-GHz spectrum reservation for a fourth operator (either a set-aside of sub-1-GHz spectrum for a fourth operator or a spectrum cap which had the same effect)

Why do spectrum reservations increase revenues?

Spectrum reservations increase auction revenues in two ways:

- increasing the scarcity of spectrum amongst the strongest bidders; and
- attracting entry that can increase competition further.

By implementing a spectrum reservation, the regulator increases the competition among incumbent operators who are ineligible for the reserved blocks. While competition within the auction can also be increased by loosening the spectrum caps on incumbent operators, this generally has the undesirable consequence of increasing concentration and raising prices in the downstream market. The spectrum reservation increases competition among incumbent operators without leading to increased market concentration.

Entry also drives up prices. It is a meaningful investment and significant managerial distraction for a company to prepare for and participate in a spectrum auction. If an entrant does not have

[29] Ofcom, "Annual licence fees for 900 MHz and 1800 MHz spectrum, Further consultation," 3.62, p. 47. For Denmark, only the price of the reserved spectrum was shown.

good prospects of winning, then the entrant may opt not to participate in the auction. This could result in a different marginal bidder setting the price, thereby hurting revenue. This effect has been known in the literature for many years.[30]

By encouraging entry with a spectrum reservation, the regulator gets the benefit of a stalking horse to help raise prices of other bidders. The additional entry provides an increase in auction competition that raises revenues from incumbent operators. This would be undesirable if it led to weaker downstream competition, but to the contrary, entry by additional firms is generally disruptive in the downstream market and the most potent pro-competition measure possible.

Conclusion

The evidence from European auctions also demonstrates the misleading nature of the Condoc's observation that the spectrum reservation reduced H3G's 800 MHz spectrum price. More than offsetting this effect, a spectrum reservation also increased the prices paid in the auction by the dominant operators. Very high prices in the Netherlands and Ireland—as well as our theoretical analysis and detailed examination of bidding in both the UK and Canada—confirms this point.

3.5 Conclusion: The spectrum reservation justifies a further downward adjustment in value estimates

The Condoc's assertion that the spectrum reservation reduced H3G's 800 MHz spectrum price is, at best, highly incomplete. For more than 30 years, it has been understood that preferences for weak bidders will also increase the prices paid in the auction by strong bidders. As a result, preferential pricing of weak bidders will often increase the overall auction revenues. In this Section 3, we have addressed this issue from several directions:

- Theoretical analysis in the literature suggests the likelihood of this conclusion.
- A careful analysis of the UK bidding data—including making modest assumptions about the likely way that H3G would have modified its bidding in the absence of a spectrum reservation—leads to the conclusion that, in the absence of a spectrum reservation, the UK auction revenue would have actually decreased by 12–15%.
- A careful analysis of Canada's 700 MHz bidding data—including making modest assumptions about the likely way that Videotron would have modified its bidding in the absence of an implicit spectrum reservation—leads to the conclusion that, in the absence of a spectrum reservation, Canada's auction revenue would have actually decreased by 19–34%.

[30] James C. Cox, Sam Dinkin, James T. Swarthout, "Endogenous Entry and Exit in Common Value Auctions,"*Experimental Economics*, October 2001, Volume 4, Issue 2, pp. 163-181.

- The evidence from other European spectrum auctions suggests that spectrum reservations have generally increased the auction revenues. In particular, a 2x5 MHz implicit reservation in Ireland and a 2x10 MHz explicit reservation in the Netherlands appears to explain the unusually high prices experienced in Ireland and the Netherlands.

To conclude, the Condoc makes a sign error in attempting to adjust auction revenues upward, in order for its estimate of full market value to take account of the effect of a spectrum reservation. In order to extrapolate from a (non-competitive) spectrum reservation to a simulated (competitive) auction, the auction revenues need to be adjusted downward.

4. EE's bids for a third and fourth block are not *bona fide* expressions of value, but attempts to increase opponents' costs

Background

The primary part of the combinatorial clock auction consists of two stages: the clock stage and the supplementary stage. In order to force bidders into revealing reliable information about their preferences during the clock rounds, the auctioneer limits supplementary bids in accordance with the clock stage bidding. Such activity rule ensures that bidders need to bid seriously in the clock rounds in order to continue serious bidding during the supplementary round. While the CCA design has been more successful than previous spectrum auction formats in providing incentives for truthful bidding, the CCA has a known limitation. Due to activity rule limits placed on bidders during the supplementary round, many supplementary bids have zero or near zero chances of becoming winning bids. If certain bids are unlikely to become winning bids, the incentives of bidders to submit such bids are ambiguous. On the one hand, bidders can decide not to place these bids at all. On the other hand, these bids might end up setting prices for the other bidders. In the latter case, bidders might decide to overstate their values in order to inflate payments of their competitors. It is a material concern for the UK 4G auction, as the auction utilised a relatively weak activity rule for the supplementary round.

In the next section, we provide evidence that EE's bids for a third and fourth 800 MHz block cannot be viewed as *bona fide* expressions of EE's value. In particular, one of these bids is EE's bid **for four A1 lots and four C lots**—the bid that is used to set the price of A1 blocks by the Condoc's marginal bidder approach. We show that this bid had a near zero probability of winning, so there is no reason to think that it corresponded in any way to EE's true value.

Analysis of the (2-A1, 5-C) bid by EE

The natural source of the allocation uncertainty during the supplementary round are the lots that were in excess supply at the end of the clock stage. When the value of unallocated lots is large, bidders tend to bid more conservatively since any of their bids can end up winning. One of the crudest measures of allocation uncertainty is the value of excess supply lots in the final clock round evaluated at the final clock round prices minus the reserve price[31]. This measure provides a theoretical upper bound for allocation uncertainty in case the auction activity rule includes a provision known as the Final Cap – a revealed preference constraint applied to all supplementary bids that uses the final clock round as a constraining round. The UK 4G auction

[31] In case the auctioneer implemented incremental reserve prices by explicitly adding fictitious bids at the reserve prices for all combinations of items to the winner determination problem.

have not utilised the Final Cap. However, the measure of allocation uncertainty calculated in this way still provides a very useful benchmark since bids tend to satisfy the Final Cap even when the rule is not actually imposed on bidders as a part of the activity rule. The total value of unallocated lots at the end of the clock stage in the UK 4G auction is calculated in Table 12.[32] The total value of unallocated lots is £1306m without adjusting for the reserve bids and £781m after the reserve bids are taken into account.

Table 12: Excess Supply in the UK 4G Spectrum Auction

Lot Category	Supply	Demand In Round 52	Price of Demand	Excess Supply in Round 52	Reserve Price	Price of Excess	Difference
A1	4	2	£846	2	£450m	£846m	£396m
A2	1	1	£846	0	0	0	0
C	14	9	£828	5	£75m	£460m	£385m
E	9	9	£219.6	0		0	0
Total			£2739.6m		£525m	£1306m	£781m

EE placed a bid for the (2-A1, 5-C) package at £1233.5m. The bid for (2-A1, 5-C) from EE fits with the other bidders final clock demands and therefore forms a feasible allocation for the winner determination problem. Using the bid for 9-E, EE's final clock package, at £225m, EE knowingly increased the value of the privately known feasible allocation of the WDP by £1008.5m (only EE knew that it had placed this bid). Accounting for the reserve bids, EE privately reduced the allocation uncertainty of the supplementary round by £484.4m (or 63% of £781m).

Table 13 calculates the residual allocation uncertainty for each bidder using the highest bid that fits with other bidders final clock demands. EE's reduction in private allocation uncertainty of 63% is the highest among all bidders with Vodafone trailing second with a reduction of 33.6%. For all other bidders, reductions are in a 10% range.

Table 13: Residual Uncertainty

Bidder	Final Clock Package	Supplementary Bid	Package Increment	Bid Increment	Private Residual Uncertainty

[32] To ease our exposition of the material, we change Telefonica's bid in Round 52 (last clock round) from bidding on the A2 lot and one D2 lot to bidding on the A2 lot only. Telefonica's supplementary bids reveal that it had absolutely no interest in actually buying one of the D2 lots, and was bidding for one D2 lot during the clock rounds just to push the clock price of C lots.

Vodafone	2-A1, 3-C	2-A1, 8-C	+ 5C	+ £337.8m	518.2m (66.4%)
Telefonica	1-A2	1-A2, 2-C	+ 2C	+ £128m	683m (87.5%)
Niche	2-C	4-C	+ 2C	+ £80m	731m (93.6%)
H3G	4-C	6-C	+ 2C	+ £100m	711m (91%)
EE	9-E	2-A1, 5-C	+2A1, +5C, -9C	+ £1008.5m	296.6m (37%)

By submitting a very competitive (2-A1, 5-C) bid, EE guaranteed that its winning allocation would not be far from the (2-A1, 5-C) in terms of expressed value. In practice, EE was likely to assume that other bidders will put some serious incremental bids for E lots on top of their final clock packages. Indeed, Vodafone placed +£108m bid for additional 5 E lots and Niche placed a +£40m for additional 4 E lots. Using this information, EE's ex-post allocation uncertainty was only £149.5m (an 81% reduction from £781m). Table 14 shows that the value difference between the actual outcome and a counterfactual outcome in which EE is restricted to win (2-A1, 5-C) is just £135.8m.

Table 14: Actual WDP vs. Counterfactual WDP

Bidder	Actual Winning Allocation	Corresponding Values	Counterfactual Winning Allocation	Corresponding Values
Vodafone	2-A1, 4-C, 5-E	£2075m	2-A1, 3-C, 5-E	£1975.3m
Telefonica	1-A2	£1219m	1-A2	£1219m
Niche	3-C, 4-E	£340.4m	2-C, 4-E	£285.4m
H3G	1-A1	£565.5m	4-C	£400.5m
EE	1-A1, 7-C	£1049.5m	2-A1, 5-C	£1233.4m
Total		£5249.5m		£5113.7m

Analysis of this section suggests that EE knowingly placed a (2-A1, 5-C) bid that produced a feasible allocation for the WDP with a value exceeding the value of the final clock allocation by more than £483.5 million. With this bid in place, it was very easy for EE to place bids for larger packages without worrying about winning them.

Analysis of the (4-A1, 4-C) bid by EE

In the final clock round, the aggregate demand for the 800 MHz spectrum was (2-A1, 1-A2). When placing the (4-A1, 4-C) bid, EE knew that this bid would need to displace a bid for two 800 MHz blocks in order to become a winning bid.

The value of the allocation where EE wins (2-A1, 5-C) is:

$$V_{-EE}(2-A1,1-A2,9-C,9-E)+Bid_{EE}(2-A1,5-C).$$

The value of the allocation where EE wins (4-A1, 4-C) is:

$$V_{-EE}(0-A1,1-A2,10-C,9-E)+Bid_{EE}(4-A1,4-C).$$

EE's bid increment for getting (4-A1, 4-C) instead of (2-A1, 5-C) is therefore:

$$Bid_{EE}(4-A1,4-C)-Bid_{EE}(2-A1,5-C)=£564.5m$$

Using the final clock prices as a constraining round for the revealed preference constraint:[33]

$$V_{-EE}(0-A1,1-A2,10-C,9-E)\le V_{-EE}(2-A1,1-A2,9-C,9-E)-£754m$$

This simple calculation suggests that the value gap between the two solutions was likely to be at least £189.5m, making sure that EE would never be awarded the (4-A1, 4-C) package.

We can extend our analysis by looking at the actual bid data to see whether the (4-A1, 4-C) bid by EE had any chance of winning. Table 15 provides a detailed comparison of the three feasible allocations. A known feasible allocation (known to EE only) generates a value of £4965.4m. Making a reasonable assumption that its opponents would place incremental bids for E lots (they did show a very strong interest in E lots until the end of the clock stage), the value of the known allocation can be even higher (£5113.7m for the actual bid set). At the same time, the value of the allocation where EE wins (4-A1, 4-C) is only £4528.5m, or £436.9m (£4965.4m - £4528.5m) less than the value of the known allocation or £585.2m (£5113.7m - £4528.5m) less than the value of the known allocation with E lots. This is consistent with our previous finding that the value gap between two allocations would be at least £189.5m.

Table 15: Comparison of relevant feasible allocations

Bidder	Known Allocation	Corresponding Values	Known Allocation + E lots	Corresponding Values	Counterfactual Winning Allocation	Corresponding Values

[33] Note that this approximation of the minimum value difference appears to be quite robust. Even though the UK 4G auction did not ultimately impose the Final Cap constraints, the Relative Cap constraints are equivalent to the Final Cap constraints for small packages. The major component of the value gap is the loss of two A1 lots. The Relative Cap constraints utilized in UK would made sure that the value decrease from dropping two 800 MHz lots is at least £846m.

Vodafone	2-A1, 3-C	£1867m	2-A1, 3-C, 5-E	£1975.3m	1-A2, 4-C, 4-E	£2042m
Telefonica	1-A2	£1219m	1-A2	£1219m		0
Niche	2-C	£245.4m	2-C, 4-E	£285.4m	2-C, 5-E	£287.9m
H3G	4-C	£400.5m	4-C	£400.5m	4-C	£400.5m
EE	2-A1, 5-C	£1233.4m	2-A1, 5-C	£1233.4m	4-A1, 4-C	£1798m
Total		£4965.4m		£5113.7m		£4528.5m

The analysis of this section conclusively shows that EE's bid for (2-A1, 5-C) made it extremely unlikely that its bids for four 800 MHz blocks (including EE's highest bid for (4-A1, 4-C)) were competitive enough for the purposes of the winner determination problem, and therefore had no chance of winning.

While the (4-A1, 4-C) bid was uncompetitive for the purposes of the actual winner determination problem, it was quite competitive for the counterfactual winner determination problems that are used to set prices for Vodafone and Telefonica. Table 16 provides the price sensitivity analysis for the (4-A1, 4-C) bid. It turns out that a modest increase of £20.5m (a 1.1% increase) makes (4-A1, 4-C) a price-setting bid for Vodafone. A larger increase of £52m (a 2.9% increase) makes this bid a price-setting bid for Telefonica as well. While the (4-A1, 4-C) bid did not actually set prices for Vodafone and Telefonica, it came extremely close to setting prices for both of these competitors.

Table 16: Price Sensitivity Analysis for (4-A1, 4-C) bid of EE

Bidder	Original Bids		(4-A1,4-C) + £20.5m		(4-A1,4-C) + £52m	
	EE's Price Bundle	EE's Contribution	EE's Price Bundle	EE's Contribution	EE's Price Bundle	EE's Contribution
Vodafone	(2-A1, 6-C)	£310.5m	(4-A1, 4-C)	£769m	(4-A1, 4-C)	£800.5m
Telefonica	(2-A1, 6-C)	£310.5m	(2-A1, 6-C)	£310.5m	(4-A1, 4-C)	£800.5m

The most likely intent of EE, in submitting the (4-A1, 4-C) bid, was to set prices for both Vodafone and Telefonica, while avoiding any risk of winning the (4-A1, 4-C) package. As such, there is no reason to think that the bid reflects EE's intrinsic, incremental value for two additional A1 lots. However, the Condoc's implementation of the marginal bidder approach uses the difference between EE's bids for (4-A1, 4-C) and (2-A1, 4-C) to estimate the value of two 800 MHz lots. If EE knowingly overstated its incremental value in an attempt to increase its opponents' prices, the marginal bidder approach (or any approach based on EE's bid for (4-A1, 4-C) would overestimate the value of 800 MHz spectrum.

For comparison purposes, we perform a similar price sensitivity analysis for the (4-A1, 9-E) bid of EE in Table 17. In Section 5, we argued that this bid can be used to carry out the marginal bidder analysis for the 800 MHz band. The (4-A1, 9-E) bid was relatively far from making a material impact on payments of both Vodafone and Telefonica. An increase of at least £185.2m (a 11.8% increase) is required for the (4-A1, 9-E) bid to become a price-setting bid for Telefonica. A still larger increase of £198.6m (a 12.7% increase) is required to make this bid a price-setting bid for Vodafone. Overall, the bid for (4-A1, 9-E) was quite far from setting prices for EE's opponents. Since EE lacked a price-setting motivation in placing this bid, we conclude that this bid is more likely to be a bona fide representation of EE's incremental value for a third and fourth A1 block.

Table 17: Price Sensitivity Analysis for (4-A1, 9-E) bid of EE

Bidder	Original Bids		(4-A1,9-E) + £185.2m		(4-A1,4-C) + £198.6m	
	EE's Price Bundle	EE's Contribution	EE's Price Bundle	EE's Contribution	EE's Price Bundle	EE's Contribution
Vodafone	(2-A1, 6-C)	£310.5m	(2-A1, 6-C)	£310.5m	(4-A1, 9-E)	£712.7m
Telefonica	(2-A1, 6-C)	£310.5m	(4-A1, 9-E)	£699.9m	(4-A1, 9-E)	£712.7m

Analysis of the EE's coverage obligation discount

In order to use bidding data from the UK 4G auction for the purposes of ALF, we need to verify that the bids submitted in the supplementary round appear to be truthful. The UK 4G auction provides a unique opportunity to evaluate the truthfulness of supplementary bids. Due to the coverage obligation condition attached to the A2 lot, we can compare bids for packages that have identical amounts of spectrum but differ in terms of their coverage obligation. In general, we expect to see bidders discounting their bids if they include the coverage obligation A2 lot.

Table 18 calculates the coverage obligation discounts implied by EE supplementary bids. EE submitted eleven pairs of bids that can be used to calculate discounts. Out of eleven pairs, seven pairs are for packages with 2x10 MHz of 800 MHz spectrum and four pairs are for packages with 2x20 MHz of 800 MHz spectrum. As can be seen from Table 18, EE's discount appears to be decreasing with the amount of additional 2.6 GHz spectrum. However, this trend breaks down for the (4-A1, 4-C) and (2-A1, 1-A2, 4-C) pair for which the coverage obligation discount is larger than for the (4-A1, 3-C) and (2-A1, 1-A2, 3-C) pair. This observation provides additional evidence that EE's bid for (4-A1, 4-C) inflated above its true value.

Table 18: Implied Coverage Obligation Discount for EE

No Coverage Obligation		Coverage Obligation		Discount
Package	Bid Amount	Package	Bid Amount	
2x10 800 MHz				
2 – A1	£650m	1 – A2	£250m	£400m
2 – A1, 2 – C	£865m	1 – A2, 2 – C	£532m	£333m
2 – A1, 9 – E	£1090m	1 – A2, 9 – E	£762m	£328m
2 – A1, 3 – C	£1035.5m	1 – A2, 3 – C	£728.5m	£307m
2 – A1, 4 – C	£1145.5m	1 – A2, 4 – C	£970.5m	£175m
2 – A1, 5 – C	£1233.5m	1 – A2, 5 – C	£1068.5m	£165m
2 – A1, 6 – C	£1360m	1 – A2, 6 – C	£1264m	£96m
2x20 800 MHz				
4 – A1	£1176.6m	2 – A1, 1 – A2	£776.6m	£400m
4 – A1, 9 – E	£1563.6m	2 – A1, 1 – A2, 9 – E	£1478.6m	£85m
4 – A1, 3 – C	£1568.5m	2 – A1, 1 – A2, 3 – C	£1472.5m	£96m
4 – A1, 4 – C	£1798m	2 – A1, 1 – A2, 4 – C	£1652m	£146m

More importantly, EE exhibited an incredible variation in the amount of its discount among different combinations, ranging from £85m to £400m! In sharp contrast, the other large bidders, Telefonica and Vodafone, were very consistent about their coverage obligation discounts. For example, Telefonica revealed a small premium for the coverage obligation lot. However, the amount of the premium was just £1k, a minimum bidding increment in the auction, showing that Telefonica was simply indifferent. Vodafone consistently discounted the coverage obligation lot by £31m in any combination with at least four C blocks, and required no discount in any combination with two or three C blocks. The fact that the other large bidders were consistent in their discounting of the coverage obligation lot, while EE was wildly inconsistent, provides further evidence that many of EE's bids from the supplementary round were strategic in nature.

5. Ofcom's implementation of the marginal bidder approach included many arbitrary and subjective decisions

Somewhat similar to the linear reference price (LRP) methodology, the marginal bidder approach tries to establish the clearing prices in the uniform price auction by looking at the highest losing bids. In Section 2 of this report, we argue the clearing prices generated by either the marginal bidder or the LRP approaches have to be adjusted downwards to match the actual UK 4G auction revenue in order to be used for the ALF purposes. However, even without prorating clearing prices generated by the marginal bidder approach, Ofcom made a number of subjective decisions and omitted important information while conducting their marginal bidder analysis. We review Ofcom's implementation of the marginal bidder analysis in this section. We start by pointing out very important value information that was omitted from the Ofcom's analysis.

Ofcom's Marginal Bidder Analysis omits Important Value Information

Ofcom calculated EE's demand (IBVs) for different amounts of 800 MHz spectrum in Table 2.5 of the condoc (pp. 25). This table is extremely important part of the condoc since it is used to derive value of 800 MHz spectrum for the ALF purposes. Since EE usually demanded 800 MHz spectrum together with 2.6 GHz spectrum, IBVs are reported for all possible levels of 2.6 GHz demand. However, Ofcom limited its attention to paired 2.6 GHz spectrum (C lots) while ignoring bids for unpaired 2.6 GHz spectrum (E lots).

During the auction, EE showed significant interest in nine E lots. As a matter of fact, EE was bidding on nine E lots in the end of the clock stage. In CCA, final clock packages play a special role and bidders always try to navigate to a comfortable package by the end of the clock stage. For some reason, Ofcom decided to omit IBVs for 800 MHz spectrum in combination with unpaired 2.6 GHz spectrum. Table 19 adds EE's IBVs for the 800 MHz spectrum in combination with 1x45 MHz of 2.6 GHz spectrum (or 9 E lots). It seems appropriate to place the 9xE line between lines with 3 C lots and 4 C lots. The position reflects EE's bids that showed a preference for 9 E lots over 3 C lots, but not over 4 C lots in combinations with 2x5 MHz, 2x10 MHz and 2x20 MHz of 800 MHz spectrum.

Table 19: Expanded version of the Table 2.5 from the condoc

Packages with	First 2x5 MHz (1xA1)	Second 2x5 MHz (2xA1)	Third 2x5 MHz (3xA1)	Fourth 2x5 MHz (4xA1)
No 2.6 GHz (0xC)	£23.0m	£42.0m	£26.33m	
2x5 MHz of 2.6 GHz (1xC)	dnb	dnb	dnb	dnb
2x10 MHz of 2.6 GHz (2xC)	£23.0m	£60.5m	£29.02m	
2x15 MHz of 2.6 GHz (3xC)	£23.0m	£55.59m	£26.65m	
1x45 MHz of 2.6 GHz (9xE)	**£25.49m**	**£61.0m**	**£23.68m**	
2x20 MHz of 2.6 GHz (4xC)	£23.0m	£50.55m	£32.63m	
2x25 MHz of 2.6 GHz (5xC)	£23.0m	£49.12m	dnb	np
2x30 MHz of 2.6 GHz (6xC)	£27.5m	£46.1m	np	np
2x35 MHz of 2.6 GHz (7xC)	£35.3m	np	np	np

The Ofcom's choice of £32.63m/MHZ as an estimate of 800 MHz band value is unjustified

Ofcom produced two value estimates for the 2x10 MHz of 800 MHz spectrum based on EE's bids. The second estimate of £32.63m, an estimate of the EE's value for the second 2x10 MHz of 800 MHz spectrum, is adopted since it excludes contiguity premium that is embedded into the first estimate of £36.8m, an estimate of the EE's value for the first 2x10 MHz of 800 MHz spectrum.

In order to produce the second estimate, Ofcom argued that the most relevant IBV for AFL purposes is the incremental value for the third and the fourth 800 MHz block in combination with 2x35 of 2.6GHz spectrum (the last row in Table 19). However, given that spectrum caps prevented EE from placing these bids, Ofcom proposes to use a similar IBV from the row with 2x20 of 2.6 GHz spectrum. To justify their choice, Ofcom provided two rationales why they think the estimate of £32.63m/MHz understates the relevant market value of the 800 MHz spectrum, and therefore can be used as a conservative estimate. Two rationales are provided below: [34]

[34] See the condoc, paragraph 2.76 on page 27.

1. *For all observed IBVs, EE's average IBV for its third and fourth 2x5 MHz lots is higher than the IBV for its first 2x5 MHz lot (for a given number of lots of 2.6 GHz spectrum), whereas £32.63m/MHz is lower than the observed IBV for the first 2x5 MHz in a package with 7xC of £35.3m.*

2. *2x20 MHz of 2.6 GHz is the largest amount of 2.6 GHz for which EE was permitted to bid alongside of 2x20 MHz of 800 MHz. The IBV is generally higher in packages with more 2.6 GHz spectrum (compare the £32.63m/MHz with the lower figures in the previous rows in Table 2.5 of £26.33m/MHz, £29.02m/MHz and £26.65m/MHz).*

Critique of rationale 1: Ofcom makes a monotonicity argument based on data points rather than providing a fundamental rationale for such monotonicity. It is unclear whether the proposed monotonicity – the value of the first 800 MHz block is lower than the average value of the third and fourth blocks – has any significance. Furthermore, the new IBVs provided Table 19 (IBVs for various amounts of 800 MHz spectrum in combination with 1x45 MHz of 2.6 GHz spectrum) disproves Ofcom's claim. The value of the first 800 MHz block is £25.49m/MHz while the average value of the third and fourth 800 MHz blocks is only £23.68m/MHz.

Critique of rationale 2: Ofcom's statement that the relevant IBVs are generally higher for packages with more 2.6 GHz spectrum is a major "red herring". Note that this statement implicitly suggests that IBVs are to some extent monotonic. Even in the original Table 2.5 of the condoc (that omits information the row with 9-E lots), IBVs for smaller packages are not monotonic in the amount of the 2.6 GHz spectrum. With new data points provided in Table 19, it appears that IBVs are likely to be decreasing (rather than increasing) in the amount of 2.6 GHz spectrum (excluding the IBV of £32.63m/MHz for the package with 2x20 of 2.6 GHz spectrum).

From the business perspective, the assumption of decreasing IBVs for EE makes a lot more sense than an assumption of increasing ones. It is unclear why EE would want to pay more for the second 2x10 MHz of 800 MHz spectrum when its amount of 2.6 GHz spectrum is significantly increased. More precisely, 800 MHz band and 2.6 GHz band are more likely to be substitutes rather than complements for EE. One possible explanation for the increasing IBVs is the foreclosure value – demanding more and more spectrum just in order to prevent other bidders from buying it. However, Ofcom should ignore foreclosure values in its calculations since they are they do not reflect true socially productive values from actually using the spectrum.

In Section 4, we provide extensive analysis of the EE supplementary bidding arguing that the bid for (4-A1, 4-C) package does not reflect EE's value for the spectrum. Given the analysis, it is very likely that IBV of £32.63m/MHz for the package with 2x20 of 2.6 GHz spectrum is just an outlier and should be ignored.

An equally plausible implementation of the marginal bidder analysis for the 800 MHz band

As a logical conclusion to this Section, we describe an equally plausible implementation of the marginal bidder analysis. The IBV expressed by EE for the third and fourth 800 MHz lots in combination with 1x45 MHz of 2.6 GHz spectrum is at least as good an indicator of EE's marginal value, as the same IBV in combination with 2x20 MHz of 2.6 GHz spectrum selected by Ofcom. While similar in spirit, selections provide very different estimate of the clearing price for the 800 MHz spectrum: £32.63m/MHz vs. £23.68m/MHz. Such variation in the price is a perfect demonstration of Ofcom's subjectivity while performing their marginal bidder analysis.

In fact, there are at least two reasons why the IBV for the second 2x10 MHz of 800 MHz spectrum in combination with 1x45 MHz of 2.6 GHz spectrum is more reliable:

1. Section 4 analyses supplementary bids placed by EE's from the incentives perspective. We argue that EE knew with near certainty that its bid for (4-A1, 4-C) won't be selected as part of the winning allocation. At the same time, the (4-A1, 4-C) package is the largest and the most expensive package within EE's eligibility limit of 9600 in the UK 4G auction, making it an ideal candidate for a pricing bid – a bid above the value in order to inflate payments of other winners. The bid for (4-A1, 9-E) is significantly less effective pricing bid due to its fitting properties. Table 17 in Section 4 shows that EE's bid for (4-A1, 9-E) was far away from making any impact on payments of EE's opponents. Thus, EE's incentives for placing the (4-A1, 9-E) bid in the supplementary round is lot less suspicious than those for the (4-A1, 4-C) bid.

2. The CCA attaches a special importance to the final clock packages: it is a unique bid that the bidder can raise by any amount in the supplementary round. Thus, in implementing the marginal bidder analysis for the 800 MHz spectrum, it is natural to take the marginal bidder's base 2.6 GHz combination to be as close as possible to its final clock package in case the actual IBV is unobserved.

The equally plausible marginal bidder analysis returns an estimate of £23.68m/MHz for 800 MHz spectrum without the coverage obligation and £19.43m/MHz for 800 MHz spectrum with the coverage obligation.

6. An alternative estimate of 800 MHz and 2.6 GHz values

Background

We generally agree with the underlying theoretical principles behind using either the linear-reference price (LRP) or marginal bidder approaches for approximating the prices of the 800 MHz and 2.6 GHz lots from the bids submitted in the UK 4G auction. As was previously mentioned in Section 2, both approaches are essentially trying to simulate the linear prices in the UK 4G auction if it had used a uniform price format like SMRA. Therefore, the resulting linear prices that are produced by either approach have to be adjusted downwards to be broadly consistent with the most fundamental auction theory principle – the Revenue Equivalence Theorem.

In the next part, we develop a procedure that prorates prices to meet the revenue target. Due to extreme complexity of the problem, auction theory does not provide any guidance on converting clearing prices from Vickrey auction into the clearing prices of the uniform price auction. With the lack of any theory arguments, we propose to prorate prices using the procedures that are simple and intuitive.

Ofcom previously suggested to add a revenue target constraint directly into the LRP procedure ("revenue-constrained LRP"). The combining of the objectives: (1) finding clearing prices and (2) matching the revenue target has a serious theoretical flaw. The linear clearing prices will create a revenue that is generally higher than the Vickrey revenue. Therefore, restricting clearing prices to generate Vickrey revenue and at the same time approximately clear as many markets as possible pushes the LRPs in some unknown direction. By separating the two objectives, the proration procedure can be carried out in a controlled way that preserves some of the desirable properties of the clearing prices while adjusting their absolute levels to satisfy the revenue constraint.

Another advantage of decoupling the LRP procedure from the price proration is that the proration procedure can be meaningfully applied to the clearing prices generated by the marginal bidder approach. Since the marginal bidder approach considers items on a one-by-one basis, there is no way to simultaneously satisfy the revenue target constraint.

Adjusting linear prices to meet revenue target

In this section, we outline three procedures to prorate clearing prices produced by either LRP procedure or marginal bidder approach to satisfy the revenue target constraint.

Suppose that $p = (p_1, ..., p_L)$ is a price vector and $S = (s_1, ..., s_L)$ is a vector of sold products. If the implied revenue $R = pS$ of allocating products in S at the price p exceeds the revenue target RT, the following proration procedures can be used:

1) Proportional Price Adjustment

   A prorated price vector p' is determined as $p' = \alpha p$ where $\alpha = \frac{RT}{R}$.

Intuitively, the linear price vector p is scaled down proportionately to make sure that the auction revenue matches the target revenue. Under this approach, only absolute prices are adjusted while the relative prices of the original price vector stay intact. In other words, if the A1 lot was estimated to be six times more expensive than the C lot at the clearing, the prorated prices of A1 lots and C lots will exhibit the same relationship.

A disadvantage of this approach is that some of the scaled prices can end up being less than the reserve price of the corresponding lots. The next approach explicitly ensures that the new price vector is bounded from below by the reserve price vector.

2) Proportional Markup Adjustment

Suppose that 1) $r = (r_1, \ldots, r_L)$ is a reserve price vector for products in S, and 2) the revenue target is above the revenue at reserve price ($rS \le RT < R$).

A prorated price vector p' is determined as follows:

$$p' = r + \alpha(p - r) \quad \text{where} \quad \alpha = \frac{RT - rS}{R - rS}.$$

Intuitively, the part of the price that exceeds the reserve price is scaled down proportionately. This approach ensures that all linear prices stay above the reserve prices of their corresponding items. This approach has another benefit over the approach (1). The revenue adjustment for the uniform price auctions is motivated by the phenomenon known as demand reduction – bidders shade their bids relative to their truthful levels. General auction theory tells us that the bidders have higher incentives to engage in demand reduction for products with a relatively low reserve price. Therefore, in a uniform-price auction, we would expect to see relatively lower prices in bands with lower reserve prices and relatively higher prices in bands with higher reserve prices.

Given the final clock prices and final bids, it appears that Ofcom misjudged the relative reserve prices of A1 and A2 lots. Based on relatively lower reserve price for the A2 lot, the proportional markup procedure underestimates the price of A2 lot. The next procedure overcomes the problem of low reserve by linking the price of A2 lot to the price of the A1 lot in a relationship established by the multiple LRP runs. Namely, we restrict the price of A2 lot to be a double of the price of A1 lot minus £31m ($P_{A2} = 2P_{A1} - £31m$).

3) Proportional Markup Adjustment with a constraint: $P_{A2} = 2P_{A1} - £31m$

The easiest way to incorporate the constraint into the proportional markup procedure is to assume that the vector of sold products has 6 A1 lots instead of four A1 lots and one A2 lot, e.g., S = (6-A1,0-A2,14-C,9-E), and the implied revenue $R = pS - £31m$. Then the proportional markup procedure can be used.

Adjusting Bids of Hutchison for Spectrum Floor effects and determining the Revenue Target

Both LRP and marginal bidder approach is based on the assumption that all bidders were bidding truthfully during the CCA auction with a core-selecting pricing rule. In the UK 4G Spectrum Auction, this assumption makes sense for all bidders but one. With the spectrum floor, Hutchison 3G was the only bidder who were guaranteed to win at least one of the minimum spectrum portfolios. Given the protection, Hutchison was expecting to pay less than the competitive price for its winnings, and therefore had incentives to overstate its values. In order to proceed with either LRP or the marginal bidder approaches, Hutchinson bids have to be adjusted to remove the effect of overstatement. Simultaneously with handling Hutchison bids, we need to calculate the fair Vickrey revenue that will be used as a revenue target.

Next, we provide the results of the LRP procedure[35] and suggested proration procedures for the three scenarios described in Section 3.2.

LRP without Revenue Constraint and original Hutchison Bids (based on Scenario 1)

Table 20 reports unconstrained LRPs that result in a total revenue of £2711m with an excursion of £77.5m.[36] The last three columns of the Table 20 calculate prorated LRPs derived using three proration procedures with a revenue target of £2500m.

Table 20: Prorated LRPS – Scenario 1

Lot Category	Lot Size	LRPs	Proportional Price	Proportional Markup	Proportional Markup with A1-A2 Constraint
A1	2x5 MHz	£312m	£287.7m	£298.4m	£296.5m
A2	2x10 MHz	£593m	£546.9m	£539.4m	£562m
C	2x5 MHz	£57m	£52.6m	£50.4m	£49.5m
E	5 MHz	£8 m	£7.4m	£6.8m	£6.6m
Revenue		£2711m	£2500m	£2500m	£2500m

[35] To be clear, we use the LRP procedure that excludes bids for packages with D1 or D2 lots. The description of the LRP procedure was taken from "800 MHz and 2.6 GHz linear reference prices and additional spectrum methodology", report prepared for Ofcom by dotecon, September 2013.

[36] Same LRPs are provided in the Annex 6, Table A6.7 (pp.22) of the Condoc.

Excursion		£77.5m			

LRP without Revenue Constraint and Adjusted Hutchison Bids (based on Scenario 2)

Using bids from Table 3 for Hutchison 3G, Table 21 reports unconstrained LRPs that result in a total revenue of £2443m with an excursion of just £4.2m. The prorated LRPs derived using all three proration procedures with a revenue target of £2082m are also reported.

Table 21: Prorated LRPS – Scenario 2

Lot Category	Lot Size	LRPs	Proportional Price	Proportional Markup	Proportional Markup with A1-A2 Constraint
A1	2x5 MHz	£274m	£233.5m	£257.6m	£254.6m
A2	2x10 MHz	£517m	£440.5m	£427.8m	£478.2m
C	2x5 MHz	£55m	£46.9m	£41.6m	£39.2m
E	5 MHz	£6.67m	£5.7m	£4.5m	£4.1m
Revenue		£2443m	£2082m	£2082m	£2082m
Excursion		£4.167m			

LRP without Revenue Constraint and Adjusted Hutchison Bids (based on Scenario 3)

Using bids from Table 5 for Hutchison 3G, Table 22 reports unconstrained LRPs that result in a total revenue of £2443m with an excursion of just £4.2m. The prorated LRPs derived using all three proration procedures with a revenue target of £2002m are also reported.

Table 22: Prorated LRPS – Scenario 3

Lot Category	Lot Size	LRPs	Proportional Price	Proportional Markup	Proportional Markup with A1-A2 Constraint
A1	2x5 MHz	£274m	£224.6m	£254.1m	£250.4m
A2	2x10 MHz	£517m	£423.8m	£408.3m	£469.8m
C	2x5 MHz	£55m	£45.1m	£38.7m	£35.7m
E	5 MHz	£6.67m	£5.5m	£4.0m	£3.5m
Revenue		£2443m	£2002m	£2002m	£2002m
Excursion		£4.167m			

Conclusion

Calculations in this section show that the Condoc's estimates of £32.63m/MHz and £5.5m/MHz for the values of 800 MHz and 2.6 GHz spectrum are overstated. We reiterate that Ofcom needs to correct its estimates in two ways. First, H3G's bids need to be properly adjusted to reflect the effect of eliminating the spectrum reservation. Second, the values calculated using bids from an auction with Vickrey pricing need to be prorated in order to be broadly consistent with the Revenue Equivalence Theorem.

We have developed alternative estimates of the "full market value" of 800 MHz and 2.6 GHz licences. We utilised LRP without a revenue constraint and we adjusted H3G's bids based on Scenario 3 of Section 3. We then prorated the prices to a simulated revenue target of £2002m (the auction revenues in the absence of a spectrum reservation), maintaining proportional markups from the reserve prices and maintaining the value relationship between A1 and A2 blocks. Our recommended values estimates are:

800 MHz band: £25.04m/MHz; and

2.6 GHz band: £3.57m/MHz.

Note that, while the 800 MHz value estimate is substantially lower than the Condoc's value estimate, it is actually slightly higher than the value obtained from utilising the "missing row" of Table 2.5 while otherwise adopting exactly Ofcom's methodology. Thus, we have substantial confidence that this reduction is justified.

7. Conclusion

In this paper, we have examined the Condoc's estimates of 800 MHz and 2.6 GHz licence values. We have identified serious shortcomings in the Condoc's methodology for estimating values. In addition, we have offered our own alternative estimates, which are substantially lower.

Perhaps the most salient observation has been the degree of reliance that the Condoc places on a single bid—EE's supplementary bid for (4-A1, 4-C). This particular bid almost jumps off the page as an outlier. For example, Table 19 looks at this bid through the lens of incremental value for a third and fourth A1 block—and it stands out as the bid with the single highest such incremental value. Meanwhile, Table 18 looks at this bid through the lens of implied discount for the coverage obligation. The difference between it and the bid for (2-A1, 1-A2, 4-C) is £50m higher than the difference displayed in the previous row of the same table (corresponding to the coverage discount implied by bids for (4-A1, 3-C) v. (2-A1, 1-A2, 3-C)). The only plausible explanation for this bid is that it was EE's attempt to increase Vodafone's and Telefonica's costs—and not a reflection of EE's true incremental value. Nonetheless, the Condoc uses this outlier to determine the fair market value of 800 MHz spectrum.

If bidders expect future auction results to be used in the same way as proposed in the Condoc, incentives for truthful demand revelation in those auctions will be destroyed. Bidders can be expected to shade their bids in future auctions to avoid paying twice for their spectrum—once during the auction and again when the data is used to extract above-market prices for purposes of revising the ALF. This bid shading introduces two sources of inefficiency into spectrum management: poor auction allocations and inaccurate ALF levels. As such, we respectfully request that Ofcom reconsider its methodology.

Annex B Analysys Mason and Aetha Consulting report.

analysys mason

aetha

Final report for Three and EE

Review of Ofcom's determination of UK lump-sum values for 1800MHz and 900MHz spectrum to set annual licence fees

25 September 2014

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1 Executive summary

Analysys Mason and Aetha have been commissioned by Three and EE to provide this joint report in response to Ofcom's second consultation on the 900MHz and 1800MHz annual licence fees (ALFs). This report considers only Ofcom's revised lump-sum value (LSV) proposals – GBP14 million per MHz for 1800MHz spectrum and GBP23 million per MHz for 900MHz spectrum.

In its second consultation, Ofcom acknowledges that it is necessary to adopt a *"conservative approach when interpreting the evidence"* to set the ALFs. However, its revised lump-sum value for 1800MHz spectrum appears to be far from conservative; in fact it is aggressive. In contrast, the 900MHz value appears to reflect Ofcom's approach of being conservative.

The essence of Ofcom's approach is to consider how the prices raised in recent European spectrum auctions for 900MHz and 1800MHz spectrum compare to the prices of 800MHz and 2.6GHz spectrum. It then applies ratios of these benchmarks to UK auction values for 800MHz and 2.6GHz spectrum to produce estimates for the UK market value of 900MHz and 1800MHz spectrum. However, this task is complicated by two effects identified by Ofcom:

- Some European auction results may not have realised market value in that country
- The market value of spectrum in another country may differ from the market value in the UK.

To try to address these sources of uncertainty Ofcom has created a complex framework that attempts to identify all reasons why the benchmarks might not reflect market value in the UK, as well as tiering these reasons in terms of the strength of their impact.

The tiering and weightings Ofcom has chosen lead to an extremely high lump-sum value for 1800MHz spectrum. They produce a weighted average of the 1800MHz benchmarks of GBP16.2 million per MHz, which is in the top 2% of the values produced by all possible combinations of placing the benchmarks into Ofcom's tiers. Almost any other tiering that Ofcom could have chosen would have resulted in a lower weighted average. Consequently, Ofcom needs to be extremely confident that its tiering framework has produced the correct outcome.

However, Ofcom's framework is far from robust. The framework gives the appearance of being an objective categorisation of benchmark data, but contains so many criteria that it effectively becomes a subjective country-by-country assessment, similar to the approach used in Ofcom's first consultation. Further, Ofcom's framework seems to look for reasons to exclude benchmarks. Indeed, the effect of benchmarks being categorised as 'Tier 3' is that they carry no weight in Ofcom's final selection of lump-sum values. The consequence is that Ofcom relies on a very small number of benchmarks when determining the lump-sum values. Ultimately, its selection of lump-sum values for both 900MHz and 1800MHz are heavily influenced by just two benchmarks – Austria and Ireland.

In our opinion, a more robust approach is to acknowledge that no individual benchmark is perfect and instead use a more inclusive approach to incorporate as much evidence as possible in the analysis.

The issues with tiering and weightings of benchmarks may be our primary concern with Ofcom's revised approach, but it is not our only one:

- There are issues with the input data used by Ofcom – notably the use of a proxy for the value of 2.6GHz spectrum in Sweden appears inappropriate given the availability of an auction price in that country. This single decision by Ofcom raises the 1800MHz weighted average value by between 7% and 10% depending on the weightings used.

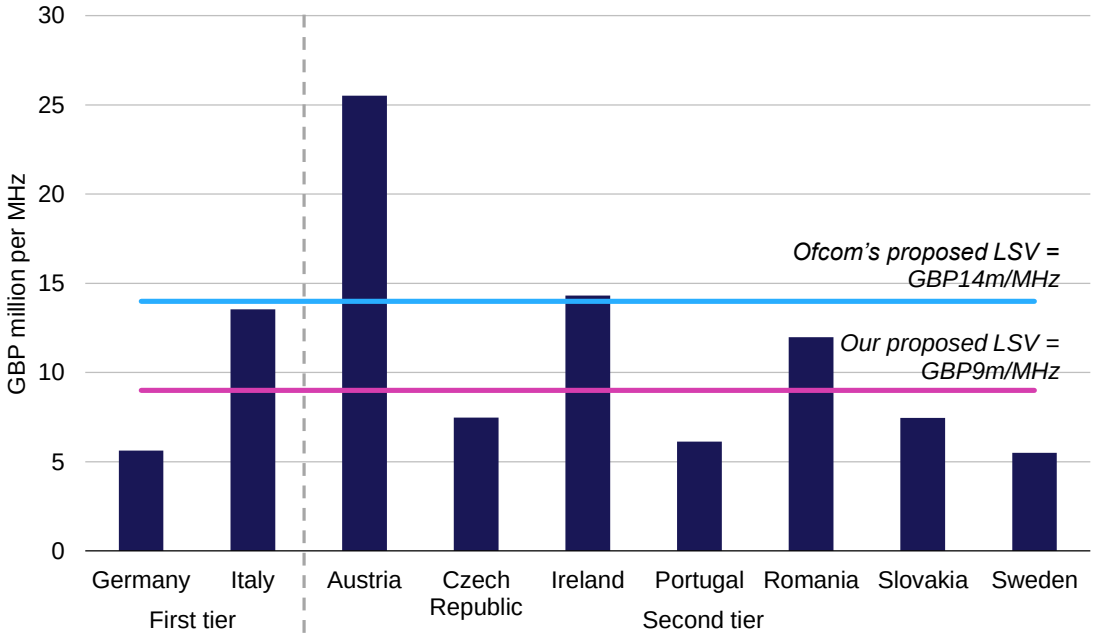
- Ofcom does not conduct any rigorous sensitivity analysis. Consequently, it appears unaware that its tiering and weighting approach produces an extreme outcome for 1800MHz spectrum, and that its decision to include a proxy for the value of 2.6GHz spectrum in Sweden has such a substantial impact on the final choice of the 1800MHz lump-sum value.

- Ofcom's cross-check using benchmark 1800MHz to 900MHz value ratios is flawed, as it excludes all benchmarks other than the two highest (Austria and Ireland). Given that Ofcom's choice of proposed 900MHz and 1800MHz lump-sum values is also heavily influenced by these two countries, it is inevitable that the ratio of Ofcom's proposed 1800MHz and 900MHz values is very close to the equivalent Austrian and Irish benchmarks. In practice, therefore, this supposed cross-check does not check anything. A more robust analysis of these benchmark ratios (i.e. being more inclusive regarding the benchmarks considered) shows that Ofcom's approach to tiering and weighting the various benchmarks is erroneous and so produces an extremely high lump-sum value for 1800MHz compared to 900MHz.

In this report, we have developed an alternative, more robust framework for tiering and weighting the available benchmarks (which results in more benchmarks being considered in the analysis) and we have corrected the identified input data errors. Although we do not necessarily agree with Ofcom's subjective approach to selecting lump-sum values for both 900MHz and 1800MHz spectrum, we have then followed this approach. The results of this revised framework are summarised below.

Figure 1.1 below presents the 1800MHz distance method benchmarks.

Figure 1.1: 1800MHz distance method benchmarks assuming Ofcom's UK values for 800MHz and 2.6GHz [Source: Ofcom, Analysys Mason and Aetha, 2014]



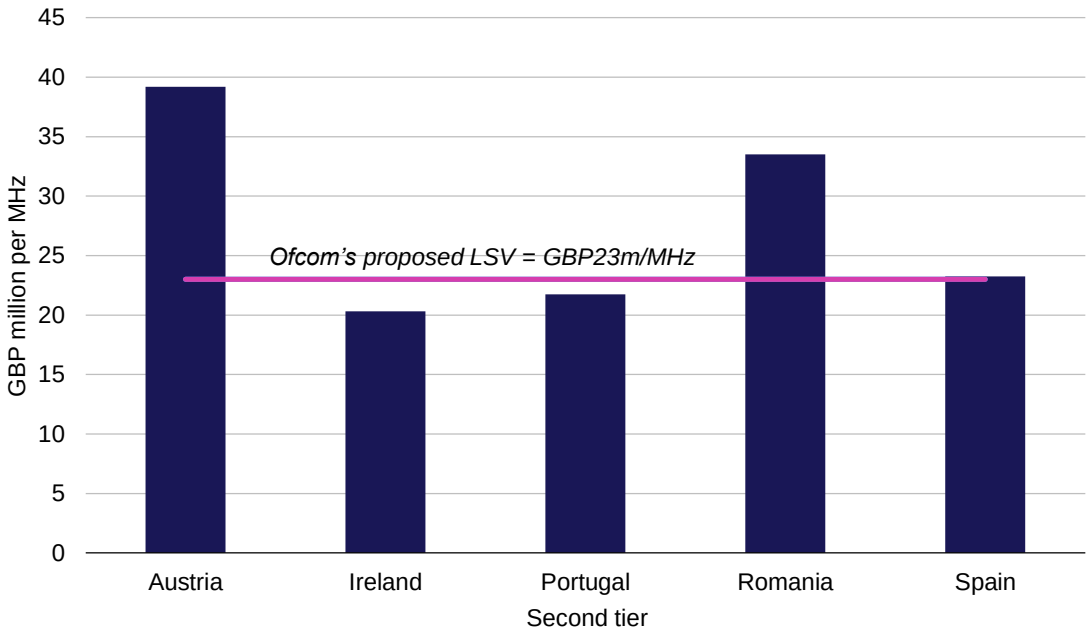
With corrected tiering and input data it becomes clear that Ofcom's proposed lump-sum value of GBP14 million per MHz is much too high. It is not only higher than both of the Tier 1 benchmarks, it is higher than five of the seven Tier 2 benchmarks.

We consider that GBP9 million per MHz is a more appropriate estimate of the UK lump-sum value for 1800MHz spectrum, assuming that Ofcom's proposed estimates for 800MHz and 2.6GHz UK values are adopted.

We understand that both EE and Three disagree with Ofcom's proposed estimates for 800MHz and 2.6GHz UK values and propose alternatives as part of their respective responses to Ofcom's second consultation. We have tested the implications on the lump-sum values of using different 800MHz and 2.6GHz UK values; on this basis we recommend a lower 1800MHz lump-sum value of **GBP8 million per MHz if EE's proposals are followed or GBP6.5 million per MHz if Three's proposals are followed**.

Figure 1.2 below presents the 900MHz benchmarks.

Figure 1.2: 900MHz benchmarks assuming Ofcom's UK values for 800MHz and 2.6GHz [Source: Ofcom, Analysys Mason and Aetha, 2014]



On balance, being mindful of Ofcom's aim of being conservative and its estimated UK values for 800MHz and 2.6GHz spectrum, we consider that **Ofcom's proposed UK lump-sum value of GBP23 million per MHz for 900MHz spectrum is appropriate**. If EE or Three's proposed UK 800MHz and 2.6GHz values were used then we would recommend revising the 900MHz lump-sum value to **GBP21 million per MHz or GBP19 million per MHz** respectively.

In a similar manner to Ofcom, we have conducted two cross-checks on our recommended lump-sum values. Firstly, a comparison to weighted averages of the available benchmarks, which shows our selected lump-sum values to be between 8% and 17% lower than the weighted averages – which is consistent with the 'discounts' considered acceptable by Ofcom in its second consultation. Secondly, we have compared the ratio of our selected 1800MHz and 900MHz lump-sum values to equivalent benchmark ratios from European auctions. Our ratio (34–39%) is very close to the geometric mean of the benchmark ratios, suggesting that our calculations are robust.

2 Introduction

Analysys Mason Ltd (Analysys Mason) and Aetha Consulting Limited (Aetha) have been commissioned by Hutchison 3G UK Limited (Three) and EE Limited (EE) to provide this joint report for the use of each operator in its respective response to Ofcom's second consultation on the 900MHz and 1800MHz annual licence fees (ALFs).

In this report, we set out our views on Ofcom's revised lump-sum value (LSV) proposals, considering both the 900MHz and 1800MHz bands. We consider only Ofcom's benchmarking of European auction prices and the selection of the lump-sum values, rather than the annualisation of the lump-sum values into ALF payments. We also do not consider whether Ofcom's estimates of 800MHz and 2.6GHz values from the UK auction are correct or whether the approach followed is the most appropriate. In this regard, Three and EE have separately provided us with alternative derivations of 800MHz and 2.6GHz value estimates from the UK auction. We assess the impact of these alternative 800MHz and 2.6GHz values on the 900MHz and 1800MHz LSVs as part of our analysis.

In October 2013, Ofcom published its first consultation regarding ALFs, in which it proposed lump-sum values of GBP25 million per MHz for 900MHz spectrum and GBP15 million per MHz for 1800MHz spectrum. We (Analysys Mason and Aetha) developed a response to these lump-sum values on behalf of Three and EE. We proposed the use of the 'distance method'[1] to interpret international benchmarks to produce a lump-sum value for 1800MHz spectrum. We concluded that a value of GBP9.0 million per MHz would be appropriate for this spectrum.[2]

On 1 August 2014, Ofcom published a second consultation (the 'second consultation') on the ALFs, in which it acknowledges that it is necessary to adopt a *"conservative approach when interpreting the evidence"* to set the ALFs. It also adopts the distance method to inform the 1800MHz lump-sum value, but relies upon benchmark ratios of 900MHz to 800MHz values to inform the 900MHz lump-sum value. Ofcom also revises its estimates of the value of 800MHz and 2.6GHz spectrum in the UK. As a result of these changes, Ofcom proposes revised lump-sum values of:

- 900MHz – GBP23 million per MHz (an 8% reduction on its original proposal)
- 1800MHz – GBP14 million per MHz (a 7% reduction on its original proposal).

The remainder of this report is laid out as follows:

- Section 3 highlights the issues with the tiering and weighting approach followed by Ofcom

1 The distance method uses benchmarks from other European countries to determine what proportion of the distance between the UK value of 800MHz and 2.6GHz spectrum the 1800MHz lump-sum value should lie.

2 Our initial report concluded that a value of GBP9.4 million per MHz was appropriate for 1800MHz spectrum, but this was revised in our subsequent addendum dated 13 June 2014 based on new auction information from Slovakia and revised band-specific prices for Austria.

- Section 4 lays out our proposed solutions to the tiering and weighting issues
- Section 5 analyses the issues with input data used by Ofcom
- Section 6 discusses the final selection of the lump-sum values
- Section 7 considers the limitations of Ofcom's 1800MHz/900MHz cross-check
- Section 8 presents the conclusions of our report.

The report also contains three annexes providing supporting information:

- Annex A discusses the use of the distance method for 900MHz
- Annex B summarises the criteria used by Ofcom for categorising benchmarks into tiers
- Annex C provides a discussion supporting our tiering recommendations for each country in the benchmark set.

3 Issues with Ofcom's tiering and weighting approach

3.1 Overview of Ofcom's approach to tiering and weighting

Ofcom categorises the benchmarks derived from each included European country (one benchmark per country for each of 1800MHz and 900MHz) into three tiers. These tiers are then given different weights in the determination of a UK lump-sum value for each band, either implicitly as part of Ofcom's *selection* of the lump-sum values or explicitly in the case of Ofcom's weighted average cross-checks.

In this section, we focus on Ofcom's weighted average *calculation* of UK lump-sum values. This is for two reasons: firstly, it allow us to make a more direct comparison to the values that we have previously calculated; and secondly, it is easier to illustrate the influence of Ofcom's tiering decisions in the calculated values – noting that the influence will be similar when selecting the lump-sum values.

In paragraphs 3.33–3.38 of the second consultation, Ofcom sets out, at a high level, its framework for categorising the benchmarks into tiers, which is based on the extent to which Ofcom considers each benchmark to be "informative of UK market value". Ofcom does not provide the details of how this framework is implemented. However, based on the argumentation provided to justify the categorisation of each country, our understanding is that it decides whether a benchmark is informative of UK market value based on whether it:

a) Represents market value in the country in question; and
b) Is relevant to the value of 1800MHz or 900MHz spectrum in the UK.

Although these are laudable objectives, they cannot be used as *criteria* to sort the benchmarks. Instead, Ofcom cites a range of criteria in the analysis of individual countries, to explain its view of whether each benchmark is firstly representative of the market value in that country and secondly whether it is relevant to the UK. In Figure 3.1 below, we attempt to collate these criteria, though we note that Ofcom does not provide a definitive list. More detail on each of the criteria is provided in Annex B.

Figure 3.1: Ofcom's criteria for categorising benchmarks into tiers [Source: Analysys Mason and Aetha, 2014]

Criteria used to determine whether a benchmark represents market value in the benchmark country	Criteria used to determine whether a benchmark is relevant to the value of 1800MHz and 900MHz in the UK
• Lot sizes too small for LTE • Incumbents prevented from bidding • Unsold lots • Spectrum selling at reserve price • Too few bidders imply market value was not achieved • Spectrum caps prevented competitive bidding • Non-contiguity of blocks created obvious contenders for certain lots	• 2G heavy markets • 1800MHz or 2.6GHz benchmark from before 2011 • Not the whole band was auctioned • Spectrum sold in separate awards

In order to calculate a weighted average for the lump-sum values, Ofcom assigns a weighting to each of the three tiers.[3] The weightings are 2 for Tier 1 benchmarks, 1 for Tier 2 benchmarks, and 0 for Tier 3 benchmarks – effectively excluding Tier 3 from the analysis, which means there is no distinction between how Ofcom treats the Tier 3 benchmarks and how it treats the benchmarks it excludes from the analysis entirely.

The results of Ofcom's weighted average calculations for 1800MHz spectrum, along with an unweighted average calculation, are shown in Figure 3.2 below.

Figure 3.2: The impact of Ofcom's weighting for 1800MHz spectrum [Source: Analysys Mason and Aetha, 2014]

Country	Distance method benchmark (GBP million/MHz)[4]	Equal weighting	Ofcom weighting
Austria	25.5	1	2
Czech Republic	7.5	1	0
Germany	5.6	1	1
Ireland	14.3	1	2
Italy	13.5	1	2
Portugal	6.1	1	0
Romania	12	1	0
Slovakia	7.5	1	0
Sweden	17.5	1	1
Weighted average (GBP million/MHz)		**12.2**	**16.2**

3 We note that this weighted average is only used as a cross-check of Ofcom's selection of a lump-sum value.

4 In this analysis we use the benchmarks as provided by Ofcom. However, as discussed in Section 5, there are issues with the input data used by Ofcom, which once corrected lead to lower benchmarks.

Using a simple unweighted average would result in a UK lump-sum value of GBP12.2 million per MHz for 1800MHz. However, using the weightings proposed by Ofcom results in a significantly higher lump-sum value of GBP16.2 million per MHz. In order to deviate so far from an unweighted average, Ofcom should be very certain of its tiering and weightings to ensure that its approach is sufficiently robust and does not result in a significant overstatement of market value.

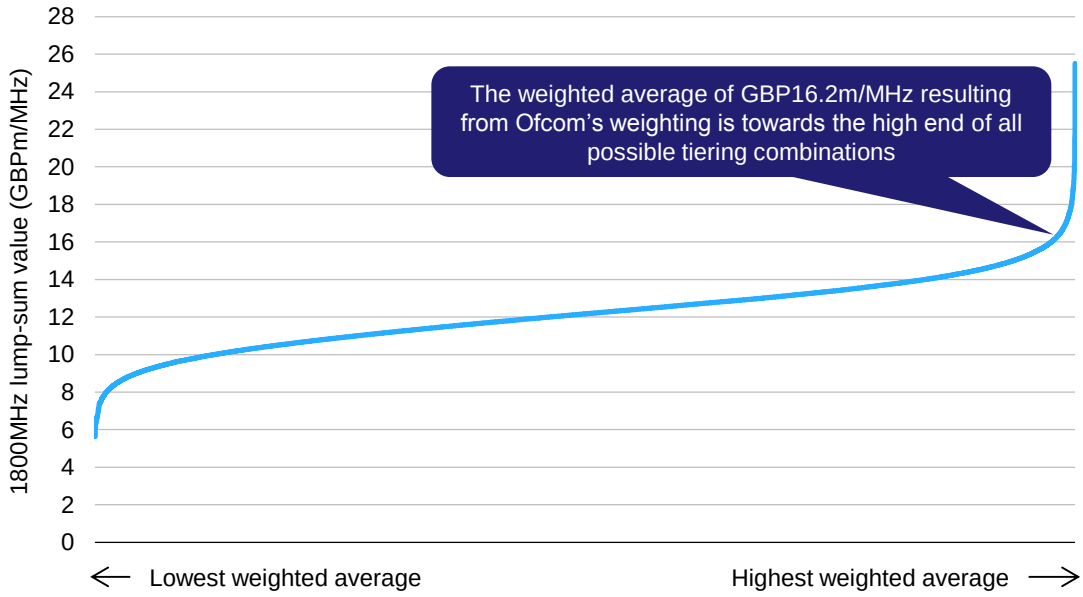
In contrast, for 900MHz, the unweighted average of Ofcom's benchmarks is GBP27.6 million per MHz,[5] compared to an average using Ofcom's proposed weightings of GBP27.3 million per MHz.

3.2 Sensitivity analysis of Ofcom's tiering approach

Ofcom's approach to the determination of lump-sum values is very sensitive to its framework for tiering and weighting the benchmarks.

We illustrate this below by considering all the possible combinations of placing the nine available 1800MHz benchmarks into Ofcom's three tiers. This produces 19 683 possible tiering combinations.[6] Figure 3.3 orders these in terms of the weighted average lump-sum value that they produce from lowest to highest. It shows that Ofcom's lump-sum value of GBP16.2 million per MHz is in the top 2% of all possible results.

Figure 3.3: Distribution of 1800MHz values for all possible tierings [Source: Analysys Mason and Aetha, 2014]



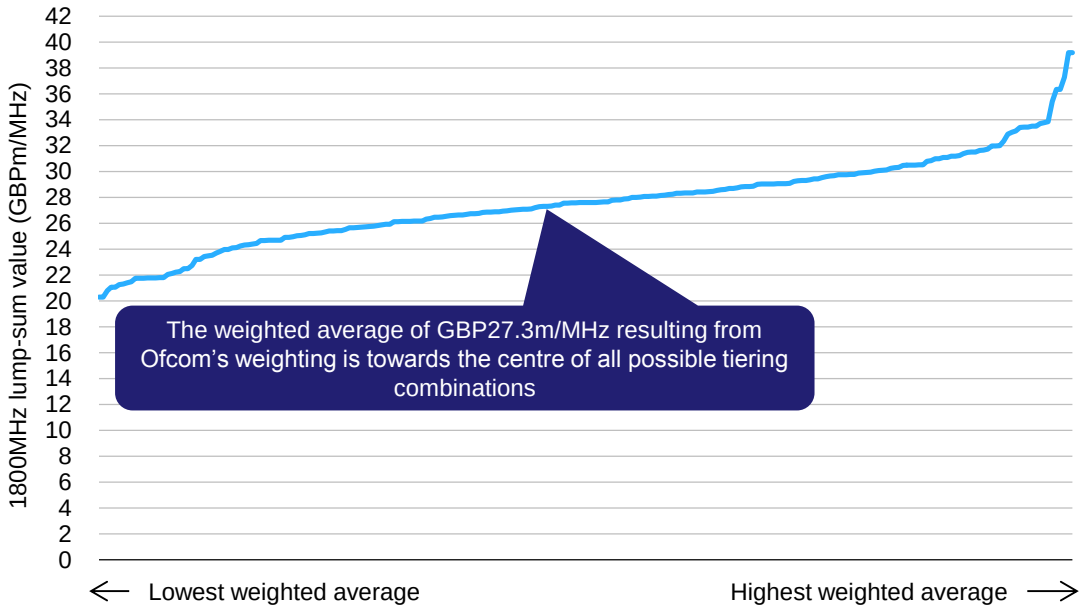
5 This figure excludes Denmark, to which Ofcom assigns a weighting of zero. We agree that Denmark should be excluded since incumbent operators were not able to bid for 900MHz spectrum.

6 Assigning each of the nine benchmark countries a weighting of either 0, 1 or 2 results in 3^9 = 19 683 possible outcomes.

Almost any other tiering that Ofcom could have chosen would have therefore resulted in a lower weighted average. Consequently, Ofcom needs to be extremely confident that its tiering criteria have produced the correct outcome. However, even a simple analysis of Ofcom's criteria shows that its approach is far from robust.

In contrast, Ofcom's 900MHz weighted average of GBP27.3 million per MHz is much closer to the centre of the range of 243 possible results,[7] as illustrated in Figure 3.4 below.

Figure 3.4: Distribution of 900MHz values for all possible tierings [Source: Analysys Mason and Aetha, 2014]



3.3 Ofcom itself acknowledges the uncertainty

Our analysis above illustrates the importance of the classification of the benchmarks into tiers. However, Ofcom itself also acknowledges that there is significant uncertainty in the interpretation of the benchmarks. Figure A8.2 in Annex 8 of the second consultation summarises the benchmarks used and Ofcom's assessment of the risks of each data point either understating or overstating the implied 1800MHz value. We reproduce the majority[8] of this figure in Figure 3.5 below.

7 Each of the five benchmark countries (noting that Denmark is excluded) is assigned a weighting of either 0, 1 or 2.

8 We exclude the final column labelled "Key considerations, indicating tendency to overstate (+) or understate (-) the benchmark" because it does not form part of our discussion here.

Figure 3.5: Reproduction of Figure A8.2 from the second consultation, showing Ofcom's summary of 1800MHz distance method benchmarks [Source: Ofcom ,2014]

Country	Implied 1800MHz value, GBP million/MHz[4]	Quality of evidence	Interpretation of benchmark: risk of under/overstatement		
			Likelihood (extent of risk)	Scale	Direction
Austria	25.5	1st tier	Unknown	Unknown	Unknown
Ireland	14.3	1st tier	Larger	Unknown	Overstate
Italy	13.5	1st tier	Unknown	Unknown	Unknown
Germany	5.6	2nd tier	Larger	Larger	Understate
Sweden	17.5	2nd tier	Unknown	Unknown	Unknown
Czech Republic	7.5	3rd tier	Larger	Unknown	Understate
Portugal	6.1	3rd tier	Unknown	Unknown	Unknown
Romania	12.0	3rd tier	Unknown	Unknown	Unknown
Slovakia	7.5	3rd tier	Unknown	Unknown	Understate

The most striking observation is that out of the nine benchmark countries, Ofcom considers the **likelihood, scale and direction** of such a risk to be unknown for five of them. Notably, this includes two of the three benchmarks that Ofcom assigns to Tier 1 (Austria and Italy). These are the benchmarks that Ofcom considers to be the "highest quality" evidence, and are almost exclusively used to determine the 1800MHz lump-sum value.[9] Ofcom is unsure of the accuracy of these benchmarks to the extent that it is not aware even of how likely any error is, never mind the direction or the scale of any error. In fact the only thing that Ofcom is aware of in interpreting its Tier 1 benchmarks is that the Irish benchmark most likely overstates market value.

3.4 Concerns with Ofcom's approach to tiering and weighting

In the above subsections we have demonstrated that Ofcom's proposed lump-sum values are very sensitive to the tiering of the benchmarks. In this subsection, we highlight a number of concerns regarding Ofcom's tiering framework. Notably:

- it effectively excludes the Tier 3 category, leading to the determination of lump-sum values that rely on very few data points
- it adopts an ad-hoc and subjective approach to choosing its criteria
- some of Ofcom's criteria are highly questionable
- it excludes key criteria from its framework.

We consider each of these concerns in more detail in the sub-sections below.

9 As mentioned previously, Ofcom's selection of a lump-sum value for 1800MHz is almost exclusively informed by its three Tier 1 benchmarks, though arguably the two Tier 2 benchmarks may have played some role if the Tier 1 benchmarks had led to a different conclusion.

3.4.1 Ofcom's effectively excludes Tier 3 benchmarks

Despite theoretically remaining distinct from the category of excluded benchmarks, Tier 3 is effectively excluded both from Ofcom's ("in the round") selection of the lump-sum values and from its weighted average cross-check. Consequently, Ofcom relies on too few data points:

- For 1800MHz, it relies exclusively on just three (Italy, Austria and Ireland) with a cross-check on two others (Germany and Sweden in Tier 2), whereas more could be used
- For 900MHz, it mainly relies on four benchmarks, with two of them given greater weight.

In our view, a weighting of zero should be reserved only for the explicitly excluded benchmarks. We therefore believe that all included data points should be given some weighting – both in Ofcom's selection of the lump-sum values and in its weighted average cross-check.

In Section 4 below, we provide our overall solution to the tiering of benchmarks. This solution removes Tier 3 as a category and places all non-excluded benchmarks in either Tier 1 or Tier 2. Consequently, all of the included benchmarks are given some weighting in the determination of the lump-sum values.

3.4.2 Ofcom adopts an ad-hoc and subjective approach to choosing its criteria

In our first report, we criticised Ofcom for using a subjective, county-by-country approach to tiering the benchmarks. In its second consultation, Ofcom has adopted a framework that uses a series of criteria for categorising the benchmarks into tiers. Although this framework has the appearance of a more objective approach, in practice it differs little from the county-by-country approach used in Ofcom's first consultation. Indeed, it appears that the criteria have not been adopted *ex ante* but instead *ad hoc*, such that benchmarks can be categorised according to a subjective view of the reliability of each benchmark.

This is illustrated by the fact that Ofcom uses a large number of criteria in its tiering framework – at least 11, which we summarised in Figure 3.1 above. This compares to just nine benchmark countries for 1800MHz and just six countries for 900MHz. This makes it possible for individual criteria or combinations of criteria to determine the tier of specific benchmarks.

Indeed, four of Ofcom's criteria appear be chosen with specific benchmark countries in mind:

- **2G heavy markets**: This criterion applies only to Romania and appears to play a crucial role in this country being categorised as Tier 3 (we note that Ofcom also cites there being unsold lots as a reason for Romania's Tier 3 categorisation, but other countries with unsold lots are categorised as Tier 2 – e.g. Portugal and Spain for 900MHz)
- **Lot sizes too small for LTE**: This criterion applies only to Slovakia and contributes to its categorisation as Tier 3
- **Non-contiguity of blocks created obvious contenders for certain lots**: This criterion only applies to Germany and appears to be instrumental in its downgrading to Tier 2 (we note that Ofcom also cites the auction being from before 2011 and only partial auctioning of the

1800MHz band as contributing to Germany's Tier 2 categorisation, but these issues also apply to Austria and Italy, yet both are categorised as Tier 1)

- **Too few bidders imply market value was not achieved**: This appears a strange criterion, which only applies to Sweden. It appears instrumental in its downgrading to Tier 2.

As explained in Section 3.4.3 below, these criteria are in any case highly questionable.

3.4.3 Some of Ofcom's criteria are highly questionable

Even a simple analysis casts doubt on some of the criteria used by Ofcom in its tiering. For example:

- **'2G heavy markets'**: Ofcom argues that where markets are more 2G-focused than the UK, the relative values of spectrum bands are very different from those in the UK. Ofcom only applies this criterion to Romania, which leads to it being downgraded to Tier 3 and thus effectively excluded from the analysis. We do not doubt that Romania has a larger proportion of 2G subscribers than the UK (although Ofcom does not present any evidence for this). However, no two European mobile markets are the same; indeed they differ across a whole range of dimensions. Some markets, such as those in Scandinavia, are more advanced than the UK in terms of 4G adoption. Others, such as Switzerland, have significantly different ARPU levels. Some markets, such as Austria and Portugal, have a different number of operators. Therefore, it appears odd that Ofcom includes this criterion –especially when it leads only to the downgrading of Romania – when there are numerous other factors that make the value of spectrum in other countries different from that in the UK.

- **1800MHz or 2.6GHz benchmark from before 2011**: Ofcom considers that benchmarks in these bands from before 2011 may be less reflective of the relative values in today's market. Ofcom's premise is that the LTE ecosystem for the 1800MHz band was less developed prior to 2011, and as a result the 1800MHz band may have increased in value, potentially at the expense of the 2.6GHz band. There are three problems with the inclusion of this criterion. Firstly, Ofcom implicitly assumes that the 1800MHz band was less valuable prior to the maturing of the 1800MHz LTE ecosystem. However, prior to 2011, the 1800MHz band was widely used across Europe to provide GSM capacity. It is not clear that the value of having GSM capacity prior to 2011 was lower than the value of having LTE today. In reality, the ecosystem in different spectrum bands is constantly evolving, and beyond the short term it is the frequency and propagation characteristics of the spectrum (for harmonised bands) which is most important. Secondly, Ofcom assumes that operators were unable to anticipate this change in use for the band – but this may not have been the case. Thirdly, there are many factors that influence the relative value of spectrum between bands over time – of which this is just one.

- **Fewer bidders imply market value was not achieved**: This appears to be a criterion introduced by Ofcom only in the context of Sweden. Ofcom argues that because there were five bidders in the 800MHz auction but only three bidders in the 1800MHz auction, the latter auction was less competitive and market value was not achieved. The absence of two bidders

from the 1800MHz auction merely indicates that they did not place as high a value on the available spectrum and accordingly their presence would not have increased the resulting auction prices. We note that, irrespective of the number of bidders, both auctions lasted many rounds with bidding rising substantially above the reserve price, and at least one of the participating bidders did not win any spectrum. Therefore, we do not believe there is strong evidence that market value was not achieved in the 1800MHz auction.

- **Lot sizes too small for LTE**: Ofcom uses this criterion to support its categorisation of Slovakia to Tier 3. It argues that where lot sizes are too small to support LTE, the benchmark is less likely to reflect full market value. However, the spectrum in question (900MHz and 1800MHz) is used for GSM, UMTS and LTE both in the UK and across Europe. Given that Ofcom does not provide evidence that one technology is more profitable than others, it does not necessarily follow that offering spectrum in small lot sizes will significantly influence the market value.

- **Not the whole band was auctioned**: Ofcom discusses this criterion in relation to Germany and Italy where, respectively, only 2×25MHz and 2×15MHz of the 1800MHz band were awarded. The extent to which this criterion is relied on as part of Ofcom's tiering decisions is unclear since in Italy a lower proportion of the 1800MHz band was awarded, but it is classified as a Tier 1 benchmark, whilst Germany is classified as Tier 2 on the basis of this and other factors. In any event we do not consider this to be an important factor in establishing whether market value was achieved in a spectrum award.

In summary, the value of spectrum between bands, between countries and over time is influenced by a large range of factors. The above criteria may indeed be five of them. However, there are many more, and we would not expect the above four to be among the strongest of them.

The large number of criteria identified by Ofcom serves to reduce the number of benchmarks considered for the lump-sum values – or at least reduces the number of benchmarks in the tiers that carry the most weight. Ofcom's framework would be more robust if the above five criteria, plus potentially other criteria, were removed such that a wider range of benchmarks were considered in the final determination of the lump-sum values.

3.4.4 Ofcom excludes key criteria from its framework

Despite including 11 criteria in its tiering framework, Ofcom misses 2 criteria that we consider to be particularly important. These are:

- Whether proxies for 2.6GHz prices are required in order for the data point to be included in the distance method calculation

- Whether inaccuracy arises through the disaggregation of package auction prices into band-specific prices.

Ofcom considers the use of proxies as part of its analysis of the benchmarks and argues that the use of a 2.6GHz proxy (e.g. in Ireland and Sweden) could lead to inaccuracies in the distance method value. However, Ofcom does not account for these inaccuracies in its tiering framework.

The second of these criteria – inaccuracies introduced through the disaggregation of package auction prices – appears to be ignored entirely by Ofcom. It appears that Ofcom decides whether a band-specific price *can* be derived from a package auction (such as a CCA) or not, but once it has determined that such prices *can* be derived, no further consideration is given to their accuracy or reliability.

The lack of this criterion is particularly important as it applies to both Austria and Ireland (among other countries), which are categorised, in our opinion incorrectly, as Tier 1.

Ofcom based its Austrian band-specific prices on a linear reference price (LRP) methodology and its Irish band-specific prices on the auction's final clock-round prices. In reality, however, neither methodology necessarily provides an accurate measure of band-specific prices. For example, Ofcom previously consulted on multiple different approaches[10] for calculating band-specific prices in the UK, given all available bid data and clear insight into the auction. This produced a range of between GBP26.85 million and GBP38.4 million per MHz[11] for 800MHz and between GBP4.55 million and GBP7.35 million per MHz for 2.6GHz.[12] These ranges show that even with all relevant data available there is still a significant uncertainty regarding the magnitude of LRPs. Furthermore, in interpreting the data from the UK auction, Ofcom ultimately settled on a marginal bidder approach rather than an LRP approach to determine the band-specific prices, arguing that it produced better estimates. In doing so, Ofcom itself acknowledges the inherent error bounds in LRP calculations. Finally, final clock-round prices in the UK were GBP84.6 million per MHz for 800MHz and GBP18.4 million per MHz for 2.6GHz, which are markedly different from any value in the respective LRP ranges. Therefore, we question how reliable final clock-round prices or LRPs can really be.

It therefore appears inconsistent that Ofcom can choose to entirely exclude certain CCAs due to that fact that band-specific prices cannot be gleaned (e.g. Switzerland), but yet also categorise benchmarks from CCAs in Austria and Ireland into Tier 1. If some CCAs are excluded, surely Ofcom should classify other CCA benchmarks as providing (at best) Tier 2 evidence.

10 Simple linear fit methodology, linear reference price methodology and additional spectrum methodology.

11 This value was originally proposed in Ofcom's 2013 consultation, which was determined using a revenue constraint. Source: Ofcom (2014), *Annual licence fees for 900MHz and 1800MHz spectrum Further consultation*, Paragraph 2.4.

12 Ofcom (2014), *Annual licence fees for 900MHz and 1800MHz spectrum Further consultation*, Table 2.4.

4 Our proposed solutions to the tiering and weighting issues

We conceptually agree with the objectives of Ofcom's tiering framework – which seeks to establish whether each benchmark firstly reflects market value in the country concerned and secondly whether it is relevant to UK value. However, we differ strongly in the implementation, and particularly how to address the inevitable uncertainty associated with the benchmarks.

In an attempt to identify more reliable data points, Ofcom's framework looks for reasons to exclude benchmarks. As a result, Ofcom relies on a very small number of benchmarks when determining the lump-sum values.

In our opinion, a more robust approach is to acknowledge that no individual benchmark is perfect and instead use a more inclusive approach to incorporate as much evidence as possible in the analysis. The rigour in the analysis then comes from the quantity of benchmarks used, meaning that shortcomings in individual benchmarks do not unduly influence the final result.

In practical terms, this means using a framework that:

- Uses a minimised number of criteria for excluding/categorising benchmarks
- Uses criteria that are clear and objective.

The result should be more rather than fewer benchmarks being used in the analysis.

In our first report and the subsequent addendum we proposed such frameworks for both 1800MHz and 900MHz spectrum. In the subsections below, we again present these frameworks, and consider whether they require adaptation following evidence presented in Ofcom's second consultation.

1800MHz spectrum

In our framework for determining 1800MHz lump-sum values we identified two sets of objective criteria that firstly excluded benchmarks that provided no reliable information, before then dividing the remainder between two 'Tiers'.[13]

First, we suggested that benchmarks should be excluded if any of the following apply:

- The 1800MHz band has not been auctioned within Ofcom's relevant time period
- For package bid auctions, no reliable information regarding the 1800MHz prices can be inferred from publicly available information (or indeed the 800MHz and 2.6GHz prices, given our recommended use of the distance method)
- Certain bidders were excluded from the auction (especially incumbent operators)
- There is no reliable 800MHz or 900MHz benchmark from the country.

[13] These were labelled as 'more important' and 'less important' evidence in our first report, in line with Ofcom's first consultation; but we now use the terminology 'Tier 1' and 'Tier 2', in line with Ofcom's second consultation.

In defining its 'excluded' category, Ofcom's approach appears to be broadly consistent with our proposed approach. However, there is an important difference in Ofcom's interpretation of the second criterion regarding the inclusion of benchmarks from package bid auctions.

Notably, Ofcom excludes Switzerland on the basis that no reliable information can be gleaned from the auction result. We do necessarily not agree with this position. However, we do accept that the band-specific data that can be derived is less reliable than for some other CCAs. Therefore, in the remainder of our analysis we have excluded Switzerland from our data set.

Nonetheless there are significant issues regarding the reliability of the band-specific prices for all CCAs, and we again note that if Switzerland is to be excluded, surely Ofcom should classify other CCA benchmarks as providing (at best) Tier 2 evidence.

In our first report we then provided criteria for categorising benchmarks as Tier 2 rather than Tier 1. These were as follows:

- Band-specific prices cannot be *directly* inferred (i.e. CCA/package auction benchmarks)
- A proxy is used for the 800MHz and/or 2.6GHz price (i.e. the 900MHz value or zero is used as a proxy for either the 800MHz or 2.6GHz values)
- There is unsold spectrum in any of the three bands relevant for the distance method (800MHz, 1800MHz or 2.6GHz)
- There is a significant time gap between the auctioning of the three required bands (800MHz, 1800MHz or 2.6GHz).

We suggest that these criteria remain appropriate. They represent a minimum set of criteria for identifying auctions that provide less information than others. They simply identify auctions where a distance method evidence point cannot be directly read (due to a package auction or the use of a proxy), where there was unsold spectrum (meaning that the price of the marginal spectrum was not found) or where there were substantial time gaps between the auctions (making the distance method less reliable).

However, having reflected on Ofcom's second consultation, we now believe that the addition of one further criterion is warranted:

- Spectrum in any of the three bands relevant for the distance method (800MHz, 1800MHz or 2.6GHz) was sold at its reserve price.

As discussed in our previous report, an auction that finished at reserve price is unlikely to reflect market value. In any case, the auction price was determined by the regulator in setting the reserve price and not by bidding in the auction. Therefore, we believe that this criterion should be included in our framework to reflect that a lower weighting is warranted in situations where the price was not determined by bidding.

We note that Ofcom includes several other criteria for relegating benchmarks to either Tier 2 or Tier 3 (the latter of which effectively excludes the benchmark). However, as discussed there are

many factors which may have affected the price achieved in an auction, and therefore we believe that the accuracy of the analysis would be improved by including more data points, rather than having large numbers of criteria for exclusion/downgrading to a lower tier.

Using our set of criteria we classify each of the nine 1800MHz benchmark countries in Figure 4.1 below. (Refer to Annex C for a brief discussion of our reasoning in each case.)

Figure 4.1: Result of categorisation of the countries included by Ofcom into Tier 1 and Tier 2 evidence for derivation of an 1800MHz lump-sum value [Source: Analysys Mason and Aetha, 2014]

Country	Band-specific prices not directly inferred?	Use of proxy for 2.6GHz?	Unsold spectrum?	Significant time gap between band auctions?[14]	Auction finished at reserve price?	Conclusion
Austria	Yes			Yes		Tier 2
Czech Republic			Yes		Yes	Tier 2
Germany						Tier 1
Ireland	Yes	Yes				Tier 2
Italy						Tier 1
Portugal			Yes		Yes	Tier 2
Romania	Yes		Yes		Yes[15]	Tier 2
Slovakia	Yes				Yes[15]	Tier 2
Sweden		Yes				Tier 2

Note that the only differences from the tiering proposed in the addendum to our original report (June 2014) are that:

- Greece is now excluded – we acknowledge Ofcom's arguments that the use of two proxies in Greece warrants exclusion (as discussed further in Section 5.2.3)
- Switzerland is now excluded – as discussed above
- The reserve price criterion is included – although in this instance this does not change the tiering outcomes, as all countries failing on this criterion also fail on another criterion.

900MHz spectrum

We believe that the distance method is also the most robust method for determining the 900MHz lump-sum value – as it uses the greatest number of evidence points both from benchmark countries and the UK auction. However, we do not have material concerns with Ofcom's chosen approach of using benchmark ratios of 900MHz to 800MHz values. This is because, given the available evidence, and if correctly implemented, both approaches produce similar results (as demonstrated

14 This criterion would apply in Sweden were a proxy for 2.6GHz not to be used.

15 Reserve prices used as proxies for band-specific prices.

in Annex A). That said, we suggest that Ofcom uses the distance method as a cross-check against its final choice of 900MHz lump-sum value, as any significant deviation would be of concern.

In response to Ofcom's May 2014 invitation for comments regarding European auctions since Ofcom's first consultation, Analysys Mason and Aetha, on behalf of EE, provided an illustration of how the distance method could be applied to the 900MHz band. As part of that illustration we set out criteria to determine whether benchmarks from different countries should be included in or excluded from the analysis and whether they should be classified as more or less important (Tier 1 or Tier 2 in the context of this document). At the time we suggested that, in line with our 1800MHz criteria, countries should be excluded if:

- The 900MHz band has not been auctioned within Ofcom's relevant time period
- For package bid auctions, no reliable information regarding the 900MHz prices can be inferred from publicly available information
- Certain bidders were excluded from the auction (especially incumbent operators)
- There is no reliable 800MHz benchmark from the country.

We continue to believe that these criteria are appropriate. Again these criteria are broadly consistent with Ofcom's approach, with the exception that Ofcom includes Denmark (despite incumbent operators being excluded from the Danish auction). However, we note that Ofcom then categorises Denmark as Tier 3, thus effectively excluding it from the determination of the lump-sum value. For consistency, we recommend that Denmark is excluded from Ofcom's benchmark set altogether.

Consistent with our approach to 1800MHz above, we then went on to recommend criteria for categorising countries as Tier 2. Adapting them for use within the 900MHz:800MHz ratio approach used by Ofcom instead of the distance method approach, these are:

- Band-specific prices cannot be *directly* inferred (i.e. CCA/package auction benchmarks)
- There is unsold spectrum in either of the two relevant bands (800MHz or 900MHz)
- There is a significant time gap between the auctioning of the two required bands (800MHz or 900MHz).

Again, we continue to believe that these criteria are appropriate. However, as for our 1800MHz approach, we now believe that the addition of the following criterion is warranted:

- Spectrum in either of the two relevant bands (800MHz or 900MHz) was sold at its reserve price.

Using our set of criteria, we classify each of the nine benchmark countries in Figure 4.2 below. Annex C provides a brief discussion of our reasoning in each case.

Figure 4.2: Result of categorisation of the countries included by Ofcom into Tier 1 and Tier 2 evidence for derivation of a 900MHz lump-sum value [Source: Analysys Mason and Aetha, 2014]

Country	Band-specific prices not directly inferred?	Unsold spectrum?	Significant time gap between band auctions?	Auction finished at reserve price?	Conclusion
Austria	Yes				Tier 2
Ireland	Yes				Tier 2
Portugal		Yes		Yes	Tier 2
Romania	Yes	Yes		Yes[16]	Tier 2
Spain				Yes	Tier 2

The result is that all benchmarks should be categorised within Tier 2. This result acknowledges that there are uncertainties associated with all five of the available benchmarks, such that it is better to weight them all equally in determining the lump-sum value. None deserves more weight than another; nor is it appropriate to rely on just a subset.

4.2 The results of our suggested solution

In Figure 4.3 below we compare the weighted average of the 1800MHz lump-sum values using our categorisation and weightings set out in Figure 4.1 with the results produced using the Ofcom weighting and an equal weighting.

Figure 4.3: Calculation of a weighted average lump-sum value for 1800MHz using our recommended tiering and weightings [Source: Analysys Mason and Aetha, 2014]

Country	Distance method benchmark (GBP million/MHz)[4]	Equal weighting	Ofcom weighting	Analysys Mason / Aetha weighting
Austria	25.5	1	2	1
Czech Republic	7.5	1	0	1
Germany	5.6	1	1	2
Ireland	14.3	1	2	1
Italy	13.5	1	2	2
Portugal	6.1	1	0	1
Romania	12	1	0	1
Slovakia	7.5	1	0	1
Sweden	17.5	1	1	1
Weighted average (GBP million/MHz)		**12.2**	**16.2**	**11.7**
Deviation from the equal weighted average			**+33%**	**–4%**

16 Reserve prices used as proxies for band-specific prices.

The result is an 1800MHz UK lump-sum value of GBP11.7 million per MHz, which is much closer to the unweighted average.

In Figure 4.4 below we provide the equivalent comparison for the 900MHz band.

Figure 4.4: Calculation of a weighted average lump-sum value for 900MHz using our recommended tiering and weightings [Source: Analysys Mason and Aetha, 2014]

Country	Benchmark (GBP million/ MHz)[4]	Equal weighting	Ofcom weighting	Analysys Mason / Aetha weighting
Austria	39.2	1	2	1
Denmark	6.1	1	0	**Exclude**
Ireland	20.3	1	2	1
Portugal	21.8	1	1	1
Romania	33.5	1	0	1
Spain	23.2	1	1	1
Weighted average (including Denmark) (GBP million/MHz)		**24.0**	**27.3**	**N/A**
Weighted average (excluding Denmark) (GBP million/MHz)		**27.6**	**27.3**	**27.6**

Our approach produces a lump-sum value equal to the unweighted average of GBP27.6 million per MHz. This follows from the fact that our criteria lead to each of the benchmarks being given equal weight. Although we do not agree with the categorisation and weightings applied by Ofcom, in this case they produce a very similar output of GBP27.3 million per MHz.

4.3 Sensitivity analysis

In Section 3.2 we conducted a sensitivity analysis that considered all of the tiering combinations that are possible under Ofcom's framework. This illustrated that the GBP16.2 million per MHz 1800MHz value implied by Ofcom's tiering framework was at the upper end of all possible values. In contrast, the 900MHz value was towards the centre of all possible values.

In this section we conduct a similar sensitivity analysis on our proposed framework. This assigns a weighting of either 1 or 2 to all included benchmarks. Notably, our framework does not assign a zero weight to any benchmark (as done by Ofcom to Tier 3 benchmarks). For the 1800MHz value this results in 512 possible weighted averages,[17] which we arrange from lowest to highest in Figure 4.5 below. Our calculated value of GBP11.7 million per MHz is just below the centre of all possible tiering combinations.

[17] Assigning each of the nine benchmark countries a weighting of either 1 or 2 results in 2^9=512 possible outcomes.

Figure 4.5: Sensitivity analysis on weightings assumed in the Analysys Mason and Aetha approach to calculating the 1800MHz weighted average [Source: Analysys Mason and Aetha, 2014]

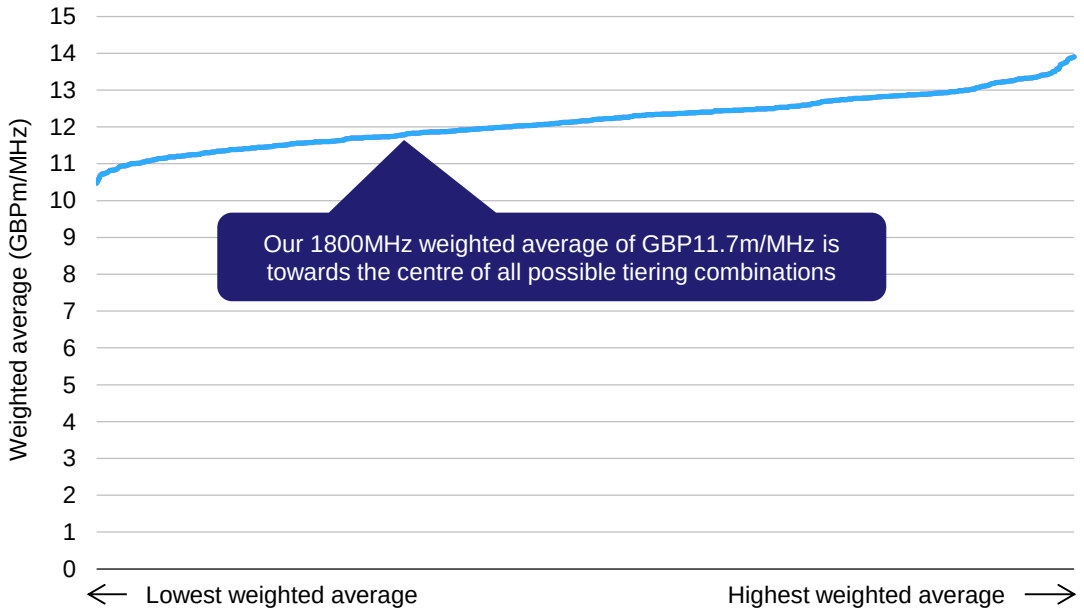
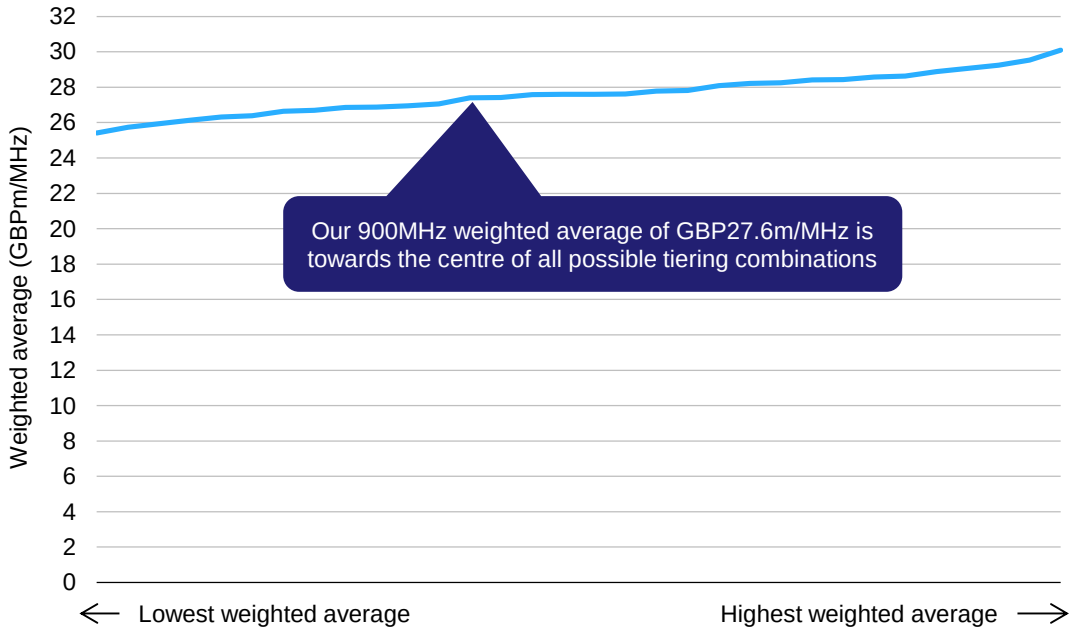


Figure 4.5 shows that the range of possible weighted averages in our suggested framework is much narrower than Ofcom's framework (see Section 3.2). This is because our framework is more inclusive in terms of the evidence points considered. It therefore avoids extremes in the resulting weighted average. In particular, this means that the GBP16.2 million per MHz weighted average calculated by Ofcom falls outside the range of possible results using our framework.

We have conducted a similar sensitivity analysis for the 900MHz weighted average and arranged the 32 possible 900MHz weighted averages[18] from lowest to highest in Figure 4.6 below.

[18] Assigning each of the five benchmark countries a weighting of either 1 or 2 results in 2^5=32 possible outcomes.

Figure 4.6: Sensitivity analysis on weightings assumed in the Analysys Mason and Aetha approach to calculating the 900MHz weighted average [Source: Analysys Mason and Aetha, 2014]



Again, the range of possible values is reduced due to never assigning a zero weighting to any of the benchmarks. However, despite the varying ranges, under both the Ofcom framework and our framework the calculated weighted average lies towards the middle of all possible tiering combinations. Therefore, in contrast to the 1800MHz results, neither framework leads to an extreme value.

Finally, it is worth noting that although the above sensitivity analysis focuses on the impact that the tiering decisions have on the weighted averages of the benchmarks, they will also have an implicit influence on the *selected* lump-sum values.

5 Input data issues

In addition to our concerns regarding Ofcom's tiering approach, we have identified three concerns regarding the input data on which Ofcom's analysis is based:

- An error in the averaging of auction prices for individual lots in benchmark countries
- Ofcom's approach to the use of proxies for 2.6GHz benchmark values appears flawed
- Ofcom could use different UK values for 800MHz and 2.6GHz spectrum.

We consider each of these points in turn in Sections 5.1 to 5.3, and then consider the impact on the 900MHz and 1800MHz lump-sum values in Section 5.4.

5.1 Approach to averaging lot values in benchmark countries

Ofcom has provided Three and EE with the Excel model developed by DotEcon to calculate the benchmark values in each country, which are used to determine the UK lump-sum values. Following a review of this model, we have found that DotEcon's approach to calculating benchmark auction values for each country and spectrum band is as follows:

- It calculates a UK equivalent price for each lot sold
- It then takes a straight average of these lots, regardless of the population covered by each lot or the size of the lot (i.e. the amount of frequency included in the lot).

We believe that this approach is incorrect. The approach adopted widely across the industry is to use a weighted average of the lots, taking account of the population covered and the size of lots. This ensures that larger lots and lots that cover larger populations carry more weight in the calculation of the average value.

This error is illustrated for the Swedish 1800MHz band in Figure 5.1 below.

Figure 5.1: Calculation of the 1800MHz lot values in Sweden [DotEcon, Analysys Mason and Aetha, 2014]

Operator	MHz won	UK equivalent price (GBP million/MHz)
TeliaSonera	2×25	8.9
Net4Mobility	2×10	10.4
Straight average (used by DotEcon)		9.7
Weighted average (correct calculation)		9.3

We have found four instances of this error occurring. These are provided below in Figure 5.2.

Figure 5.2: Instances of averaging errors in DotEcon's analysis [DotEcon, Analysys Mason and Aetha, 2014]

Country	Band	Straight average	Weighted average
Sweden	1800MHz	9.7	9.3
Portugal	1800MHz	3.2	3.3
Czech Republic	800MHz	45.2	44.1
Spain	2.6GHz	3.3	1.9

5.2 The use of proxies for 2.6GHz benchmark values

Our original proposal for the use of the distance method for 1800MHz spectrum included two important principles:

- As many data points should be included as possible – given the uncertainty associated with any individual benchmark, this approach increases the overall accuracy of the derived lump-sum values
- Country-specific evidence points should be included where possible – as this creates as accurate a picture as possible for the value of spectrum in each benchmark country.

These principles led us to the following approach to the use of proxies for band-specific benchmarks:

- Evidence points from auctions in benchmark countries should be used wherever possible – even when the spectrum was auctioned prior to the period being considered by Ofcom (2010–2014). The rationale for this is that it is better to use a less recent evidence point (perhaps compensating by placing less weight on the benchmark derived from that country when determining the lump-sum value), than to simply reuse data from other benchmark countries or to entirely dismiss the benchmark.
- Where no evidence is available at all (i.e. no auctions have taken place for a certain spectrum band in that country), the use of a proxy is preferable to not including the country at all. In the case of 2.6GHz spectrum, we suggested a proxy of zero as this would produce an upper bound for the 1800MHz distance method value.

In its second consultation, Ofcom has taken the approach that a proxy value must be used if there is no evidence point available since the start of 2010. The method used to calculate the 2.6GHz proxy is to find the ratio of the UK equivalent 2.6GHz value to the UK equivalent 800MHz value for each country (for all countries that have auctioned the 800MHz and 2.6GHz bands since 2010) and then simply take the geometric mean of these ratios. This is the method used for generating 2.6GHz proxies in both Sweden and Ireland. The benchmarks used to calculate this proxy are shown in Figure 5.3 below.

Figure 5.3: UK equivalent 2.6GHz/800MHz benchmark ratios [Ofcom, August 2014]

Country (auction date)	800MHz value (GBP million per MHz)	2.6GHz value GBP million per MHz)	2.6GHz to 800MHz ratio
Austria (2010; 2013)	72.2	1.9	3%
Belgium (2011; 2013)	30.0	5.0	17%
Czech Republic (2013)	44.1	3.0	7%
Denmark (2010; 2012)	16.2	10.3	64%
Germany (2010)	52.9	1.6	3%
Italy (2011)	52.1	3.8	7%
Portugal (2011)	37.3	2.5	7%
Romania (2012)	43.9	10.6	24%
Slovakia (2013)	38.5	4.6	12%
Spain (2011)	40.4	3.3	8%
Geometric mean			**9.6%**

The above benchmark ratios vary considerably between countries. It therefore appears that a proxy based on this approach is likely to have sizable error bounds. Furthermore, in keeping with our principle to include as many evidence points as possible, we note that this approach taken by Ofcom introduces no new evidence points – it essentially recycles the 2.6GHz benchmarks from other countries. It would seem much more reasonable to use specific evidence points from each benchmark country, where these are available, even if this was from before Ofcom's (arbitrary) cut-off period.

In the subsections below, we consider the approach taken by Ofcom for each of the countries in which proxies have either been used by Ofcom or suggested to be used by Analysys Mason and Aetha – namely Sweden, Ireland and Greece.

5.2.1 Sweden

An auction price for 2.6GHz spectrum is available for Sweden as this band was auctioned in May 2008. Ofcom chooses to ignore this data point as it was before its (arbitrary) 2010 cut-off date, and instead uses a proxy value of GBP2 million per MHz. This results in a distance method 1800MHz value of GBP17.5 million per MHz.

We calculate that, using DotEcon's methodology, the Swedish 2.6GHz UK equivalent price would be GBP9.6 million per MHz (based on the May 2008 auction). This is lower than the GBP9.7 million per MHz UK equivalent value for 1800MHz spectrum calculated by DotEcon/Ofcom. However, as noted above in Section 5.1, we believe that the Swedish benchmark for the UK equivalent value for 1800MHz spectrum should be GBP9.3 million per MHz (i.e. using a weighted averaging of lots rather than DotEcon's approach of using a straight average). Using this corrected 1800MHz value and our calculated 2.6GHz value for Sweden, the distance method 1800MHz value would be GBP4.7 million per MHz.

We note that Ofcom is reluctant to use a distance method benchmark for 1800MHz where the input data contains a 2.6GHz value that is higher than the 1800MHz value.[19] We do not necessarily agree with this position; however, rather than exclude the 2.6GHz benchmark in favour of an estimated proxy, we suggest adjusting the value of the 2.6GHz benchmark down to be equal to the value of the 1800MHz spectrum (in other words a proxy based on actual evidence from Sweden). We note that this implies only a small adjustment to the 2.6GHz benchmark (from GBP9.6 million per MHz to GBP9.3 million per MHz). In our view this provides a much more representative figure for the market value of 2.6GHz spectrum in Sweden than a simple average based on market value in other countries. This approach leads to a distance method 1800MHz value of GBP5.5 million per MHz.

Given that Ofcom's approach, using a proxy for the 2.6GHz value benchmark, results in an 1800MHz value of GBP17.5 million per MHz, whilst alternatives using the benchmark value from the 2008 Swedish 2.6GHz auction result in 1800MHz values of GBP4.7–5.5 million per MHz, Ofcom's decision to use its chosen proxy clearly has a large upward impact on the final 1800MHz lump-sum value. In this context, as well as lacking justification, it does not appear consistent with Ofcom's stated aim of taking a conservative approach to setting the 1800MHz lump-sum value.

Further, we note that Ofcom uses a 2.6GHz benchmark for Austria despite the band being auctioned in 2010, only just past Ofcom's (arbitrary) cut off point and three years before the auction of the 800MHz and 1800MHz bands. Despite these matters, which Ofcom's logic would imply are weaknesses in the Austrian data point, Ofcom categorises the resulting distance method benchmark as Tier 1. The stark difference in how Ofcom treats the Austrian and Swedish 2.6GHz benchmarks appears unjustified.

5.2.2 Ireland

The situation in Ireland is different from that in Sweden because 2.6GHz spectrum has never been auctioned. Therefore, the use of a proxy for the 2.6GHz value is required in order to calculate a distance method 1800MHz value. In our previous report we suggested using zero as the proxy value, which would provide an upper bound to the distance method value. However, Ofcom has chosen to use a proxy based on the average 2.6GHz/800MHz ratio in other benchmark countries. Despite the limitations of this proxy, we agree that it is likely to be more accurate (and conservative) than a zero proxy.

Despite Ofcom's use of this approach, we note that Ireland is still far from a conservative benchmark, since the 1800MHz price in Ireland is likely to have been skewed upwards as a result of there (unusually) being no 2.6GHz spectrum available in the market.

[19] As shown when Ofcom excludes Denmark from distance method benchmarking on this basis, in paragraph A8.99 of the second consultation.

5.2.3 Greece

In our previous report, we suggested that Greece should be included in the distance method calculation for deriving a UK lump-sum value for 1800MHz spectrum. This was despite the fact that it would require the use of proxies for both the 800MHz and 2.6GHz values. Ofcom has chosen to exclude Greece, based on the uncertainty created by having proxies for both bands. Although our belief is that more rather than fewer benchmarks should be included in the analysis, we understand that there is a need for a cut-off point, and this point is inevitably subjective. The use of two proxies clearly makes the Greek benchmark less reliable than others, therefore we believe that its exclusion is not unreasonable.

5.3 The choice of UK values for 800MHz and 2.6GHz spectrum

In its second consultation, Ofcom changes its approach for estimating the UK value of 800MHz and 2.6GHz spectrum from an linear reference price (LRP) approach to a 'marginal bidder' approach. This results in the following UK values for 800MHz and 2.6GHz spectrum.

Figure 5.4: Ofcom's UK values as produced by a marginal bidder approach, in GBP million per MHz [Source: Ofcom, 2014]

800MHz spectrum	Without coverage obligation	With coverage obligation
Net of DTT co-existence costs	32.63	31.08
Gross of DTT co-existence costs	35.63	34.08
2.6GHz spectrum	**5.5**	

Consideration of the UK values for 800MHz and 2.6GHz spectrum is outside the scope of this report. However, we understand that both EE and Three have considered this aspect carefully and have come to separate views on the most appropriate figures to use for the UK values for 800MHz and 2.6GHz spectrum.

The choice of UK values for 800MHz and 2.6GHz will have an influence on any calculated, or selected, lump-sum values for 900MHz and 1800MHz spectrum. Therefore, in the remainder of this report we consider the 900MHz and 1800MHz lump-sum values assuming both Ofcom's estimated UK values for 800MHz and 2.6GHz spectrum (as per its marginal bidder approach) as well as the values provided to us by both EE and Three, which are summarised in Figure 5.5 (for EE) and Figure 5.6 (for Three) below.

Figure 5.5: EE's UK values for 800MHz and 2.6GHz, in GBP million per MHz [Source: EE, 2014]

800MHz spectrum	Without coverage obligation	With coverage obligation
Net of DTT co-existence costs	26.89	25.34
Gross of DTT co-existence costs	29.89	28.34
2.6GHz spectrum	**4.99**	

Figure 5.6: Three's UK values for 800MHz and 2.6GHz, in GBP million per MHz [Source: Three, 2014]

800MHz spectrum	Without coverage obligation	With coverage obligation
Net of DTT co-existence costs	25.04	23.49
Gross of DTT co-existence costs	28.04	26.49
2.6GHz spectrum	**3.57**	

5.4 Impact on the 900MHz and 1800MHz results

Figure 5.7 below shows the impact of correcting issues raised in this section on the UK 1800MHz weighted average values, using both Ofcom's and our tiering approaches. The results are also shown separately using the 800MHz and 2.6GHz UK values proposed by Ofcom, EE and Three.

Figure 5.7: Impact of our suggested changes on the 1800MHz lump-sum values [Ofcom, Analysys Mason and Aetha, 2014]

	1800MHz weighted average values (GBP million per MHz)	
	Using Ofcom's tiers and weightings	Using Analysys Mason & Aetha tiers and weightings
Value prior to amendments	16.2	11.7
Correction to averaging	16.2	11.6
Use of Swedish 2.6GHz auction result	14.7	10.8
After both changes but using Ofcom's proposed UK 800MHz/2.6GHz values	14.7	10.6
After both changes plus using EE's proposed UK 800MHz/2.6GHz values	12.6	9.2
After both changes plus using Three's proposed UK 800MHz/2.6GHz values	11.0	7.7

Using either tiering and weighting approach, the correction to DotEcon's averaging approach has relatively little impact on the 1800MHz weighted average value.

However, in contrast, the impact of using a proxy instead of the Swedish 2.6GHz auction result is substantial. This single decision by Ofcom raises the 1800MHz weighted average value by between 7% and 10% depending on the weightings used. However, despite its importance, Ofcom appears not to have calculated the impact of this decision or conducted any sensitivity analysis on the resulting lump-sum value.

The impact of using EE or Three's proposed UK values for 800MHz and 2.6GHz spectrum is also substantial, reducing the weighted averages by between 13% and 27%.

Finally, the issues raised in Sections 5.1 and 5.2 do not impact on the calculated 900MHz weighted averages. Although Spain and Portugal are included in Ofcom's evidence set, the changes to these benchmarks do not affect the 900MHz or 800MHz benchmarks. However, the

adoption of EE or Three's proposed UK values for 800MHz and 2.6GHz spectrum reduces the 900MHz weighted average by between 16% and 23%, as illustrated in Figure 5.8 below.

Figure 5.8: Impact of changes on the 900MHz lump-sum values (in GBP million per MHz) [Ofcom, Analysys Mason and Aetha, 2014]

	Using Ofcom's tiers and weightings	Using Analysys Mason & Aetha tiers and weightings
Prior to amendment	27.3	27.6
Using EE's UK 800MHz/2.6GHz values	22.8	22.9
Using Three's UK 800MHz/2.6GHz values	21.3	21.3

6 Our proposed selection of lump-sum values

In our original report, we raised concerns about Ofcom's qualitative approach for selecting its proposed lump-sum values. In its second consultation, Ofcom continues to qualitatively select the lump-sum values, but it now uses a calculated weighted average of the benchmarks to then cross-check its proposed lump-sum values.

Although in principle we continue to believe that determining the lump-sum values via a calculation is the most appropriate method, we do not have concerns with Ofcom's approach, as long as a weighted average cross-check is used and the proposed lump-sum values are set conservatively when compared to the cross-check. This is then in accordance with Ofcom's aim of following a *"conservative"* approach.

In this section, we therefore follow Ofcom's approach to choosing the lump-sum values – i.e. selecting values ("in the round"), before then conducting a weighted average cross-check of the benchmarks. The only differences from Ofcom's approach are that we:

- use the tierings and weightings proposed in Section 4
- use the corrections to the averaging of benchmark prices and the use of 2.6GHz proxies outlined in Sections 5.1 and 5.2
- choose lump-sum values assuming both Ofcom's estimated UK values for 800MHz and 2.6GHz spectrum and those proposed by EE and Three.

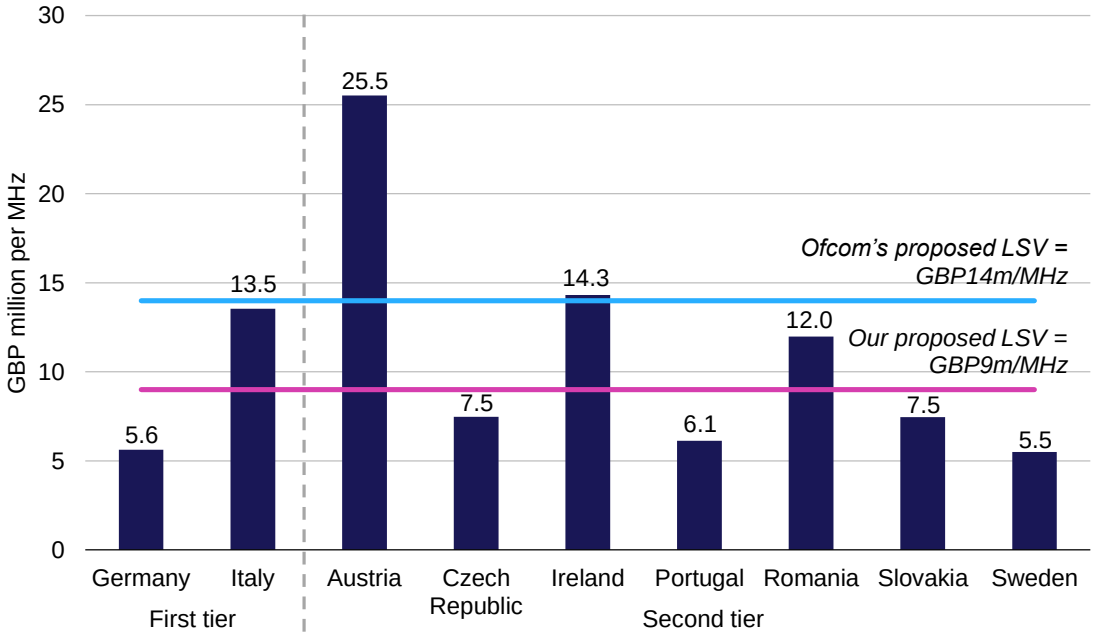
6.1 Lump-sum values assuming Ofcom's UK values for 800MHz and 2.6GHz spectrum

In this section we choose lump-sum values assuming Ofcom's estimated UK values for 800MHz and 2.6GHz spectrum.

6.1.1 1800MHz spectrum

Having corrected for the tiering and input data errors, Figure 6.1 below presents the 1800MHz distance method benchmarks. This is equivalent to Figure 3.3 in Ofcom's second consultation.

Figure 6.1: 1800MHz distance method benchmarks assuming Ofcom's UK values for 800MHz and 2.6GHz [Source: Ofcom, Analysys Mason and Aetha, 2014]



The above chart clearly shows that, with corrected tiering and input data, Ofcom's proposed lump-sum value of GBP14 million per MHz is much too high. It is not only higher than both of the Tier 1 benchmarks (Germany and Italy), it is higher than five of the seven Tier 2 benchmarks.

The average of the two Tier 1 benchmarks is GBP9.6 million per MHz. However, consistent with Ofcom's aim to adopt a conservative approach, we believe that the lump-sum value should be set at the lower end of the range of Tier 1 benchmarks.

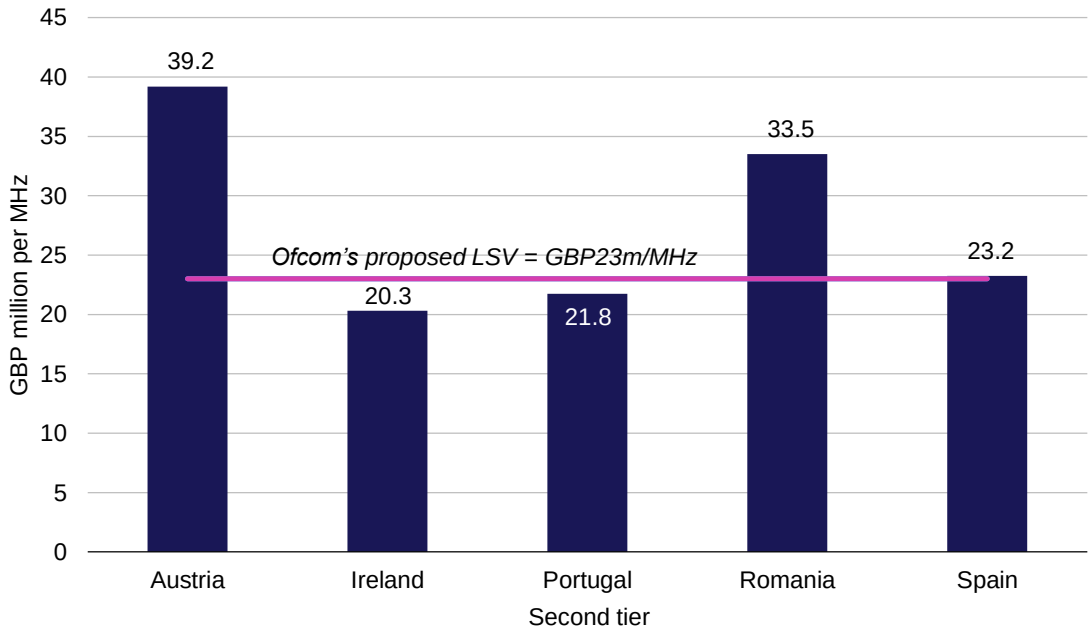
Considering the Tier 2 benchmarks, we note that there is a large range of values, from GBP5.5 million per MHz (Sweden) to GBP25.5 million per MHz (Austria). Four of the seven Tier 2 benchmarks are below the Tier 1 average of GBP9.6 million per MHz; but at GBP11.2 million per MHz, the average of the Tier 2 benchmarks is above the average of the Tier 1 benchmarks. Overall, this suggests that only a small discount on the Tier 1 average is warranted.

We consider that, assuming Ofcom's UK values for 800MHz and 2.6GHz spectrum, **GBP9 million per MHz** is an appropriate estimate of the UK lump-sum value for 1800MHz spectrum.

6.1.2 900MHz spectrum

Having corrected for the tiering of benchmarks, Figure 6.2 below presents the 900MHz benchmarks. This is an equivalent chart to Figure 3.2 in Ofcom's second consultation.

Figure 6.2: 900MHz benchmarks assuming Ofcom's UK values for 800MHz and 2.6GHz [Source: Ofcom, Analysys Mason and Aetha, 2014]



For 900MHz spectrum, we consider that all five benchmarks should be given the same weight (Tier 2). The mean of the benchmarks is GBP27.6 million per MHz. However, two of the benchmarks are significantly higher than the others (Austria and Romania), leading to the median (GBP23.2 million per MHz) being below the mean. Again, to be consistent with Ofcom's approach, the lump-sum value should be set at the lower end of the range of benchmarks.

On balance, being mindful of Ofcom's aim of being conservative and its estimated UK values for 800MHz and 2.6GHz spectrum, we consider that Ofcom's proposed UK lump-sum value of **GBP23 million per MHz** is appropriate.

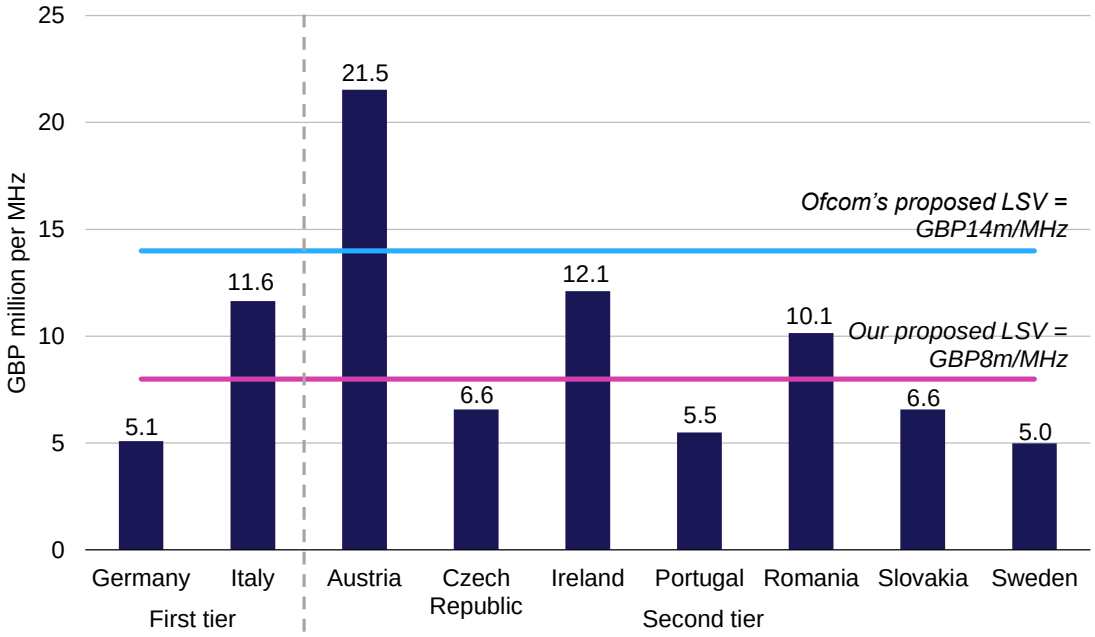
6.2 Lump-sum values assuming EE's UK values for 800MHz and 2.6GHz spectrum

In this section we choose lump-sum values assuming EE's proposals for the UK 800MHz and 2.6GHz values, as outlined in Section 5.3.

6.2.1 1800MHz spectrum

Figure 6.3 below presents the 1800MHz distance method benchmarks assuming EE's UK values for 800MHz and 2.6GHz spectrum.

Figure 6.3: 1800MHz distance method benchmarks assuming EE's UK values for 800MHz and 2.6GHz [Source: Ofcom, EE, Analysys Mason and Aetha, 2014]



With the revised UK 800MHz and 2.6GHz values, Ofcom's proposed lump-sum value appears even more aggressive. It is higher than eight of the nine benchmarks, including both Tier 1 benchmarks.

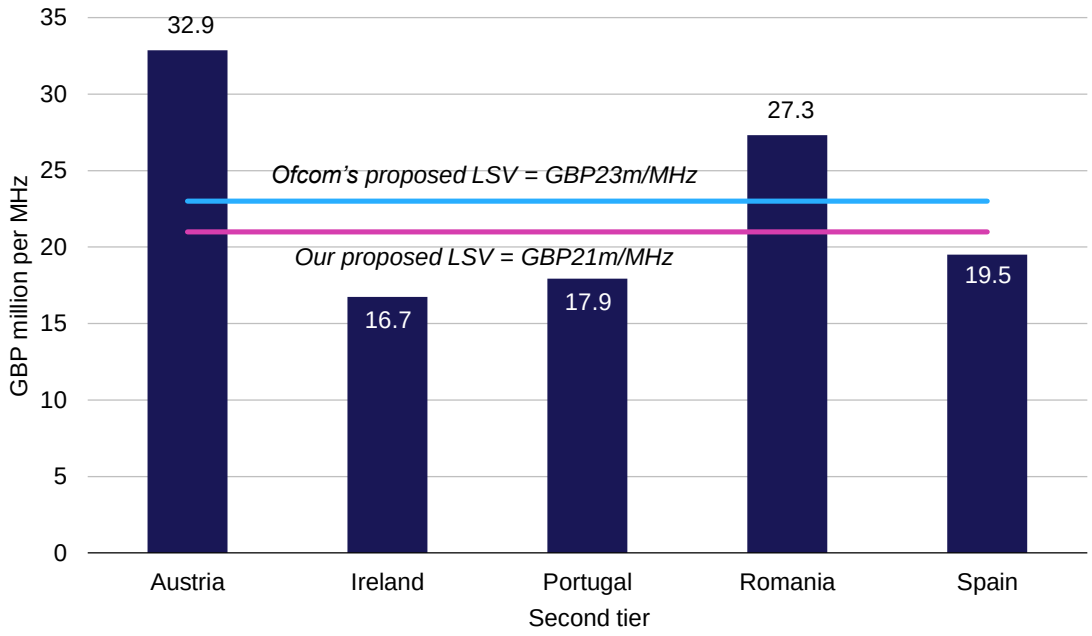
The average of the Tier 1 benchmarks is GBP8.4 million per MHz, whilst for the Tier 2 benchmarks it is GBP9.6 million per MHz. Therefore, in order to be conservative, we believe that the lump-sum value should be set at a small discount to the average of the Tier 1 benchmarks.

Therefore, assuming EE's UK values for 800MHz and 2.6GHz spectrum, we consider that **GBP8 million per MHz** is an appropriate estimate of the UK lump-sum value for 1800MHz spectrum.

6.2.2 900MHz spectrum

Figure 6.4 below presents the 900MHz benchmarks assuming EE's UK values for 800MHz and 2.6GHz spectrum.

Figure 6.4: 900MHz benchmarks assuming EE's UK values for 800MHz and 2.6GHz [Source: Ofcom, EE, Analysys Mason and Aetha, 2014]



With the revised UK 800MHz and 2.6GHz values, Ofcom's proposed lump-sum value now appears too high, especially given that it is above both the mean (GBP22.9 million per MHz) and median (GBP19.5 million per MHz) of the benchmarks.

On balance, assuming EE's UK values for 800MHz and 2.6GHz spectrum, we consider that **GBP21 million per MHz** is an appropriate estimate of the UK lump-sum value for 900MHz spectrum.

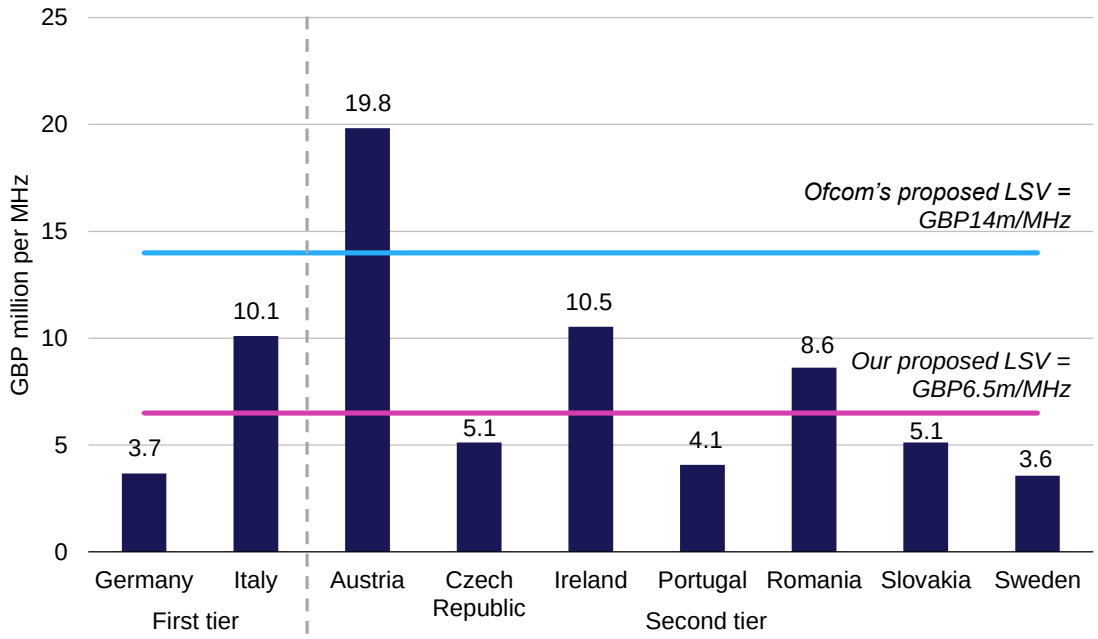
6.3 Lump-sum values assuming Three's UK values for 800MHz and 2.6GHz spectrum

In this section we choose lump-sum values assuming Three's proposals for the UK 800MHz and 2.6GHz values, as outlined in Section 5.3.

6.3.1 1800MHz spectrum

Figure 6.5 below presents the 1800MHz distance method benchmarks assuming Three's UK values for 800MHz and 2.6GHz spectrum.

Figure 6.5: 1800MHz distance method benchmarks assuming Three's UK values for 800MHz and 2.6GHz [Source: Ofcom, Three, Analysys Mason and Aetha, 2014]



With the UK 800MHz and 2.6GHz values proposed by Three, Ofcom's proposed lump-sum value again appears very aggressive. It is again higher than eight of the nine benchmarks, including both Tier 1 benchmarks.

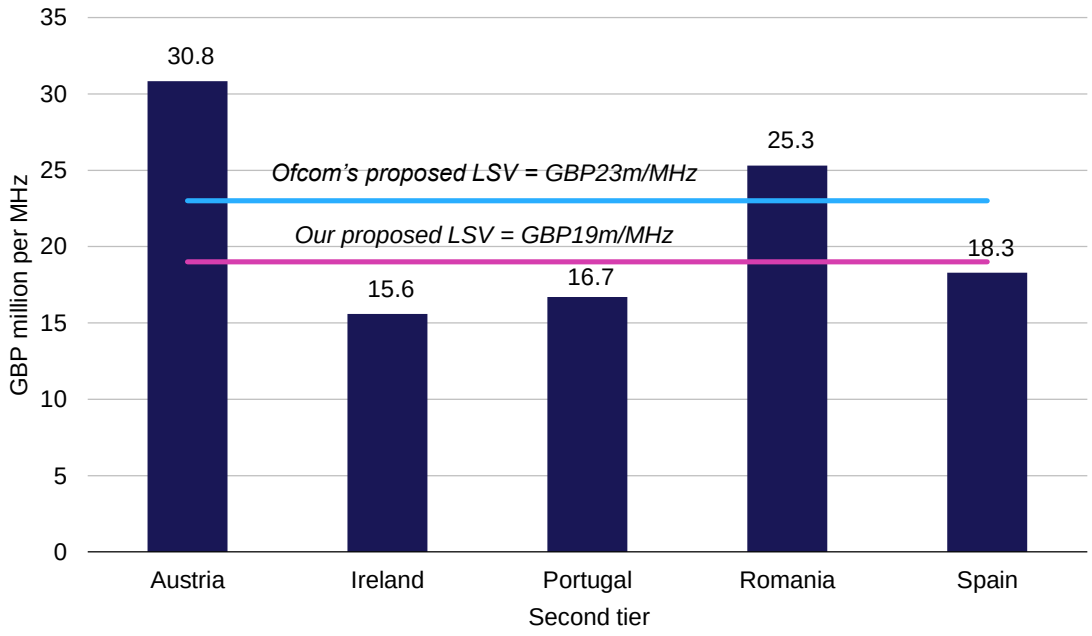
The average of the Tier 1 benchmarks is now GBP6.9 million per MHz, whilst for the Tier 2 benchmarks it is GBP8.1 million per MHz. Therefore, in order to be conservative, we again believe that the lump-sum value should be set at a small discount to the average of the Tier 1 benchmarks.

Therefore, assuming Three's UK values for 800MHz and 2.6GHz spectrum, we consider that **GBP6.5 million per MHz** is an appropriate estimate of the UK lump-sum value for 1800MHz spectrum.

6.3.2 900MHz spectrum

Figure 6.6 below presents the 900MHz benchmarks assuming Three's UK values for 800MHz and 2.6GHz spectrum.

Figure 6.6: 900MHz benchmarks assuming EE's UK values for 800MHz and 2.6GHz [Source: Ofcom, Three, Analysys Mason and Aetha, 2014]



With the revised UK 800MHz and 2.6GHz values, Ofcom's proposed lump-sum value again appears too high. The mean of the benchmarks is now GBP21.3 million per MHz and the median is GBP18.3 million per MHz.

On balance, assuming Three's UK values for 800MHz and 2.6GHz spectrum, we therefore consider that **GBP19 million per MHz** is an appropriate estimate of the UK lump-sum value for 900MHz spectrum.

6.4 Weighted average cross-check of the lump-sum values

In Sections 4 and 5, we presented our view of the lump-sum values as calculated using weighted averages of the available benchmarks. These are presented in Figure 6.7 below and compared to the lump-sum values selected above.

Figure 6.7: Comparison of our selected and weighted average lump-sum values [Source: Analysys Mason and Aetha, 2014]

	1800MHz	900MHz
Assuming Ofcom's UK values for 800MHz/2.6GHz		
Weighted average lump-sum value	10.6	27.6
Selected lump-sum value	9.0	23.0
Discount to the weighted average	15%	17%
Assuming EE's UK values for 800MHz/2.6GHz		
Weighted average lump-sum value	9.2	22.9
Selected lump-sum value	8.0	21.0
Discount to the weighted average	13%	8%
Assuming Three's UK values for 800MHz/2.6GHz		
Weighted average lump-sum value	7.7	21.3
Selected lump-sum value	6.5	19.0
Discount to the weighted average	16%	11%

Our selected lump-sum values represent a small discount to the corresponding weighted averages, which is consistent with Ofcom's aim of setting the lump-sum values conservatively. We also note that, in its second consultation, Ofcom selects lump-sum values that have similar discounts to its calculated weighted averages (16% for 900MHz and 14% for 1800MHz).

7 1800/900MHz cross-check

In its second consultation, Ofcom includes a comparison of the ratio of its proposed 1800MHz to 900MHz lump-sum values to equivalent ratios in the benchmark sample. We welcome this comparison as a valuable cross-check of the proposed lump-sum values. However, we believe that Ofcom interprets the results incorrectly and thus derives misleading conclusions.

As shown in Figure 7.1, six European countries have auctioned both 900MHz and 1800MHz spectrum.[20]

Figure 7.1: 900MHz and 1800MHz UK equivalent values, in GBP million per MHz [Source: Ofcom, Analysys Mason and Aetha, 2014]

	900MHz	1800MHz	1800MHz/900MHz ratio
Ireland	39.6	25.2	64%
Austria	79.4	48.6	61%
Greece	32.8	14.5	44%
Denmark	2.9	1.2	43%
Romania	47.3	19	40%
Portugal	24.9	3.2	13%
Geometric mean			**40%**

The ratio of Ofcom's proposed 1800MHz and 900MHz lump-sum values is 61% (GBP14 million per MHz divided by GBP23 million per MHz). This is right at the upper end of the range of benchmarks, and therefore suggests that Ofcom's proposed 1800MHz lump-sum value is too high compared to its proposed 900MHz lump-sum value.

However, when interpreting the results of this cross-check, Ofcom completely disregards all of the benchmarks except for Ireland and Austria – which provide the two highest benchmark ratios (by a considerable margin). Ofcom's rationale is that it has earlier categorised Ireland and Austria as Tier 1 countries, whilst it categorised either one or both of the 900MHz and 1800MHz values in the remaining countries as Tier 3.[21] Therefore, Ofcom states that it should place *"very little weight on them"*. In reality it appears to place no weight on them at all.

In Section 3, we reviewed Ofcom's approach to its tiering and concluded that:

- It is far from robust

[20] Although both 900MHz and 1800MHz spectrum have been awarded in Spain, 1800MHz spectrum was only awarded via a beauty contest. Therefore, consistent with Ofcom's analysis, we have excluded it from the 1800/900MHz cross-checks.

[21] In fact Ofcom categorises Spain's 900MHz benchmark as Tier 2 and its 1800MHz benchmark as Tier 3. We presume that Ofcom defaults to a country's lowest tier category, although this is not explicitly stated.

- Ofcom excludes too many data points, largely due to effectively excluding the Tier 3 benchmarks, and therefore relies on too few data points

- The inclusion of Austria and Ireland as Tier 1 data points is highly questionable, given:
  - the inevitable error bounds in calculating band-specific prices from CCAs – even when an LRP calculation is conducted using the bid data or final-round prices are known
  - the fact that Ofcom completely disregards all other multiband CCAs from the analysis because no reliable information regarding band-specific prices can be gleaned.

The shortcomings of Ofcom's tiering are then inevitably evident in this cross-check using the ratio of 1800MHz and 900MHz values. Indeed, the manner in which Ofcom conducts this cross-check provides no new information at all:

- Ofcom's 900MHz lump-sum value is heavily influenced by the Austrian and Irish benchmarks – which constitute the only two Tier 1 benchmarks out of the four benchmarks that are effectively considered (given that Ofcom places no weight on the Tier 3 benchmarks)

- Ofcom's 1800MHz lump-sum value is also heavily influenced by the Austrian and Irish benchmarks – which constitute two of the three Tier 1 benchmarks (Ofcom also considers two Tier 2 benchmarks, Germany and Sweden, but these do not affect its conclusion of the appropriate 1800MHz lump-sum value)

- Therefore, it is a mathematical inevitability[22] that the ratio of Ofcom's proposed 1800MHz and 900MHz values is very close to the equivalent Austrian and Irish benchmarks.

In practice, therefore, Ofcom's supposed cross-check does not check anything.

Ofcom should instead have used this cross-check to verify that the approach it has taken to determine the lump-sum values, and particularly the weightings that it places on each benchmark country, is reasonable. On this measure, the evidence clearly suggests that Ofcom's approach is in fact seriously flawed.

Giving each 1800MHz to 900MHz ratio benchmark equal weighting and assuming that the benchmarks follow a normal distribution curve, we calculate that the ratio of Ofcom's proposed 1800MHz and 900MHz lump-sum value (61%) is on the 97th percentile.[23] This result implies that for Ofcom's ratio to be valid, the actual distribution of European 1800MHz to 900MHz ratios must be vastly different from that suggested by the above six benchmarks. For Ofcom to believe that this is the case, it must be very confident that its tiering and weighting is robust. As discussed in Section 3, however, this is clearly not the case.

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22 To the extent that Ofcom's *selected* lump-sum values are similarly discounted from the weighted average cross-checks, which we established was indeed the case in Section 6.

23 Using the six 1800MHz to 900MHz price ratios, we calculate a standard deviation of 11%, and that the ratio between Ofcom's proposed 1800MHz and 900MHz LSVs (61%) is 1.9 standard deviations above the geometric mean of 40%. Our 97th percentile result is based on the cumulative density function at the 61% level.

Therefore, in our opinion, the correct interpretation of this cross-check is that Ofcom's proposed 1800MHz lump-sum value is very high compared to its proposed 900MHz value.

In comparison, the ratio of our suggested 1800MHz and 900MHz lump-sum values is either 34%, 38% or 39% (depending on whether Three, EE or Ofcom's proposed UK 800MHz and 2.6GHz values are assumed). These are all very close to the geometric mean of the benchmark ratios, suggesting that our calculations are more robust than Ofcom's to the assumptions used.

8 Conclusions

In our opinion Ofcom's revised lump-sum value for 1800MHz spectrum of GBP14 million per MHz remains unduly high. In contrast, the proposed lump-sum value for 900MHz spectrum of GBP23 million per MHz appears more reasonable. This outcome is the product of serious shortcomings in Ofcom's revised approach:

- Ofcom's tiering and weighting framework is over-complicated and relies on too many subjective criteria. The framework appears to look for reasons to exclude data points, whereas a more inclusive approach designed to incorporate as much evidence as possible would be far more robust. The result is that Ofcom relies on too few data points in reaching its conclusions.

- There are issues with the input data used by Ofcom – notably the use of a proxy for the value of 2.6GHz spectrum in Sweden appears inappropriate given the availability of an auction price in that country. This single decision by Ofcom raises the 1800MHz weighted average value by between 7% and 10% depending on the weightings used.

- Ofcom does not conduct any rigorous sensitivity analysis. Consequently, it appears unaware that its tiering and weighting approach produces an extreme outcome for 1800MHz spectrum, and that its decision to include a proxy for the value of 2.6GHz spectrum in Sweden has such a substantial impact on the final choice of 1800MHz lump-sum value.

- Ofcom's cross-check using benchmark 1800MHz to 900MHz value ratios is flawed, as it excludes all benchmarks other than the two highest. A more robust analysis of these benchmark ratios shows that Ofcom's approach to tiering and weighting the various benchmarks must be erroneous and so produces an extremely high lump-sum value for 1800MHz compared to 900MHz.

In this report, we have proposed revisions to Ofcom's tiering and weighting, as well as corrections to some of Ofcom's input data set. Using the same approach to select the lump-sum values as Ofcom (firstly selecting a value, then conducting a cross-check using weighted averages), and also adopting Ofcom's aim to use a *"conservative approach when interpreting the evidence"* (which Ofcom adopts in its second consultation), we propose that the following lump-sum values are appropriate estimates of UK market value:

Figure 8.1: Our proposed lump-sum values, GBP million per MHz [Analysys Mason and Aetha, 2014]

	1800MHz	900MHz
Assuming Ofcom's UK values for 800MHz/2.6GHz	**9**	**23**
Assuming EE's UK values for 800MHz/2.6GHz	**8**	**21**
Assuming Three's UK values for 800MHz/2.6GHz	**6.5**	**19**

Annex A Using the distance method for 900MHz

A.1 Introduction

As discussed in Section 2, whilst we believe that the distance method is the most robust method for determining the 900MHz lump-sum value, we do not have material concerns with Ofcom's chosen approach of using benchmarks of the relative value of 900MHz to 800MHz. This is because both approaches produce similar results, as we demonstrate in this annex.

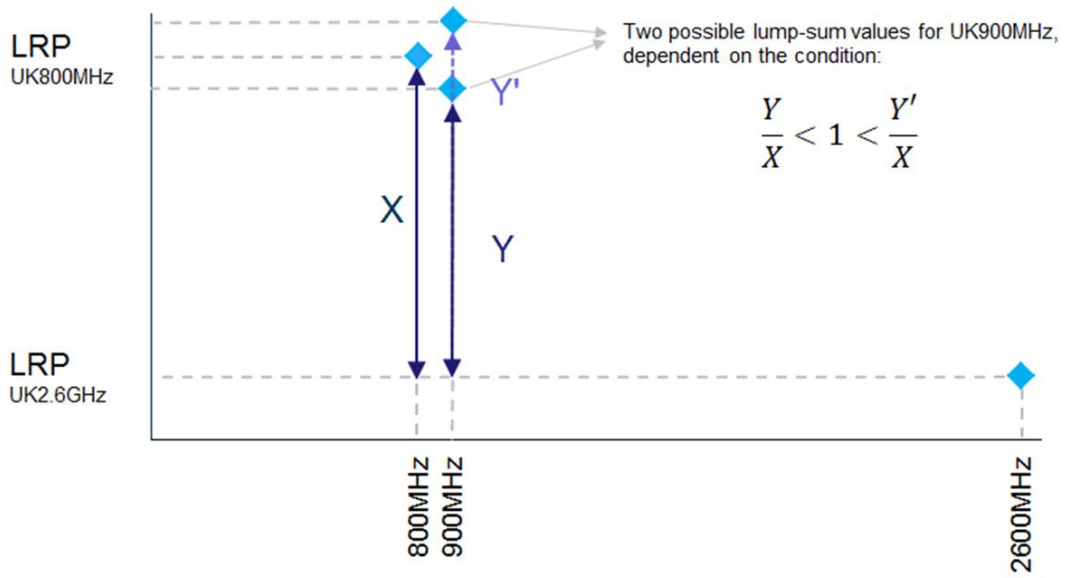
A.2 The application of the distance method for the 900MHz band

Given the clear benefits of the distance method, we note that there are no reasons, *a priori*, why the same methodology should not be applied to the calculation of lump-sum values for 900MHz spectrum. We note that unlike for the 1800MHz band, Ofcom uses only 800MHz auction prices to determine relative values for 900MHz spectrum. Therefore, an opportunity is missed to also use 2.6GHz price information from the UK auction to inform the 900MHz value.

The distance method can be applied to 900MHz spectrum using exactly the same formula as for 1800MHz spectrum. One additional point to note, however, is that the value of $\frac{Y}{X}$ may not necessarily be less than 1, since in some cases 900MHz spectrum has achieved higher auction values than 800MHz spectrum (e.g. in Romania and Austria). This is analogous to the value of $\frac{Y}{X}$ not necessarily needing to be greater than zero for 1800MHz spectrum, in particular when the benchmark for 1800MHz is lower than the benchmark for 2.6GHz in a particular market.[24]

[24] There was one such example, Sweden, in our distance method calculation for 1800MHz – using our corrected benchmark values calculated in Section 4 rather than a proxy for 2.6GHz.

Figure A.1: Illustration of the distance method as applied to the 900MHz band [Source: Analysys Mason and Aetha, 2014]



We are not of the opinion that the 800MHz value is necessarily an upper limit on the value of 900MHz. The 900MHz band is critical for the immediate, ongoing delivery of GSM services, and a substantial ecosystem for UMTS/HSPA+ at 900MHz is already in place. We understand that both Telefónica and Vodafone have deployed UMTS900 in the UK. Furthermore, although the 800MHz band is the leading low-frequency band for LTE, the device ecosystem for LTE900 is progressing rapidly (e.g. included in the specification for the iPhone 5s).

A.3 What objective criteria should be applied to the selection of benchmarks?

As discussed in Section 4, we previously set out criteria to determine whether benchmarks from different countries should be included or excluded in the analysis and whether they should be classified as more or less important (Tier 1 or Tier 2 in the context of this document). We suggested that, in line with our criteria for determining a relevant sample for 1800MHz benchmark analysis, countries are excluded from the 900MHz lump-sum determination if:

- The 900MHz band has not been auctioned within the relevant time period (as specified by Ofcom)
- For package bid auctions, no reliable information regarding the 900MHz prices can be inferred from publicly available information
- Certain bidders were excluded from the auction (particularly incumbent operators), as this would significantly constrain demand in the auction
- There is no reliable 800MHz benchmark – a requirement for the distance method calculation for 900MHz spectrum. In the absence of a 2.6GHz benchmark, a proxy could be used.

We continue to believe that these criteria are appropriate. These criteria are broadly consistent with Ofcom's approach in its second consultation, with the exception that Ofcom includes Denmark, despite incumbent operators being excluded from the Danish 900MHz auction. We therefore recommend that Denmark is excluded from Ofcom's set of benchmark countries.

Furthermore, we now suggest that, if using the distance method, countries are considered as Tier 2 if any of the following apply:

- Band-specific prices cannot be *directly* inferred (i.e. CCA/package auction benchmarks)
- A proxy is used for 2.6GHz price when using the distance method
- There is unsold spectrum in any of the three bands relevant for the distance method (800MHz, 900MHz or 2.6GHz)
- There is a significant time gap between the auctioning of the three required bands (800MHz, 900MHz or 2.6GHz)
- Spectrum in either of the three relevant bands (800MHz, 900MHz or 2.6GHz) was sold at its reserve price.

We therefore conclude that all 900MHz benchmarks should be classified as Tier 2, as set out in Figure A.2 below. As none of the 900MHz benchmarks is entirely without fault we therefore believe it is most informative to give each benchmark the same weighting.

Figure A.2: Result of categorisation of countries included by Ofcom into Tier 1 and Tier 2 evidence for derivation of a 900MHz lump-sum value [Source: Analysys Mason and Aetha, 2014]

Country	Band-specific prices not directly inferred?	Use of proxy for 2.6GHz?	Unsold spectrum?	Significant time gap between band auctions?	Auction finished at reserve price?	Conclusion
Austria	Yes			Yes		Tier 2
Ireland	Yes	Yes				Tier 2
Portugal			Yes			Tier 2
Romania	Yes		Yes			Tier 2
Spain					Yes	Tier 2

A.4 Results of the application of the distance method for the 900MHz band

Applying the distance method calculation for the above countries yields five estimates for the lump-sum value of the 900MHz band in the UK, as summarised in Figure A.3 below.

Figure A.3: Results of the application of the distance method for the 900MHz band [Source: Analysys Mason and Aetha, 2014]

Country	800MHz	900MHz	2.6GHz	Tier	UK 800MHz price used[25]	Distance method result for 900MHz UK lump-sum value
Austria	72.2	79.4	1.9	2	35.63	38.7
Ireland	63.5	39.6	6.8[26]	2	32.63	21.2
Portugal	37.3	24.9	2.5	2	32.63	22.9
Romania	43.9	47.3	10.6	2	31.08	33.7
Spain	40.4	26.4	1.9[27]	2	35.63	24.2
AVERAGE						**28.1**

This produces a weighted average result of GBP28.1 million per MHz for the lump-sum value for 900MHz spectrum in the UK.

A.5 Conclusion

The result of GBP28.1 million per MHz for the lump-sum value of the 900MHz spectrum using the distance method is only slightly higher than the figure of GBP27.3 million per MHz that was calculated using Ofcom's 900MHz to 800MHz ratio benchmarking method. As such, whilst we still believe that the distance method is the most robust method for determining the 900MHz lump-sum value, we do not have strong objections to Ofcom's use of the 900MHz to 800MHz ratio method to determine this value, although we note that it adds a further element of conservatism to the result.

25 In our calculations we have used the UK 800MHz value as indicated by Ofcom in Tables 3.2 and 3.3 of its second consultation.

26 Here we use a proxy value of GBP6.8 million per MHz as calculated by Ofcom.

27 This value is the one attained after a weighted average was taken into account, as discussed in Section 5.1.

Annex B Summary of criteria used by Ofcom for categorising benchmarks into tiers

As described in Section 3.1, Ofcom adopts a framework for categorising the benchmarks into tiers, which is based on the extent to which Ofcom considers the benchmark to be "informative of UK market value". Ofcom develops several criteria, which are cited in the analysis of individual countries, to explain its view of whether a benchmark is firstly representative of the market value in that country and secondly whether it is relevant to the UK. In this annex we list these criteria and provide a brief summary of each.

Criteria relating to whether a benchmark represents market value

► *Lot sizes too small for LTE*

Ofcom argues that where the lot sizes of at least some lots available in the auction (generally those available to incumbents) are not suitable for LTE (i.e. are smaller than 2×5MHz) then the benchmark may be less representative of market value.

► *Incumbents prevented from bidding*

Ofcom considers that where incumbent operators are prevented from bidding, the benchmark may be less representative of market value.

► *Unsold lots*

Ofcom suggests that where lots are unsold this may indicate that market value was not achieved because the prices were not set by bids.

► *Spectrum selling at reserve price*

Similarly, where spectrum sells at reserve price Ofcom argues that the price is not set by bidding and therefore the benchmark may be less representative of market value.

► *Too few bidders imply market value was not achieved*

Ofcom mentions on one occasion (for Sweden) that for an auction with fewer bidders (1800MHz) than other auctions in the same country (800MHz) there may have been less competition for the spectrum, resulting in the benchmark being less representative of market value.

► *Spectrum caps prevented competitive bidding*

Ofcom argues that tight spectrum caps can prevent an auction from revealing market prices if potential bidders are prevented from bidding their valuation due to the caps.

► *Non-contiguity of blocks created obvious contenders for certain lots*

This criterion only applies to Germany. Ofcom argues that the fact that T-Mobile already held block 4 in the 1800MHz band before the auction made it an obvious contender for blocks 1, 2 and 3, as it was the only operator capable of creating a 2×20MHz carrier out of this spectrum.

Criteria relating to whether a benchmark is relevant to the value in the UK

► *2G heavy markets*

For Romania, Ofcom argues that high 900MHz prices are a reflection that prices were driven to a large extent by the much greater importance of 2G in Romania compared with the UK.

► *1800MHz or 2.6GHz benchmark from before 2011*

Ofcom argues that where 1800MHz or 2.6GHz spectrum was auctioned before the eco-system for LTE in the 1800MHz band was as developed as it is today (i.e. prior to 2011), there may have been an impact on operators' relative valuations of these two bands.

► *Not the whole band was auctioned*

Ofcom considers whether the whole band was available for auction in one go, noting that where this was not the case this represents a difference from the UK situation.

► *Spectrum sold in separate awards*

This criterion only applies to Sweden, where the 800MHz and 1800MHz bands used to calculate the distance method result were auctioned in March and October 2011 respectively.

Annex C Discussion of individual countries

In this annex we provide a country-by-country discussion of our recommended classification in support of Section 4.

C.1 Austria

Ofcom uses the Austrian benchmark in the selection of both the 900MHz and the 1800MHz lump-sum values.

All spectrum in the Austrian CCA sold above reserve prices.

As discussed in Section 3, we do not agree with Ofcom's inconsistent treatment of package auctions. The auction in Austria was a CCA auction, which makes it difficult to infer band-specific prices from the available evidence. Nonetheless Ofcom categorises this benchmark as Tier 1. In contrast, Switzerland is excluded from Ofcom's benchmark set entirely, on the grounds that no reliable information is available regarding band-specific prices. Whilst there may be some differences between the results of the Swiss and Austrian auctions which mean that band-specific prices are harder to infer in Switzerland, there is still some evidence that can be gleaned from it – for example, that the price of 900MHz was clearly relatively high. However, if Switzerland is excluded due to reliable band-specific prices not being available, then it seems inconsistent for this issue to be completely ignored for other CCAs such as Austria. In other words, it is not consistent that Swiss band-specific prices are considered totally unreliable to the point that they should be completely excluded, but at the same time for no consideration to be given to lack of reliability of band-specific prices in Austria, and hence for Austria to considered as Tier 1 evidence.

A further reason to question Ofcom's decision to consider Austria as Tier 1 evidence is the fact that some bidders are legally challenging the auction result due to alleged irregularities with the auction procedure. Therefore the auction result may yet be subject to revision. Given that Ofcom's 1800MHz benchmark relies on only three countries and Austria makes such a material difference to its value, what would happen if the Austrian auction result was overturned after Ofcom has set ALF? Would Ofcom then need to re-calculate the 1800MHz ALF (using just two data points)?

Finally, as shown in Section 3.3 above, according to Ofcom, the likelihood, scale and direction of any risk of overstating or understating market value in Austria are not known. Therefore, taking this fact in conjunction with the arguments above, we do not consider Austria to be a benchmark with sufficient certainty to be classified as Tier 1. We believe that it should instead be classified as Tier 2 under our proposed framework and note that, other concerns notwithstanding, the lack of band-specific prices should be sufficient for the Austrian award to be downgraded to Tier 2.

C.2 Czech Republic

Ofcom uses the Czech benchmark in the calculation of only the 1800MHz lump-sum value.

The Czech auction was an SMRA comprising the 800MHz, 1800MHz and 2.6GHz bands. Five bidders entered the auction, but only the three incumbents won spectrum. There was unsold spectrum in the 1800MHz, 2.6GHz FDD and 2.6GHz TDD bands. Nonetheless, in both the 800MHz and 1800MHz bands spectrum sold above reserve prices, whereas the 2.6GHz band did not. The 1800MHz blocks won by incumbents were less than the minimum carrier size for LTE (i.e. less than 2×5MHz).

Conversely, as Ofcom notes in paragraphs A8.72 and A8.73 of the second consultation document,[28] the unsold spectrum in the 1800MHz band could mean that the reserve price was set too high and therefore exceeded market value, though the fact that incumbents were not allowed to bid for the unsold spectrum may also mean that full market value was not reached. Ultimately however, the spectrum that was sold was not influenced by the reserve price, as it sold for more.

In summary, there are a number of reasons why the Czech Republic may overstate or understate market value. As these reasons are likely to at least partly offset one another, we believe that the 1800MHz price can nonetheless provide some valuable evidence and should be considered as Tier 2 evidence under our proposed framework and in Ofcom's calculation of a weighted average 1800MHz lump sum value.

C.3 Denmark

Ofcom uses the Danish benchmark in the calculation of only the 900MHz lump-sum value.

As three of the incumbent operators were not allowed to bid in the 900MHz and 1800MHz auction in Denmark, Ofcom give this benchmark a weighting of zero in the calculation of the 900MHz weighted average lump-sum value (by classifying it as Tier 3). While, as mentioned previously, we do not agree with the approach of giving any tier a weighting of zero, we agree with the ultimate exclusion of Denmark. We do not consider that it provides valuable evidence on full market value of the 900MHz spectrum for the above reason and therefore recommend excluding it from the analysis.

C.4 Germany

Ofcom uses the German benchmark in the calculation of only the 1800MHz lump-sum value.

All spectrum sold above reserve prices in the auction.

In paragraphs A8.113 to A8.118 of Annex 8 of the second consultation, Ofcom speculates as to bidders' strategies in the 1800MHz band in some detail. Nonetheless, Ofcom arrives at the

[28] Ofcom (2014), *Annual licence fees for 900MHz and 1800MHz spectrum – Further consultation*.

conclusion that "[…] *there are possible reasons why the price of 1800 MHz spectrum might understate or overstate market value in Germany* […]".[29]

Our view is that Ofcom's interpretations are merely one possible explanation of the bids that were made and do not constitute reliable evidence for a non-competitive auction outcome. That notwithstanding, we comment on Ofcom's observations below. These are based on the auction outcome shown in Figure C.1 below.

Figure C.1: Spectrum holdings in the German 1800MHz band after the auction [Source: Analysys Mason and Aetha, Ofcom, 2014]

Ofcom comments on the first point made in our first report (that there were not 'obvious contenders' for all blocks) by arguing that E-Plus had the intention of only winning block E, and not block D. Ofcom argues that E-Plus was faced with the option of either:

a) bidding slightly higher on block D and probably winning it; or
b) not bidding higher on block D, definitely not winning it but probably having to pay for its withdrawn bid for it.

If Ofcom's assumption is correct, the price of block D may have been higher than E-Plus initially intended to bid for it. However, in this case the increase in the price paid by E-Plus is likely to be just a single bid increment, which is unlikely to materially change the price raised for this block, let alone the payment for the average lot.

Ofcom comments on the second point raised in our first report (that 2×15MHz lots are sufficiently large to be of value to all bidders, and not just those holding adjacent spectrum) by suggesting that T-Mobile was possibly the obvious bidder for blocks A, B and C, as it was the only bidder which could make a 2×20MHz carrier with these three blocks. Having access to a 2×20MHz carrier is important to mobile network operators as it allows them to offer and therefore advertise the fastest available peak speed on LTE to their customers. However:

[29] Ofcom (2014), *Annual licence fees for 900MHz and 1800MHz spectrum – Further consultation*, Annex 8, Paragraph 8.118.

a) All operators except E-Plus won 2×20MHz in the 2.6GHz band and are therefore able to advertise the fastest peak speeds in any case (although at an arguably lower coverage level). They would have been aware of the likelihood of this outcome, as 2×70MHz were available to the four operators in this band

b) 2×15MHz of 1800MHz delivers a comparable incremental capacity to operators with and without a further contiguous 2×5MHz. Consequently the capacity benefit, which is the other significant source of value, would have been similar for T-Mobile and the other operators

c) Telefónica, which following Ofcom's logic would have been the obvious bidder for block D, did not end up winning this block of spectrum

d) With intra-band carrier aggregation on the horizon (at the time of the German auction) and long licence durations, operators may not have placed as much importance as Ofcom implies on holding all 2×20MHz of spectrum in a contiguous block.

Therefore we do not consider that Ofcom's argument clearly demonstrates that T-Mobile was the obvious winner and that other operators did not bid up the price of blocks A, B and C to competitive levels.

For these reasons we do not consider the German benchmark to be significantly affected by the types of bidding behaviour which Ofcom suggests. As a result, we consider Germany to provide one of the best available benchmarks for 1800MHz and we classify it, according to the rules proposed by our framework, as Tier 1 evidence.

C.5 Ireland

Ofcom uses the Irish benchmark in the calculations of both the 900MHz and the 1800MHz lump-sum values.

All spectrum in the Irish auction sold above reserve prices.

As we described in Section C.1 regarding Austria, we do not consider it consistent to exclude Switzerland on the grounds that no band-specific prices can be reliably inferred from its auction but to categorise Ireland, another CCA, as Tier 1 evidence.

Furthermore, in the calculation of the Irish distance method benchmark for 1800MHz, Ofcom uses a proxy for the 2.6GHz band, as the 2.6GHz band was not auctioned in Ireland. This reduces the accuracy of the distance method benchmark and should also mean that the benchmark cannot be considered as Tier 1 evidence.

Furthermore, not only does the lack of a 2.6GHz price benchmark mean that one of the inputs to the distance calculation is not available for this benchmark, but it also means that 1800MHz prices are likely to have been inflated, as the band can be considered a substitute for the unavailable

2.6GHz spectrum. Therefore the 1800MHz band prices in Ireland risk overstating market value in the UK.

For these reasons we do not agree with a classification of Ireland as Tier 1 evidence and recommend that Ofcom should reclassify it as Tier 2 evidence, according to the criteria set out under our proposed framework.

Finally, we stand by the comments we made in our first report on the process followed for obtaining the Ireland benchmark. Vodafone selectively provided this benchmark to Ofcom, but we understand that it has not provided other similar benchmarks from other auctions that Vodafone Group was involved in. This is understandable from Vodafone's perspective, since it is in Vodafone's interests to provide a low 900MHz benchmark, whilst having less regard for the value of the accompanying 1800MHz benchmark. We are aware that Ofcom has validated the benchmark with the Irish regulator, ComReg, but the fact remains that without Vodafone's intervention Ofcom would not be using a benchmark from Ireland (as ComReg declined Ofcom's request to conduct LRP analysis on the bid data). To our mind this introduces a bias to the process, favouring the interests of a stakeholder which selectively provided Ofcom with the additional benchmark.

C.6 Italy

Ofcom uses the Italian benchmark in the calculation of only the 1800MHz lump-sum value.

We agree with Ofcom's assessment that Italy provides a Tier 1 evidence point, as there are no substantial arguments why this benchmark would not have provided market value in the relevant bands. We note that only 2×15MHz of spectrum was awarded in the 1800MHz band but agree with Ofcom that this should not be a reason for the benchmark not to be classified in Tier 1. As set out in our proposed framework criteria, this principle should be applied consistently in all benchmark countries.

C.7 Portugal

Ofcom uses the Portuguese benchmark in the calculations of both the 900MHz and the 1800MHz lump-sum values.

In the Portuguese auction all spectrum was sold at reserve prices, which in isolation could mean that the benchmark overstates market value. This is because the highest losing bid, which sets the price if there had been no reserve price, would have been lower than the reserve price. However, as we described in our first report,[30] the presence of spectrum caps may mean that despite spectrum selling at reserve prices the market value was not achieved. That is because a bidder that was prevented from bidding could in theory have submitted a bid higher than the reserve price that

[30] Analysys Mason and Aetha (2013), *Review of Ofcom's benchmarking of the value of the 1800MHz bands to determine annual licence fees,* Section 5.1.3.

would have become the highest losing bid and therefore the price paid. Because spectrum in Portugal sold at reserve prices and stringent spectrum caps were in place, we cannot be sure whether market value is understated or overstated for this benchmark. However, we see no reason to exclude it entirely and therefore recommend that Ofcom should classify it as Tier 2 benchmark, in accordance with our proposed framework.

C.8 Romania

Ofcom uses the Romanian benchmark in the calculations of both the 900MHz and the 1800MHz lump-sum values, classifying it as Tier 3 in both cases.

We agree that Romania is not a perfect benchmark since:

a) It was a package auction, which makes it difficult to determine band-specific prices, despite the fact that in this instance reserve prices can be used as a proxy for band-specific prices
b) There was unsold spectrum in the relevant bands.

However, as discussed in Section 3.4.3, we do not agree with Ofcom's assessment that the greater importance of 2G in Romania makes it a less relevant benchmark, as no market is a perfect representation of UK circumstances and this criterion only excludes a single benchmark. Therefore we recommend that Romania is classified as a Tier 2 benchmark, in accordance with our proposed framework.

C.9 Slovakia

Ofcom uses the Slovakian benchmark in the calculation of only the 1800MHz lump-sum value.

The auction in Slovakia was a CCA. However, we agree with Ofcom that it is possible to disaggregate prices in a meaningful way using reserve prices. Nonetheless, as discussed in Section C.1 above, we do not consider any disaggregation of CCA payments reliable enough to avoid relegation out of Tier 1. At the same time, however, we do not consider that the Slovakian benchmark should be excluded entirely.

Ofcom considers a number of reasons why the 1800MHz and 800MHz prices in Slovakia may risk overstating or understating market value in each case. It is argued that the 1800MHz reserve price could be higher than market value, as it was paid (subject to inaccuracies in the disaggregation of prices by band) by all winners. However, prices may also have been depressed due to the fragmentation of the available lots. Similarly, the 800MHz price was not pushed beyond reserve price through competition, but some operators argued that the reserve price was above market value.

The reserve price was used for the 2.6GHz value, which Ofcom suggests could have a risk of understating market value, but by an unknown amount.

Given this inconclusive evidence we do not agree with Ofcom's assessment that the distance method result will necessarily understate market value. We do not therefore see any objective reason to weight Slovakia differently from any other Tier 2 benchmark and therefore we recommend that Ofcom should classify it as such under our proposed framework.

C.10 Spain

Ofcom uses the Spanish benchmark in the calculation of only the 900MHz lump-sum value.

We are only considering the November 2011 auction for deriving a benchmark for Spain (i.e. not the preceding beauty contest). The caps in the 900MHz auction in 2011 effectively precluded some incumbents from bidding and therefore Spain is excluded from our benchmarks as per the framework we propose and describe in Section 4.

The November 2011 auction had spectrum caps set sufficiently high such that all incumbents could compete. The spectrum sold at its reserve price. Therefore it is possible that the benchmark could overstate the market value to some extent. However, we also note that only 2×5MHz of 900MHz was auctioned, and depending on the value that operators assigned to having contiguous spectrum lots of greater than 5MHz, it is also possible, although probably less likely, that the benchmark could understate market value. Consequently, overall we do not consider there to be clear evidence that Spain is overestimating or underestimating market value. On balance we therefore recommend that Ofcom should categorise it in Tier 2 under our proposed framework.

C.11 Sweden

Ofcom uses the Swedish benchmark in the calculation of only the 1800MHz lump-sum value.

In both the 800MHz and the 1800MHz auctions spectrum sold above reserve prices.

In Section 5.2.1 we discussed our view that an adjustment to the actual 2.6GHz price should be used, rather than a non-market-specific proxy as Ofcom suggests. Nonetheless, we agree with Ofcom's current classification of Sweden as a Tier 2 benchmark because:

a) We do use a proxy (albeit a different one) for the 2.6GHz band price by setting it equal to the 1800MHz band price
b) There is a time gap between the 800MHz and 1800MHz auctions.

Therefore, we do not recommend a change to the classification of Sweden from Ofcom's proposed Tier 2, and consider Tier 2 to also be the most appropriate categorisation under our proposed framework. However, in line with our arguments in Section 5.2.1 we strongly recommend that the Swedish benchmark is corrected both to use a more reasonable proxy and for the weighted averaging of lots described in Section 5.1.

Annex C Economic Insight report.

A report on Ofcom's proposed discount rate for setting ALFs

This report sets out our review and analysis of Ofcom's proposed discount rate for annual licence fees (ALFs) for 900 MHz and 1800 MHz spectrum. Whilst we agree with Ofcom that the relevant discount rate should be some form of cost of debt (rather than the WACC) the relevant debt cost should be much closer to the risk free rate than that proposed by Ofcom. In particular, we find that both the probability of default, and expected loss in the event of default are likely to be much lower in relation to the ALF than implied within Ofcom's proposals. On a pre-tax real (CPI) basis, our proposed cost of debt is 2.8%, compared to an equivalent of 3.8% under Ofcom's proposals.

Overview and context

In August 2014 Ofcom issued a further consultation ("the consultation") regarding its approach for deriving the annual licence fees (ALFs) with respect to radio spectrum in the 900 MHz and 1800 MHz bands. This followed its first consultation issued in October 2013 ("the October 2013 consultation"); a subsequent consultation relating specifically to determining a methodology for setting the ALF on the basis of CPI (rather than RPI) inflation; and an update on further European spectrum auctions that have been concluded since the October 2013 consultation.

In the October 2013 consultation Ofcom proposed to derive the ALFs by annualising the 'lump sum' value of the 900 MHz and 1800 MHz spectrum using an assumed discount rate. In principle such an approach ensures that the present value of the stream of ALF payments is equal to the market value

of the lump sum. The underlying economic rationale for this is that, assuming capital market efficiency (and assuming competitive purchasing and leasing markets) one would normally expect the net present value (NPV) of asset ownership to be equivalent to that of asset leasing (and in the current case, the ALF can be considered as equivalent to leasing spectrum from the Government, rather than purchasing it outright via an auction).

In order to apply the above approach in practice, however, Ofcom has had to consider: (i) what the appropriate discount rate should be; (ii) whether it should be set in real or nominal terms (and what the appropriate measure of inflation should be); and (iii) whether it should be set on a pre or post-tax basis.

In the current consultation, Ofcom has revised its approach to setting the ALFs (relative to the October 2013 consultation) in a number of ways. In particular, it has:

- updated the analysis of the market value of 800 MHz and 2.6 GHz spectrum in the UK;
- revised the interpretation of international benchmark evidence; and
- altered the choice of discount rate used to convert the 'lumps sum' values of the 900 MHz and 1800 MHz spectrum into annual licence fee equivalents (in particular, Ofcom is now proposing to use a cost of debt rather than a WACC, and is assuming that the spectrum would be 100% debt financed).

In the above context, Hutchison 3G UK Ltd (Three) asked Economic Insight to review Ofcom's latest proposals and provide our views regarding their appropriateness. In this note we therefore set out a range of evidence and analysis regarding this – focused primarily on the question of the choice (and level) of the appropriate discount rate, which we consider should be somewhat lower than that proposed by Ofcom – primarily because Ofcom's proposals include a debt premium that does not reflect the actual risk faced by Government under the proposed arrangements. The remainder of this paper is structured as follows:

- a summary of Ofcom's proposed discount rate (and supporting rationale and evidence);
- our views and comments regarding Ofcom's proposed approach;
- our analysis and evidence regarding the appropriate discount rate; and
- our review of Ofcom's revised proposed tax adjustment factor.

Ofcom's proposed discount rate

Context to Ofcom's proposals

As noted in the consultation, Ofcom makes use of discount rates for a number of different – but related – purposes. For clarification therefore, here we are focusing on the discount rate used for the purpose of annualising the estimated lump-sum values of spectrum, so as to derive the ALFs. In doing this it is important to note that the purpose of the discount rate is not to reproduce the original cash flows on which any lump sum values were themselves based. Rather – and as acknowledged by Ofcom – it is "*seeking to spread the lump-sum value over the period covered by the ALFs to calculate a constant real annual payment from the MNOs to the Government, the ultimate recipient of revenue from ALF payments.*"[1]

Consistent with the above, conceptually the ALF arrangements can be characterised as Government providing finance to MNOs in relation to the spectrum. That is to say, the ALF payments represent a 'cash flow' stream from the MNOs to Government in order to 'lease' the 900 MHz and 1800 MHz spectrum. Given this, the 'discount rate' that Ofcom is setting for deriving the ALF represents the opportunity cost to Government of providing that finance – that it is to say, it should capture both the *time value of money* (i.e. the risk free rate) and any appropriate *risk premium.* In relation to the latter, the critical issue is that any 'risk' should specifically relate to the riskiness of the cash flows from Government's perspective.

The fact that the discount rate should reflect risk borne by Government is non-contentious and is acknowledged by Ofcom: "*the discount rate used to annualise the lump-sum value should reflect the*

[1] '*Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.*' Ofcom (2014). Para 4.12

risk of the cash flows coming from MNOs to the Government through the ALF, rather than the risk to the MNOs of the cash flows associated with using the spectrum."[2] This, then, raises the question as to precisely 'what' risks Government faces and how these should be quantified and reflected within any discount rate – these are the issues we consider subsequently.

Deriving the discount rate using the cost of debt rather than the WACC

In the current consultation Ofcom is proposing to use the cost of debt (2.6% post-tax real) for deriving the ALFs. This represents a change from the October 2013 consultation in which Ofcom proposed to use a WACC. In summary, Ofcom's proposal to use a cost of debt is based on its view that: (i) in reality, the discount rate should be some way between the cost of debt and the WACC; (ii) but it is most likely closer to the cost of debt; and (iii) it would be practically difficult to determine a discount rate between the cost of debt and the WACC (and so Ofcom is being intentionally 'conservative' by electing to use the cost of debt). In the following we expand on each of these points as set out by Ofcom.

Ofcom suggests the discount rate could be between the cost of debt and the WACC

Ofcom arrives at the conclusion that the appropriate discount rate should lie between the cost of debt and the WACC by considering two different "what if" scenarios for the risk-profile of the ALFs.

- Firstly, Ofcom considers that were ALF payments *"set up such that the risk of the ALF payment were the same as the risk of future after-tax cash free cash flows (e.g. through some form of net revenue sharing arrangement between the MNOs and the Government), the correct discount rate to use would be the rate used to convert the expected cash flows from using the spectrum into the bid value. This may be approximated by the MNOs' WACC."*[3]

- Secondly, Ofcom considers another scenario, where were ALF payments are *"set up so that they were completely fixed regardless of circumstances, and MNOs had no option but to pay this level of fee, the ALF would effectively be akin to a form of highly secured debt and the correct discount rate would be the corresponding interest rate for such a debt instrument"*[4].

In relation to why the WACC might be a relevant reference point (i.e. why the risk profile of ALF payments from the perspective of Government might approximate the risk profile of MNOs' underlying cash flows) Ofcom makes two statements:

- Firstly, that MNOs can avoid repaying the ALFs by handing back spectrum. This, therefore, allows them to default without there being any wider impact on their financial operations – which, Ofcom asserts, might be expected to increase the default probability relative to other forms of debt.

- Secondly, that the value of the ALF could be revised up or down in future. Ofcom states that where such revisions reflect changes in the market value of spectrum, this transfers some cash flow risk back to Government – and so would point to the ALF lying between the debt case and the WACC case.

Given the above, Ofcom states that – ideally – the correct discount rate would be based on the following formula:

*ALF discount rate = debt rate + Government share of operating risk * (WACC – debt rate)*

Ofcom further specifically states that in all eventualities the risk free rate is not appropriate, because by definition Government faces *some* risk of MNOs defaulting on payments.[5]

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[2] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para 4.12*

[3] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para 4.13*

[4] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para 4.13*

[5] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para 4.14*

Ofcom states that the discount rate is most likely closer to the cost of debt

Whilst Ofcom believes that the 'true' discount rate should lie between the cost of debt and the WACC, it explicitly states that the rate appears to be closer to the cost of debt than the WACC.[6] Ofcom cites two key reasons for this:

- "*the ALF payable is fixed in advance and does not vary depending on the return the MNOs actually earn from the spectrum; and*
- *the ALF payment is secured against an asset (i.e. the spectrum the licence entitles the MNO to use), which is returned to Ofcom if the ALF is not paid.*"[7]

Within the annex to the current consultation, Ofcom further states that: *"If the ALF obligation was an entirely fixed fee MNOs had to pay under all circumstances, it would be very similar to a leasing arrangement…"* in which case *"the equivalent discount rate would therefore be a current market long-term fixed index-linked secured debt rate."*[8]

For practical reasons, and to be conservative, Ofcom proposes to use the cost of debt

Ofcom ultimately takes the view that it is impractical to determine the extent of any 'risk transfer' to Government under the ALF arrangements. This, Ofcom states, is because it depends on the extent to which ALF can be reviewed and revised in future – the exact mechanism through which any such review is undertaken; and also whether any review and revision reflects changes to the underlying value of spectrum, or is instead driven by other factors.[9]

Taking the above into consideration, along with: (a) its view that the appropriate discount rate should be closer to the cost of debt than the WACC (as above); and (b) its view that it is appropriate to be 'conservative' when setting the discount rate,[10] Ofcom ultimately proposes to use the cost of debt.

Empirical evidence used by Ofcom to set the cost of debt

Having set out Ofcom's proposals and underlying rationale above, in the following we briefly summarise the primary empirical evidence relied upon by Ofcom to support its proposal to apply a cost of debt of 2.6% (post-tax real).

Ofcom examined two different approaches to derive the appropriate cost of debt rate: a spread analysis; and a yield to maturity analysis, using bonds issued by the UK MNO parent companies as the closest comparator. The table below summarises the spread data Ofcom used, which relates to the sterling denominated debt of each MNO parent company with a maturity date at least 20 years in the future, or with the longest maturity date.

[6] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para 4.17*

[7] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para 4.17*

[8] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Annex 10, 10.7-10.8.*

[9] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para 4.24*

[10] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para 4.25*

Table 1 Spread over government gilts for parent companies of UK MNOs reported by Ofcom

MNO parent	Debt maturity	12 month average spread	12 month min	12 month max	Current spread (July 2014)
Vodafone	2032	1.1%	1.0%	1.3%	1.1%
Telefonica	2029	2.0%	1.5%	2.9%	1.6%
Orange	2034	1.4%	1.2%	1.7%	1.3%
	2050	1.4%	1.2%	1.7%	1.4%
Deutsche Telekom	2030	1.2%	1.0%	1.4%	1.1%

Source: Ofcom

Ofcom considers that a range of 1.0% -1.7% would be a reasonable measure of the long-term debt premium for an average efficient MNO.[11] Reflecting the view that relatively more weight should be placed on Vodafone's data – and relatively less on Telefonica's – Ofcom states that a reasonable interpretation of the spread data would be a debt premium of 1.2%, slightly below the midpoint of its identified range. Ofcom adds this debt premium to an assumed nominal risk-free rate of 4.6% (using the same real risk-free rate of 1.3% as used in the LLU and BCMR Statements) giving a pre-tax nominal cost of debt of 5.8% and a post-tax nominal cost of debt of 4.7%,[12] where the post-tax cost of debt is given as: *pre-tax rate x (1-marginal tax)*.

Ofcom also examined the yield to maturity of the same sample of sterling denominated debt listed in the previous table. Based on this Ofcom considered 4.6% to be a reasonable yield to maturity for an average MNO – which implies a 4.6% pre-tax nominal cost of debt and a post-tax nominal rate of 3.7%.[13]

The above two approaches imply a somewhat different cost of debt. The spread approach suggests a post-tax cost of debt of 4.7% compared to 3.7% under the yield to maturity method. Ofcom prefers the spread approach, based on the fact that it is the method applied when calculating the cost of debt for the WACC.[14] Consequently, Ofcom uses the 4.7% post tax nominal cost of debt derived from the spread analysis, then adjusts this for inflation (as the spreads are not indexed linked and will move as inflation expectations change).[15] This, finally, results in a proposed cost of debt of 2.6% (post-tax real, on a CPI basis).

Our views regarding Ofcom's proposed discount rate

In this section we set out our views regarding Ofcom's position – and relatedly – the implications for setting a discount rate for determining the ALF. We have two main points to make in relation to Ofcom's proposed approach.

» Firstly, an appropriate characterisation of the proposed ALF arrangements shows that the MNOs' WACC is not a relevant reference point for setting the discount rate for determining the ALF – largely for the reasons Ofcom now recognises. The appropriate discount rate ***must*** be below this – and should reflect some form of debt rate.

[11] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para A.10.13*

[12] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para A.10.18*

[13] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para A.10.24*

[14] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para A.10.30*

[15] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para A.10.39*

- Secondly, Ofcom should set a cost of debt that only reflects the actual risks borne by Government. In particular, by benchmarking the cost of debt with reference to existing MNOs bonds, Ofcom's current approach instead reflects an 'average' of the prevailing portfolio of default risks. This will result in the discount rate being over-stated, given the characteristics of the ALF arrangement (in our view the ALF is more akin to highly securitised debt – and should be closer to the risk free rate than the WACC). Further, and as set out in the subsequent sections of this paper, it is possible to use empirical evidence and analysis to inform what the appropriate 'risk' and therefore discount rate should be, and this is preferable to relying on benchmarks (such as MNO parent company spreads on unsecured debt, as used by Ofcom) that will, by definition, not reflect the default risk Government will face.

In the remainder of this section we expand on the above points in turn.

MNO WACC is not a relevant benchmark

Ofcom's start point for examining the appropriate discount rate (as summarised previously) was to undertake a "what if" analysis, based on examining the case where (i) the WACC was the appropriate discount rate; and (ii) where a (securitised) cost of debt was the appropriate discount rate.

With regard to the former, Ofcom specifically stated that the MNOs WACC would be appropriate where: *"the ALF payment were set up such that the risk of the ALF payment were the same as the risk of the future after-tax cash flows [of MNOs]."*[16] However, it is clear that the proposed framework for the ALF payments means that this is simply not the case. Indeed, as Ofcom states, this would only be true if there was some form of net revenue sharing arrangement between the Government and MNOs, or where the ALFs were revised for changes in economic value in 'real time' – so that 100% of the relevant risk was transferred to Government. Neither of these are true, and consequently, Ofcom's own logic suggests that the risk profile of the ALF payments - from Governments' perspective - is not analogous to that of the overall cash flows of MNOs.

Further to the above, to the extent that any risk transfer to Government depends (as stated by Ofcom) on the degree and frequency with which ALFs can be subsequently revised – and the degree to which this reflects changes in its underlying economic value – we note the following issues:

- That Ofcom has now committed to there not being a review of the ALF for a period *of at least five years* – and is initially setting the ALF over a 20 year period. In other words, for the next five years (at least) Government bears *none* of the risk associated with the economic value of spectrum diverging from that used to derive the ALFs.

- Secondly, that Ofcom has stated that it will likely only review the ALF where there are grounds to believe that a material misalignment had arisen between the level of these fees and the value of the spectrum. In other words, risks associated with future variations in the economic value of spectrum (and the cash flows MNOs relatedly generate) relative to the lump sum estimates used to derive the ALF will be *entirely borne by the MNOs* (not Government) unless that variation is "material". In other words, Government's risk is effectively 'capped' and could perhaps be characterised more in terms of low probability / high impact events that could cause spectrum value to diverge materially from that currently estimated by Ofcom. Again, it seems highly questionable as to why the MNOs' WACC is relevant in this context, therefore.

- Thirdly, Ofcom has not, so far, set out any formal review framework or process, or indicated its intention to do so. Therefore, other than the above guidance (taken from the latest consultation) both the process, grounds and timings (beyond five years) of any review remain unknown. Critically, this means that it is within Ofcom's / Government's control as to the extent to which any such future, unspecified, process might transfer risk to Government.

[16] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Para 4.13*

» Fourthly, and related to the above, as Government / Ofcom retains control of any review process, arguments could be made that – even to the extent that there may be some risk share, it is asymmetric in Government's favour.

The above are not 'minor' considerations that suggest that, whilst the MNOs WACC may be relevant, the true discount rate for deriving the ALFs should be only a little below this. Rather, they imply that the MNOs' WACC is not a relevant benchmark for deriving the ALFs at this time – and that therefore, the appropriate discount rate should be substantively below this. Put simply, without a clear and transparent framework for future ALF reviews (under which the rules and procedures are clearly set out) and whereby it can clearly be evidenced that there is a cash flow risk transfer – we would suggest that postulating that there 'may' be a risk transfer is insufficient grounds for considering the WACC to be a suitable benchmark in the first place.

The corollary of the preceding is that – if Ofcom really believes the current arrangements do transfer some MNO cash flow risk to Government, then by definition, investors in MNOs would be willing to accept a lower rate of return in future – and so one would expect to see this reflected in MNOs' WACC. In Ofcom's latest MCT market review there is no discussion (or evidence) in relation to the determination of the WACC that implies that Ofcom has factored any risk transfer from MNO equity or debt holders to Government into its approach.[17] Relatedly, we do not consider it credible that MNO investors would regard the underlying riskiness of their cash flows to have been reduced by the current proposed ALF arrangements.

The cost of debt used should be consistent with the actual risks faced by Government under the proposed arrangements

In setting out its rationale as to why the risk free rate is not the appropriate benchmark, Ofcom states: *"we note that even where the ALF payments are completely fixed, there is still a risk that the Government does not receive the payments due to the risk that the license holder may default on its payments. Therefore the appropriate discount rate would be some form of cost of debt (which includes a premium to reflect such risk) rather than the risk-free rate, as argued by some stakeholders."*[18]

Whilst we do not believe the WACC to represent a meaningful reference point for determining the ALFs (for the reasons set out above) we agree with Ofcom that Government does bear *some* theoretical risk – and that consequently, the appropriate discount rate may be above the risk-free rate – and should, in fact, be some form of debt rate. In our view, the two key risks Government potentially faces, relative to a risk free cash flow, are: (i) any sharing of risks associated with a change in spectrum value – discussed above; and (ii) risks associated with non-payment by MNOs. Regarding the second of these, here we are referring to the risk of MNOs defaulting on their payments (or, potentially, handing back the spectrum – were this to happen) and relatedly the risk of a subsequent 'fallow' period thereafter. Our view, therefore, is that it is appropriate to properly identify (and quantify) the actual risks faced by Government under the current proposed arrangements and use this to inform the setting of the discount rate.

Related to the above, in the following we set out the economic theory and evidence regarding the relationship between default risk, the spreads on corporate debt, and the relevance of this to Ofcom's proposed discount rate.

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[17] *'Mobile call termination market review 2015-18.' Ofcom (2014). See in particular annexes 14 and 17 in which there is no discussion of there being any risk transfer to Government.*

[18] *'Annual license fees for 900 MHz and 1800 MHz spectrum: further consultation.' Ofcom (2014) paragraph 4.14.*

The theoretical framework for bond yields and default risk

The economics and corporate finance literature sets out the framework that links credit spreads to default probabilities. That is to say, the expected loss faced by a lender is given as:

$$\mathrm{L} = p(1 - RR)$$

Where L is the expected loss, p is the probability of default, and RR is the expected recovery rate (which is the proportion of the value that can be recovered in the event of a default arising).

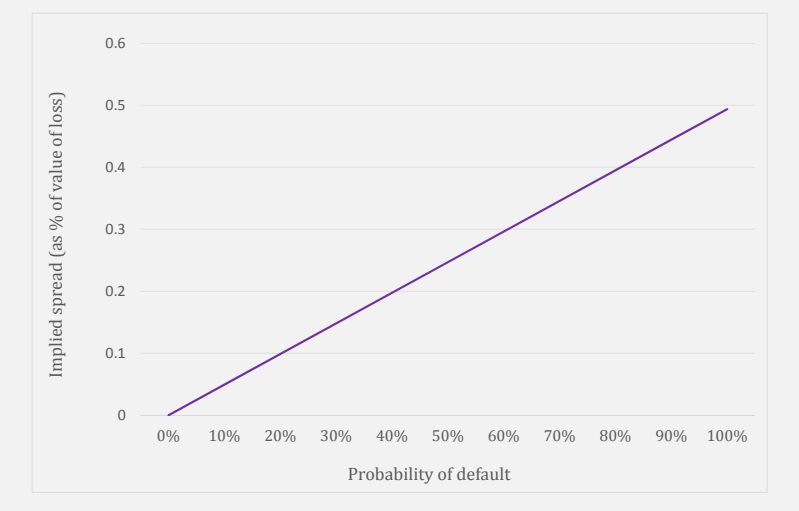
Assuming there are no market frictions, the 'spread' on debt is a direct function of the above expected loss. That is to say, the premium for default is exactly equal to the present value of the expected default loss – and so the spread is given as:

$$S = \frac{p(1 - RR)}{1 + r}$$

Where S is the spread on the debt, $p(1 - RR)$ is the expected loss, as above, and r is the risk free rate.

The above result is derived from the 'structural model' framework and has its origins in Black and Scholes (1973)[19] and Merton (1974)[20]. Put simply, it implies that absent any market imperfections, the credit spread should always be the annualised risk-neutral probability of a loss. The figure below illustrates this, assuming a 50% recovery rate. Intuitively, once the probability of default reaches 100% the required spread will be equal to 50% of the expected value of the loss, reflecting the fact that the lender is guaranteed to recover half of the underlying value – and so needs to price for the half that it will not recover.

Figure 1: Illustration of spread / default risk relationship



Source: Economic Insight

Applying default risk framework to Ofcom's proposed cost of debt

It is helpful to consider Ofcom's proposed cost of debt in the context of the above framework. In particular (and as summarised previously) Ofcom's proposed cost of debt is based on an assumed spread of 1.2% (nominal pre-tax). One could take the view that conceptually this 'spread' represents the default risk (i.e. the probability and extent of loss) associated with MNOs not making ALF payments to Government.

[19] *'The Pricing of Options and Corporate Liabilities.' Black and Scholes. The Journal of Political Economy, Vol. 81, No. 3 (1973).*

[20] *'On the Pricing of Corporate Debt: the Risk Structure of Interest E Rates' Merton, Journal of Finance 29 (1974).*

It is clear that there is some uncertainty regarding quite what risks Government will face under the current proposed arrangements. Nonetheless, there are two key known features of the arrangements of relevance to the above:

- That the ALF is secured against an asset, which Government would continue to own even in the event of default, and which could subsequently be reassigned (this characteristic is linked to the default possibility identified above). With reference to the previous discussion, this means that one would expect the *recovery rate* for Government to be 100%, with *potentially* only a minor downward adjustment to reflect any value loss during a fallow period (which we discuss in the section below).

- That Government does bear the risk associated with the possibility of 'default' with regard to the ALF payments – but we believe that this risk is likely to be extremely minimal for the reasons outlined subsequently.

The ALF is secured against an asset, implying a high recovery rate for Government

A key feature of the ALF arrangements is that the debt finance implicitly being provided by Government is entirely secured against an asset, because the Government retains ultimate ownership of the spectrum under all eventualities. This means that, in the event of default (as described above) Government can recover non-payment and, in the unlikely event of spectrum being handed back, can quickly re-lease the spectrum in order to realise its value.

All of the above is critical, because it means that the expected default losses, from Government's perspective, will be lower than those implied within Ofcom's proposed 2.6% cost of debt, which reflects the senior unsecured debt of the MNO parent companies.

There is, then, a question of whether the ALF should be treated as 'fully secured' debt, or 'highly secured debt' – and this, critically, rests on what one believes would happen in the (unlikely) event of a fallow period. Here, in principle, there could be two possibilities:

- That the rents Government forgoes during any fallow period are essentially 'lost', so that when the spectrum is re-leased, the loss from the fallow period remains unrecovered.

- Alternatively, one might expect Government to fully recover any 'lost' rents from the fallow period in any subsequent re-leasing of the spectrum.

The above relates directly to the assumed 'recovery rate' for Government. Under the former outcome, the recovery rate for Government would be slightly below 100%. That is to say, it would be adjusted down to reflect the ratio of the lost income during any fallow period to the overall lifetime value of the ALF. Under the latter outcome, the recovery rate would, of course, simply be 100% (because Government would always be expected to recover the entirety of the value). In our view, the characteristics of the ALF (i.e. it is a non-depleatable asset) would tend to indicate that the appropriate start point is to assume that Government would always recover 100% of the value, even in the event of a fallow period. Further, there are two key reasons as to why a fallow period is unlikely altogether, which would also imply a 100% recovery rate. These are as follows:

- Firstly, if any individual MNO no longer required a proportion of its spectrum holdings, it would be free to resell them to another MNO. In this case, given that the ALF is set (on a conservative basis) at market value, the spectrum should always have a positive value to the purchasing MNO, who would take over the ALF payments. This would tend to suggest that resale is more likely than hand back (as hand back provides zero value to the MNO in question).

- Secondly, in the event that an MNO was in financial difficulty, then its most likely options would seem to include merging with another MNO, or again re-sale of the spectrum (as hand back is a zero value option). In either eventuality there would be no fallow period.

Consequently, given the above, we would suggest that the appropriate characterisation of the debt is that it is fully secure. However, even allowing for non-recovery during a fallow period, the debt

would remain 'highly secure' with a recovery rate close to 100% (we discuss this further in our assessment of the appropriate discount rate).

Regardless of whether the debt is fully secure (with a 100% recovery rate) or just highly secure (with a recovery rate slightly below 100%) the central point remains: namely that there is clearly a high degree of security from Government's perspective, and that this will not be reflected in the unsecured debt rates that Ofcom has used to set its benchmark. Indeed, we note that Ofcom specifically states that: *"secured debt would attract a lower rate than an unsecured debt due to the greater probability of the creditor recovering a greater proportion of their investment in the event of a default."*[21] We agree with this – again noting that the possibility of default does not affect the central point – that relative to unsecured debt, Government would expect to recover a greater proportion of debt in relation to the ALFs.

In our view, therefore, it is clear that – not only is the risk borne by Government under the ALF arrangement much more akin to a debt rate than the MNOs' WACC – but in fact is highly similar to secure debt, regardless of whether it is fully secured or not.

The default risk faced by Government is likely to be minimal

The default probability arises from the possibility that a licensee (MNO) could either default directly (i.e. the MNO fails and ceases to make ALF payments); or indirectly (by 'handing back' the spectrum). As these possibilities are present, it is clear that a risk premium must be included within the discount rate to reflect this. However, a consideration of the features of the asset in question, and the nature of the ALF arrangements, indicates that this risk is likely to be minimal. In particular:

- Firstly, the spectrum is an essential input into the provision of mobile telephony services – consequently, the existing MNOs could not continue to provide their services without it. Consequently, the possibility of *direct* default would seem to arise where an MNO was in insolvency and was thus exiting the market (for reasons unrelated to the economic value of the spectrum – which we discuss below). This is a relatively low likelihood event. Indeed, in its first ALF consultation Ofcom acknowledged this, stating that such considerations *"significantly reduce the chances of the ALFs we propose being set (inadvertently) so much higher than the actual market value that they trigger a return of spectrum."*[22]

- Secondly, the possibility of 'hand back' would seem to arise in cases where there was a material misalignment between the prevailing ALFs and the underlying value of the spectrum. In theory this could occur where: (i) the economic value of the spectrum had *fallen* to a point where it was optimal for MNOs to do without the spectrum (because alternative assets were more value adding from their perspective); or where (ii) the economic value of the spectrum had *risen* to a point where for Government it would be optimal for Government to allow hand back in order to re-auction the spectrum to users other than the MNOs (even allowing for any fallow period – see below). In the first case, this would indicate that the ALF is too high and should be revised down. In the second case, it would seem that the spectrum is of greater value if put to alternative uses. In either case, Government has not lost out. Further, this would seem to suggest that, for default to occur for reasons linked to economic value, a more efficient use of the spectrum would need to exist (such that the ALF could not be revised up or down so that it would remain optimal for the spectrum to continue to be leased to the MNOs).

With regard to the potential length of the any fallow period, we note that:

- In the event of a 'direct default' due to MNO insolvency (which here is unrelated to the economic value of the spectrum – which is addressed in the bullet below) the remaining MNOs would most likely need to acquire the associated spectrum (as their existing capacity would be insufficient to meet the demand of the customers of the insolvent MNO). In this eventuality, any fallow period

[21] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Annex 10, 10.33*

[22] *'Annual licence fees for 900 MHz and 1800 MHz spectrum Consultation.' Ofcom (2013), see A9.4*

would most likely be relatively short, and would primarily be a function of the 'processes' required in order to re-auction the spectrum.

» With regards to the latter (i.e. where default is triggered by a misalignment in economic value) then the expected length of the fallow period would also be the re-auctioning process as above. This is because, whilst the number of potential buyers for the spectrum could vary depending on what the economically best use of it was, this would merely determine the "price", and should not – in and of itself – drive the fallow period.

Implications for the approach to setting the discount rate

In our view, the characteristics of the ALFs, when considered in totality, imply that the total default risk Government faces in this instance is likely to be lower than that embedded with Ofcom's proposed 1.2% spread. This is because both the probability of default and the expected loss in the eventually of default are likely to be lower in the ALF case relative to the evidence Ofcom has relied upon in setting its cost of debt. In short this arises from the fact that Ofcom has relied on benchmarks based on average senior unsecured debt, which will not reflect:

- that for Government the ALF is either fully secured, or highly secured, such that the recovery rate will be at, or close to, 100%; and
- that the probability of any default is likely to be extremely low (i.e. lower than the average reflected in the overall portfolio of senior unsecured debt) given the characteristics of the ALF.

The implication of this is that the 'default risk' element of Ofcom's debt rate is likely to be over-stated. Consequently, in our view, it would be appropriate to seek to develop evidence and analysis to ensure that this element of the debt rate better reflected the appropriate level of default risk.

In principle, there are two ways in which one could seek to capture the 'lower' risk faced by Government relative to the overall 'average' default risk captured by Ofcom's proposals:

- 'bottom up' modelling that parameterises the default risk and converts it into a risk premium to be converted within the discount rate; and / or
- 'top down' comparisons – for example, based on rates for securitised and unsecuritised debt.

In relation to the latter, we acknowledge that (as noted by Ofcom) there may be practical barriers to identifying any simple 'securitised / unsecuritised' adjustment in this regard. Similarly, in relation to former approach, input parameters will remain subject to some uncertainty. Nonetheless, we think that a combination of the above two methods is likely to provide a better – and more direct – measure of the relevant default risk. More importantly, we think that despite the limitations identified here, it is preferable to attempt to assess the relevant default risk than to assume the default risk embedded within bond spreads of the MNO parent companies (for unsecured debt) which Ofcom accepts will over-state that default risk. This is particularly the case given that Ofcom has explicitly stated its intention to be 'conservative' when setting the ALFs.

Our assessment of an appropriate discount rate

Based on the views and evidence set out in the preceding sections of this report, we believe that some form of debt rate is the appropriate basis for annualising the ALFs. However, here the spread over the risk free rate should reflect:

- a minimal level of default probability; and
- an assumed recovery rate of either 100% or close to 100% (depending on whether one assumes any fallow period would arise, and whether the associated rents would genuinely be forgone from Government's perspective).

Estimating debt spreads based on assumed default risks

In line with the discussion above, in the following we set out our calculation of implied debt spreads based on default probabilities and recovery rates that we consider to be aligned with the ALF.

Approach to setting the probability of default

Establishing the appropriate default probability is subject to uncertainty. However, given what we know about the ALFs' characteristics, we know that it may be greater than zero (i.e. it is not riskless) but will be markedly lower than the average probability implied by the overall debt premium for MNO parent company unsecured bonds.

Our analysis suggests that Ofcom's debt premium of 1.2% implies a default probability of 2.41% (in year), as shown in the table below. To calculate the implied probability, we have had to assume a recovery rate (i.e. the proportion of value that would be recovered in the event of default). As Ofcom's debt premium of 1.2% is based on senior unsecured debt, we have here assumed a recovery rate of 48%. This reflects Standard and Poor's assessment of the average recovery rate for senior unsecured European bonds between 2003 and 2010[23] and so is broadly likely to reflect the recovery rates implicit in the MNO numbers referenced by Ofcom. Note, as we explain subsequently, in practice we consider that the appropriate recovery rate for the ALF should be materially higher than this. However, as here we first seeking to identify the default probability implied by Ofcom's proposed spread, we should impose a recovery rate consummate with the comparators they used. As we believe the probability of default will be lower in relation to the ALF (for reasons outlined above), this suggests that the 2.41% implied by Ofcom's spread should represent an upper bound when considering the appropriate discount rate for the ALF.

Further to the above, however, in practice the recovery rate for the ALF is likely to be much higher than for senior unsecured debt. This is because, in the unlikely event of default, we would expect Government to recover most, if not all, of the spectrum's value. It is therefore informative to calculate the default probability implied by Ofcom's spread of 1.2% using a higher recovery rate, more in keeping with the ALF. We think that a suitable recovery rate for modelling purposes is 93% (as we explain later, this reflects a plausible assessment of lost rents during a fallow period), although again as discussed previously, 100% recovery may be more plausible.

Taking a 93% recovery rate results in Ofcom's spread implying a default probability (in year) of 17.9%. Put simply, using a recovery rate commensurate with that likely to apply in the case of the ALF, Ofcom's spread would appear to be materially overstated (see table overleaf).

[23] *"Senior [European] unsecured debt… achieved recoveries of 48.0% between 2003 and 2010, which compares well with the U.S. long-term empirical average of 51.8%." Taken from 'Europe's Senior Loan Market Delivers A Strong Recovery Performance Over Its First Cycle.' Standard and Poors' Global Credit Portal (2012).*

Table 2 Illustrating default probabilities implied by Ofcom's spread

Calculation step	Ofcom parameters	
	Scenario A	Scenario B
Spread	1.2%	1.2%
Nominal risk free rate	4.6%	4.6%
Assumed recovery rate	48%	93%
Implied default probability *(1+RFR) / (1- recovery rate) * spread*	2.41%	17.93%

Source: Ofcom and Economic Insight analysis

Determining the recovery rate – fallow periods

As explained previously, we think it would be reasonable to assume that Government would achieve a 100% recovery rate with regards to the ALF. This is because, even in the unlikely event of a fallow period, there is no reason as to why the economic value (including any income forgone during the fallow period) would not ultimately be recovered through re-leasing.[24]

In circumstances where the above does not hold, however, the recovery rate is essentially a function of the likely length of any fallow period. Here our view is that, regardless of the cause of the default, the expectation should be that any fallow period is equal exactly to expected time it would take to re-auction the license. This is because any misalignment between the ALFs and spectrum value should be dealt with through 'price', rather than impacting the time to reassign the spectrum.

Given this we have examined the timetables Ofcom used for both the 4G and 3G spectrum auctions. Focusing firstly only on the auction process itself, we found that:

- The total elapsed time between applications for auction pre-qualification and license award was 3 months.[25]
- In relation to the 3G auction, the total elapsed time from auction pre-qualification to license award was 4 months.[26]

In addition to the auction process itself, however, Ofcom would have to determine the appropriate approach for the auction – which might need to include time for consultation. In principle, the re-auction of spectrum might be anticipated in advance, facilitating a relatively quick sale process. However, even allowing for consultation (in addition to the above auction process) 18 months would appear to be the maximum period one might reasonable assume – and therefore this

[24] *As the recovery rate is defined here as the proportion of total economic value recovered – and so in principle, temporary periods of non-payment do not necessarily result in a recovery rate <100%.*

[25] *See: http://consumers.ofcom.org.uk/news/ofcom-finalises-4g-auction-rules/ Ofcom published the timetable on November 12th 2012. Application for pre-qualification was December 2012. 4G licenses were awarded in March 2012 – giving elapsed time of 3 months.*

[26] *See http://licensing.ofcom.org.uk/radiocommunication-licences/mobile-wireless-broadband/cellular-wireless-broadband/policy-and-background/history-of-cellular-services/ the DTI announced qualified applicants for the auction on January 12th 2000. 3G spectrum licenses were awarded to One 2 One, and TIW Ltd on May 9th 2000.*

provides an upper bound with regards to the length of any fallow period (noting in any case, that for reasons explained elsewhere, the likelihood of this occurring at all would appear to be low).

Arguably the above is a conservative approach. Indeed, in the event of default Ofcom / Government could choose to re-award to spectrum in question through some other mechanism – or indeed could intentionally run some form of expedited process (e.g. one that was more reflective of the 3 to 4 months of elapsed time from pre-qualification to license award). For example, if the default is unrelated to a material change in economic value (say instead it was due to insolvency of an MNO) the prevailing ALF price (and therefore spectrum value) may be deemed to be appropriate.

In any case, on the assumption that a fallow period could last for 18 months, the implied recovery rate, assessed over 20 years (to reflect the notional license term) in the first instance, is given by:

$$Recovery\ rate = 1 - \frac{18}{20 * 12}$$

The above implies a recovery rate for the ALF of 93%, as shown in the previous table.

Modelling results

Given the preceding evidence, we then modelled the implied default related spread based on:

- a probability of default in any given year ranging from 0% to 2.50% (which is slightly above the 2.41% based on Ofcom's spread, as shown earlier – which, as we have explained, should represent the upper bound); and
- a recovery rate of 93%, based on an 18 month fallow period over 20 years.

The table below shows the results of this analysis, where we find that the appropriate spread could vary from between 0.03% to 0.14%, depending on precisely what one assumes regarding the default probability. This is materially lower than the spread of 1.2% proposed by Ofcom.

Table 3 Credit spreads implied by range of plausible default probabilities

Calculation step	Our scenarios				
	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
Nominal risk free rate	4.60%	4.60%	4.60%	4.60%	4.60%
(1+ risk free rate)	104.60%	104.60%	104.60%	104.60%	104.60%
Recovery rate	93.00%	93.00%	93.00%	93.00%	93.00%
1 – RR	7.00%	7.00%	7.00%	7.00%	7.00%
Probability of default	0.50%	1.00%	1.50%	2.00%	2.50%
Spread *P*(1-RR) / (1+RFR)*	**0.03%**	**0.07%**	**0.10%**	**0.13%**	**0.17%**

Source: Economic Insight analysis

Implied cost of debt

There is no obvious objective way of determining the appropriate default probability from the range shown above. However, the results do allow us to conclude that the maximum appropriate spread would be 0.17%, and so we have assumed that this applies in calculating the ALF discount rate (cost of debt) below. We consider this to be an upper bound because: (i) the recovery rate of 93% assumes that there would be a fallow period, and it would last for 18 months, which we consider to be a maximum plausible length; and (ii) it reflects a default probability of 2.5%, slightly above that embedded in Ofcom's spread (as shown earlier) which for reasons also explained elsewhere we consider to be 'above' the default probability associated with the ALF.

The results of our analysis show that the above (lower) debt premium of 0.17% translates to a post-tax real cost of debt of just 1.8% compared to a figure of 2.6% currently proposed by Ofcom. On a pre-tax real basis, the cost of debt is 2.8% (CPI). The following table sets out the details of the relevant parameters.

Table 4 Implied cost of debt

Cost of debt parameter	Ofcom's proposal	With lower debt premium
Inflation (RPI)	3.3%	3.3%
Inflation (CPI)	2.0%	2.0%
Real risk-free rate (RPI)	1.3%	1.3%
Nominal risk-free rate	4.6%	4.6%
Real risk free rate in CPI terms	2.6%	2.6%
Debt premium (nominal)	1.2%	0.17%
Tax rate	20.0%	20.0%
Cost of debt (nominal pre-tax)	5.8%	4.8%
Cost of debt (real pre-tax) (CPI)	3.8%	2.8%
Cost of debt (nominal post-tax)	4.7%	3.8%
Cost of debt (real post-tax) (CPI)	**2.6%**	**1.8%**

The risk free rate

The above analysis assumes that the real risk free rate is 1.3% - as proposed by Ofcom (and that the RPI / CPI wedge is 1.3%). In our previous reports for Three in relation to the setting of ALFs, we set out 'up to date' estimates of the key parameters used to set an MNO WACC. This included an assessment of the risk free rate, which we concluded should be set at 1.2% (real terms RPI). We note that in the current consultation Ofcom has accepted the principle that the discount rate should be set using the latest available evidence.[27]

Given the above, we have updated our analysis of the risk free rate, to again reflect the latest available data. Full details of this are contained in Annex A – but in summary we have:

[27] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Further consultation.' Ofcom (2014). Annex 10, 10.4-10.6*

- re-analysed the real yields on 5 and 10 year UK treasury gilts using the latest available data; and
- have updated our analysis of regulatory precedent.

Based on this we remain of the view that the latest available evidence is consistent with a risk free rate of 1.2%, just below Ofcom's proposed risk free rate of 1.3%. Were this slightly lower risk free rate to be applied, the post-tax real cost of debt implied by our above analysis would fall to 1.7% (on a post-tax real basis) and 2.7% (on a pre-tax real basis) – both CPI.

Cross checks from top-down securitised debt comparators

With regard to the issues identified in this report, we consider the preceding analyses regarding default risk. However, a consideration of theoretical and empirical evidence regarding the spread between secured and unsecured debt could be regarded as relevant. That is to say, one of the key reasons why the default risk is lower under ALFs relative to MNO parent company unsecured debt is that one would expect Government to recover a significant proportion of the asset value under default in relation to ALFs. Therefore, the 'secured / unsecured' spread could be viewed as an alternative approach for considering the impact of this. Of course, this should be caveated with the observations that: (i) the ALF debt is not fully secured; and (ii) there is no 'simple' secured adjustment that can be applied.

Annex B to this report contains evidence relating to the spread between senior secured and unsecured debt. Relating to this, we note that OXERA, in its report in support of Vodafone's submission also provided evidence on this matter. Specifically, OXERA stated that: *"financing costs must be lower for a secured loan than an unsecured bond debt."*[28] Further, whilst OXERA noted that, in practice, the delta between the premium for secured and unsecured debt can be low, this was due to factors associated with liquidity, rather than credit risk. In summary, our key observations are as follows:

- That, over the long term, spreads on securitised debt tend to be lower than for senior unsecured debt.

- However, the differential can be small and can vary.

In the round, however, the above further suggests that Ofcom's approach (where by definition the 'default probability' implicit in its benchmarked spreads will reflect unsecured debt) is likely to overstate the appropriate the level of discount rate. Perhaps of more relevance to our calculations, Standard and Poor's finds the recovery rate for European senior secured debt to be 76% between 2003 and 2010. This is broadly consistent with our assumption that the recovery rate for Government in relation to the ALF is likely to be much higher than that implicit in Ofcom's proposed spread of 1.2%. Further, whilst our assumed recovery rate (above) of 93% is some way above the 76%[29], our view is that this properly reflects the highly secured nature of the ALF payments, in which non-recovery would seem to be capped at the value of payments over any potential fallow period.

Our review of Ofcom's revised tax adjustment factor

As set out previously, the underlying principle of annualising the lump sum spectrum value to derive an ALF is to ensure that there is value equivalence between the two in NPV terms. In Ofcom's first consultation, it noted that for tax purposes a lump sum amount would be treated differently from an annual fee – and that in particular:

- A lump sum payment for spectrum would result in that being added to the balance sheet, with a corresponding amortisation charge going through the profit and loss. Accordingly, under the lump sum approach, taxable profit is reduced by the amount of amortisation charge.

[28] *'What is the right discount rate for an ALF?' OXERA (January 2014) page 22.*

[29] *'Europe's Senior Loan Market Delivers A Strong Recovery Performance Over Its First Cycle.' Standard and Poors' Global Credit Portal (2012).*

» In comparison, under an annual licence fee approach, the full amount of the annual fee would be reported in the profit and loss, reducing taxable profit by this amount.

As a consequence of this, total taxable profit (and thus tax paid) would be different under the two approaches, by the amount of the difference between the amortisation charge and the ALF. Therefore, in order to ensure value equivalence under the two approaches, Ofcom proposed a tax adjustment factor (to be applied to the value of the lump sum) which in its initial proposals was estimated to be 11%.[30] In our previous reports for Three on this matter, we accepted the in principle need for such an adjustment, noting that value equivalence was the appropriate objective. However, our view was that Ofcom's calculation of the adjustment factor was flawed because it failed to take into account the difference in financing arrangements between the two approaches, and in particular the fact that:

- if purchased as a lump sum, the spectrum would most likely be 100% debt financed; and
- as such it would generate a tax shield in relation to the interest component, reducing tax paid and thus lowering the adjustment factor.[31]

In Ofcom's current consultation, it has substantially revised its position on this matter – and in particular, Ofcom has accepted that spectrum would be debt financed, stating: *"We now consider that for these purposes, the ALF is close to being a form of debt instrument… This implies that the ALF payments displace 100% debt capacity… This does imply that the tax deduction on interest payments for such a lump sum payment needs to be captured. We do this by using the after-tax debt rate to discount the ALF. That is, the tax deduction for interest payments is embedded in the after-tax debt rate, so it is not necessary to make an additional adjustment to the tax adjustment factor (TAF) to allow for this as suggested by stakeholders."*

We agree with Ofcom's revised position and its implementation – in the sense that it accurately reflects: (a) that the spectrum would be 100% debt financed; and (b) by using the post-tax cost of debt it is ensuring that the benefit of the tax shield under a lump sum approach is properly taken account of. However, we note that under Ofcom's approach, the amortisation charge is falling in real terms, even though the ALF itself is flat in real terms. In effect, to set the ALF, Ofcom assumes that the value of the underlying spectrum will rise with inflation. But, in calculating the amortisation charge for the tax adjustment factor, Ofcom assumes that companies would not revalue the spectrum and recalculate an associated higher amortisation charge.[32] Although one would not necessary expect companies to revalue the spectrum (and therefore change the amortisation charge) annually, we would expect periodic revaluations of the asset to reflect material value changes. With this mind, we note that the impact of inflation by the end of 10 and 20 years is 20% and 46% respectively.

Conclusions

In conclusion we consider that some form of debt rate is the appropriate basis for setting the discount rate for deriving the ALFs. However, we consider that Ofcom's proposed cost of debt of 2.6% (real post-tax CPI) is over-stated – primarily because it reflects a debt premium consistent with the overall average of senior unsecured debt for MNO parent companies. In practice, in relation to the ALF:

- the recovery rate for Government is likely to be much higher than for unsecured debt; and
- the probability of default in the first instances is likely to be much lower.

Using modelling that parameterises both default probability and the recovery rate, we find that the maximum appropriate debt premium would be 0.14%, implying a real post-tax cost of debt of 1.8%,

[30] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: a consultation.' Ofcom (October 2013). See paragraphs 5.53-5.65.*

[31] *'A note on Ofcom's proposed ALF tax adjustment.' Economic Insight (2013).*

[32] *However, we understand that, in practice, this need not be the case – as accounting rules may allow MNOs to make an upwards or downwards revaluation adjustment to reflect market value.*

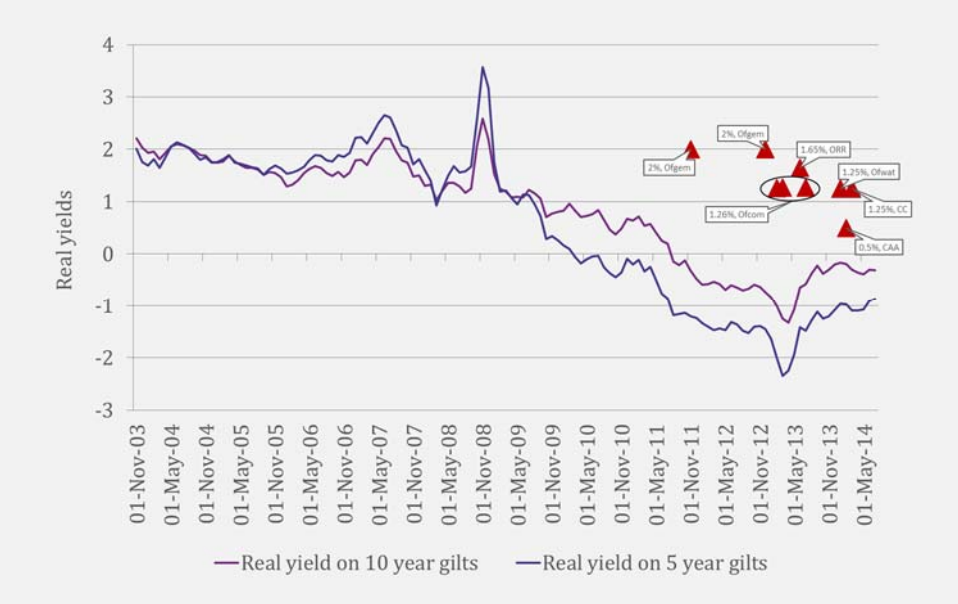
materially below the 2.6% proposed by Ofcom. On a pre-tax, real, CPI basis, our proposed cost of debt is 2.8%, compared to 3.8% under Ofcom's proposals.

Annex A – updated evidence regarding the risk free rate

In our previous advice to Three we proposed a real risk-free rate (RFR) of 1.2%, whereas in its current form, Ofcom is calculating the ALF using a RFR of 1.3%. We believe that Three should re-state its position that the RFR should be lower (1.2%) and to support this we have updated our previous evidence based on the latest available data. Specifically we look at: the real yields on 5 and 10 year gilts; and previous regulatory determinations.

The chart below shows the real yield on 5 and 10 year gilts, and a range of recent regulatory RFR determinations.

Figure 2: Real yield on 5 and 10 year gilts and recent regulatory decisions



Source: Bank of England, Economic Insight analysis and regulatory determinations

When reviewing data on real gilt yields to inform its position regarding the RFR for the MCT determination, Ofcom focused on average yields over a 10 year period, up until the date of that decision. Using the above latest data on real gilt yields, we find that long-run average yields up until July 2014 inclusive are:

- for 10 year gilts, 0.8% over 10 years; and
- for 5 year gilts, 0.5% over 10 years.[33]

The above compares to real yields on 5 year gilts of between 1.3% and 1.7% over 5 and 10 years as reported by Ofcom at the time of the MCT decision.[34] The lower long-term averages using the above data are consistent with the fact that yields have continued be negative in real terms since the MCT decision.

Of course, in determining the RFR for the purpose of making regulatory cost of capital decisions, a key issue is the need to balance current market evidence against a longer-term perspective – particularly in the context of those regulatory decisions being forward-looking. Indeed, this issue has been highlighted by Ofcom as current negative yields are 'unusual' when compared to longer-term data. In this regard, however, we note that the 10 year average yield already provides a relatively long-term perspective and that in its MCT decision, Ofcom ultimately attached substantial weight to this analysis. We therefore suggest that the above data on 10 and 5 year gilt years over 10 years provides strong evidence that the appropriate RFR for determining the ALF WACC is somewhat lower than that which Ofcom is proposing.

In determining the RFR within its March 2011 decision, Ofcom also relied on regulatory precedent, and drew particular attention to the Competition Commission's decision with respect to Bristol Water. We therefore consider it appropriate to similarly consider what more recent regulatory precedent might imply today. These are summarised in the following table.

Table 5 Summary of risk free rates assumed in regulatory determinations

Regulator	Determination	Date	Real risk free rate
Ofgem	TPCR4 Rollover Final Proposals	Nov-11	2.00%
Ofgem	RIIO gas distribution final proposals	Dec-12	2.00%
Ofcom	Financial terms for the Channel 3 and Channel 5 licences	Feb-13	1.26%
Ofcom	Business connectivity market review	Mar-13	1.26%
ORR	PR13 draft determinations	Jun-13	1.65%
Ofcom	LLU and WLR Charge Controls	Jul-13	1.26%
Ofwat	PR14 – Risk and Reward guidance	Jan-14	1.25%
CAA	Q6 Price Control Review of Heathrow Airport	Feb-14	0.5%
CC	Northern Ireland Electricity Limited price determination	Mar-14	1.25%

Source: Review of regulatory determinations

[33] *Rounded to 1dp.*

[34] *'Wholesale mobile voice call termination Modelling Annexes.' Annex 8: Cost of Capital, Ofcom, paras A8.7 – A8.53 (March 2011).*

The above table shows that, with the exception of the ORR PR13 decision, since 2013 regulators are assuming a RFR that is at or below the 1.3% currently being proposed by Ofcom. Notably, the CAA assumed a RFR of 0.5% in their Q6 price control of Heathrow airport. They note that this should be viewed in conjunction with the equity risk premium as they were set together. PwC advised that the RFR was in the range 0.5% to 1% and the CAA decided on the lower bound to ensure total market returns consistent with their beliefs.[35]

Similarly, across its own more recent determinations, whilst Ofcom has consistently noted that caution should be attached to the recent history of very low (and negative) yields, it nonetheless determined that it was: *"appropriate… to reflect the continued fall in estimates of the real risk free rate to some degree."*[36]

Overall, given the persistence of low gilt yields and the relatively value assumed by the CAA, we maintain our assertion that the RFR should be 1.2%, slightly less than Ofcom's currently proposed 1.3%.

[35] *Technical appendix, Q6 Price Control Review of Heathrow Airport, CAA, February 2014*

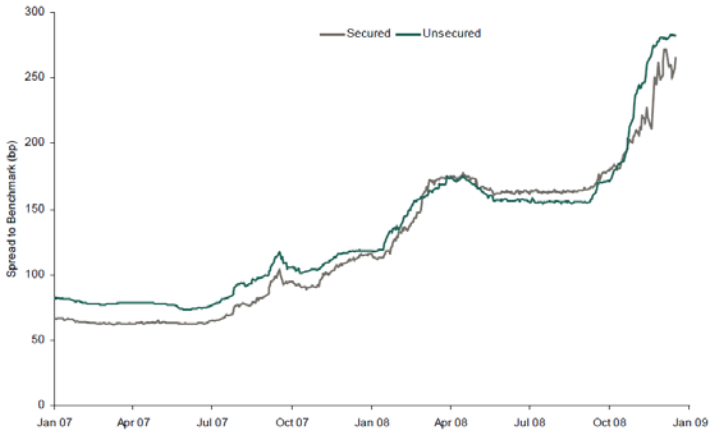
[36] *'Business Connectivity Market Review: Annex 8.' Ofcom (July 2013).*

Annex B – evidence on the spreads between secured and unsecured debt

To date there have not been many empirical studies analysing the spread differential between secured and unsecured corporate debt. In their seminal study, John, Lynch, and Puri (2000)[37] find that the yield differential between secured and unsecured debt is positive and largely driven by nonmortgage secured assets. They also find that the yield differential is higher for low credit-rated issues as compared to high credit-rated ones. Realdon (2006)[38] recognises that the credit spread on secured loans increases with the borrowers default probability. Ghent and Valkanov (2013)[39] find that large loans are 42% more likely to be securitised than small loans. Across a range of literature, however, the general picture is one whereby the spread in secured debt is, in most cases, lower than for senior unsecured debt – although the differential can be small.

In the UK water industry, Welsh Water, Anglian Water, and Southern Water, all issued secured bonds. The spread difference between secured and unsecured bonds has not been very pronounced, however, on average secured bonds tend to have a lower spread (see chart below).[40]

Graph 5: Evolution of spreads between companies with secured and unsecured structures



Moving away from public utilities and corporates, the spread of European banks' bonds demonstrates the recent trend in the spread between secured and unsecured debt, as reported by Moody's.[41] Consistent with the water industry data, this shows that the spread on senior secured debt is slightly lower, on average, than that for senior unsecured debt. It is clear that the spread differential between secured and unsecured bonds is very small during 2009-10 and starts

[37] *Journal of Business: "Credit Ratings, Collateral, and Loan Characteristics: Implications for Yield." Kose John, Anthony W. Lynch, Manju Puri (2003).*

[38] *Journal of Business, Finance & Accounting: "Pricing the Credit Risk of Secured Debt and Financial Leasing." Marco Realdon (2006).*

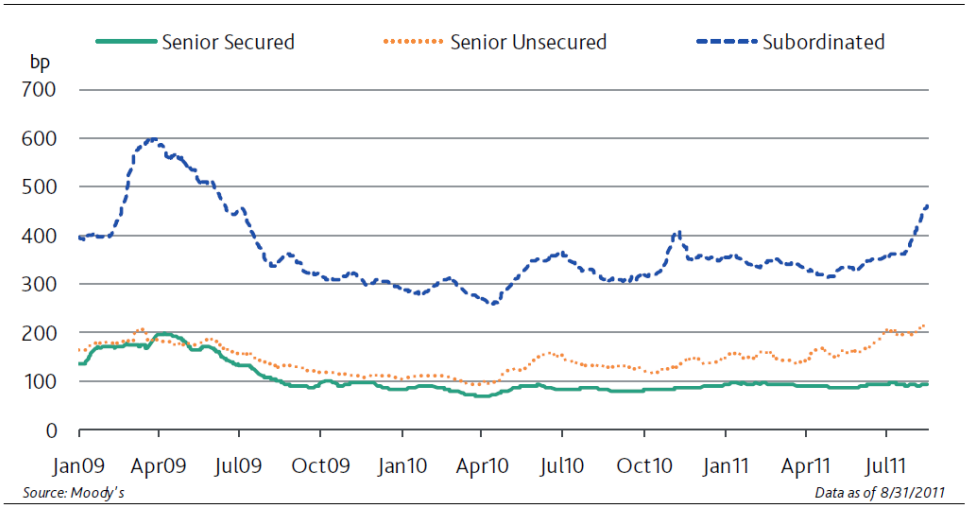
[39] *"Comparing Securitized and Balance Sheet Loans: Size Matters." Andra Ghent and Rossen Valkanov (2013), http://www.usc.edu/schools/business/FBE/seminars/papers/RECR_3-5-14_VALKANOV.pdf*

[40] *'Competition proposals and financing issues: A report for Ofwat.' Richard Nouse (2009).*

[41] *'Market Signals Review: Signs of Stress: Market Differences Grow Between Secured and Unsecured European Bank Bonds.' Moody's Analytics (2011).*

increasing slightly from the end of 2010 onwards. At the end of 2011, the spread differential was 100 bps. This reflects the increased risk of unsecured bonds.

Figure 1: 10-day trailing average bond spread for European banks



In their analysis of the securitisation of corporate bank loans in the form of collateralised loan obligations, Nadauld and Weisbach (2012)[42] find that loan facilities that are subsequently securitised are associated with a 17bps lower spread than facilities that are not securitised. So, demand for secured loans lowers the cost of debt for companies.

Based on our review of the existing evidence, we find that:

- As expected, over the long-term, the spread on secured debt tends to be lower than that for senior unsecured debt.
- However, the differences are small and can be hard to measure – meaning that it is hard to identify a 'security' adjustment factor, consistent with Ofcom's findings.

[42] *Journal of Financial Economics: "Did securitization affect the cost of corporate debt?" Taylor Nadauld and Michael Weisbach (2012).*

Further information

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Annex D Data inputs used for our lump-sum estimates.

This Annex presents the data inputs we have used to calculate our proposed lump-sum values, namely:

– Our UK 800MHz (with and without coverage obligation, gross and net of co-existence costs) and 2.6GHz values;
– Three's corrected input values from recent EU auctions, and the resulting UK 900MHz and 1800MHz estimates; and
– Our proposed two Tiers and weights (2 for Tier 1 and 1 for Tier 2), and the classification set out in Table u.

Our proposed UK 800MHz and 2.6GHz values from Section 1 are as follows:

Table 12: Three's proposed 800MHz and 2.6GHz UK values

£m per MHz	Without coverage obligation	With coverage obligation
800MHz, net of DTT costs	£25.04m	£23.49m
800MHz, gross of DTT costs	£28.04m	£26.49m
2.6GHz	£3.57m	-

Source: Three

The individual data points, resulting 900MHz and 1800MHz UK values and our Tiers are shown in Table 13. This is identical to Table 3.1 of the Consultation, except for minor corrections highlighted in yellow. These are explained in Section 5 of the Analysys Mason and Aetha report.

Table 13: Results of European Auctions

£m per MHz, UK equivalent	800MHz	900MHz	1800MHz	2.6GHz
Austria	72.2	79.4	48.6	1.9
Czech Republic	44.1		6.0	3.0
Germany	52.9		1.9	1.6
Ireland	63.5	39.6	25.2	6.8
Italy	52.1		16.7	3.8
Portugal	37.3	24.9	3.3	2.5
Romania	43.9	47.3	19.0	10.6
Slovakia	38.5		7.1	4.6
Spain	40.4	26.4		1.9
Sweden	21.2		9.3	9.3
Simple average	**46.6**	**43.5**	**15.2**	**4.6**

Source: Three, based on Figure 3.1 of the Consultation

The resulting UK values based on the 900MHz/800MHz ratio for 900MHz and the distance method for 1800MHz are as follows.

Table 14: Our proposed 900MHz and 1800MHz values

	900MHz			1800MHz		
£m per MHz, UK equivalent	900/ 800	900	Weight	D	1800	Weight
Austria	110%	30.8	1	66%	19.8	1
Czech Republic				7%	5.1	1
Germany				1%	3.6	2
Ireland	62%	15.6	1	32%	10.5	1
Italy				27%	10.1	2
Portugal	67%	16.7	1	2%	4.0	1
Romania	108%	25.3	1	25%	8.5	1
Slovakia				7%	5.1	1
Spain	65%	18.3	1			
Sweden				0%	3.5	1
Weighted average			**21.3**			**7.7**

Source: Three.