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

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16 January 2014

Executive Summary.

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

Ofcom arrives at its proposed ALFs in two steps. First, Ofcom determines a "lump-sum" value for 900MHz and 1800MHz spectrum based on UK and other auction benchmarks. Second, it converts the lump-sum value into a series of annual payments using a discount rate and assumed licence duration.

Three agrees with Ofcom's overall framework, but not with Ofcom's proposed ALFs, especially of £1.19m per MHz for 1800MHz spectrum. In contrast, Three calculates that the ALF for 1800MHz spectrum should be £0.50m per MHz.

Three considers that this is because Ofcom's lump-sum values do not reflect full market value, as required by the Government Direction, as:

– other country evidence shows that 1800MHz is much closer in value to 2.6GHz than to 800MHz;
– Ofcom's benchmarking methodologies contain major flaws;
– Ofcom's classification of the benchmarks contains large inconsistencies;
– a proper benchmarking approach produces a much lower 1800MHz lump-sum value; and
– Ofcom's proposed 1800MHz lump-sum value does not adequately reflect technical and other evidence.

Furthermore, Three considers that Ofcom's calculation of the proposed annual fees is incorrect, as:

– Ofcom's proposed discount rate should be the risk-free rate, not the cost of capital;
– Ofcom's proposed tax adjustment is invalid; and
– Ofcom should increase future annual fees by the Consumer Price Index (CPI), not the Retail Price Index (RPI).

Overall, Three believes that Ofcom has overestimated the 1800MHz ALF by almost two-and-a-half times, through combination of an over-estimate of the 1800MHz lump-sum value and application of the wrong discount rate and tax adjustment, as shown in Table 1 below.

Table 1: Ofcom has over-estimated the 1800MHz ALF by almost two-and-a-half times.

	Ofcom value	Three value
1800MHz lump-sum value	£15m per MHz	£9.1m per MHz
Discount rate	4.1%	1.2%
Tax adjustment	+11%	-1.3%
1800MHz ALF	£1.19m per MHz per year	£0.50m per MHz per year

Source: Ofcom, Three.

Lastly, Three believes that Ofcom should modify its proposals for implementing the new annual fees. This is because Three considers that Ofcom's proposals for implementing the new fees are inconsistent with the Licence Charges Regulations and Government Direction.

In conclusion, Three considers that Ofcom's proposals do not carry out the Government's Direction, especially in revising the 900MHz and 1800MHz licence fees so that they reflect full market value.

The remainder of this Executive Summary explains each of the above points in further detail.

The remainder of our response explains each of the above points in further detail still, including supporting technical annexes, expert reports from Aetha Consulting, Analysys Mason and Economic Insight, and responses to Ofcom's specific consultation questions.

Other country evidence shows that 1800MHz is much closer in value to 2.6GHz than to 800MHz.

Ofcom proposes a lump-sum value for 1800MHz spectrum of £15m per MHz, near the simple average of the UK auction values of £29.9m per MHz for 800MHz and £5m per MHz for 2.6GHz spectrum.

However, evidence from all other European countries that have auctioned 1800MHz since 2010 shows that 1800MHz spectrum was much closer in value to 2.6GHz spectrum than to 800MHz spectrum.

This comparison suggests that Ofcom's proposed 1800MHz lump-sum value is too high and does not reflect a proper benchmarking of the auction evidence from other countries.

Three has commissioned expert reports from Analysys Mason and Aetha Consulting (jointly with EE), included with our response, which support these conclusions.

Ofcom's benchmarking methodologies contain major flaws.

Ofcom uses three benchmarking methodologies for estimating the UK 1800MHz value from evidence in other countries, namely:

1 Ofcom's absolute method;
2 Ofcom's relative method; and
3 Ofcom's combinations of UK values method.

Overall, there are significant problems with each of Ofcom's benchmarking methods.

First, Ofcom's **absolute method** takes no account of UK auction values in its estimate of the UK 1800MHz value. Three considers that this is not consistent with the Government Direction, which requires Ofcom to have particular regard to bids made in the UK auction. This method is also unduly influenced by non-UK country-specific factors, exchange rate adjustments and other effects that could lead to significant over- or under-estimates of the correct UK 1800MHz value. Overall, in Three's view, Ofcom's absolute method is only informative as a sense check and should not be used in the derivation of UK values.

Second, Ofcom's **relative method** is better than the absolute method, in that it does have regard to the UK auction values and is less affected by adjustments to convert local results into UK equivalent values. However, this method tends to produce widely varying "scattergun" estimates of 1800MHz value. For example, in some cases, the estimated UK 1800MHz value is less than the UK 2.6GHz value or greater than the UK 800MHz value. Accordingly, this method must be applied with great care.

Third, Ofcom's method based on **combinations of UK values** takes no account of evidence from other countries. Indeed, it produces an arbitrary estimate of the UK 1800MHz value. Accordingly, this method cannot meaningfully be said to represent full market value in the UK, as required by the Government Direction.

Our expert reports from Analysys Mason and Aetha Consulting support these conclusions.

Ofcom's classification of its 1800MHz UK value benchmarks contains large inconsistencies.

Ofcom uses its three benchmarking methods to estimate values of 1800MHz spectrum in the UK. Ofcom classifies the resulting values as either "more important" or "less important", or omits them entirely. Ofcom then arrives at its proposed 1800MHz UK value based on the range of values derived for each of its more and less important benchmarks.

Three agrees with Ofcom that it is necessary to classify each benchmark value as more or less important, or omit entirely, reflecting the quality of the underlying evidence. However, the logic for classifying data points and arriving at the resulting 1800MHz UK value should be clear and consistent.

At present, in our view, Ofcom's treatment of its UK value benchmarks contains some large inconsistencies. This is particularly concerning given the wide range of values produced by Ofcom's methods. Three considers that this leads to a systematic bias in Ofcom's overall estimate of the UK 1800MHz value.

In particular, under Ofcom's classification approach, Ofcom's 1800MHz UK value progressively increases from an underlying £8.7m per MHz average produced by its three methods to its final £15m per MHz estimate. There are three main causes of this, namely:

- Ofcom omits various observations produced by its three methods and also counts the same observation several times over;
- Ofcom's classification of benchmarks as more or less important is inconsistent and appears to be skewed towards higher 1800MHz values; and
- Ofcom sets an 1800MHz value above the average of its more important evidence and effectively disregards the less important evidence entirely.

Overall, Three considers that Ofcom's proposed UK 1800MHz lump-sum value of £15m per MHz represents a significant overestimate. This reflects a combination of unreliable benchmarking methodologies, inconsistent classification of other country benchmarks and lack of transparency in the derivation of its 1800MHz UK value.

Our expert reports from Analysys Mason and Aetha Consulting support these conclusions.

A proper benchmarking approach produces a much lower 1800MHz lump-sum value.

There are inherent limitations to any benchmarking approach for estimating the value of 1800MHz spectrum in the UK. Nevertheless, Three considers that there is a simpler and better method available than Ofcom's, namely considering the value of 1800MHz in relation to both 800MHz and 2.6GHz together, or the "distance" method.

In Three's view, the distance method produces much more reliable estimates of the UK 1800MHz value than Ofcom's methods across a range of criteria. In particular, the distance method:
– minimises the impact of non-UK country-specific factors;
– produces much greater consistency of 1800MHz estimates; and
– generates better predictions of the 1800MHz value in other countries.

In addition, a proper benchmarking approach should apply consistent and objective criteria for classifying benchmarks produced by the distance method as more or less important, or omitting them entirely.

The overall result of this approach is a UK 1800MHz value of £9.1m per MHz, in comparison to Ofcom's proposed value of £15m per MHz.

Alternatively, correcting Ofcom's relative method for the above issues generates a very similar UK 1800MHz value of £9.2m per MHz.

Our conclusions here particularly rely on our expert reports from Analysys Mason and Aetha Consulting.

Ofcom's proposed 1800MHz lump-sum value does not adequately reflect technical and other evidence.

A significant problem with Ofcom's approach is that there is no proper cross-checking of its proposed 1800MHz value. Such a cross-check would have revealed that Ofcom's 1800MHz value of £15m per MHz is too high and does not reflect a reliable benchmarking of the evidence.

In comparison, an 1800MHz value of £9.1m per MHz is much more consistent with the available evidence. In particular:
– £9.1m per MHz is much more consistent with Ofcom's absolute benchmarks;
– £9.1m per MHz is much more consistent with Ofcom's 1800/900 relative benchmarks;

- £9.1m per MHz is much more consistent with Ofcom's valuations for the UK 4G auction – Ofcom valued 1800MHz at £9.2m to £13.8m per MHz and recognized that even the low end of that range risked overstating the 1800MHz UK value;
- our 1800MHz value is more consistent with the technical evidence – from a technical perspective, 1800MHz and 2.6GHz are closer in value to an operator (as capacity offloads from a 2.1GHz layer), while 800MHz has much greater value (as it can be used for wide-area coverage); and
- Ofcom is wrong to conclude that 1800MHz is a closer substitute for 800MHz than 2.6GHz based on bidding in the UK 4G auction – as [✂].

Our expert reports from Analysys Mason and Aetha Consulting, and internal technical report, support these conclusions. [✂]

Ofcom's proposed discount rate should be the risk-free rate, not the cost of capital.

Ofcom proposes to calculate the ALFs as an annuity whose present value is equivalent to the lump sum amount derived from the auction. Three agrees with this.

Accordingly, in order to convert lump-sum spectrum values to ALFs, Ofcom proposes a discount rate of the post-tax real weighted-average cost of capital (WACC), of 4.2%, based on Ofcom's 2011 Mobile Call Termination (MCT) decision.

Three disagrees however that the WACC is appropriate discount rate for converting lump-sum spectrum values to ALFs.

In particular, using the WACC as the discount rate does not result in an ALF whose present value is equivalent to the corresponding lump-sum value derived from the auction. This is because – paying for spectrum through ALFs is equivalent to paying for spectrum through lump-sum fees financed by the licensee through external debt finance.

Namely, paying for spectrum through ALFs is effectively the licensee receiving financing from the Government. However, this financing is highly secured and, from the Government's perspective, risk-free. It therefore should attract a risk-free rate.

Hence, the risk-free rate is the relevant rate for converting lump-sum values to ALFs. Based on the most relevant data, the risk-free rate is 1.2%.

Three commissioned an external expert report from Economic Insight, included with our response, which provides the most relevant estimate of the risk-free rate.

Ofcom's proposed tax adjustment is invalid.

Ofcom proposes an 11% upward tax adjustment to the ALFs, on the basis that ALFs result in a larger tax deduction than the amortisation of lump-sum licence fees. Ofcom is right that, in themselves, ALFs would result in a larger tax deduction than the corresponding amortisation of lump-sum fees.

However, Ofcom's proposal does not take into account the financing of lump-sum licence fees and associated tax deductibility of debt interest payments. Taking this into account means that there should actually be a negative tax adjustment, of -1.3%.

Three commissioned a separate external expert report from Economic Insight, included with our response, which supports this conclusion.

Ofcom should increase future annual fees by the Consumer Price Index (CPI), not Retail Price Index (RPI).

Ofcom proposes that future ALFs should be increased by the Retail Price Index (RPI). The RPI index has however become increasingly obsolete and unreliable and therefore should not be used as the basis for setting ALFs over a long-term future period.

The Consumer Price Index (CPI) has already replaced RPI as the official standard UK and EU inflation measure, and therefore represents a much more satisfactory measure for setting ALFs.

Three's first external expert report from Economic Insight supports this conclusion.

Ofcom should modify its proposals for implementing the new annual fees.

Ofcom sets out two main proposals in relation to the implementation of the new ALFs:

– the timing of introduction of ALFs: Ofcom proposes to set a Common Effective Date (CED), with all 900MHz and 1800MHz licensees paying full market value from that point in time; and
– the phasing-in of the new licence fees: Ofcom proposes to implement ALF immediately after the new fees regulation come into force, without phasing-in the new ALFs.

Three disagrees with Ofcom's proposed implementation of the new ALF fees. Namely, in our view, Ofcom has misinterpreted the Licence Charges Regulations 2011 and has not adequately justified its proposal not to phase-in the new fees.

In particular:

– Ofcom wrongly assumes that licence fees are payable in advance;
– under the Charges Regulations, fees are payable in arrears;
– Ofcom's proposal requires operators to pay more than prescribed by the Regulations and is in breach of the Government Direction; and
– Ofcom should carry out a proper impact assessment before concluding that it is not necessary to phase-in the new fees.

Our conclusions are based on external legal advice.

Conclusion: Ofcom's proposals do not carry out the Government's Direction – Ofcom should reconsider and should adopt Three's proposed approach.

Three considers that Ofcom's proposals do not carry out the Government's Direction, either in revising the 900MHz and 1800MHz licence fees so that they reflect full market value or in having particular regard to the sums bid in the 4G auction.

This is through combination of Ofcom's proposed benchmarking methods for determining the lump-sum value of 900MHz and 1800MHz spectrum, discount rate for converting lump-sum values to ALFs, tax adjustment, index for increasing future ALFs, and proposals for implementing the new fees.

Accordingly, Ofcom should reconsider its analysis and proposals in relation to each of these. Ofcom should instead adopt Three's alternative proposed approaches on each of these, especially Three's proposed

distance method, risk-free rate discount rate, corrected tax adjustment, CPI and revised implementation proposals. Three considers that, in combination, these would properly carry out the Government's Direction.

Three notes that the UK MNO industry's return on investment has been persistently below Ofcom's own estimate of the corresponding industry cost of capital for over ten years, and shows little signs of improvement. Indeed, Ofcom's licence fee proposal in itself will reduce industry returns almost in half.

This is nevertheless at a time when the Government is calling for ever greater investment in communications infrastructure and lower prices for consumers.

Ofcom should therefore carry out a more thorough impact assessment of its proposals.

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1. Other country evidence shows that 1800MHz is much closer in value to 2.6GHz than to 800MHz.

Ofcom proposes a lump-sum value for 1800MHz spectrum of £15m per MHz, near the simple average of the UK auction values of £29.9m per MHz for 800MHz and £5m per MHz for 2.6GHz spectrum.

However, evidence from all other European countries that have auctioned 1800MHz since 2010 shows that 1800MHz spectrum was much closer in value to 2.6GHz spectrum than to 800MHz spectrum.

This comparison suggests that Ofcom's proposed 1800MHz lump-sum value is too high and does not reflect a proper benchmarking of the auction evidence from other countries.

Three has commissioned expert reports from Analysys Mason and Aetha Consulting (jointly with EE), included with our response, which support these conclusions.

Ofcom's 1800MHz value is close to the UK 800MHz and 2.6GHz average value.

In December 2010, the UK Government directed Ofcom to revise 900MHz and 1800MHz spectrum fees to reflect full market value, having particular regard to sums bid for licences in the UK 800MHz and 2.6GHz auction. Consistent with the Direction, Ofcom has estimated the 800MHz and 2.6GHz UK values based on actual bids made in the UK 4G auction.

Three agrees with Ofcom that, in normal circumstances, the 1800MHz value is likely to lie between the 800MHz and 2.6GHz UK prices. This reflects that, everything else being equal, lower frequency spectrum tends to be more valuable than higher frequency spectrum. Therefore, the 800MHz and 2.6GHz UK prices provide a reliable guide to the upper and lower-bound value of 1800MHz spectrum in the UK. They are the two key prices to be used as anchor points in the estimation of the 1800MHz UK value.

Ofcom's task is then to use auction results and other evidence to set an 1800MHz value between the 800MHz and 2.6GHz UK prices. Table 2 shows Ofcom's estimates of full market value for the 900MHz and 1800MHz spectrum, together with the 800MHz and 2.6GHz UK 4G auction prices based on its Linear Reference Price methodology.

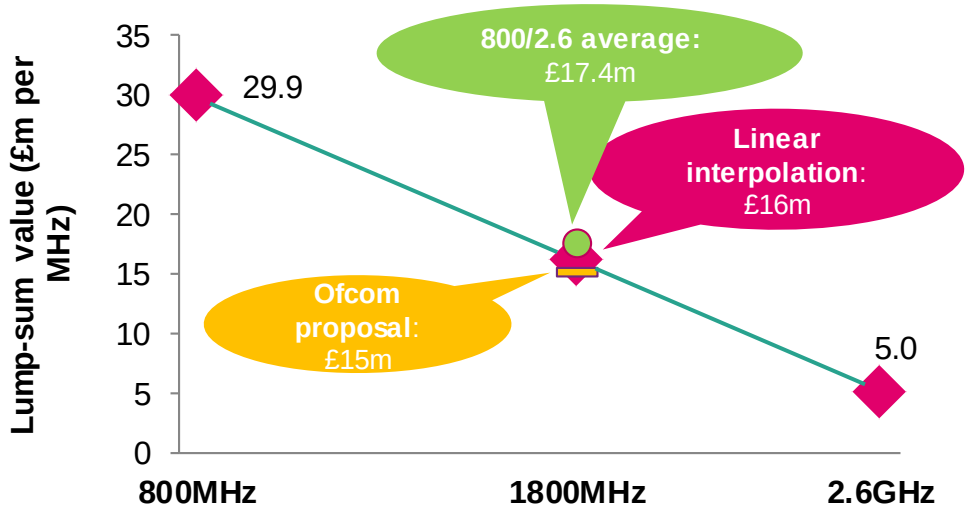
Table 2: Ofcom's lump-sum estimates of UK spectrum value

Band	800MHz	900MHz	1800MHz	2.6GHz
£m per MHz	£29.9m	£25m	£15m	£5m
Value relative to 800MHz	100%	83.6%	50%	16.7%

Source: Figure 1.1 and paragraph 4.25 of the Consultation.

Indeed, Ofcom's approach values 1800MHz at 50% of the 800MHz value and three times the 2.6GHz price. This places Ofcom's 1800MHz value close to the 800/2.6 UK simple average value, and closer still to the linear interpolation of those values, as shown in Figure 1.[1]

Figure 1: Ofcom values 1800MHz close to the 800MHz/2.6GHz simple average.



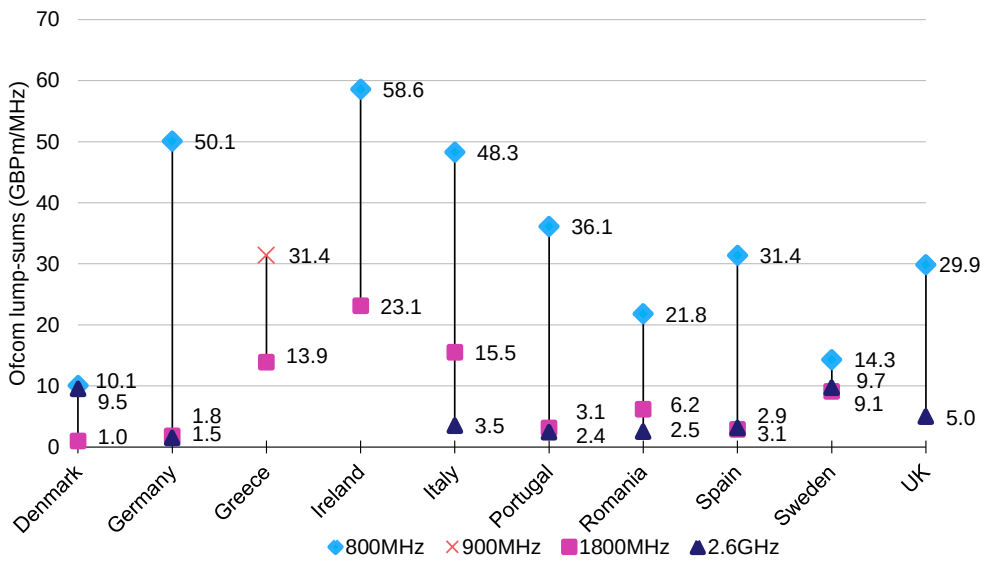
Source: Three.

[1] i.e. drawing a straight line between the 800MHz and 2.6GHz values and taking its value at 1800

Ofcom's other country evidence shows that 1800MHz is much closer in value to 2.6GHz than to 800MHz.

Three considers that Ofcom's 1800MHz valuation is inconsistent with the auction evidence on which it has relied. In particular, Figure 2 presents Ofcom's own estimates from EU countries that have recently auctioned 1800MHz spectrum, which Ofcom considers provide more appropriate benchmarks.[2]

Figure 2: 1800MHz was much closer in value to 2.6GHz than to 800MHz.



Source: Three, based on Figure 4.2 of Ofcom's consultation

The results of this are clear. 1800MHz was much closer in value to 2.6GHz than to 800MHz in every country considered by Ofcom.

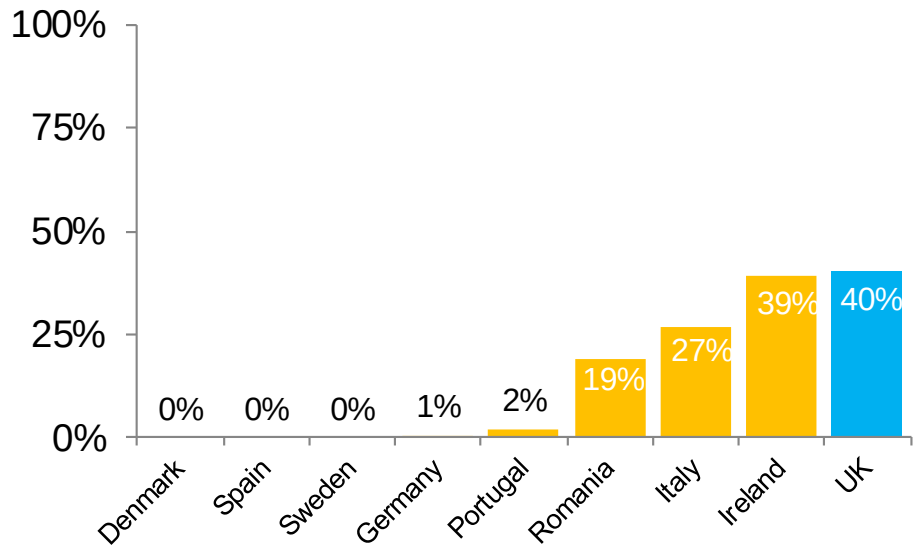
We agree with Ofcom that the 1800MHz values in Denmark and Spain were anomalously low and below the 2.6GHz price, due to lack of competition in those awards. In Sweden, a recession between the 2008 2.6GHz auction and the 2011 1800MHz award explains why the 1800MHz price is below the 2.6GHz value.

[2] Paragraph 4.27 of the Consultation document.

Nevertheless, in all other countries assessed by Ofcom, the 1800MHz value was significantly less than half-way between the 800MHz and 2.6GHz values. In Ireland, which has not auctioned 2.6GHz, the 1800MHz value must be much closer to 2.6GHz (as the 2.6GHz value cannot be negative). The same is true in Greece, particularly so if Ofcom is right that 800MHz is more valuable than 900MHz spectrum.

For comparison, Figure 3 shows the relative distance between the 1800MHz value and the 800MHz/2.6GHz prices in Ofcom's sample of countries. A value of 0% means that the 1800MHz price was equal to the 2.6GHz value in the country in question. Conversely, if the value is 100% the 1800MHz price was equal to the 800MHz value. In Denmark, Spain and Sweden we assign a value of 0%, given that the 1800MHz price was anomalous and below the 2.6GHz value due to country-specific factors.

Figure 3: Ofcom's 1800MHz UK price is closer to the average of the 800/2.6 values than any other benchmark.



Source: Three, based on Figure 4.2 of Ofcom's consultation.

In contrast, Ofcom's 1800MHz UK value sits 40% along the way between the 2.6GHz and 800MHz UK values. In effect, Ofcom concludes that the 1800MHz value must be closer to the 800MHz price (and further from the 2.6GHz value) in the UK than in any other European country it has assessed.

Ireland is the only other 1800MHz value that is close to the 800MHz/2.6GHz simple average value (50%) and to the linear interpolation of those values (44%). However, the Irish 1800MHz value (39%) was unusually high, as 2.6GHz spectrum has not yet been auctioned in Ireland. In addition, the figure overestimates the relative distance in that country – for the purpose of the calculation, we have valued the 2.6GHz spectrum in Ireland at zero and therefore conservatively assumed the maximum potential distance between 2.6GHz and 1800MHz spectrum (given the 800MHz and 1800MHz values in Ireland).

In summary, the auction evidence presented by Ofcom indicates that its proposed 1800MHz lump-sum value is too high and does not reflect a proper benchmarking of the evidence from other countries.

To consider the reasons for this result, Three has assessed Ofcom's analytical framework, developed an alternative methodology (the "distance" method) and commissioned a benchmarking report from Analysys Mason and Aetha Consulting jointly with EE, attached as Annex A. Sections 2 to 5 of this response describe our assessment of Ofcom's 1800MHz lump-sum value method.

2. Ofcom's benchmarking methods contain major flaws.

Ofcom uses three benchmarking methodologies for estimating the UK 1800MHz value from evidence in other countries, namely:

1 Ofcom's absolute method;
2 Ofcom's relative method; and
3 Ofcom's combinations of UK values method.

Overall, there are significant problems with each of Ofcom's benchmarking methods.

First, Ofcom's **absolute method** takes no account of UK auction values in its estimate of the UK 1800MHz value. Three considers that this is not consistent with the Government Direction, which requires Ofcom to have particular regard to bids made in the UK auction. This method is also unduly influenced by non-UK country-specific factors, exchange rate adjustments and other effects that could lead to significant over- or under-estimates of the correct UK 1800MHz value. Overall, in Three's view, Ofcom's absolute method is only informative as a sense check and should not be used in the derivation of UK values.

Second, Ofcom's **relative method** is better than the absolute method, in that it does have regard to the UK auction values and is less affected by adjustments to convert local results into UK equivalent values. However, this method tends to produce widely varying "scattergun" estimates of 1800MHz value. For example, in some cases, the estimated UK 1800MHz value is less than the UK 2.6GHz value or greater than the UK 800MHz value. Accordingly, this method must be applied with great care.

Third, Ofcom's method based on **combinations of UK values** takes no account of evidence from other countries. Indeed, it produces an arbitrary estimate of the UK 1800MHz value. Accordingly, this method cannot meaningfully be said to represent full market value in the UK, as required by the Government Direction.

Our expert reports from Analysys Mason and Aetha Consulting support these conclusions.

Ofcom uses three methods to estimate the 900MHz and 1800MHz lump-sum values.

Ofcom uses three methods to derive its benchmarks of 1800MHz UK value:

– Ofcom's **absolute method** – namely, the 1800MHz value in recent EU auctions, adjusted for UK population and licence duration,

inflated to today and converted into GBP (using purchasing power parity exchange rates);
– Ofcom's **relative method** – namely, based on the product of the 800MHz and 2.6GHz UK linear reference prices and the 1800/800 and 1800/2.6 ratios observed in recent EU auctions respectively; and
– Ofcom's **combinations of UK values method** – namely, the simple average of UK 800MHz and 2.6GHz values, their linear interpolation and the inverse exponential fit.

Ofcom does not critically assess or compare its estimation methods.

Ofcom's choice of methodology clearly plays a decisive role in determining the range of 900MHz and 1800MHz UK value estimates and, ultimately, on Ofcom's chosen ALFs. It is therefore surprising that the consultation does not discuss the relative merits of the different benchmarking methods, or explain the basis on which Ofcom has chosen its methods in preference to other alternatives.

In contrast, Three has considered each of Ofcom's methods against relevant criteria, namely:
– is the method consistent with the UK Government Direction?
– to what extent does the method control for country-specific factors?
– are the resulting value estimates unduly affected by the method used to convert local results into UK-equivalent values?

We assess Ofcom's methods against these criteria in turn.

Ofcom's methods are not equally consistent with the Government Direction.

The UK Government Direction requires Ofcom to revise 900MHz and 1800MHz spectrum fees to reflect "*full market value*", having "*particular regard*" to sums bid for 800MHz and 2.6GHz in the UK 4G auction. This sets out two requirements: i) that fees must reflect full market value; and ii) that Ofcom must give significant weight, or at least particular consideration, to sums bid in the UK 4G Auction.

However, Ofcom's absolute method pays no regard to the UK 800MHz and 2.6GHz auction bids. Similarly, Ofcom's combinations of UK values method entails an 1800MHz estimate that is not based on any comparator market values – it simply produces estimates that could be anywhere between the 800MHz and 2.6GHz UK values. Accordingly,

these methods do not meet the requirements set out by the Government Direction.

In contrast, Ofcom's relative method does meet the second requirement in the Direction – namely, that it must give significant weight, or at least particular consideration, to sums bid in the UK 4G Auction – as it is based on sums bid for 800MHz and 2.6GHz spectrum in the UK (as reflected in their price). Nonetheless, Three considers that Ofcom's relative does not meet the first requirement of the Direction, as the method produces value estimates that cannot meaningfully be said to represent market value, for reasons explained below.

Ofcom's methods do not control sufficiently for country-specific factors.

Spectrum has an intrinsic value arising from its propagation characteristics. In particular, lower frequencies travel further and penetrate better through buildings than higher frequency spectrum.

However, as Ofcom has recognized elsewhere, spectrum value can be significantly affected by factors other than its physical properties.[3] Furthermore, Analysys Mason/Aetha Consulting have explained in their report that, in their extensive experience, local factors tend to dominate spectrum values.[4]

In particular, the main issue in deriving a UK 1800MHz value from a sample of recent EU auctions is to control for country-specific factors that affect absolute and relative spectrum values between countries (on a per MHz per capita basis). Those may include, for instance:

– the level of competition in the mobile market – for example, number of mobile operators, presence of challenger operators and incidence of pro-competitive regulatory policies;
– population growth, income per capita, average revenue per user (ARPU) and pre-pay/post-pay split – all which affect the revenue that an MNO can generate from spectrum;
– the country's topography, population density, split between rural and urban areas, planning restrictions and cost of backhaul – all of which impact the cost of deploying additional sites for coverage and capacity as an alternative to spectrum; and

[3] For example, "SRSP: The revised Framework for Spectrum Pricing. Our policy and practice of setting AIP spectrum fees" (Dec 2010), paragraph 3.27-3.30.
[4] Section 4.3.3 of the Analysys Mason/Aetha report attached as Annex A.

– the design and features of the auction – for example, the amount of spectrum held by each operator prior to the award, amount spectrum on sale, the degree of competition in each band, spectrum caps and set-asides, coverage obligations, and auction format and information rules.

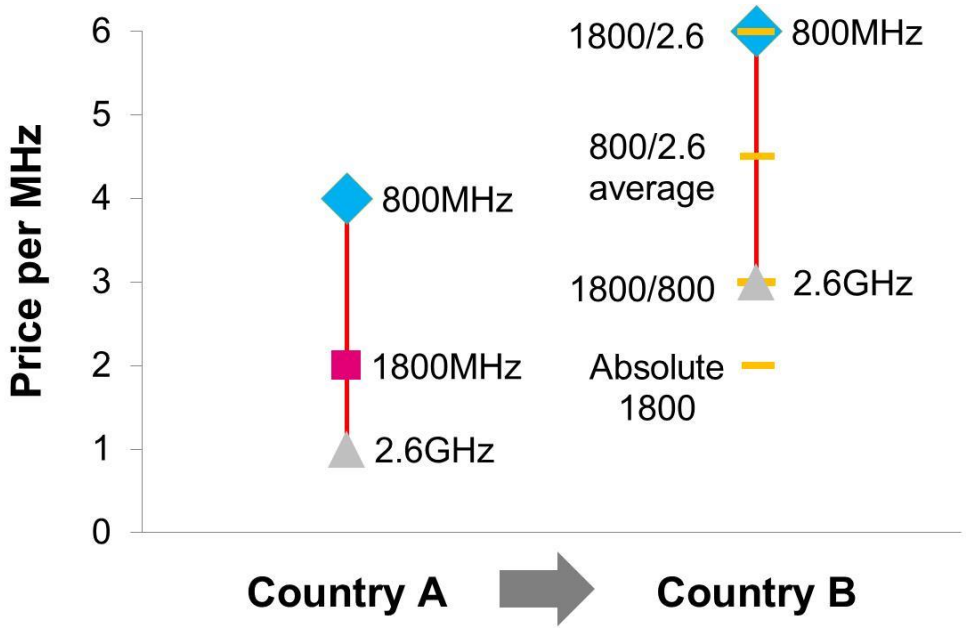
Indeed, Three considers that there are features of Ofcom's methods that can systematically overshoot or undershoot the 1800MHz UK value, as they do not control sufficiently for such country-specific factors.

A simple numerical example illustrates why this can happen. Suppose countries A and B have the same population, currency and licence conditions. The 800MHz, 1800MHz and 2.6GHz prices achieved in country A are 4, 2 and 1 respectively. Country B has not auctioned 1800MHz. The 800MHz and 2.6GHz prices in country B are 6 and 3. What is therefore the 1800MHz value in country B, based on values observed in country A?

This is exactly the same challenge that Ofcom faces, namely, to determine the UK 1800MHz value based on UK 800MHz and 2.6GHz values and 800MHz, 1800MHz and 2.6GHz spectrum values in other countries.

Figure 4 below illustrates this example and shows the implied 1800MHz values in country B.

Figure 4: Ofcom's methods produce anomalous estimates.



Source: Three.

In particular, Figure 4 shows that Ofcom's methods generate a wide range of anomalous estimates of 1800MHz value in country B:

– Ofcom's **absolute method** values 1800MHz well below 2.6GHz – as it does not take into account that spectrum is generally more valuable in country B;
– Ofcom's **relative method** produces two extreme values – the 1800/2.6 measure values 1800MHz and 800MHz equally, while the 1800/800 measure values 1800MHz the same as 2.6GHz. The reason is that the method does not take into account that 800MHz is relatively less valuable (and 2.6GHz relatively more valuable) in country B than in A; and
– Ofcom's **combinations of UK values method** – and in particular the simple average of the 800MHz and 2.6GHz UK values – produces an 1800MHz estimate half-way between the country B 800MHz and 2.6GHz values, which bears no relation to the outcome in country A.

More generally, Ofcom's **absolute method** is driven by country-specific factors that may have no relevance to the UK situation and do

not account for UK-specific factors that do influence spectrum value.[5] Overall, absolute measures generate a wide range of values and can easily over- or under-estimate the UK 1800MHz value.

In comparison, **Ofcom's relative method** tends to produce an extremely wide range of values, of which some are clearly inconsistent with the result in the benchmark country. In particular, this method does not sufficiently control for country-specific factors that affect the relative value of 800MHz and 2.6GHz spectrum in the benchmark and target country.

Lastly, Ofcom's **combinations of UK values method** take no account of evidence from other countries.

Ofcom's absolute method can be significantly affected by the approach used to convert local results into UK-equivalent values.

To arrive at its estimates of 1800MHz value in the UK, Ofcom scales for licence duration, converts auction outcomes in local currency (mostly in EUR) into USD (using purchasing power parity rates), adjusts for US inflation (using a US CPI index), and converts to GBP using a USD/GBP purchasing power rate.

Section 4.1 of the Analysys Mason/Aetha Consulting report explains that absolute measures can be significantly affected by these adjustments. In summary, exchange rates are volatile, it is possible to convert from EUR to GBP directly, there are several inflation measures available and alternative methods of scaling for licence duration or purchasing power may be equally valid. These factors can therefore introduce significant error margins in the derivation of absolute measures.

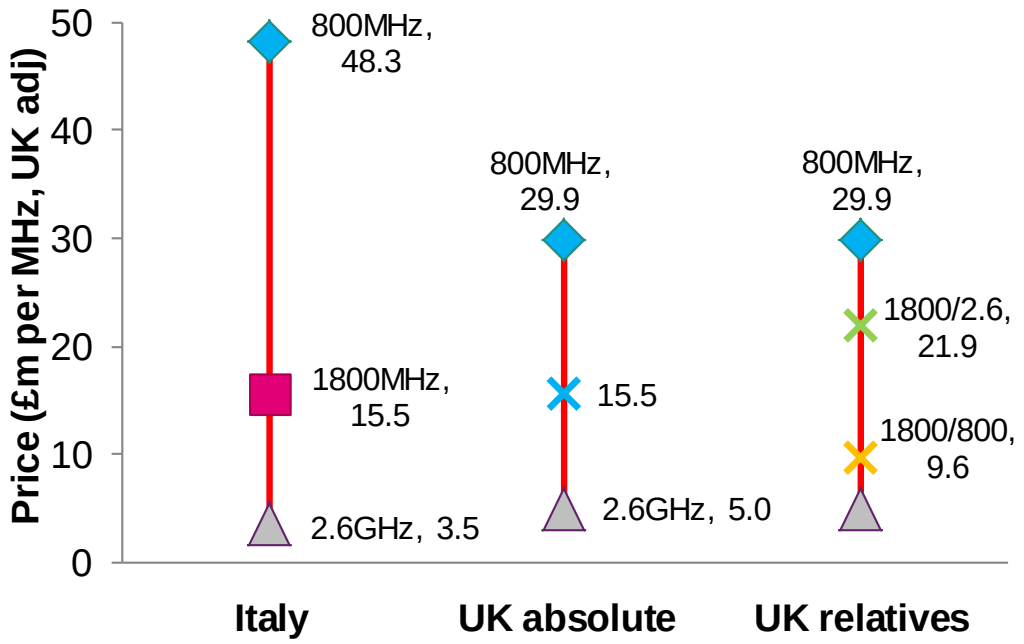
On the other hand, relative measures are considerably less impacted by these factors. Similarly, because they take no account of evidence from other countries, combinations of UK values are not affected by these conversions.

[5] Adjustments used to normalize benchmark values are only able to capture a few country-specific factors (ie purchasing power and licence duration).

For instance, Ofcom's methods entail anomalous 1800MHz value estimates from Italy.

The fact that Ofcom's absolute and relative methods produce unreliable value estimates can be seen by analysing the resulting 1800MHz UK benchmarks based on Italy, as shown in Figure 5, which Ofcom considers to be "more important" evidence.

Figure 5: Ofcom methods entail anomalous 1800MHz UK value estimates from Italy.



Source: Three.

Figure 5 shows that in Italy, 2.6GHz spectrum achieved a similar price (per MHz per pop) as in the UK, whereas 800MHz was much more valuable in Italy. However, Ofcom's methods do not account for this variation in spectrum values.

Indeed, Ofcom's absolute method yields an 1800MHz UK value of £15.5m per MHz. That value is much closer to the 800MHz value (and further from the 2.6GHz) value than in Italy.

Similarly, instead of looking at the Italian results holistically, Ofcom's relative method considers each of the 1800/2.6 and 1800/800 ratios

only in isolation. This produces two widely different estimates of the 1800MHz UK value, namely:

- the 1800/2.6 relative measure values UK 1800MHz at £21.9m per MHz, almost as much as 900MHz spectrum (£25m per MHz) which is clearly wrong. This places UK 1800MHz closer in value to 800MHz than to 2.6GHz (which itself is inconsistent with the outcome in Italy);
- the 1800/800 relative measure values UK 1800MHz at £9.6m per MHz – in this case, the UK 1800MHz value is closer to the 2.6GHz value than in the Italian auction, again an anomaly; and
- the simple average of both relative measures yields an 1800MHz UK value of £15.8m per MHz, about half-way between the 800MHz and 2.6GHz UK values – also inconsistent with the auction outcome in Italy, where the 1800MHz value was much closer to the 2.6GHz than 800MHz.[6]

In general, Ofcom's relative method will only result in a single consensus 1800MHz estimate – that is consistent with the outcome in the benchmark country – if the 800/2.6 ratio in that country and in the UK are the same. In contrast, where the 800/2.6 ratios differ significantly between both countries, one relative measure will produce a value that is "too high" while the other one yields an estimate that is "too low" (as in Figures 4 and 5).[7] Moreover, the average of both values may not provide either a meaningful estimate of the 1800MHz UK value. We provide an algebraic proof for this in Annex E.

Annex E shows that the 800/2.6 ratio is significantly lower in the UK than in most benchmark countries. This gives rise to very large differences in the UK 1800MHz relative values, depending on whether the 1800/800 or the 1800/2.6 ratio is used. In effect, Ofcom's relative method generate a wide range of UK 1800MHz values, ie a "scattergun" effect.

Moreover, Ofcom's relative method can also generate extreme values. For example, had the 800/2.6 UK ratio in Figure 5 been even smaller (or that in the benchmark country larger), Ofcom's relative method could have produced 1800MHz UK estimates at the extreme ends of (or even outside) the range of 800MHz and 2.6GHz UK values. Section 3 below discusses several instances and Ofcom's treatment of these.

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[6] The 1800MHz UK value that bears the same distance to the 800MHz and 2.6GHz values in both countries is £11.6m per MHz.

[7] If the 800/2.6 ratio is higher in the benchmark country than in the UK, the 1800/2.6 value will be too high and the 1800/800 measure too low (provided the 1800MHz lies between 800MHz and d2.6GHz in the benchmark country). This is reversed if the 800/2.6 ratio is lower in the benchmark country. See section on relative measures in Annex E.

Conclusion: Ofcom's benchmarking methods maybe unreliable and must be treated with care.

Table 3 ranks each method according to the criteria set out in this section.

Table 3: Ofcom's methods generate poor estimates of 1800MHz UK value

Criteria	Ofcom absolute method	Ofcom relative method	Ofcom combinations of UK values method
Consistent with Government Direction			
Less affected by country-specific factors			
Independent of inflation measure, exchange rates, etc.			

Source: Three.

In summary, Ofcom's absolute method and combinations of UK values method do not score well across these criteria. In general, they produce unreliable value measures and should not be used in the derivation of 1800MHz UK values.

Of Ofcom's alternative methods, Ofcom's relative method is preferable, as it has regard to bids made in the UK 4G auction and is more independent of adjustments than Ofcom's absolute method. Nevertheless, Ofcom's relative method is still a "scattergun" metric that tends to produce arbitrarily high and low values (in some cases outside the 800MHz- 2.6GHz value range) that are often inconsistent with the outcome in the benchmark country.

3. Ofcom's classification of its 1800MHz UK value benchmarks contains large inconsistencies.

Ofcom uses its three benchmarking methods to estimate values of 1800MHz spectrum in the UK. Ofcom classifies the resulting values as either "more important" or "less important", or omits them entirely. Ofcom then arrives at its proposed 1800MHz UK value based on the range of values derived for each of its more and less important benchmarks.

Three agrees with Ofcom that it is necessary to classify each benchmark value as more or less important, or omit entirely, reflecting the quality of the underlying evidence. However, the logic for classifying data points and arriving at the resulting 1800MHz UK value should be clear and consistent.

At present, in our view, Ofcom's treatment of its UK value benchmarks contains some large inconsistencies. This is particularly concerning given the wide range of values produced by Ofcom's methods. Three considers that this leads to a systematic bias in Ofcom's overall estimate of the UK 1800MHz value.

In particular, under Ofcom's classification approach, Ofcom's 1800MHz UK value progressively increases from an underlying £8.7m per MHz average produced by its three methods to its final £15m per MHz estimate. There are three main causes of this, namely:

- Ofcom omits various observations produced by its three methods and also counts the same observation several times over;
- Ofcom's classification of benchmarks as more or less important is inconsistent and appears to be skewed towards higher 1800MHz values; and
- Ofcom sets an 1800MHz value above the average of its more important evidence and effectively disregards the less important evidence entirely.

Overall, Three considers that Ofcom's proposed UK 1800MHz lump-sum value of £15m per MHz represents a significant overestimate. This reflects a combination of unreliable benchmarking methodologies, inconsistent classification of other country benchmarks and lack of transparency in the derivation of its 1800MHz UK value.

Our expert reports from Analysys Mason and Aetha Consulting support these conclusions.

Ofcom's classification of the benchmarks progressively increases its 1800MHz UK value.

Ofcom's methods yield (up to) three different value estimates from each of its 10 benchmark countries (namely the value derived from the absolute method and up to two values derived from the relative method). In addition, Ofcom's methods generate three 1800MHz estimates derived from combinations of UK auction values. This generates a total of 30 estimates of the 1800MHz UK value.[8]

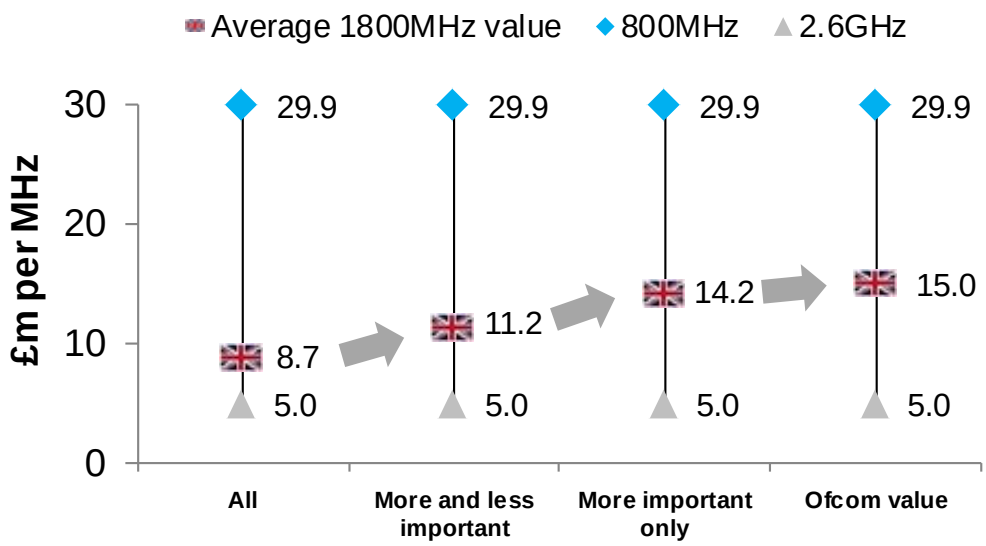
Ofcom then handles this evidence as follows:

– Ofcom omits 10 out of the 30 potential 1800MHz UK values entirely;
– of the remaining 20 data points, Ofcom classifies 11 observations as more important and 9 as less important; and
– finally, Ofcom arrives at its 1800MHz UK value based on the range of values derived for each category.

The individual data points, their classification and average values are documented at Annex F to this response. Figure 6 compares the simple average 1800MHz UK value across the whole sample (including the omitted values), the more and less important estimates, the more important data only and Ofcom's final 1800MHz UK value.

[8] The countries are shown in Table 4 below

Figure 6: Ofcom's classification of the evidence significantly increases its 1800MHz value estimate.



Source: Three.

In summary, Ofcom's treatment of the evidence brings the 1800MHz UK value progressively closer to the 800MHz/2.6GHz simple average value – from £8.7m to the final £15m per MHz. We assess each of those steps in detail in the rest of this section.

Ofcom omits data points produced by its three methods and counts the same auction outcome several times over.

Ofcom classifies each 1800MHz UK value estimate as either "more important" or "less important" based on two criteria: i) whether it is likely to reflect market value in the country concerned, and ii) its relevance to the value of 1800MHz in the UK.[9]

Three agrees with Ofcom that it is necessary to classify each benchmark, to reflect the quality of the underlying evidence. However, Three considers that Ofcom's approach contains large inconsistencies. This is particularly concerning given the wide range of potentially arbitrary values produced by its three methods.

[9] Paragraph 4.12 of the Consultation.

Table 4 presents Ofcom's classification of the evidence, including more important values (in green), less important data (in yellow) and the omitted values (in pink).[10]

Table 4: Ofcom classifies its evidence inconsistently.

	DK	DE	EL	IE	IT	NL	PT	RO	ES	SE	UK
1800 absolute	●	●	●	●	●	●	●	●	●	●	-
1800/800	●	●	-	●	●	●	●	●	●	●	-
1800/2.6	●	●	-	-	●	-	●	●	●	●	-
Reserve	-	-	-	-	-	●	-	-	-	-	-
800/2.6 average	-	-	-	-	-	-	-	-	-	-	●
800/2.6 interpolation	-	-	-	-	-	-	-	-	-	-	●
800/2.6 exponential fit	-	-	-	-	-	-	-	-	-	-	●

● More important ● Less important ● Omitted "-" n/a or irrelevant

Source: Figures 4.4 and 4.5 of the Consultation.

First, Ofcom omits 9 relative measures from Denmark, Germany, Netherlands, Portugal and Spain – if it considers that an absolute 1800MHz value is less important, then it disregards relative measures from that country.[11] Ofcom also omits the 1800/2.6 relative measure in Sweden.[12]

As shown in Figure 6 (and Annex F), as the 10 data points that Ofcom has disregarded produce lower 1800MHz values, this has the effect of increasing the average 1800MHz UK value from £8.7m per MHz to £11.2m per MHz.

Moreover, Ofcom's exclusion of certain relative values also generates an inconsistent treatment of the underlying evidence: namely, absolute

[10] Other boxes represent data points that are either not available (e.g. relative measures in Greece, which did not auction 800MHz or 2.6GHz), are not relevant (e.g. combinations of 800/2.6 values outside the UK or reserve prices in countries where actual prices are available), or for which no reliable price information is available due to the combinatorial nature of the auction (e.g. Netherlands).
[11] Paragraph A7.2 of the Consultation.
[12] Three assumes that the 1800/2.6 value from Sweden (which appears in Figure 4.2 of the Consultation) has been excluded from Figure 4.5 because 2.6GHz was awarded in 2008 in that country, which is outside the period considered by Ofcom.

1800MHz values from five countries are considered less important, but not the resulting relative measures. To be consistent, Ofcom should have classified those relative values as less important and taken them into account in the determination of the 1800MHz UK lump-sum value.

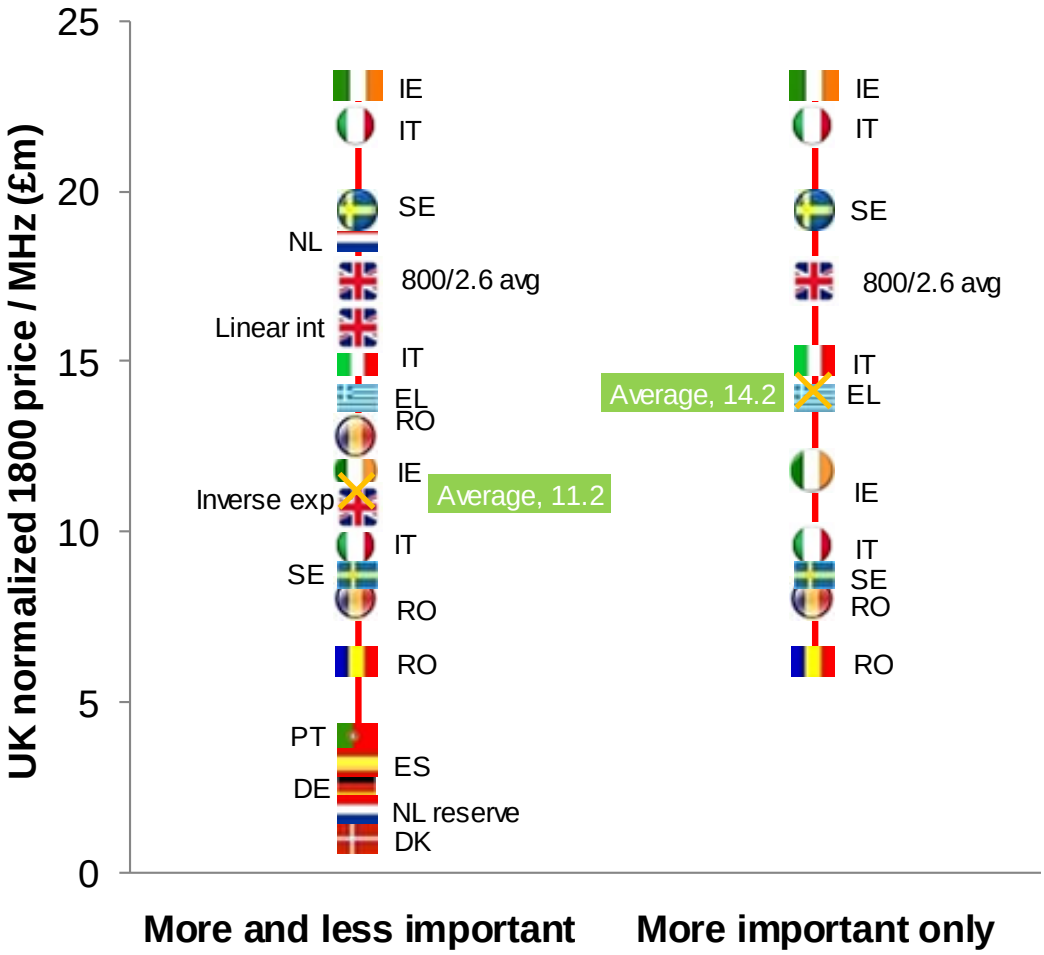
Second, Table 4 shows that Ofcom uses multiple benchmarks from one and the same auction, effectively counting the same outcome several times over. Therefore, some countries are more influential than others without an explicit weighting being assigned to them. For example, Ireland and Italy, which achieved the highest 1800MHz prices in the EU on a price/MHz/pop basis, contribute five separate estimates averaging £16.4m per MHz or nearly half of Ofcom's "more important" data points.

Ofcom's classification of its benchmark values as "more" or "less important" is inconsistent and appears skewed towards higher 1800MHz values.

Figure 7 provides further detail about Ofcom's more and less important evidence (in the left-hand column), and the more important evidence only (to the right).[13]

[13] Rectangular markers represent Ofcom's absolute values, round markers are relative values, and square markets refer to combinations of UK values.

Figure 7: Ofcom's sample of more important UK values appears skewed upwards.



Source: Figures 4.4 and 4.5 of the Consultation.

It is apparent from the left-hand column in Figure 7 that Ofcom's methods generate anomalous estimates of 1800MHz UK value at both the lower and the higher end, namely:

– at the higher end of the value range, five of Ofcom's 1800MHz estimates are above the linear interpolation of the 800MHz and 2.6GHz UK prices – which is inconsistent with the auction outcomes in those countries (see Section 1, Figure 3);
– at the bottom end of the value range, five other estimates value 1800MHz spectrum less than 2.6GHz (i.e. below £5m per MHz, the

UK 2.6GHz linear price), which may also be considered an anomaly.

Indeed, a fundamental problem with Ofcom's benchmarking methods is that they produce arbitrarily high and low UK value estimates, which Ofcom then subsequently manually excludes from its more important sample, albeit selectively. Indeed, Ofcom has mostly excluded outliers at the bottom end of the range. This in itself has the effect of inflating the average 1800MHz value from £11.2m to £14.2m per MHz.

In particular, Ofcom sets a floor on the 1800MHz UK value at £5m per MHz (the UK 2.6GHz value) for the purpose of excluding values below this. In effect, Ofcom automatically considers all estimates below that value as "*not credible*" and "*less important*", on the grounds that 1800MHz cannot be worth less than 2.6GHz spectrum.[14]

Yet Ofcom never considers setting a corresponding ceiling on the 1800MHz value to exclude anomalously high values at the higher end of its sample, such as:

– the absolute value in Ireland (£23.1 per MHz), which is a clear overestimate of the UK 1800MHz value, as 2.6GHz will not be available to mobile operators in that country for the foreseeable future. This makes 1800MHz much more valuable in Ireland than in the UK. Indeed, Ofcom's method values 1800MHz almost as much as 900MHz (£25m per MHz), which is clearly unlikely;
– the relative 1800/2.6 measure from Italy, which places the 1800MHz UK value (£21.9m per MHz) much closer to 800MHz (£29.9m per MHz) than to 2.6GHz (£5m per MHz), which itself is inconsistent with the auction outcome in Italy. The same is true of the relative estimate from Sweden, where in fact 1800MHz achieved a lower price than 2.6GHz (see Figure 2); and
– the simple 800/2.6GHz UK average, which is entirely arbitrary and takes no account of evidence from other countries – as discussed in Section 2.

In Three's view, taken as a whole, Ofcom's UK value estimates in Figure 7 are unreliable, for the reasons highlighted above. Nonetheless, if Ofcom is to persist in using its current method, it should at least be consistent with its manual adjustments. Namely, if a floor is needed to exclude unduly low 1800MHz values, then a ceiling is also needed to remove from the "more important" category values that are anomalously high.

[14] Paragraphs 4.45 and 4.57d and Figures 4.4 and 4.5 of the Consultation.

Indeed, Ofcom sets an "upper limit" on the 900MHz value equal to the 800MHz UK price (£29.9m per MHz).[15] This is on the basis that, in Ofcom's view, 900MHz is not as valuable as 800MHz because it fetched a lower price in most recent EU auctions.[16] However, in respect of 1800MHz the position is even clearer: 1800MHz did not fetch a price above the linear interpolation of the 800MHz/2.6GHz values in any of the countries considered by Ofcom (see Section 1).

This suggests that, should Ofcom persist with its current methods, it should at minimum set a ceiling on the 1800MHz UK value equal maximum to £16m per MHz, the linear interpolation of the 800MHz and 2.6GHz UK values.

Ofcom sets an 1800MHz value above the average of its more important evidence and effectively disregards the less important evidence[17].

The final step in Ofcom's methodology is to determine a lump-sum 1800MHz UK value from the range of more and less important estimates. Ofcom emphasises the need to avoid a mechanistic approach because "*no specific evidence may be relied upon in a determinative way*".[18]

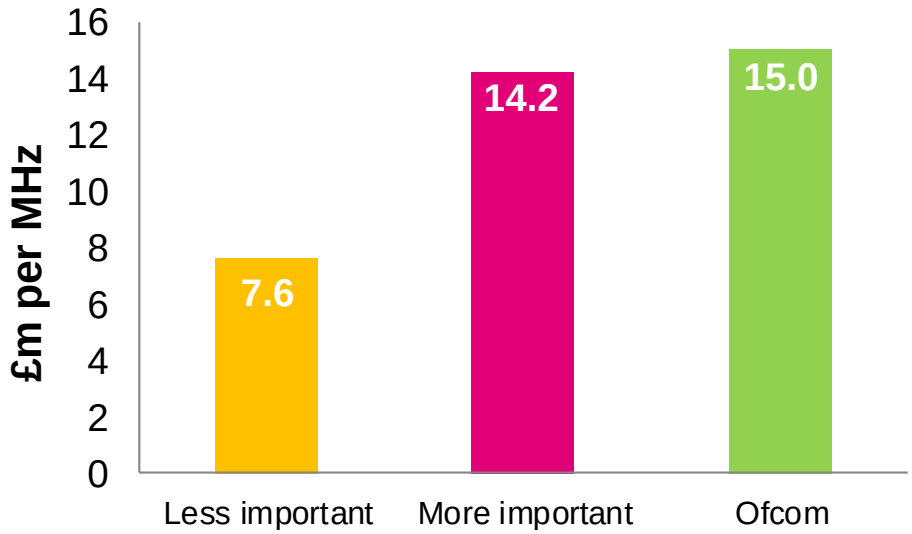
In practice, Ofcom seems to strike a visual average of its more important 1800MHz values at £15m per MHz, which it says is supported by two nearby values – absolute values in Italy (£15.5m per MHz) and Greece (£13.9m per MHz). Ofcom then points to higher and lower estimates above and below £15m per MHz (some more important, some less important) as further supporting its chosen value.[19]

In Three's view, Ofcom's approach is extremely crude and has the effect of inflating the 1800MHz value in a way that cannot reasonably be justified by "*regulatory expertise and judgment*". This can be seen by considering what a mechanistic approach would have to assume in order to arrive at an 1800MHz value of £15m per MHz.

[15] Paragraph 4.42.
[16] But in this case 900MHz values above the upper limit are not automatically considered "less important". See Figure 4.4 and paragraph 4.57d of the Consultation.
[17] On this, see Section 6 of the Analysis Mason/Aetha report.
[18] Paragraph 4.51.
[19] Paragraph 4.58.

Namely, Figure 8 shows that Ofcom's proposed 1800MHz value of £15m per MHz is above the average value of both Ofcom's "*more important*" and "*less important*" evidence.

Figure 8: Ofcom's proposed 1800MHz value is above Ofcom's "more important" and "less important" averages.



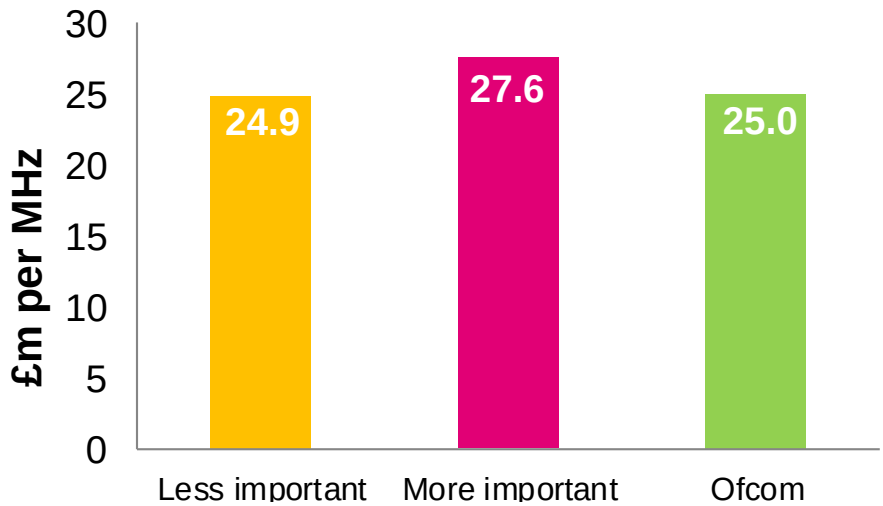
Source: Three, Ofcom.

This means that the large number of "less important" benchmarks do not impact Ofcom's chosen value at all – in effect, Ofcom disregards that evidence in arriving at its proposed lump-sum figure. Moreover, to go from £14.2m to £15m per MHz a mechanistic approach would also have to assign greater weight to the higher values within the pool of "more important" data points, namely, derived from Ireland, Italy and Sweden.

In comparison, a more transparent approach would have been to assign explicit weights to the more and less important evidence, using an appropriate average as the 1800MHz lump-sum value and then test the sensitivity of that value to the weights employed. This would have produced a value between £7.6m and £14.2m per MHz, with the actual value determined by the weights applied. Stakeholders would then be able to understand more clearly what Ofcom is doing and comment sensibly on its determination of the 1800MHz value.

Apart from being highly unsatisfactory, Ofcom's approach also discriminates against the 1800MHz licensees. Namely, in relation to 900MHz spectrum, Ofcom sets a value (£25m per MHz) close to the average of its less important evidence (£24.9m per MHz), and below the average of Ofcom's more important values (£27.6m per MHz), as shown in Figure 9.

Figure 9: Ofcom's proposed 900MHz value is almost equal to the average of its less important values.



Source: Three, Ofcom.

4. A proper benchmarking approach entails a much lower 1800MHz lump-sum value.

There are inherent limitations to any benchmarking approach for estimating the value of 1800MHz spectrum in the UK. Nevertheless, Three considers that there is a simpler and better method available than Ofcom's, namely considering the value of 1800MHz in relation to both 800MHz and 2.6GHz together, or the "distance" method.

In Three's view, the distance method produces much more reliable estimates of the UK 1800MHz value than Ofcom's methods across a range of criteria. In particular, the distance method:

– minimises the impact of non-UK country-specific factors;
– produces much greater consistency of 1800MHz estimates; and
– generates better predictions of the 1800MHz value in other countries.

In addition, a proper benchmarking approach should apply consistent and objective criteria for classifying benchmarks produced by the distance method as more or less important, or omitting them entirely.

The overall result of this approach is a UK 1800MHz value of £9.1m per MHz, in comparison to Ofcom's proposed value of £15m per MHz.

Alternatively, correcting Ofcom's relative method for the above issues generates a very similar UK 1800MHz value of £9.2m per MHz.

Our conclusions here particularly rely on our expert reports from Analysys Mason and Aetha Consulting.

There is an alternative benchmarking method available for estimating the UK 1800MHz value.

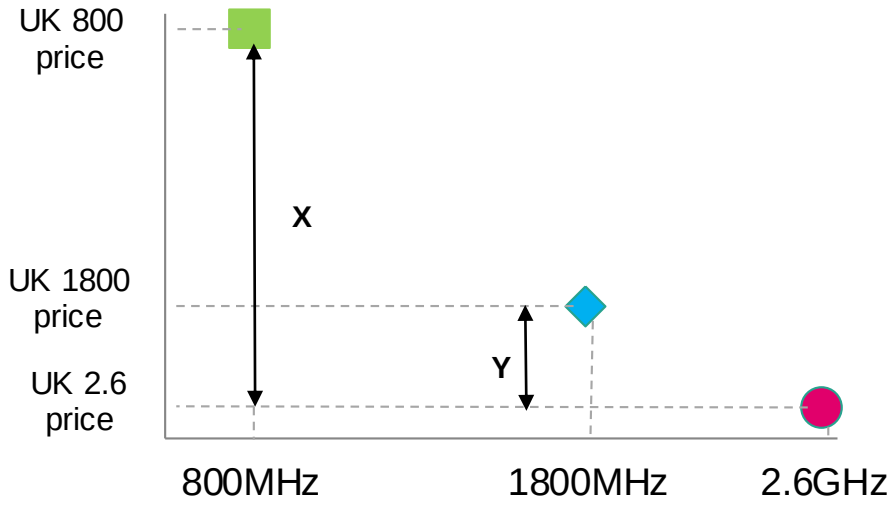
Three has developed an alternative method for estimating the 1800MHz UK value – namely, considering the value of 1800MHz in relation to both 800MHz and 2.6GHz together, or "distance" method.

The distance method measures the distance ratio D as the difference between the 1800MHz and 2.6GHz values in recent EU auctions, as a proportion of the distance between the 800MHz and 2.6GHz values in those awards. The method then applies D to the 800MHz and 2.6GHz values in the UK to generate an estimate of 1800MHz UK value.[20]

[20] i.e. D equals (1800 price-2.6 price)/(800 price -2.6 price) in the auction in question. The absolute difference between the 800MHz and 2.6GHz values in the UK is multiplied by D and added to the 2.6GHz value to arrive at the 1800MHz UK estimate.

In other words, the method asks: what should the UK Y/X ratio in Figure 10 be, based on the same ratio in the benchmark country?

Figure 10: The distance method asks: what is the UK Y/X ratio?



Source: Three.

For instance, if D equals 27% in the Italian multi-band auction, then the corresponding 1800MHz UK value would also sit 27% along the way between the 2.6GHz and 800MHz UK linear reference prices.

The distance method is a relative measure, not unlike Ofcom's relative method. It can also be seen as a variant of Ofcom's third method – combinations of UK values – where the 1800MHz value is a weighted average of the 800MHz and 2.6GHz UK linear prices (with weights of D and 1-D respectively).

The distance method provides better estimates of the UK 1800MHz value than Ofcom's methods.

It is straightforward to show that the distance method provides better estimates of 1800MHz UK value than Ofcom's methods, on almost all criteria. Table 5 ranks Ofcom's measures and the distance method against the criteria set out in Section 2.

Table 5: The distance method is superior to absolute and relative measures.

Criteria	Ofcom absolute method	Ofcom relative method	Ofcom combination of UK values method	Distance method
More consistent with Government Direction				
Less affected by country-specific factors				
Independent of inflation measure, exchange rates, etc.				

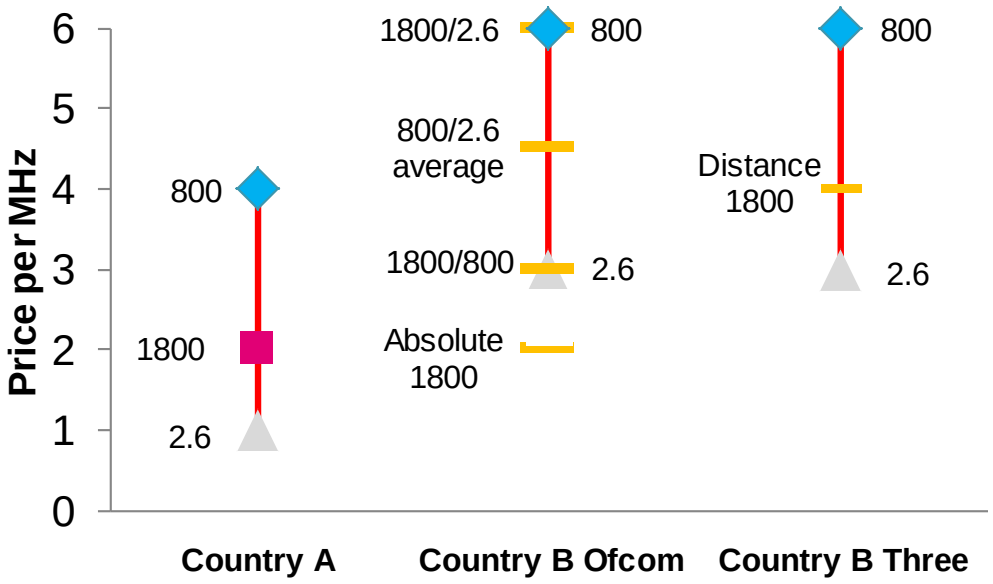
Source: Three.

In summary, use of the distance method is more consistent with the Government Direction. Distance values are firmly based on sums bid for 800MHz and 2.6GHz spectrum in the UK (as reflected in their price), and can be meaningfully said to represent full market value.

The key advantage of the distance method is that it controls for country-specific factors better than any of Ofcom's methods. Indeed, the distance method produces a single value from each benchmark country that i) takes into account the relativities to both the 800MHz and the 2.6GHz benchmarks; and ii) is more consistent with the outcome in the benchmark country than Ofcom's values.

Figure 11 reproduces the example in Section 2, Figure 4, where the 800MHz, 1800MHz and 2.6GHz prices achieved in country A are used to estimate the 1800MHz value in country B, given the 800MHz and 2.6GHz prices in that country.

Figure 11: The distance method produces a value consistent with the outcome in the reference country.



Source: Three.

As explained in Section 2, Ofcom's methods generate four quite different estimates of the 1800MHz value in country B. In comparison, the distance method produces a single value that bears the same relation to the 800MHz and 2.6GHz values in the reference country.

Unlike Ofcom's methods, individual distance estimates should always sit within the 800MHz and 2.6GHz range (provided that the 1800MHz value sits between those values in the reference country).

The distance method is also much more statistically reliable than any of Ofcom's methods, as it controls for country-specific factors better. This is set out in greater detail in Annex E. In summary, it is possible to test the statistical reliability of each method in two ways:

– calculating the standard deviation of the UK 1800MHz values produced by each method; and
– testing each method's predictive power, by comparing each method's predicted 1800MHz value among the benchmark countries with the actual 1800MHz price achieved in those awards.

Table 6 sets out the standard deviation and average absolute errors associated with each of Ofcom's methods.

This highlights that the distance method produces an unambiguously lower standard deviation than any other method, i.e. showing the distance method produces much greater consistency and consensus of UK 1800MHz value estimate.

It also shows that the distance method leads to similarly low average absolute errors, when predicting 1800MHz values in the comparator countries, compared to any of Ofcom's methods. This also confirms the reliability of the distance method.

Please see Annex E for further details of the methodology and calculations behind these results.

Table 6: Observed spectrum values (UK-normalized, in £m/MHz)

Method	Standard deviation of UK estimates	Average absolute error of sample estimates
Ofcom absolute method	10.8	8.5
Ofcom combination of UK values method	-	10.6
Ofcom relative method	22.7	7.9
Distance method	5.1	7.0

Source: Three.

Other country benchmarks should be classified as more or less important evidence using objective and consistent criteria.

Three agrees with Ofcom's view that different auction benchmarks should not all carry equal weight, as some benchmarks provide better evidence than others. A key difficulty with any benchmarking exercise is that there are not many recent awards of 1800MHz spectrum available, thereby reducing its statistical reliability and robustness.

Therefore as general principles to address this problem:

– the benchmarking analysis should include as many observations as possible, and use as much price information as can be

extracted from recent EU awards (as some information will tend to be better than no information); and
– only recent EU auctions that provide no useful information regarding the 1800MHz value should be excluded from the analysis.

Our analysis therefore starts with the UK-equivalent benchmarks in Figure 4.2 of Ofcom's consultation, together with price information from auctions completed since Ofcom's consultation (Austria, the Czech Republic and Norway), and evidence from Switzerland (which Ofcom decided to exclude). We then exclude some of these benchmarks, as required, and classify the remaining ones as more or less important.

Section 5 of the Analysys Mason/Aetha Consulting report sets out the criteria we propose in further detail. In summary, we exclude Denmark, Spain, Norway and the Netherlands, as incumbents were not allowed to participate in the 1800MHz auction in the first two countries, and no reliable 1800MHz prices can be inferred from publicly available information in the other two.[21]

Of the remaining benchmarks therefore included in the analysis, we consider less important those which meet at least one of the following conditions:
– **band-specific prices cannot be directly inferred** – i.e. benchmarks from package auctions like Austria, Ireland and Switzerland would be less important at best;
– there is **unsold spectrum in any of the three bands** (800MHz, 1800MHz or 2.6GHz, or 900MHz if used as a proxy for 800MHz);
– **the 900MHz value is used as a proxy for the 800MHz value (or zero for the 2.6GHz value**) – the distance method requires values for the 800MHz, 1800MHz and 2.6GHz bands. Absent 800MHz or 2.6GHz values, it is possible to use the 900MHz value as a proxy for 800MHz, and/or zero as a proxy for the 2.6GHz value. This provides an upper bound for the value of 1800MHz in both cases (e.g. in Ireland and Greece);[22] and
– there is a **significant time gap between the auctioning** of those three bands (e.g. Sweden).

Table 7 summarizes our classification of the distance estimates derived from each award based on the above criteria.

[21] Belgium and France are also excluded, on the basis that they did not auction 1800MHz within Ofcom's time period.
[22] See Section 5, footnote 42 of the Analysys Mason/Aetha report attached as Annex A.

Table 7: Three's proposed classification of evidence points.

Country	Price can't be directly inferred	Use of proxy	Unsold spectrum	Time gap between auctions	More/less important
Austria	✓				Less
Czech Rep			✓		Less
Germany					**More**
Greece		✓			Less
Ireland	✓	✓			Less
Italy					**More**
Portugal			✓		Less
Romania	✓		✓		Less
Sweden				✓	Less
Switzerland	✓		✓		Less

Source: Section 5 of the Analysys Mason/Aetha Consulting Report.

Section 5 of the Analysys Mason/Aetha Consulting report sets out the reasons why we disagree with Ofcom's classification in some cases. In our analysis, Ofcom is wrong to consider evidence from Ireland, Sweden and Romania as more important, and to downgrade results from the German auction as less important.

In our view, only Germany and Italy provide more important evidence. This is particularly relevant given that, out of the above sample of countries, those two nations are the most comparable to the UK in terms of population, purchasing power and economic output.

The distance method and our classification of benchmarks entails a lump-sum 1800MHz value of £9.1m per MHz.

Table 8 presents the distance parameter D for each country in our sample, together with Three's 1800MHz value estimates based on our distance method and the above categorization of the evidence.

We present two scenarios:

i) **100% contribution to Digital Mobile Spectrum Limited (DMSL)** – following Ofcom's approach, the 800MHz UK price is assumed to be £29.85m per MHz, including the full contribution of the 800MHz licensees to DMSL for the purpose of funding co-existence with Digital Terrestrial Television (DTT);[23]

ii) **50% contribution to DMSL** –in our view it is appropriate to include only 50% of the DMSL contribution in the 800MHz price, to reflect Three's (and we believe other operators') expectations of the likely DMSL costs at the time of the auction.[24] This results in a correspondingly lower 800MHz UK price of £28.35m per MHz which, given the distance parameter in each country, reduces the resulting 1800MHz UK value estimate.

In both scenarios we assign weights of two and one to our more important and less important evidence respectively. Section 7 of the Analysys Mason/Aetha Consulting report in Annex A explains our distance calculations in further detail.

[23] This is the approach adopted in Section 7 of the Analysys Mason/Aetha Consulting report, which were not asked to comment on Ofcom's determination of the UK linear reference prices.
[24] The £30m per 2x5MHz 800MHz block DMSL cost was only ever an upper bound on licensee's liability 4G/TV interference mitigation costs. As we knew then and has been confirmed now, the £30m cost was based on extremely conservative assumptions about the likely interference levels and associated mitigation costs. For example, in October 2012, Vodafone circulated a memo among the UK MNOs and to Ofcom (entitled "800MHz Coexistence Experience from deployments") which highlighted that there were greatly fewer interference cases than originally feared, primarily owing to LTE equipment standards. This was also the 3 Group's experience in Sweden, where extremely limited TV interference occurred. Three therefore heavily discounted the potential DMSL cost liability in its UK 800MHz spectrum valuation, assuming 50% of the maximum potential cost. As we know now, 4G/TV experience in the UK has so far been only 1-2% of the level originally predicted prior to deployment. While costs are not proportionally lower, current cost expectations are in the region of 50-70% of the maximum operator liability.

Table 8: The distance method generates an 1800MHz UK value between £9.1m and £9.4m per MHz.

Country	D	1800 UK value based on 100% DMSL contribution (£m/MHz)	1800 UK value based on 50% DMSL contribution (£m/MHz)	Weight	Comments
Austria	59%	19.6	18.7	1	Band-specific prices cannot be inferred. We use final clock prices.
Czech Rep	7%	6.7	6.6	1	
Germany	1%	5.1	5.1	2	
Greece	44%	16.0	15.3	1	We use zero as a proxy for 2.6 and 900 value for 800. This overestimates UK 1800 price.
Ireland	39%	14.8	14.2	1	We use zero as a proxy for 2.6 value. This overestimates UK 1800 price.
Italy	27%	11.6	11.2	2	
Portugal	2%	5.5	5.4	1	
Romania	19%	9.7	9.4	1	
Sweden	-13%	1.7	1.9	1	2.6 fetched higher price than 1800, so value is below UK linear price.
Switzerland	0%	5.0	5.0	1	Band-specific prices cannot be inferred. We use reserve prices.
Weighted	**18%**	**9.4**	**9.1**		

average					

Source: Three.

Table 8 shows that the weighted average distance parameter is 18%. The resulting 1800MHz valuation based on the distance method is £9.1m per MHz (assuming 50% DMSL contributions). This can be compared with Ofcom's implicit distance of 40% and lump-sum value of £15m per MHz (see Figure 3).

This confirms that Ofcom's proposed 1800MHz lump-sum value is considerably overstated and does not reflect a proper benchmarking of the auction evidence from other countries.

Section 7 of the Analysys Mason/Aetha Consulting report tests the sensitivity of our 1800MHz distance valuation (based on a 100% contribution to DMSL) to different assumptions. In summary of that:

– the 1800MHz valuation estimate is not overly sensitive to the more important/less important weights used – as the 1800MHz value is bounded by the averages of the more important and the less important evidence; and
– excluding the two highest distance estimates (Austria and Greece) would lower the resulting 1800MHz value from £9.4m to £7.7m per MHz, while excluding the bottom two estimates (Sweden and Switzerland) would increase it to £10.6m per MHz.

Alternatively, a corrected application of Ofcom's relative method yields an 1800MHz lump-sum value of £9.2m per MHz.

Three considers that the distance method is the most accurate method for estimating lump sum UK 1800MHz value. However, Annex E explains that it is possible to arrive at a similar UK lump-sum value by using Ofcom's relative method appropriately.

First, when using relative ratios it is important to include as many data points as possible – including all countries presented in Table 8. This gives a far greater number of relative ratios than used by Ofcom.

Second, as discussed in Section 2 (Figure 4), when considered in isolation, relative 1800/800 and 1800/2.6 ratios from a given benchmark country produce widely varying estimates of 1800MHz spectrum value. A correct application would therefore at minimum take account of both the 1800/800 and 1800/2.6 ratios from a benchmark country, thereby controlling for the difference in 800/2.6 ratios between that country and the UK.

Third, a further issue arises with using relative ratios due to the difference in scale between the 1800/800 ratio and the 1800/2.6 ratio. This means that when calculating either the average ratio or the average implied 1800MHz value by ratio across the group of benchmark countries, it is important to use the geometric mean rather than the arithmetic mean. A full explanation for this is provided in Annex E.

Accordingly, Annex E estimates the UK 1800MHz spectrum value using relative ratios by:

– considering relative ratios across the whole group of benchmark countries in Table 8;
– taking a geometric average of both the 1800/800 and 1800/2.6 ratios across the group of benchmark countries where relevant spectrum values are available;
– applying the respective average ratio to the UK 800MHz values (the 1800/800 ratio) and UK 2.6GHz value (the 1800/2.6) ratio, thereby controlling for the difference in 800/2.6 ratios between the benchmark country and the UK; and
– calculating the average of the two UK 1800MHz values implied by the two average ratios.

This results in an estimate of UK 1800MHz value of £9.2m – an almost identical result to that implied by the distance method. This shows that, when relative ratios are correctly applied, they provide a similar estimate of UK 1800MHz value to the distance method.

5. Ofcom's proposed 1800MHz lump-sum value does not adequately reflect technical and other evidence.

A significant problem with Ofcom's approach is that there is no proper cross-checking of its proposed 1800MHz value. Such a cross-check would have revealed that Ofcom's 1800MHz value of £15m per MHz is too high and does not reflect a reliable benchmarking of the evidence.

In comparison, an 1800MHz value of £9.1m per MHz is much more consistent with the available evidence. In particular:

- £9.1m per MHz is much more consistent with Ofcom's absolute benchmarks;
- £9.1m per MHz is much more consistent with Ofcom's 1800/900 relative benchmarks;
- £9.1m per MHz is much more consistent with Ofcom's valuations for the UK 4G auction – Ofcom valued 1800MHz at £9.2m to £13.8m per MHz and recognized that even the low end of that range risked overstating the 1800MHz UK value;
- our 1800MHz value is more consistent with the technical evidence – from a technical perspective, 1800MHz and 2.6GHz are closer in value to an operator (as capacity offloads from a 2.1GHz layer), while 800MHz has much greater value (as it can be used for wide-area coverage); and
- Ofcom is wrong to conclude that 1800MHz is a closer substitute for 800MHz than 2.6GHz based on bidding in the UK 4G auction – as some bids made in the auction may not necessarily reflect underlying spectrum value.

Our expert reports from Analysys Mason and Aetha Consulting, and internal technical report, support these conclusions. Three also commissioned an additional expert report from Analysys Mason on bidding behaviour in the auction, included with our response, which supports the final conclusion above.

An 1800MHz value of £9.1m per MHz is much more consistent with Ofcom's absolute benchmarks.

A significant problem with Ofcom's approach is that there is no systematic cross-checking of its proposed 1800MHz value. Such a cross-check would have revealed that Ofcom's value may be too high and does not necessarily reflect a reliable benchmarking of the evidence.

As set out in Section 2, in our view absolute measures should not be used in the derivation of UK lump-sum values. But they can prove

useful as a "cross check" of the values Ofcom has arrived at. Table 9 presents Ofcom's estimates of prices achieved in recent EU auctions.

Table 9: Ofcom's 1800MHz value is out of line with the EU average value.

£m per MHz, UK-equivalent	800MHz	900MHz	1800MHz	2.6GHz
Austria				1.8
Belgium				4.5
Denmark	10.1	2.4	1.0	9.5
France	34.2			5.2
Germany	50.1		1.8	1.5
Greece		31.4	13.9	
Ireland	58.6	35.7	23.1	
Italy	48.3		15.5	3.5
Portugal	36.1	24.1	3.1	2.4
Romania	21.8	24.9	6.2	2.5
Spain beauty contest		17.2	2.9	
Spain	31.4	24.9		3.1
Sweden	14.3		9.1	9.7
Average	**33.9**	**22.9**	**8.5**	**4.4**
Ofcom's UK	**29.9**	**25.0**	**15.0**	**5.0**

Source: Figure 4.2 of the Consultation.

In summary, Ofcom's 800MHz, 900MHz and 2.6GHz UK values are broadly in line with the average price achieved in recent EU auctions for those bands. By contrast, Ofcom's 1800MHz value of £15m per MHz is significantly higher than the corresponding EU average of £8.5m per MHz. This is a clear indicator that Ofcom has significantly overvalued 1800MHz spectrum in the UK.

An 1800MHz value of £9.1m per MHz is much more consistent with Ofcom's 1800/900 relative benchmarks.

Ofcom values 1800MHz and 900MHz spectrum at £15m and £25m per MHz respectively. This implies that 1800MHz spectrum is worth 60% of the 900MHz value according to Ofcom. As a cross-check, it is instructive to compare this relative value against Ofcom's own auction evidence from countries that have auctioned both bands.

Table 10: Ofcom's 1800/900 value is too high based on its own auction evidence.

£m per MHz, UK-equivalent	900MHz	1800MHz	1800/900
Ireland	35.7	23.1	65%
Ofcom	25.0	15.0	60%
Greece	31.4	13.9	44%
Denmark	2.4	1.0	42%
Three	25.0	9.1	36%
Netherlands (NSR)	68.4	18.8	27%
Romania	24.9	6.2	25%
Spain beauty contest	17.2	2.9	17%
Netherlands reserve	10.2	1.6	16%
Portugal	24.1	3.1	13%
Spain multiband auction	24.9	2.9	11%

Source: Figures 4.2 and 4.5 of the Consultation.

Table 10 shows that Ofcom's implied 1800/900 ratio of 60% is significantly greater than the actual 1800/900 ratio in any country in Ofcom's sample except Ireland.

Ofcom classifies these relative values as more or less important and concludes that its proposed 1800/900 value relativity of 60% "*sits*

within, although towards the top end of the range" of its more important values: Ireland (65%), Greece (45%) and Romania (25%).[25]

This is characteristic of Ofcom's overall approach. Ofcom discards the majority of data points and then justifies its chosen value by reference to the highest data point of the more important benchmarks. There is no questioning by Ofcom of whether that value may reflect country-specific factors (for instance, the fact that 1800MHz is much more valuable in Ireland than in the UK, as 2.6GHz is not available to mobile operators in that country for the foreseeable future).

In comparison, Three's 1800MHz valuation of £9.1m per MHz values that spectrum at 36% of the 900MHz price. This figure sits well within Ofcom's range of relative values (as shown in Table 10) and is therefore much less likely to be affected by country-specific factors.

£9.1m per MHz is much more consistent with Ofcom's valuations in the UK 4G auction.

In order to set reserve prices in the UK 4G auction, Ofcom commissioned Dotecon and Aetha Consulting to estimate the market value of 800MHz, 1800MHz and 2.6GHz spectrum. Ofcom's consultants valued those bands based on international benchmarks, business modelling and advice from an Expert Panel. The results are shown in Table 11.

Table 11: Ofcom's 1800MHz valuation is above the Dotecon - Aetha range [26].

£m per MHz	800	1800	2.6	2.6 unpaired
Dotecon/Aetha low	15.9	9.2	5.0	0.7
Dotecon/Aetha high	45.0	13.8	7.6	3.7
Ofcom ALF value	29.9	15.0	5.0	1.5

Source: Figure 8.2 of Ofcom's Assessment of Future Mobile Competition (24 July 2012).

[25] Paragraph 4.58 e of the Consultation.
[26] The ranges provided are for both "small bidders" and "large bidders", as defined in the Dotecon/Aetha report.

Ofcom's proposed valuation of 800MHz and 2.6GHz unpaired sit well within the Dotecon/Aetha range, while the 2.6GHz paired value is at the lower end of that range. On the other hand, Ofcom's 1800MHz value is above the top end of the Dotecon/Aetha range.[27] Ofcom has not explained which auction results, or change of methodology, since July 2012 have led to this significantly revised valuation.

This is especially surprising given the views Ofcom expressed during the auction consultation. Dotecon/Aetha recommended an 1800MHz reserve price of £9.2m per MHz,[28] the lower end of their range. Ofcom's Expert Panel had highlighted uncertainty about the value of 1800MHz in view of low prices paid in key auctions (e.g. Germany), and said that even the bottom end of the range would be regarded by many financial analysts as high in the event that Three acquired that spectrum.[29]

Following that recommendation, and in light of significant uncertainty about the 1800MHz value, Ofcom set the 1800MHz reserve price at £7.5m per MHz, significantly below the DotEcon/Aetha range.[30] Ofcom now values 1800MHz at £15m per MHz, or twice the level of the reserve price it set following its concern that Three may not otherwise be able to afford that spectrum.

Accordingly, Three considers that Ofcom's 1800MHz value is inconsistent with its previous statements and is well above the range of values prepared for the UK 4G auction without apparent justification.

By contrast, Three's proposed 1800MHz value of £9.1m sits just below the bottom end of the Dotecon/Aetha range (which the Expert Panel and Ofcom itself thought could overstate the true 1800MHz value), and is much more consistent with Ofcom's previously stated views.

An 1800MHz value of £9.1m per MHz is also much more consistent with technical evidence.

Ofcom uses technical evidence to inform its 1800MHz UK lump-sum value, finding that 1800MHz has "*substantially better*" propagation

[27] Paragraph 103 of Dotecon/Aetha's Spectrum Value of 800MHz, 1800MHz and 2.6GHz Report for Ofcom (July 2012).
[28] Ibid, paragraph 263.
[29] Ibid, paragraph 262.
[30] Paragraph 8.63 of Ofcom's Assessment of Future Mobile Competition and Award of 800MHz and 2.6GHz. Statement (24th July 2012).

characteristics and is a closer substitute for 800MHz spectrum than 2.6GHz.[31] [32]

Ofcom concludes from this that 1800MHz cannot be less valuable than 2.6GHz in the UK.[33] The view that propagation characteristics deteriorate linearly with frequency also apparently supports Ofcom's conclusion that the value of 1800MHz spectrum must be about half-way between that of 800MHz and 2.6GHz spectrum.[34]

In Three's view, standard radio technical analysis shows that 1800MHz is much closer in value to 2.6GHz than to 800MHz.

The motive and benefit of deploying an 1800MHz network is similar to deploying a 2.6GHz network. Both bands are deployed for capacity relief. On the other hand, the introduction of an 800MHz layer is primarily for the provision of wide-area coverage improvement and deeper in-building penetration. This enables an operator to increase its market share through the wider provision of mobile data services and creates a significant value premium between 800MHz on the one hand and 1800MHz/2.6GHz on the other.

Annex D presents Three's technical analysis. The Annex compares the relative coverage and capacity benefits of the different frequency bands (800MHz, 1800MHz, 2.1GHz and 2.6GHz).

Annex D shows first that 800MHz is [✂] larger in cell area than 1800MHz according to our propagation model. It compares this figure with Real Wireless' report for Ofcom, which uses a different model to arrive at [✂] cell area increase of 9.89 times.[35] We also show that [✂].

Annex D then goes on to establish how, even for a very large number of sites, propagation differences between 800MHz and 1800MHz

[31] Paragraphs 4.43-4.44
[32] [✂]
[33] Paragraphs 4.45.
[34] See Consultation, para. 4.46.
[35] Real Wireless; "Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030"; April 2012; Version 1.16.

result in significant (and business-changing) population differences in all-important indoor locations, particularly where deep indoor penetration is concerned.

Next, Annex D looks at 1800MHz from a capacity perspective and conclude that the value of 1800MHz in providing incremental capacity on an existing 2.1GHz network is the same as the value of 2.6GHz used for the same purpose. This is due to the ability of operators to efficiently load balance their networks.

Finally Annex D provides a high level illustration of the relatively high incremental value derived from low frequencies such as 800 MHz, and demonstrate that the value derived from high frequency spectrum (1800MHz or 2.6GHz) is much lower.

Using a methodical approach, Annex D demonstrates [✂].

This evidence therefore shows strongly that 1800MHz should be treated and valued much closer to the valuation of 2.6GHz for the purposes of the Annual Licence Fee considerations.

Ofcom is wrong to conclude that 1800MHz is a closer substitute for 800MHz than 2.6GHz based on bidding in the UK 4G auction.

Ofcom finds that bidding behaviour in the UK 4G auction confirms that 1800MHz is a closer substitute for 800MHz than 2.6GHz. In Ofcom's view, this is because Telefónica and Vodafone (which did not have substantial holdings of 1800MHz) bid strongly for 800MHz, whereas EE and Three (who did) bid less strongly for that spectrum.[36]

– [✂];[37]

[36] Paragraph 4.44 of the Consultation.
[37] [✂]

– Second, [✂]

[✂]

6. Ofcom's proposed discount rate should be the risk-free rate, not the cost of capital.

Ofcom proposes to calculate the ALFs as an annuity whose present value is equivalent to the lump sum amount derived from the auction. Three agrees with this.

Accordingly, in order to convert lump-sum spectrum values to ALFs, Ofcom proposes a discount rate of the post-tax real weighted-average cost of capital (WACC), of 4.2%, based on Ofcom's 2011 Mobile Call Termination (MCT) decision.

Three disagrees however that the WACC is appropriate discount rate for converting lump-sum spectrum values to ALFs.

In particular, using the WACC as the discount rate does not result in an ALF whose present value is equivalent to the corresponding lump-sum value derived from the auction. This is because – paying for spectrum through ALFs is equivalent to paying for spectrum through lump-sum fees financed by the licensee through external debt finance.

Namely, paying for spectrum through ALFs is effectively the licensee receiving financing from the Government. However, this financing is highly secured and, from the Government's perspective, risk-free. It therefore should attract a risk-free rate.

Hence, the risk-free rate is the relevant rate for converting lump-sum values to ALFs. Based on the most relevant data, the risk-free rate is 1.2%.

Three commissioned an external expert report from Economic Insight, included with our response, which provides the most relevant estimate of the risk-free rate.

The risk-free rate is the relevant discount rate for converting lump-sum spectrum values.

Ofcom highlights that it proposes to calculate the ALFs as an annuity whose present value is equivalent to the lump sum amount derived from the auction[38].

Ofcom then states that it considers the MCT WACC remains a reasonable proxy for the discount rate which should be used to calculate the lump sum values. [39]

[38] Consultation, para. 5.5.
[39] Consultation, para. 5.67.

Ofcom explains that this is because the MCT WACC aims to estimate the WACC applicable to a hypothetical UK mobile-only operator and that this is likely to capture the systematic risks which would apply to the licences covered by the annual licence fees. Ofcom also states that it thinks the WACC reflects the systematic risk associated with the 4G spectrum – the value of which Ofcom has used to inform its analysis of the lump-sum spectrum values.

First, Three strongly agrees that Ofcom should calculate ALFs as an annuity whose present value is equivalent to the lump sum amount derived from the auction.

Second, Three agrees that the MCT WACC is an estimate of the WACC applicable to a hypothetical UK mobile-only operator.

Third, Three also strongly agrees that the WACC is likely to capture the systematic risks associated with the 900MHz and 1800MHz licences and that the WACC is the correct discount rate for informing Ofcom's analysis of lump-sum values. For the same reasons, the WACC is the relevant discount rate for operators to assess the lump-sum value of spectrum, based on expected future incremental cash flows accruing as a result of ownership of that spectrum.

However, it does not follow that the WACC is the correct discount rate for converting lump-sum spectrum values to ALFs. This is because, while the WACC is the discount rate that appropriately reflects the level of risk (measured by volatility) inherent in aggregate cash flows associated with spectrum cash flows – the ALF payments have a much lower level of risk (of non-payment) and should have a commensurately lower discount rate. Indeed, the ALF payments should be viewed as risk free.

Accordingly, the relevant test of equivalence to determine the appropriate ALF discount rate is – how would a hypothetical operator finance a lump-sum spectrum licence compared to a licence paid for by ALFs?

As described below in Section 7, in relation to Ofcom's proposed tax adjustment, paying for spectrum through ALFs is equivalent to paying for spectrum through lump-sum fees financed through external debt finance, as:

– neither scenario entails internal financing of spectrum (namely from retained earnings);

– neither scenario entails shareholder equity financing of spectrum; and
– both scenarios leave an MNO in the same balance sheet financial position, namely, with an additional intangible asset (namely, the spectrum licence) and a corresponding liability (either the future ALF payments or debt repayment and interest).

Therefore, for the annuity of the ALFs whose present value is equal to the lump-sum value derived from the auction, the relevant discount rate must be the interest rate that the licensee would have paid for external debt finance to a corresponding counterparty.

In the case of ALFs, the corresponding counterparty is the Government. Namely, the ALFs payments are a liability for the licensee to the Government. However, the risk to the Government of not receiving the ALF payments is extremely low, as:
– as Ofcom notes, "any operator who needs a particular block of spectrum in order to be credible is likely to place a high valuation on it, and is relatively unlikely to hand it back to avoid paying ALF"[40]; and
– if a licensee were to not pay the ALF, then Ofcom has the power to revoke the licence.

The only small risk for the Government is the loss of revenue during a fallow period following the handing back of a licence and before re-auctioning or re-issue. As the licences are always likely to highly saleable, this is unlikely to be a long period.

Accordingly, ALF payments are highly secure revenues for the Government, so for all intents and purposes, should be treated as risk-free. Hence, the corresponding ALF financing cost should be the risk-free rate.

The relevant risk-free rate is 1.2%.

Ofcom proposes that the relevant WACC for converting lump-sum spectrum values to ALFs is Ofcom's March 2011 MCT determination, on grounds that Ofcom does not consider that the parameters used within the WACC calculation have changed materially since the MCT determination, among other things.

[40] Consultation, para. A9.32.

Ofcom has nevertheless adjusted the proposed WACC to reflect changes to UK corporation tax rates since the MCT WACC determination.

However, in Three's view, the underlying parameters of the WACC, including the risk-free rate, have changed materially since the MCT WACC determination. Indeed, there was a gap of almost two years between the MCT Determination calculations and the 4G auction, which is a material time period.

Three therefore commissioned Economic Insight to review the underlying parameters of Ofcom's MCT WACC determination. Economic Insight confirms that many of the underlying parameters of the WACC have changed materially in between the MCT determination and the 4G auction. In particular, Economic Insight finds that the relevant risk-free rate should be 1.2%, compared to Ofcom's proposed risk-free rate of 1.5%. Economic Insight also finds that the overall WACC should be 3.8%, compared to Ofcom's proposed WACC of 4.2%, although this should not be relevant to Ofcom's ALF calculations.

Please see Economic Insight's report, attached at Annex C.

7. Ofcom's tax adjustment is invalid.

Ofcom proposes an 11% upward tax adjustment to the ALFs, on the basis that ALFs result in a larger tax deduction than the amortisation of lump-sum licence fees. Ofcom is right that, in themselves, ALFs would result in a larger tax deduction than the corresponding amortisation of lump-sum fees.

However, Ofcom's proposal does not take into account the financing of lump-sum licence fees and associated tax deductibility of debt interest payments. Taking this into account means that there should actually be a negative tax adjustment, of -1.3%.

Three commissioned a separate external expert report from Economic Insight, included with our response, which supports this conclusion.

Ofcom is correct in principle to adjust ALFs for any tax advantage or disadvantage relative to lump-sum licence fees.

Ofcom's objective in settings ALFs is that MNOs should be no better or worse off paying spectrum fees by ALF or by equivalent lump-sum fee. Namely, as described in Section 6 above, on the correct discount rate, Ofcom proposes to calculate the ALFs as an annuity whose present value is equivalent to the lump sum amount derived from the auction.

Ofcom is therefore right to consider whether any adjustment to ALFs is necessary to compensate for any tax advantage or disadvantage of paying spectrum fees by ALF compared to lump-sum fees, to ensure "tax neutrality" between the two approaches.

Ofcom concludes that there is a tax advantage of paying spectrum fees by ALF, compared to payment by lump-sum fee, and therefore that a positive tax adjustment is necessary to compensate for this.

In the case of ALFs, Ofcom argues that ALFs will be recorded as a revenue expense in MNOs' profit and loss accounts.[41] In contrast, in the case of lump-fees, Ofcom notes that the initial lump-sum fee will typically be recorded as an intangible asset that will be subsequently amortised as an annual charge to MNOs' profit and loss accounts.

[41] Three notes that there is no necessary accounting requirement to treat ALFs as a revenue expense. On the contrary, MNOs can instead recognise the underlying spectrum licence as an intangible asset, with the ALF payments treated as a corresponding liability. In this case, like lump-sum spectrum fees, only the annual amortisation of the spectrum asset would be deducted from the profit and loss account, rather than the ALF payment.

Taking into account this relative accounting treatment of ALFs and lump-sum fees alone, Ofcom is correct that ALFs will attract a tax advantage relative to lump-sum fees. This is because ALFs will always tend to be greater than the corresponding lump-sum amortisation charge. This is because ALFs include an implicit financing cost and inflation adjustment, whereas amortisation of a lump-sum spectrum fee does not.

Hence, everything else equal, ALFs would tend to result in lower taxable profits than lump-sum licence fees, and therefore a corresponding tax advantage.

Overall, Ofcom calculates that the benefit of this tax advantage is worth 11% of the lump-sum spectrum values, therefore an 11% positive tax adjustment to ALFs is necessary to compensate for this tax advantage.

Ofcom's approach does not take into account the financing of lump-sum licence fees and associated tax deductibility of debt interest payments.

The chief difference between financing of lump-sum spectrum fees and ALFs from the perspective of an MNO is that:

– in the case of lump-sum fees, MNOs need to finance the upfront acquisition of licences themselves (either through internal or external finance); and
– in the case of ALFs, the Government is effectively financing the acquisition of licences on behalf of the MNOs (as reflected in the discount rate applied in calculating the ALF payments).

Ofcom is therefore wrong not to consider how MNOs might finance the acquisition of lump-sum licences and any associated tax effects of this.

Indeed, as a matter of equivalence, paying for spectrum through ALFs is equivalent to paying for spectrum through lump-sum fees financed entirely through external debt finance, as:

– neither scenario entails internal financing of spectrum (namely from retained earnings);
– neither scenario entails shareholder equity financing of spectrum; and
– both scenarios leave an MNO in the same balance sheet financial position, namely, with an additional intangible asset (the spectrum licence) and a corresponding liability (either the future ALF payments or debt repayment and interest).

Accordingly, as debt interest payments are tax deductible, the impact on taxable profits of a lump-sum licence fee will not merely be the amortisation of the lump-sum fee, but also the interest payments on the debt necessary to finance the lump-sum spectrum licence.

Three has commissioned Economic Insight to analyse the need for and magnitude of a tax adjustment for setting ALFs. Economic Insight concurs that Ofcom has not taken into account the financing of lump-sum licence fees and associated tax deductibility of interest payments, and therefore that Ofcom's proposed tax adjustment of +11% is incorrect.

In conclusion, Economic Insight calculates that the corrected ALF tax adjustment should reduce ALFs, by -1.3%. Please see Economic Insight's report attached at Annex B and attached spreadsheet calculations.

8. Ofcom should increase future annual fees by the CPI, not RPI, inflation index.

Ofcom proposes that future ALFs should be increased by the Retail Price Index (RPI). The RPI index has however become increasingly obsolete and unreliable and therefore should not be used as the basis for setting ALFs over a long-term future period.

The Consumer Price Index (CPI) has already replaced RPI as the official standard UK and EU inflation measure, and therefore represents a much more satisfactory measure for setting ALFs.

Three's first external expert report from Economic Insight supports this conclusion.

In particular:

– RPI has recently had its official status as a National Statistic removed. This is due to concerns about the way the RPI is calculated and clearly brings into question both the robustness of RPI and its longevity.
– UK economic regulators (including Ofcom) are now actively considering and using CPI as an alternative to RPI.
– An assessment of MNO costs suggests they may be more highly correlated with CPI than RPI.

Three has commissioned Economic Insight to review the relative merits of RPI and CPI and agrees with these conclusions. Please see Economic Insight's report, attached at Annex C.

9. Ofcom should modify its proposal for implementing the new annual fees.

Ofcom sets out two main proposals in relation to the implementation of the new ALFs:

– the timing of introduction of ALFs: Ofcom proposes to set a Common Effective Date (CED), with all 900MHz and 1800MHz licensees paying full market value from that point in time; and
– the phasing-in of the new licence fees: Ofcom proposes to implement ALF immediately after the new fees regulation come into force, without phasing-in the new ALFs.

Three disagrees with Ofcom's proposed implementation of the new ALF fees. Namely, in our view, Ofcom has misinterpreted the Licence Charges Regulations 2011 and has not adequately justified its proposal not to phase-in the new fees.

In particular:

– Ofcom wrongly assumes that licence fees are payable in advance;
– under the Charges Regulations, fees are payable in arrears;
– Ofcom's proposal requires operators to pay more than prescribed by the Regulations and is in breach of the Government Direction; and
– Ofcom should carry out a proper impact assessment before concluding that it is not necessary to phase-in the new fees.

Our conclusions are based on external legal advice.

Ofcom wrongly assumes that fees are payable in advance.

The Consultation helpfully sets out the 900MHz and 1800MHz licensees' payment dates, as shown in Table 12:

Table 12: Licensees' payment dates differ

Operator	EE	Vodafone	O2	Three
Payment date	28 Feb	31 Jul	31 Jul	31 Oct

Source: Figure 6.1 of the Consultation.

Because payment dates vary between licensees, if the introduction of ALF is "staggered" to coincide with those dates some operators would pay full market value earlier than others, which is clearly unacceptable. Ofcom therefore sets out two alternative ways of avoiding this problem:

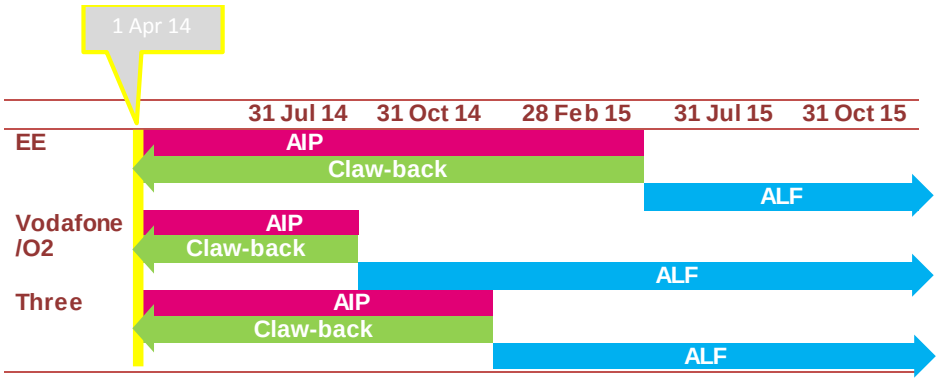
– to change licensees' payment dates so that they are identical; or
– to set a CED from which all 900MHz and 1800MHz licensees would pay full market value.

Three agrees that a CED provides a better solution than changing long established payment arrangements. Nevertheless, we do not agree with Ofcom's proposed schedule of payments.

Ofcom proposes that a licensee's first payment after the CED would include two components:[42]
– the new ALF, plus
– the difference between the revised ALF and the current spectrum fee based on Administered Incentive Pricing (AIP), pro-rated in relation to the number of months between the CED and the licensee's payment date.

For instance, if the CED were 1 April 2014, Three's first payment date after the CED would be 31st October 2014. On that date, Three would pay the new ALF in respect of the following year (Oct 2014-Oct 2015), plus the amount of the underpayment (ie the difference between the new ALF and the old AIP) between April and October 2014. Other MNOs would be subject to a similar "claw-back", as shown in Figure 12.

Figure 12: Operators would face a claw-back payment under Ofcom's proposal.



Source: Three.

[42] Paragraph 6.13 of the Consultation

However, in making this proposal, Ofcom presumes that licence fees are payable in advance, so that on the first payment date post-CED there is a need to claw-back the underpayment up to that point, in respect of the months following the CED. Three considers that this is a misinterpretation of the Licence Charges Regulations 2011.

Under the Charges Regulations licence fees are payable in arrears.

Under Regulation 4(1) of the Licence Charge Regulations 2011, licence payments are due:

> *"(a) on the issue of the licence and on the variation of the licence where such variation is prescribed in Schedule 2; and*
>
> *(b) on the last day of the period of twelve, twenty-four, thirty-six or (as the case may be) sixty months prescribed in Schedule 2, if any, in respect of the class of licence in question (the "prescribed payment interval") and on the last day of each subsequent prescribed payment interval thereafter (the first prescribed payment interval having begun on the day of the issue of the licence) for which the licence continues in force" (emphasis added)*

Therefore, payments are due both at the start and at the end of the licensed period: there is always one more payment than licensed periods. For example, a licensee holding a one-year licence would face two fees: one upon issue and a second one upon expiry of the licence at the end of the year.

This means that the Regulations provide for fees to be payable in arrears. The first payment (on issue of the licence) must be in respect of the issue of the licence, while each subsequent payment must be in respect of the rights to use spectrum over the previous 12-month period (as the prescribed payment interval for mobile operators is 12 months).

Licence fees cannot be payable in advance, on the basis of the Regulations, as the Regulations demand a final payment on the last day of each of 12-month period for which the licence continues in force. Hence, payment would still be due on the last day of the period even if the licence were terminated the next day.

Moreover, if fees were payable in advance, the number of fees would equal the number of licensed periods. There would be no need to

distinguish, as the Regulations do, between payment on issue of the licence and payment in respect of each prescribed payment interval. The Regulations would simply require payment at the beginning of each prescribed period.

Ofcom's proposal requires operators to pay £245m more than prescribed by the Regulations and is in breach of the Government Direction.

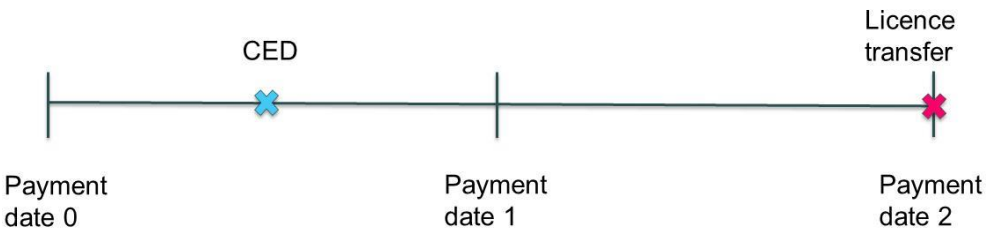
In consequence, Ofcom should amend its proposal to reflect that licence fees are payable in arrears. On the first payment date after the CED, a licensee's payment for the rights to use spectrum during the previous year should include two components:

– first, the old AIP fee, pro-rated by the number of months between the last payment date and the CED; and
– The new ALF fee, pro-rated by the number of months following the CED.

This affects not only the timing of payments but also the total amount payable over the licensed period. In effect, Ofcom's proposal requires operators to pay more than prescribed by the Regulations. The reason is that the Regulations demand a final payment on the last day of the 12-month period for which the licence is in force.

For instance, suppose that the licence fee increases from £a to £b from the CED. Suppose further that the CED falls 6 months after an operator's last payment date, and that the operator transfers its licence 1.5 years after the CED, as shown in Figure 13.

Figure 13: Assumed timing of payments and events.



Source: Three.

Table 13 shows the operator's payments on each payment date under our interpretation of the Regulations and under Ofcom's approach.

Table 13: Ofcom's proposal requires operators to pay more than prescribed by the Regulations.

	Date 0	Date 1	Date 2	Total	Delta vs arrears
Ofcom	a	b + ½ (b – a)	b	0.5a + 2.5b	b – a
Arrears (Regs)	a	½ (a + b)	b	1.5a + 1.5b	-

Source: Three.

Ofcom's proposal requires operators to make one more payment at the higher ALF rate of £b (and one less payment at the lower AIP rate of £a) than prescribed by the Regulations. Under both approaches, a final payment would be due on date 2, the last day of the period (between dates 1 and 2) for which the licence was in force. With Ofcom's approach, however, the operator would pay the higher ALF rate over 2.5 years, even though it would only hold the licence for 1.5 years after the CED.

More generally, operators' payments over time would be the same under both approaches, except on the first payment date post-CED. On that date, Ofcom would ask operators to pay £244.4m more than prescribed by the Regulations – the difference between the total ALF fee of £308.9m and the existing AIP fee of £64.5m (in real terms).

This represents a clear breach of the Government Direction and is inconsistent with the Charges Regulations. Under the Regulations, the obligation to pay on payment date 1 is the result of the operator holding the licence between payment dates 0 and 1. It is not a payment for the right to use the spectrum between payment dates 1 and 2. Therefore, under Ofcom's proposal the amount due on payment date 1 would greatly exceed the full market value of the right to use spectrum over the previous period.

Ofcom should carry out a proper impact assessment before concluding that it is not necessary to phase-in fees.

Ofcom intends to issue a Notice giving effect to the new fees with its ALF Statement, and proposes to set the CED on the first day of the month following the new fees regulations coming into force.[43]

Ofcom does not consider necessary to phase-in fees after the CED as in its view, the new ALFs would be unlikely to create detrimental impacts for consumers. This is for two reasons: i) licensees have been aware of the impending increase in fees since the Government Direction; ii) in the 4G auction operators were willing to pay for spectrum (over and above the sums actually paid) much more than the proposed increases in first-year ALF payments.

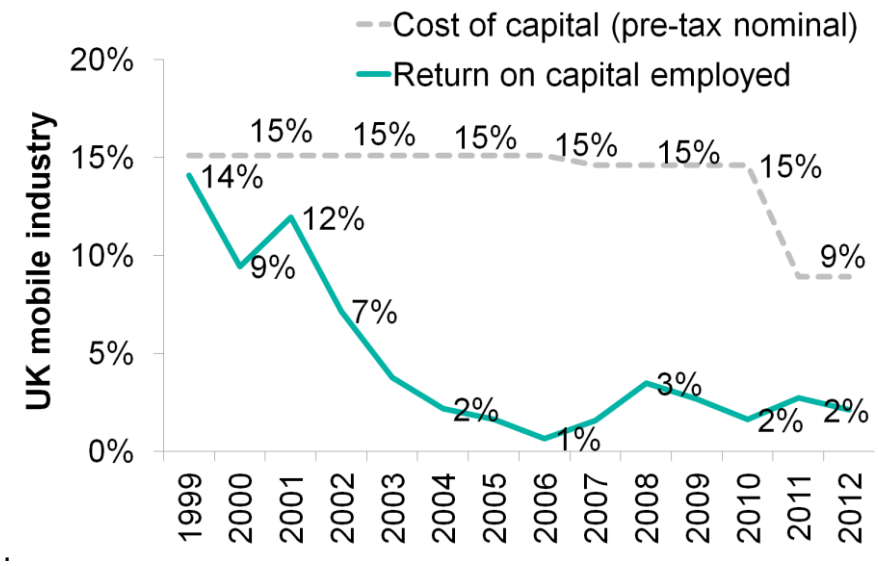
In Three's view, Ofcom has not conducted a proper impact assessment of its ALF proposals to justify its conclusion. We set out our views in detail in Annex G to this response. In summary, Ofcom is under statutory duty to carry out an impact assessment where the proposal appears to it to be "important". In practice, Ofcom will undertake one in relation to the great majority of its policy decisions, according to its Better Policy Making Guidelines (the "Guidelines").[44]

Ofcom is proposing a fivefold increase in fees across the industry, from £65m to £309m (plus cumulative inflation) per annum. Three has seen no proper consideration from Ofcom of the economic and financial impact that a fee increase of this magnitude will have on the mobile communications market, especially in terms of competition, investment and consumer retail prices.

As shown in Figure 14, financial returns in the UK mobile industry are already very low, and certainly below Ofcom's industry cost of capital estimate of 9%[45]. This represents Ofcom's view of the minimum return expected by investors in order to invest in the mobile industry rather than in other alternatives. Fee increases of the magnitude proposed by Ofcom will only further reduce the profitability of UK operators, with potential consequences on competition, investment and prices.

[43] Paragraph 6.16 of the Consultation.
[44] Better Policy Making: OFCOM's approach to Impact Assessment, issued on 21 July 2005 ("the Guidelines") para 4.1.
[45] Ofcom's estimated mobile industry pre-tax nominal weighted-average cost of capital (WACC), as determined in Ofcom's 2011 Mobile Call Termination decision.

Figure 14: Financial returns in the UK mobile industry are already very low.



Source: Three, based on operators' statutory accounts and Ofcom MCT decisions.

For this reason, Three asks Ofcom to carry out a proper impact assessment and consider whether any detrimental impact on operators and the wider mobile market could be alleviated by phasing-in the new ALF fees.

Annex A Analysys Mason/Aetha Consulting report: Review of Ofcom benchmarking.

analysys mason

aetha

Report for Three UK and EE

Review of Ofcom's benchmarking of the value of the1800MHz spectrum band to determine annual licence fees

9 January 2014

Mark Colville, Lee Sanders, Andreas Kater, Noel Perera

Ref: 38441-23

www.analysysmason.com

Contents

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1 Executive summary

1.1 Introduction

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

In this report, we set out our views on the appropriateness of the benchmarks selected, as well as the methodology used by Ofcom to derive its proposed 1800MHz lump-sum value from these benchmarks. Our focus is primarily on the 1800MHz band, in which both Three and EE hold spectrum licences and where Ofcom has proposed a lump-sum value of GBP15 million per MHz for a 20-year period.

Our analysis considers only the derivation of this lump-sum value, rather than the subsequent process by which this lump-sum is annualised into ALF payments.

1.2 Ofcom's overall approach

Ofcom bases its approach to determining its proposed lump-sum value for 1800MHz spectrum mainly on three sources of information. These are:

1. Absolute values of benchmarks.
2. A simple average of UK linear reference price (LRP) values for the 800MHz and 2.6GHz bands.
3. Relative values of benchmarks.

However, there are clear issues with each of these three approaches.

Absolute-value benchmarks

Any approach focusing on absolute benchmarks from different countries to estimate the market value of spectrum in the UK will have significant error margins, due to the following:

- The inherent inaccuracies associated with converting European auction results into UK-equivalent values, notably: choice of exchange rate; WACC; inflation rate; how to scale auction benchmarks for licences of a different duration to the UK; and how to scale benchmarks to reflect differences in wealth/purchasing power between the UK and the benchmark country – all of which introduce potential errors into the results.

- Underlying differences between the UK and other benchmark countries, including: the level of competition; average revenue per user (ARPU); population densities; network topologies; and the amounts of total spectrum held by operators.

Furthermore, the Government's Direction to Ofcom states that "*OFCOM must have particular regard to the sums bid for licences in the Auction*".[1] This suggests that benchmarks based primarily on the UK 4G auction prices should have greater weight in the setting of the 900/1800MHz ALFs.

Therefore we believe absolute values from other countries should be given very little or no weight as evidence points in the determination of the UK lump-sum values for 900MHz and 1800MHz.

Simple average of UK LRP values

Ofcom classifies the simple average of the UK 800MHz and 2.6GHz LRPs values as a more important evidence point for the determination of the 1800MHz lump-sum value. While we agree that the 1800MHz value should lie between the 800MHz and 2.6GHz values, a simple average seems to be as arbitrary as any other value between these two points. In fact a number of sources, which we discuss in Section 4.3, suggest that the value of the 1800MHz band is well below the simple average of the 800MHz and 2.6GHz values.

Relative-value benchmarks

Ofcom uses relative values based on the ratios of 1800MHz/800MHz and 1800MHz/2.6GHz auction prices in benchmark countries. We agree that using relative measures is a better method than using absolute values, as this largely eliminates the inherent inaccuracies involved in converting European auction results to UK equivalents described above. However, even relative benchmarks cannot successfully adjust for all country-specific factors as underlying differences between the UK and benchmark countries may affect the relative value of different spectrum bands in different ways.

Moreover, using two different relative values, even from the same auction, may produce two very different results. The relative-value approach followed by Ofcom does not, therefore, provide a consistent view of where the 1800MHz value should lie relative to the 800MHz and 2.6GHz LRPs in the UK.

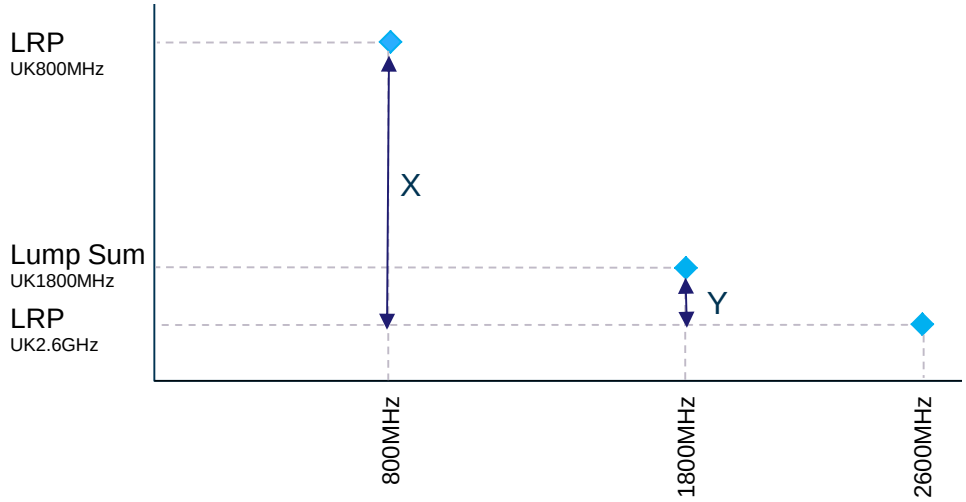
This leads us to propose a simpler, more robust approach that results in a single relative value for each benchmark country, which takes into account the relativities to both the 800MHz and the 2.6GHz benchmarks: the 'distance method'. We describe this method and why it is superior to Ofcom's relative-value approach below.

[1] Statutory Instrument 2010 No. 3024, Wireless Telegraphy Act 2006 (Directions to Ofcom) Order 2010 Page 3, available at: http://www.legislation.gov.uk/uksi/2010/3024/pdfs/uksi_20103024_en.pdf.

Distance method

We propose the use of a method that places emphasis on the UK 800MHz and 2.6GHz LRPs (as recommended by the Government's Direction) and finds how far between these two values the 1800MHz lump-sum value should lie. Evidence suggests that the 1800MHz value should lie much closer to the 2.6GHz value than the 800MHz value, and therefore the distance method calculates the value of $\frac{Y}{X}$ as shown in Figure 1.1 below, using benchmark countries for which the required information is available and reliable.

Figure 1.1: Illustration of distance method [Source: Analysys Mason, Aetha, 2013]



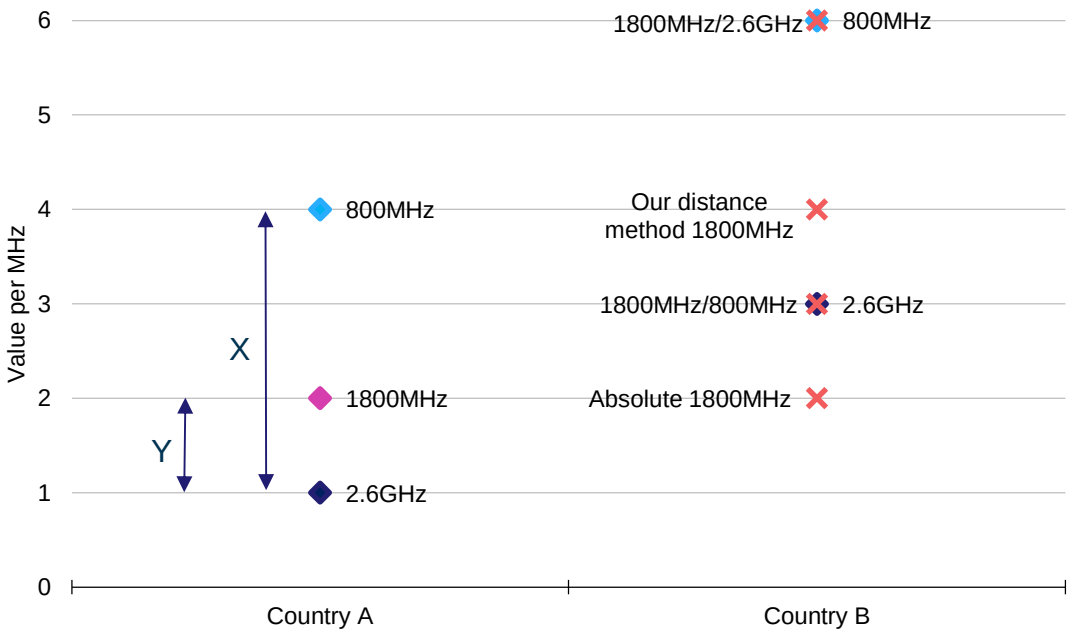
The following example explains why the distance method yields a more accurate value for the 1800MHz band than the absolute-value- or relative-value-based approaches used by Ofcom. We consider two countries, A and B, that are in essence identical (e.g. same population, currency, licence conditions) and that have both held spectrum auctions with the values shown in Figure 1.2 below.

Figure 1.2: Example auction outcomes in Country A and Country B [Source: Analysys Mason, Aetha, 2013]

Spectrum band	Value in Country A	Value in Country B
800MHz	4	6
1800MHz	2	not auctioned
2.6GHz	1	3

Based on the prices paid in Country A, we attempt to determine the 1800MHz value in Country B (where this band was not auctioned) using both Ofcom's absolute and relative approaches, as well as the distance method. The results are shown in Figure 1.3 below.

Figure 1.3: Example of Ofcom's absolute and relative methods and the distance method [Source: Analysys Mason, Aetha, 2013]



Using Ofcom's absolute-value approach, the 1800MHz value in Country B is below the 2.6GHz value in the same country, which is clearly not informative in this instance. The result is flawed because it does not take into account the country-specific conditions that lead to the higher values for the 800MHz and 2.6GHz in Country B. This illustrates why we do not consider absolute benchmarks to be informative evidence points.

The relative values of 1800MHz/800MHz and 1800MHz/2.6GHz for Country B produce two very different values. The 1800MHz/2.6GHz relative value provides a figure that is equal to the 800MHz band in Country B. The 1800MHz/800MHz relative value, on the other hand, provides a value equal to the 2.6GHz price. Clearly, the correct value lies between these two extremes. Our concern is that Ofcom's relative approach is effectively like a 'scatter-gun', producing a range of benchmarks that appear unjustifiably wide. By considering either the relative 1800MHz/800MHz or 1800MHz/2.6GHz ratios in isolation, Ofcom is failing to reflect the country specific factors which lead to differences in relativities between spectrum bands. In the example above, using just the 800MHz/1800MHz ratio to derive a benchmark Country B 1800MHz value takes no account of the fact that the 800MHz/2.6GHz ratios (and therefore likely other ratios) in the two countries are very different. A holistic consideration of all relevant of observed 800MHz and 2.6GHz values in both countries would better control for population wide differences in spectrum values between the two countries than the two relative measures.

Using the distance method, the results of the auction in Country A gives a ratio of $\frac{Y}{X}$ of $\frac{1}{3}$. Applying this to Country B results in a value of 4 for the 1800MHz. This value takes into account the relativities between the different bands (established from benchmarks in Country A) as well as the country-specific factors that make spectrum generally more valuable in Country B. For these

reasons, we consider the distance method a more appropriate method to use in interpreting the available benchmark data.

1.3 Ofcom's selectivity of benchmarks

We agree with Ofcom's overarching principle that auction benchmarks differ in the amount and reliability of information that they provide for determining the lump-sum values in the UK. Therefore, different benchmarks should not necessarily all carry equal weight when determining the lump-sum values. However, in our opinion, Ofcom's categorisation of the benchmarks into more and less important evidence lacks objectivity and consistency, and as a consequence, the approach injects inaccuracy into the resulting lump-sum values. This is particularly concerning, given the very wide range of values produced by Ofcom's absolute and relative benchmarking approach.

We believe that the process of determining the lump-sum values would greatly benefit from a set of objective criteria, which could then be transparently and consistently applied. We have, therefore, recommended such a set of objective criteria to determine firstly whether or not the benchmark should be included, and secondly the weighting that should be applied.

We propose that benchmarks are excluded in the calculation of the 1800MHz lump-sum if any of the following apply:

- the 1800MHz band has not been auctioned in the relevant time period (as specified by Ofcom)
- no reliable information regarding 1800MHz prices can be inferred from publicly available information
- certain bidders were excluded from the auction, which may lead to prices that are far from market value
- there is no reliable[2] 800MHz or 900MHz benchmark from the country – this requirement is specific to the distance method, which ideally relies on benchmarks being available for the 800MHz, 1800MHz and 2.6GHz bands. However, in the absence of either 800MHz or 2.6GHz benchmarks, we think that it is valuable to use the 900MHz band as a proxy for the 800MHz band and/or zero as a proxy for the 2.6GHz band.

Of course, as stated above, some countries provide more valuable benchmarks than others. We believe, like Ofcom, that this is most appropriately accounted for by giving them more weight in the final determination of the lump-sum values. We recommend that countries are considered as less important if:

- band-specific prices cannot be *directly* inferred – this would mean that benchmarks from package bid auctions would at best be considered as less important

[2] In the same way as described for 1800MHz in the above bullet points; in particular, if bidders were excluded or reliable, band-specific prices cannot be inferred from a package auction, then we would not consider that a reliable 800MHz or 900MHz benchmark is available from the country.

- a proxy is used for the 800MHz and/or 2.6GHz price when using the distance method (i.e. we use the 900MHz value or zero 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 – or the 900MHz band, if used as a proxy)
- there is a significant time gap between the auctioning of the three required bands (800MHz, 1800MHz or 2.6GHz – or the 900MHz band, if used as a proxy).

1.4 Conversion of benchmarks to lump-sum values

Ofcom's approach in interpreting the available data and determining the UK 1800MHz lump-sum value is non-transparent in that it places a lot of weight on Ofcom's "*regulatory expertise and judgement*".[3] Indeed, Ofcom is explicit in the fact that it does not use a *"mechanistic approach"* to derive the final lump-sum value. The extent to which this judgement influences the final proposed 1800MHz lump sum is illustrated by the fact that the lump-sum value Ofcom arrives at is above both the average of the more important evidence points and the average of the less important evidence points. Therefore, no 'mechanistic' weighting of benchmarks that Ofcom considers more and less important can mathematically reproduce Ofcom's proposed lump-sum. This implies to us that much of the available evidence appears not to have been considered in arriving at the proposed lump-sum figure.

Conversely, we have set out an approach based on the distance method, with weightings applied to more and less important evidence points. This allows for a mechanistic calculation of a lump-sum value.

The values of $\frac{Y}{X}$ for benchmark countries (as described above), the associated lump-sum value and the weightings we have applied in calculating our suggested 1800MHz lump-sum are all shown in Figure 1.4 below. Detailed reasoning for each proposed weighting is discussed in Section 5 of this report – although the final output is not significantly dependent on the weighting, as we describe in Section 7.4.

The weighted average from these figures is GBP9.4 million per MHz, which is significantly lower than Ofcom's proposed figure of GBP15 million.

[3] Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum Consultation.* Paragraph 4.51.

Figure 1.4: Summary of Analysys Mason and Aetha benchmarks used, $\frac{Y}{X}$ values, 1800MHz values, weightings and weighted average [Source: Analysys Mason, Aetha 2013]

Country	Y/X	Distance method 1800MHz value (GBP million per MHz)	Analysys Mason/ Aetha weighting
Austria	0.59	19.60	1
Belgium	not applicable[4]	not applicable[4]	0
Czech Republic	0.07	6.7	1
Denmark	not applicable[5]	not applicable[5]	0
France	not applicable[4]	not applicable[4]	0
Germany	0.01	5.1	2
Greece	0.44[6]	16.0	1
Ireland	0.39	14.8	1
Italy	0.27	11.6	2
Netherlands	not applicable[7]	not applicable[7]	0
Norway	not applicable[8]	not applicable[8]	0
Portugal	0.02	5.5	1
Romania	0.19	9.7	1
Spain	not applicable[9]	not applicable[9]	0
Sweden	-0.13	1.7	1
Switzerland	0.00	5.0	1
Weighted average			**9.4**

We have conducted a sensitivity analysis to the above result, changing the weightings applied to each benchmark. Our findings show that given the robust nature of the distance method, the resulting 1800MHz lump-sum value is relatively stable over a wide range of possible weightings.

1.5 Conclusions

Given the available evidence, we consider a value of GBP9.4 million per MHz to more accurately reflect the value of 1800MHz in the UK than Ofcom's proposed lump-sum figure. Therefore, we suggest Ofcom adopts the distance method described in this report, as well as our simple and objective criteria for selecting countries to include within the evidence base and for classifying evidence as more or less important. Finally, assigning weightings to these classifications and

4 No 1800MHz value available.

5 Not applicable because the 2.6GHz value is significantly above the 1800MHz value.

6 No 800MHz and 2.6GHz value available, so we assume that 800MHz is equal to 900MHz in value and the 2.6GHz has a value of zero to generate the distance-method value.

7 Not applicable, as no band-specific prices are available due to auction format.

8 Not applicable, as no band-specific prices are available due to auction format.

9 Not applicable, as the three largest operators were not allowed to bid for 1800MHz spectrum.

applying a mechanistic calculation to reach a lump-sum value would strengthen Ofcom's conclusion by making the derivation of the lump-sum values fully transparent and objective.

2 Introduction

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In this report, we set out our views on the appropriateness of the benchmarks selected, as well as the methodology used by Ofcom to derive its proposed lump-sum payments from these benchmarks. Our focus is primarily on the 1800MHz band, in which both Three and EE hold spectrum licences, where Ofcom has proposed a lump-sum value of GBP15 million per MHz for a 20-year period.

Our analysis considers only the derivation of this lump-sum value, rather than the subsequent process by which this lump-sum is annualised into ALF payments.

The remainder of this document is laid out as follows:

- **Section 3** discusses key questions that arise from the lump-sum values proposed by Ofcom
- **Section 4** critiques the overall approach taken by Ofcom for the derivation of the lump-sum and presents a more robust alternative approach
- **Section 5** discusses Ofcom's selectivity in the benchmarks it considers more or less important and those it ignores
- **Section 6** considers the approach by which Ofcom converts its selected benchmarks to a single UK lump-sum value for each band
- **Section 7** presents the lump-sum value that would result if Ofcom had followed the more robust approach suggested in this report
- **Section 8** presents our conclusions, including answering the key questions raised in Section 3.

3 Key questions that arise from Ofcom's proposed lump-sum values

When determining the lump-sum values proposed in its consultation, Ofcom has used a framework which we analyse in detail in Section 4. However, before doing so, we would like to highlight four observations regarding the lump-sum values that result from Ofcom's analysis:

1. The proposed 1800MHz lump-sum value is higher than the benchmark range provided by DotEcon and Aetha in their July 2012 report, which was used by Ofcom to set the reserve prices for the 800MHz and 2.6GHz auction.[10] Yet, the price achieved for 800MHz spectrum in the auction was at the mid-point of the benchmark range provided by DotEcon and Aetha; and the price achieved for 2.6GHz spectrum was even below the benchmark range:

   - The valuation range for 1800MHz spectrum provided by DotEcon/Aetha was GBP0.146–0.219 per MHz per population, yet Ofcom's proposed lump-sum value for 1800MHz is GBP0.236 per MHz per population.

   - DotEcon/Aetha's valuation ranges for 800MHz and 2.6GHz spectrum were GBP0.253–0.714 per MHz per population and GBP0.080–0.121 per MHz per population respectively.[11] Ofcom's calculated linear reference prices (LRPs) from the auction are GBP0.471 per MHz per population for the 800MHz band and GBP0.079 per MHz per population for the 2.6GHz band.

2. The proposed 1800MHz lump-sum value also appears inconsistent with statements made by Ofcom within the current consultation document. In particular, Ofcom states that "*with the exception of Ireland, 900 MHz prices were more than twice as high as for 1800 MHz*".[12] Ofcom also assumes that 900MHz spectrum must be worth less than 800MHz spectrum.[13] The combination of these assumptions clearly implies that the 1800MHz lump-sum value should be set at less than 50% of the 800MHz LRP value.

3. As illustrated in Figure 3.1 below, the proposed 1800MHz lump-sum value is higher, on an unadjusted price per MHz per population basis, than any 1800MHz auction in Europe to date where band-specific prices can be directly inferred. Although this high-level comparison is not rigorous because it does not account for country-specific factors affecting spectrum value, it does provide a useful cross-check.

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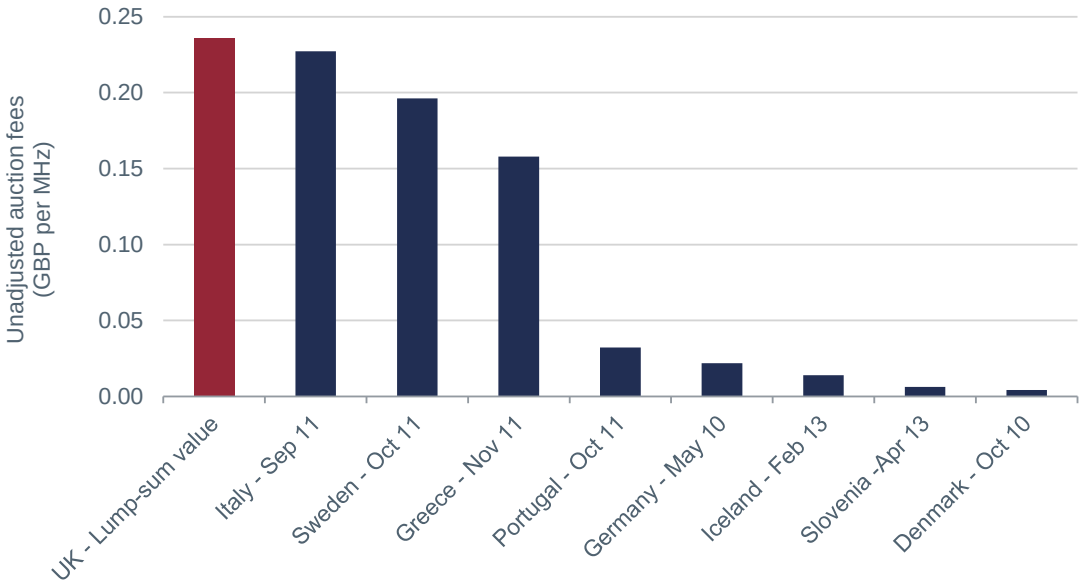
10 DotEcon and Aetha (2012), *Spectrum value of 800MHz, 1800MHz and 2.6GHz*, Executive Summary.

11 The ranges provided are for both "small bidders" and "large bidders".

12 Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum Consultation.* Paragraph 4.52.

13 Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum Consultation.* Paragraph 4.42.

Figure 3.1: European 1800MHz auction prices [Source: Analysys Mason, Aetha, 2013][14]

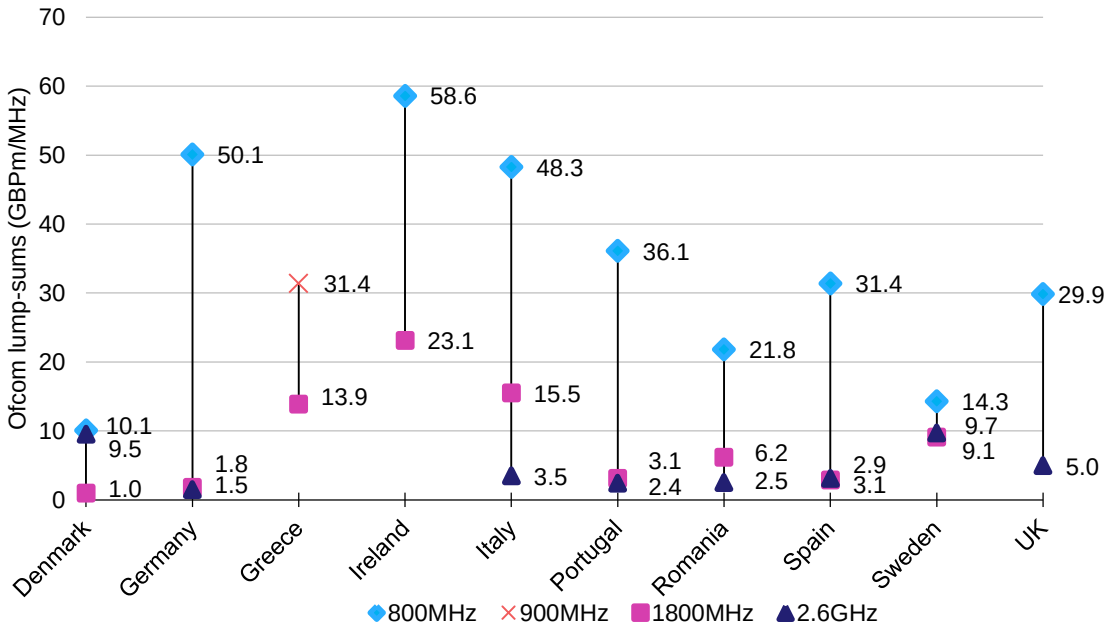


4. The proposed 1800MHz lump-sum value is only slightly below a simple average of the 800MHz and 2.6GHz LRPs; yet the results of recent European auctions overwhelmingly show that the value of 1800MHz spectrum is much closer to the value of 2.6GHz than 800MHz, as shown in Figure 3.2 below.[15]

[14] Benchmark prices include only revenue paid in the auctions converted to GBP at the prevailing exchange rate at the time. Multi-band package bid auctions have been excluded, as an 1800MHz band price cannot be directly calculated.

[15] Figure 3.2 only provides benchmarks from countries considered by Ofcom in its consultation. Other relevant benchmarks arising from auctions which have been completed since the publication of Ofcom's consultation are considered later in this document.

Figure 3.2: Ofcom's UK-equivalent benchmark figures[16,17] [Source: Ofcom, Analysys Mason, Aetha, 2013]



These four observations raise several important questions:

- Is it reasonable for Ofcom to assume an 1800MHz lump-sum value that is above DotEcon/Aetha's benchmark range, when just 11 months ago the 800MHz/2.6GHz auction produced values at the middle/bottom of DotEcon/Aetha's benchmark ranges for those bands? Is there any evidence that the value of 1800MHz spectrum has increased substantially since the auction?

- Is it reasonable for Ofcom's approach to produce an 1800MHz lump-sum value that is higher than any prices raised in other European auctions where band-specific prices can be directly inferred? Clearly, historical auction prices should be converted to reflect the UK situation, but does Ofcom's approach have an inherent bias?

- Is it reasonable for the proposed 1800MHz lump-sum value to be close to the simple average of the 800MHz and 2.6GHz LRPs?

16 The Netherlands has been excluded, as we do not consider that band-specific prices can be reliably inferred in this case, as explained in detail in Section 5.

17 In Ireland, no corresponding 2.6GHz price is available, although even an assumption of zero would show that the 1800MHz price is considerably below a simple average of 800MHz and 2.6GHz prices.

4 Evaluation of Ofcom's overall approach

Ofcom bases its approach to determining its proposed lump-sum value for 1800MHz mainly on three sources of information. These are:

1. Absolute values of benchmarks.
2. Relative values of benchmarks.
3. A simple average of UK LRP values for 800MHz and 2.6GHz.

However, there are clear issues with each of these three approaches, which we discuss in Sections 4.1 to 4.3 below. We then go on to suggest a simpler, more robust approach in Section 4.4.

4.1 Absolute values of benchmarks

In developing the lump-sum values, Ofcom uses absolute benchmarks from a range of European spectrum auctions. These are based on values provided in a benchmarking report conducted by DotEcon (*International benchmarking of 900MHz and 1800MHz spectrum value*, 2013). In this report, DotEcon adjusts the raw spectrum auction results to produce 'UK equivalent' benchmark values. We have two concerns regarding this approach.

First, there are inevitably significant error margins associated with the adjustments conducted by DotEcon. As an example, the approach requires exchanging auction benchmark results from local currency to GBP. However, currency exchange rates are volatile and therefore the exact dates of exchange rates chosen has a significant impact on the results. We note that the majority of the benchmark countries come from the Euro Zone. As illustrated in Figure 4.1 below, the EUR to GBP exchange rate fluctuated by up to around 25% during the period considered by Ofcom and DotEcon.[18]

[18] We note that DotEcon actually converts from local currency (e.g. EUR) to USD (using PPP exchange rates) before then converting to GBP (again using PPP exchange rates). However, short-term fluctuations in exchange rates would still significantly impact the results, notably including the local currency to USD exchange rate at the time of the auction and the USD:GBP exchange rate at the time of conversion to GBP.

Figure 4.1: EUR/GBP exchange rates over the last five years [Source: Analysys Mason, Aetha, 2013]

Furthermore, the adjustments undertaken by Ofcom/DotEcon are not straightforward and require a number of assumptions to be made. These include:

- The choice of WACC (for converting annual licence fees to up-front equivalents and for adjusting for licence duration).
- How to scale auction benchmarks for licences of a different duration to the UK.
- Whether and how to account for inflation for auctions that occurred in previous years.
- Whether and how to scale benchmarks to reflect differences in wealth/purchasing power between the UK and the benchmark country.

In each case, alternative methods to the ones chosen by Ofcom/DotEcon are to an extent equally valid, but may produce differing results.

Second, even after such adjustments, the benchmarks do not take into account the many other factors that influence spectrum values between countries. These include:

- Differences in levels of competition in different markets.
- Differences in average revenue per user (ARPU).
- Differences in population densities.

- Differences in network topologies, which impact the cost of providing services and the network cost savings enabled by additional spectrum.

- Different amounts of total spectrum held by operators (e.g. in Ireland, the 2.6GHz band is not available for mobile operators, which is likely to make other spectrum bands, such as the 1800MHz band, more valuable).

Therefore, it is likely that any approach focusing on absolute benchmarks from different countries to estimate the market value of spectrum in the UK will have significant error margins.

Furthermore, the Government's Direction to Ofcom states that "*OFCOM must have particular regard to the sums bid for licences in the Auction*".[19] This suggests that benchmarks based primarily on the UK 4G auction prices should have greater weight in the setting of the 900/1800MHz ALFs.

Therefore, we believe absolute values from other countries should be given very little or no weight as evidence points in the determination of the UK lump-sum values for 900MHz and 1800MHz.

4.2 Relative values of benchmarks

Ofcom uses relative values based on the ratios of 1800MHz/800MHz and 1800MHz/2.6GHz auction prices in benchmark countries. We agree that using relative measures is a better method than using absolute values, as this largely eliminates the inherent inaccuracies involved in converting European auction results to UK equivalents. However, even relative benchmarks cannot successfully adjust for all country-specific factors as underlying differences between the UK and benchmark countries may affect the relative value of different spectrum bands in different ways.

Moreover, using two different relative values, even from the same auction, may produce two very different results. This is illustrated in the example in Section 4.4 below, using both of the ratios relied upon by Ofcom can produce inconsistent and arbitrary results.

We have also calculated these two different relative values for those countries for which we have actual 1800MHz price data available. Doing so illustrates how accurate the method is in predicting the actual value based on the set of European benchmarks which are available.

The values for this comparison were calculated as follows:

- We calculated the 1800MHz/800MHz ratio in each country for which informative data was available.[20] The geometric mean[21] of the resulting ratios is 0.20. This average was multiplied

[19] *Statutory Instrument 2010 No. 3024, Wireless Telegraphy Act 2006 (Directions to Ofcom) Order 2010* page 3, available at: http://www.legislation.gov.uk/uksi/2010/3024/pdfs/uksi_20103024_en.pdf.

[20] For the 1800MHz/800MHz ratio, this includes Austria, Czech Republic, Denmark, Germany, Ireland, Italy, Portugal, Romania, Spain, Sweden and Switzerland.

by the 800MHz price fetched in each country to produce an 1800MHz value estimate for that country.

- Similarly, we calculated the 1800MHz/2.6GHz ratio in each country for which data was available.[22] The geometric mean of the resulting ratios is 2.26[21]. This average was multiplied by the 2.6GHz price fetched in each country to produce another 1800MHz value estimate for that country.

Figure 4.2 shows the actual 1800MHz value in each benchmark country as well as estimates of 1800MHz value derived from each relative-value approach.

Figure 4.2: 1800MHz values by method in GBP million per MHz [Source: Analysys Mason, Aetha, 2013]

Country	Actual (absolute) value	1800MHz/ 800MHz relative value	1800MHz/ 2.6GHz relative value
Austria	38.1	12.55	4.06
Belgium	not available	not available	10.16
Czech Republic	5.6	8.46	6.36
Denmark	1.0	2.00	21.45
France	not available	6.79	11.74
Germany	1.8	9.92	3.39
Greece	13.9	not available	not available
Ireland	23.1	11.60	not available
Italy	15.5	9.56	7.90
Netherlands	not available	not available	not available
Norway	not available	not available	not available
Portugal	3.1	7.15	5.42
Romania	6.2	4.32	5.65
Spain	2.9	6.22	7.00
Sweden	9.1	2.83	21.90
Switzerland	3.4	1.88	7.68

In Austria, the Czech Republic, Denmark, Germany, Ireland, Italy, Portugal, Romania and Spain the actual 1800MHz value lies outside of the range suggested by the two relative values, so that no average of the two relative values could result in the actual value. Only in Sweden and Switzerland does the range encompass the actual value. However, for these two, as for the other countries, the two relative values provide an extremely wide range for the 1800MHz value, which make them a poor predictor of this value.

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21 Whilst we would generally advocate using an arithmetic mean, when averaging ratios, the geometric mean is the correct averaging technique to use. This is because it returns the same value regardless of which way around the ratio is defined. In particular, using a geometric mean the average of a set of 1800MHz/800MHz ratios will be the same as the reciprocal of the average of a set of 800MHz/1800MHz ratios based on the same raw data sets. This would not be the case using an arithmetic mean unless all ratios where equal.

22 For the 1800MHz/2.6GHz ratio, this includes Austria, Czech Republic, Germany, Italy, Portugal, Romania, Sweden and Switzerland.

Given the weaknesses of using two relative values, we propose an alternative approach that results in a single relative value for each benchmark country. This takes into account the relativities to both the 800MHz and the 2.6GHz benchmarks. It is described in Section 4.4 below together with the reasons why it produces more accurate results than Ofcom's relative-value approach.

Finally, in considering relative benchmarks, we note that Ofcom could have also considered the ratio of 1800MHz/900MHz values as a cross-check on the results obtained. Although no UK LRP for 900MHz is available, the 1800MHz/900MHz ratio could have been multiplied by the UK 800MHz LRP. Given that Ofcom considers 800MHz spectrum to be more valuable than 900MHz spectrum, this would have resulted in benchmarks that risk overstating market value and could therefore only be considered as an upper bound.

As mentioned above, while far from perfect, this approach could have provided an additional cross-check on the results obtained. As shown in Figure 4.3 below, if this cross-check is carried out for countries where both 1800MHz and 900MHz benchmarks are available,[23] then an average result of GBP8.8 million per MHz is obtained, which we note risks overstating the market value.

Figure 4.3: Results or relative approach when multiplying 1800MHz/900MHz ratio by UK 800MHz LRP [Source: Analysys Mason, 2013]

Country	1800MHz/900MHz ratio	Value if multiplied by UK 800MHz LRP (GBP million/MHz)
Denmark	42%	12.4
Greece	44%	13.2
Ireland	65%	19.3
Portugal	13%	3.8
Romania	25%	7.4
Spain	17%	5.0
Geometric mean[21]	**29%**	**8.8**

4.3 Simple average of UK LRP values

Ofcom classifies the simple average of the 800MHz and 2.6GHz LRP values as a more important evidence point for the determination of the 1800MHz lump-sum value. The degree to which Ofcom uses this evidence point is a little unclear, as it is not explicitly mentioned in paragraph 4.58 of Ofcom's consultation. Nonetheless, the simple-average value does appear in Figure 4.4 of Ofcom's consultation showing all of the more important evidence points used; and our understanding is that paragraph 4.58 is not intended to provide an exhaustive explanation of the evidence considered by Ofcom in arriving at its 'non-mechanistic' conclusion.

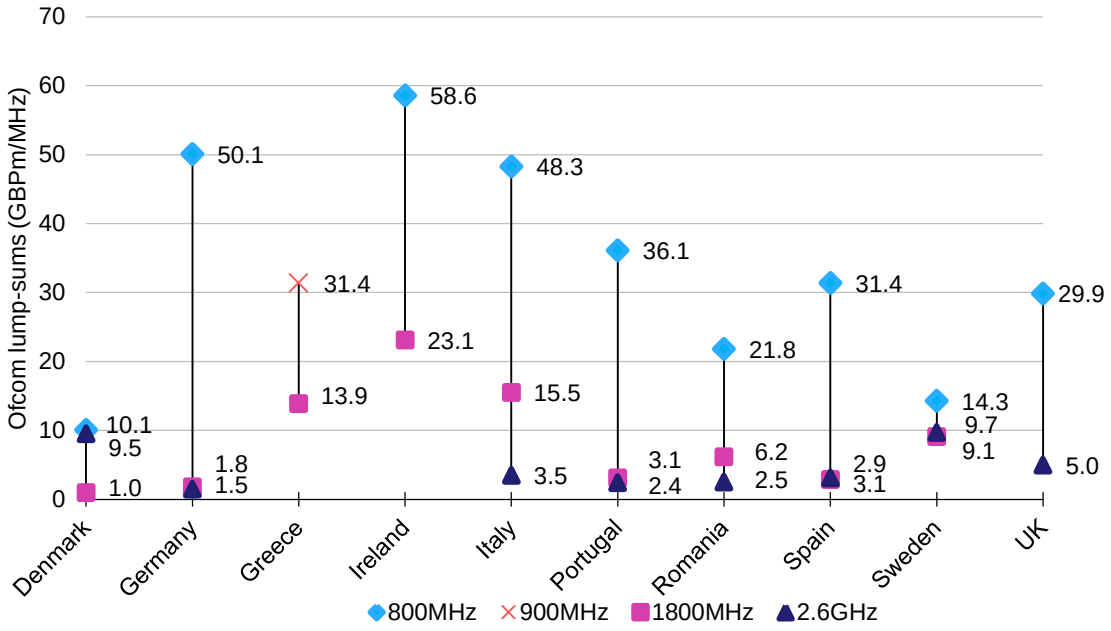
23 As discussed in later sections, it may be the case that not all of these benchmarks should be considered as reliable evidence. However, for the purposes of this cross-check we include them. Conversely, we do not include benchmarks in the above cross-check which were not available to Ofcom at the time of its consultation publication.

While we agree that the 1800MHz value should lie between the 800MHz and 2.6GHz values, a simple averaging seems to be as arbitrary as any other value between these two points. In fact a number of sources suggest that the value of the 1800MHz band is well below the straight average of the 800MHz and 2.6GHz values. We address each of these sources in detail below.

4.3.1 Empirical evidence

Empirical evidence suggests that the 1800MHz band is much closer in value to the 2.6GHz band than the 800MHz band. Figure 4.4 below, which is based on Ofcom's UK equivalent benchmark values, illustrates this point.[24]

Figure 4.4: Ofcom's UK-equivalent benchmark figures[25] [Source: Ofcom, Analysys Mason, Aetha, 2013]



In Ireland, Ofcom's evidence did not include a 2.6GHz figure, as the 2.6GHz band is yet to be awarded. However, as this value cannot be less than zero (and is likely to be greater), these benchmarks also suggest that the 1800MHz value is (significantly) less than half way between the value of 800MHz and the value of 2.6GHz.

Aetha and DotEcon's report for Ofcom on spectrum values used benchmarks from European spectrum awards to determine a range for the values of the 800MHz, 1800MHz and 2.6GHz

[24] Figure 4.4 only provides benchmarks from countries considered by Ofcom in its consultation. Other relevant benchmarks arising from auctions which have been completed since the publication of Ofcom's consultation are considered later in this document.

[25] The Netherlands has been excluded as we do not consider that band specific prices can be reliably inferred in this case, as explained in detail in Section 5.

bands.[26] A range was specified for each band for small bidders and large bidders, on a GBP per MHz per population basis, as shown in Figure 4.5 below.

Figure 4.5: Relative values of 800MHz, 1800MHz and 2.6GHz derived from DotEcon/Aetha's benchmark ranges [Source: DotEcon/Aetha, Analysys Mason, 2013]

	800MHz value (GBP/MHz/pop)	1800MHz value (GBP/MHz/pop)	2.6GHz paired value (GBP/MHz/pop)	Fraction of the distance between 2.6GHz and 800MHz at which 1800MHz is located
Small bidder range	0.253–0.434	0.146–0.219	0.080–0.121	
Mid-point	0.344	0.183	0.101	**34%**
Large bidder range	0.460–0.714	0.146–0.219	0.087–0.121	
Mid-point	0.587	0.183	0.104	**16%**

The large bidders represent established operators, while the small bidders are late or new entrants. The set of values for small bidders and the set of values for large bidders can each be used to calculate the distance between the 800MHz and 2.6GHz value at which the 1800MHz value lies.

We have used the mid-point of the range of values presented in that report for each band and size of bidder to calculate the distance between the 800MHz and 2.6GHz at which the 1800MHz value lies. For both small and large bidders, the mid-point of benchmarks for 1800MHz is much closer to the mid-point of benchmarks for 2.6GHz than for 800MHz. For a small bidder and a large bidder, benchmarks indicate that the 1800MHz values are 34% and 16% respectively of the distance between the 2.6GHz and 800MHz values.

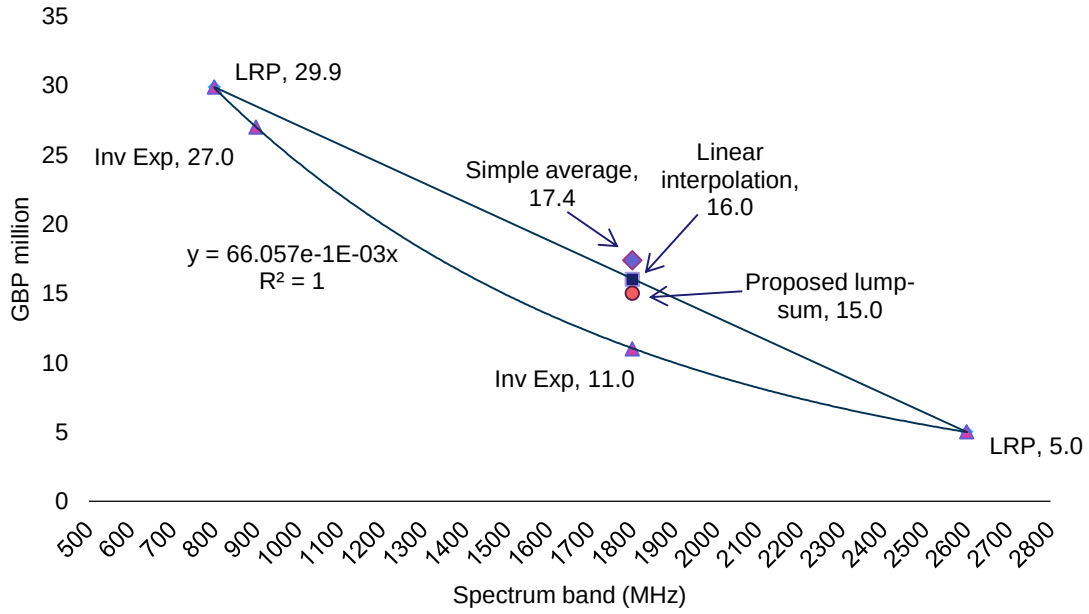
4.3.2 Evidence from academia

Although the specific topic of relative values of spectrum bands has not been widely discussed in academic literature, as Ofcom mentions, there is one academic and impartial paper by Kerans et al entitled *Pricing of Spectrum based on Physical Criteria*.[27] Using empirical data, it finds an inverse exponential relationship between value and spectrum band. This relationship is shown in Figure 4.6 below.

[26] DotEcon & Aetha (2012), *Spectrum value of 800MHz, 1800MHz and 2.6GHz*, Executive Summary. Available at: http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/statement/spectrum-value.pdf

[27] Kerans et al (2011), *Pricing of Spectrum based on Physical Criteria,* IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN).

Figure 4.6: Ofcom's simple average and proposed 1800MHz lump-sum value relative to inverse exponential and linear interpolation based values [Source: Ofcom, Analysys Mason, Aetha, 2013]



In its report, DotEcon cautions: "*[…] we note that this study draws from a narrow sample of auctions in Australia, US and Sweden, and is somewhat dismissive of some observations without strong reason. One should therefore be careful when using these findings […].*"[28]

Ofcom uses the inverse exponential values implied by this paper's curve for the 900MHz and 1800MHz bands as less important evidence in Figure 4.5 of the consultation document. Nonetheless, Ofcom states: *"[…] we do not consider that there is a strong basis for expecting [the inverse relationship] to be true in this case and, for that reason, we have preferred the simpler measure of averaging 800 MHz and 2.6 GHz values."*[29]

This apparent dismissal of the evidence seems hasty, particularly when there is no evidence to support Ofcom's chosen alternative. We do not mean to imply that the exact curve suggested by the limited evidence used in this paper is directly applicable to the UK. However, the paper suggests a functional form of a curve that we would expect to apply, at least roughly, in a more general context. In particular, this evidence-based form of interpolation would seem to be far more relevant as part of Ofcom's evidence base than an arbitrary simple average of 800MHz and 2.6GHz LRPs, if indeed any such evidence point were to be used.

28 DotEcon (2013) *International benchmarking of 900MHz and 1800MHz spectrum value*, Paragraph 302, available at: http://www.dotecon.com/publications/international-benchmarking-of-900mhz-and-1800mhz-spectrum-value/.

29 Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum Consultation.* Footnote 32, Available at http://stakeholders.ofcom.org.uk/binaries/consultations/900-1800-mhz-fees/summary/900-1800-fees.pdf.

4.3.3 Combined experience of Analysys Mason and Aetha

Analysys Mason and Aetha have extensive experience in spectrum valuation, as both regularly conduct such valuations for operators. Indeed, between the two companies, we have advised bidders to value spectrum ahead of auctions in the majority of countries considered within this report.

In our opinion, country-by-country valuations can vary significantly as local factors tend to dominate the valuation itself: hence our view that using absolute benchmarks is not a robust approach. However, based on our collective valuation modelling experience, 800MHz is likely to have a significant premium over both 1800MHz and 2.6GHz spectrum. Our experience suggests that the value of 1800MHz would, under any normal circumstances, be much closer to 2.6GHz than to 800MHz.

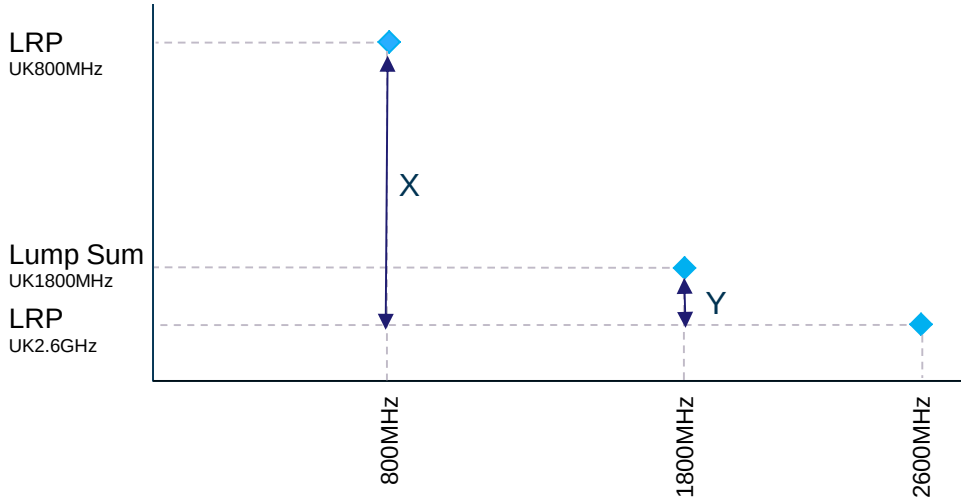
This is due to the inherently superior propagation characteristics of the 800MHz band, compared to higher frequency bands, which allow for operators to realise much greater network cost savings. Typically, the better quality of service provided by networks using 800MHz spectrum also allows for increased revenue opportunities and reductions in non-network costs.

4.4 A simpler, more robust approach

Given the evidence suggesting that 1800MHz spectrum is much closer in value to 2.6GHz spectrum than 800MHz, and the weaknesses of the absolute and relative values derived by Ofcom, we suggest a simple and more robust approach for interpreting the evidence available from benchmarks.[30] This approach does not require the level of apparently subjective judgement that must be made when combining Ofcom's proposed evidence points. In addition, this approach uses the UK 800MHz and 2.6GHz LRPs as its starting point, in line with the Government's Direction and focuses the analysis on determining where in between them the 1800MHz lump-sum should fall; i.e. it answers the question 'What is $\frac{Y}{X}$?' in Figure 4.7 below.

[30] Our proposed approach would resolve much of the unclear interpretation of evidence illustrated in Ofcom's approach by paragraphs 4.57 and 4.58 of the consultation document.

Figure 4.7: Illustration of distance method [Source: Analysys Mason, Aetha, 2013]



This ratio should be based on observations in benchmark countries for which 800MHz, 1800MHz and 2.6GHz values are available and, ideally, representative of full market value.

Once this ratio is known for the relevant countries, the lump-sum value for the 1800MHz band in the UK can be calculated from the two evidence points on which the Direction placed particular emphasis, namely the UK 800MHz LRP value and the UK 2.6GHz LRP value.

The distance method can also be used, perhaps as less important evidence, for countries where 2.6GHz values are not available (e.g. Ireland) by assigning a value of zero to the 2.6GHz band. In reality, the 2.6GHz value is likely to be greater than zero, which would reduce the ratio and hence the implied 1800MHz value. Consequently, setting the 2.6GHz value equal to zero gives the upper bound on the value of 1800MHz in this country. Similarly, where 800MHz values are not available but 900MHz values are (e.g. Greece), an upper bound for the 1800MHz value in this country can be calculated by assigning the 900MHz value to the 800MHz band.

We refer to this approach through the remainder of this report as the '*distance method'*, as it determines how far along the distance between the 2.6GHz and 800MHz values the 1800MHz value lies.

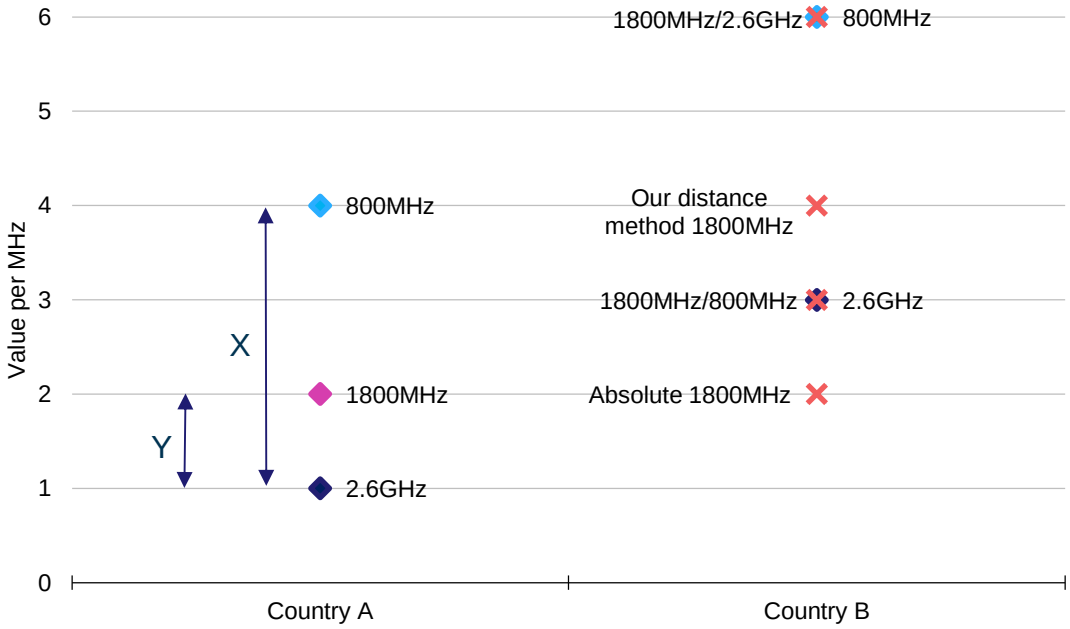
The following example explains why the distance method yields a more accurate value for the 1800MHz band than the absolute value or relative value based approaches used by Ofcom. We consider two countries, A and B, that are in essence identical (e.g. same population, currency, licence conditions) and that have both held spectrum auctions with the values shown in Figure 4.8 below.

Figure 4.8: Example auction outcomes in Country A and Country B [Source: Analysys Mason, Aetha, 2013]

Spectrum band	Value in Country A	Value in Country B
800MHz	4	6
1800MHz	2	not auctioned
2.6GHz	1	3

Based on the prices paid in Country A, we attempt to determine the 1800MHz value in Country B (where this band was not auctioned), using both Ofcom's absolute and relative approaches, as well as the distance method. The results are shown in Figure 4.9 below.

Figure 4.9: Example of Ofcom's absolute and relative methods and the distance method [Source: Analysys Mason, Aetha, 2013]



Using Ofcom's absolute value approach, the 1800MHz value in Country B is below the 2.6GHz value in the same country, which is clearly not informative in this instance. The result is flawed because it does not take into account the country-specific conditions that lead to the higher values for the 800MHz and 2.6GHz in Country B. This illustrates why we do not consider absolute benchmarks to be informative evidence points.

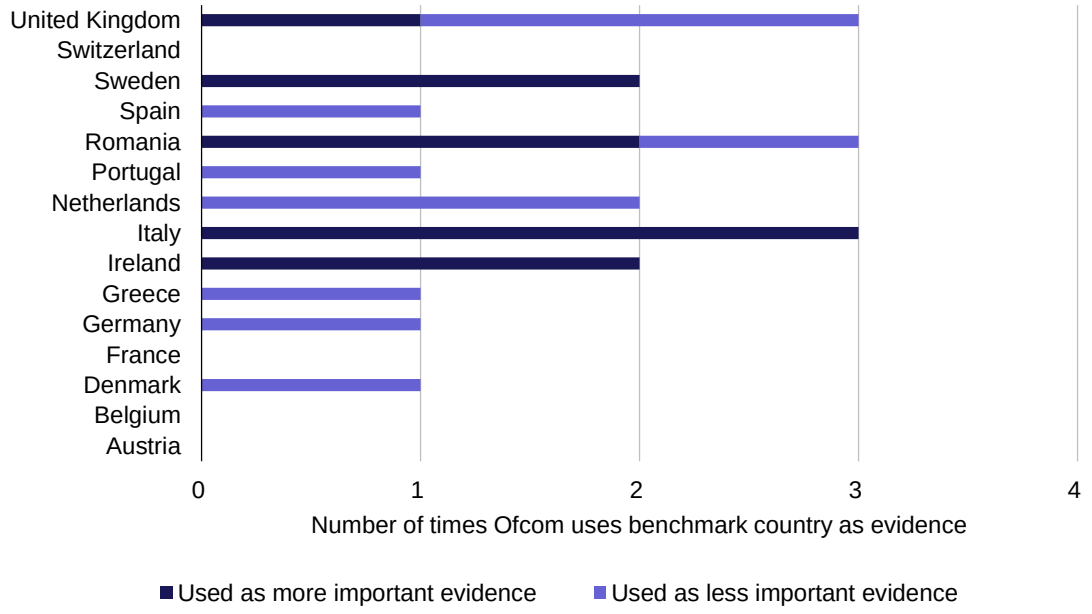
The relative values of 1800MHz/800MHz and 1800MHz/2.6GHz for Country B produce two very different values. The 1800MHz/2.6GHz relative value provides a figure that is equal to the 800MHz band in Country B. The 1800MHz/800MHz relative value, on the other hand, provides a value equal to the 2.6GHz price. Clearly, the correct value lies between these two extremes. Our concern is that Ofcom's relative approach is effectively like a 'scatter gun', producing a range of benchmarks that appear unjustifiably wide. Moreover, the two relative values produced by Ofcom's approach do not use the available information on where in-between these two extremes

the true value should lie. The distance method does this, whilst producing a single benchmark value for each country.

Using the distance method, the results of the auction in Country A gives a ratio $\frac{Y}{X}$ of $\frac{1}{3}$. Applying this to Country B results in a value of 4 for the 1800MHz. This value takes into account the relativities between all of the different bands (established from benchmarks in Country A) as well as the country-specific factors that make spectrum generally more valuable in Country B. For these reasons, we consider the distance method a more appropriate method to use in interpreting the available benchmark data.

Furthermore, Ofcom applies its absolute approach and relative approaches to the benchmark countries a number of times, depending on how applicable it considers each approach in each country. This means that a number of benchmark countries are used multiple times, while others are not considered at all, as shown in Figure 4.10 below.

Figure 4.10: Number of times Ofcom uses benchmark countries as evidence for 1800MHz lump-sum [Source: Analysys Mason based on Ofcom, 2013]



Ofcom's approach, therefore, appears to introduce a further level of complexity in which some benchmark countries are more influential than others, without an explicit weighting being assigned to them. Conversely, the distance method produces a single robust value for each benchmark country.

We very much disagree with Ofcom's approach in interpreting the available evidence, for the reasons explained above. However, we provide a detailed critique of Ofcom's approach in Sections 5, 6 and 7. This highlights further concerns we have with Ofcom's methodology, while

suggesting possible remedies. In Section 8, we calculate the lump sum that would be produced if the more robust, distance method was used.

5 Ofcom's selectivity of benchmarks

Having established the UK equivalent benchmark values for the selected benchmark countries, Ofcom proceeds by classifying each data point as more important evidence or less important evidence.

In this section, we address some aspects of Ofcom's approach that apply to multiple countries in Section 5.1. We then go on to consider a consistent framework for determining which countries to include/exclude and which to classify as more important/less important evidence in Section 5.2. In Section 5.3, we assess individual auctions against this framework and conclude the section by summarising our findings in Section 5.4.

5.1 Aspects of Ofcom's approach applying to multiple countries

5.1.1 The excluded category

Ofcom summarises its more and less important evidence points in Figures 4.4 and 4.5 of the consultation document.[31] For various reasons some benchmarks do not appear in these figures.[32] Therefore, in addition to more important and less important evidence, a third category can be considered to be the 'excluded' benchmarks. This category includes Austria and Belgium, as these countries had only auctioned the 2.6GHz in the relevant timeframe,[33] as well as France, where the 900MHz and 1800MHz bands were not auctioned in the relevant timeframe. These countries are therefore not considered by Ofcom to provide UK-equivalent benchmarks of 900MHz or 1800MHz value in the UK.

We agree with the principle that these auctions are excluded from the benchmarks, with the exception of Austria, which due to newly available information can now be included. That said, in our opinion, Ofcom could have set out which benchmarks were excluded in a more transparent manner.

5.1.2 The limited relevance of absolute values from other countries

Almost half (9 out of 20) of the evidence points that Ofcom considers in determining the UK 1800MHz lump-sum are absolute values. Five of these are considered more important evidence. However, for the reasons described in Section 4.1 and in the example in Section 4.3, we do not consider absolute-value benchmarks to be informative for the UK market, other than as a sense

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31 Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum Consultation.* Figures 4.4 and 4.5.

32 Although we note that Ofcom classifies these countries as "less important" in Annex 7 of its consultation, we presume that their exclusion from Figures 4.4 and 4.5 means that they are excluded from the analysis.

33 Subsequent to the publication of Ofcom's consultation the Austrian multi-band auction in 800MHz, 900MHz and 1800MHz bands and the Belgian 800MHz auction have concluded.

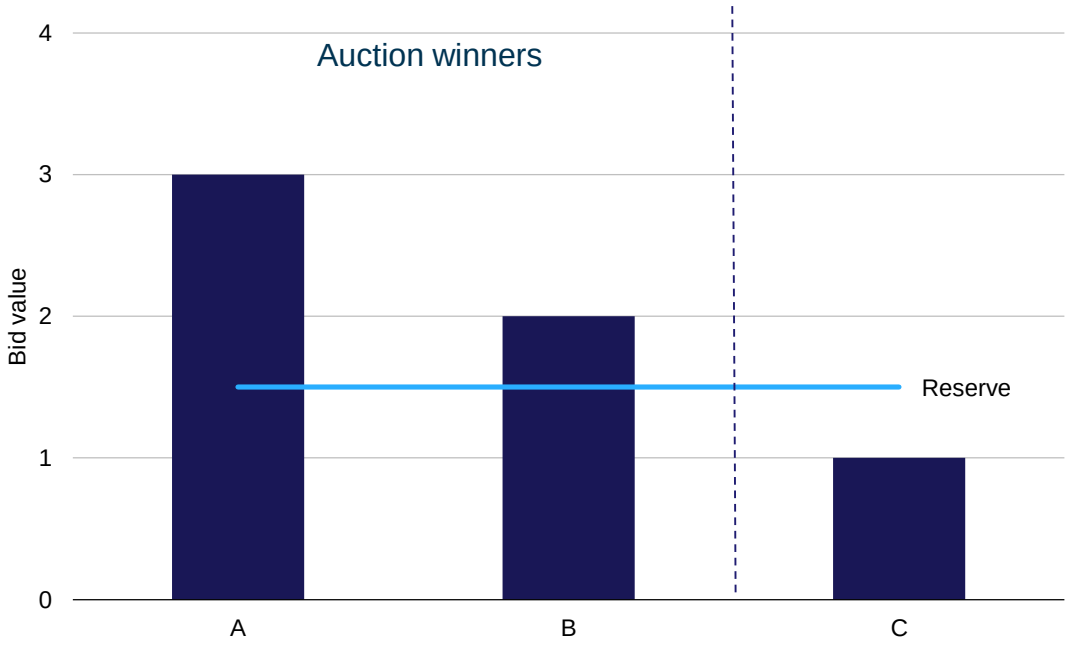
check. This is because the adjustments used in normalising the benchmarked values are only able to capture some country-specific factors that affect the value of spectrum in different countries. The Directive highlights the UK 4G auction outcome as the most important evidence. Therefore we consider it more appropriate to base the UK lump-sum values primarily on the UK LRPs, together with appropriately calculated relative-value benchmarks from other relevant countries, excluding absolute benchmarks from the considered evidence base.

5.1.3 Payments at reserve may exceed market value

In the consultation document, Ofcom argues that in a number of countries *"realised prices were at or close to reserve prices. We consider that there is a significant risk that this may have been symptomatic of limited competition in these auctions, as in a competitive auction bidding would tend to drive prices above any reserve price which was set below market value, while a reserve price set above market value would lead to unsold spectrum."*[34] Based on this argument, Ofcom considers some countries, where spectrum was sold at or near reserve prices, to risk understating market value.

However, in auctions where no spectrum is left unsold and reserve prices are paid, we believe that the opposite is in fact often true. In these cases, it is likely that the market value of the spectrum was exceeded by the reserve price, but not sufficiently high as to leave spectrum unsold. We illustrate this using the example shown in Figure 3.1 below.

Figure 5.1: Example auction scenario in which all spectrum sells at reserve [Source: Analysys Mason, Aetha, 2013]



[34] Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum Consultation.* Paragraph 4.33, Available at http://stakeholders.ofcom.org.uk/binaries/consultations/900-1800-mhz-fees/summary/900-1800-fees.pdf.

In this hypothetical auction, there two identical lots on offer and three bidders (A, B and C). A bids a value of 3, B bids a value of 2 and C bids (or, in the absence of a reserve price, would bid) a value of 1. All bidders consider the value of a second lot to be below 1. The reserve price is set at 1.5.

A and B are the winners of the two lots and both pay the reserve price (assuming a multi-round auction or a sealed bid format with a second price rule). However, the market value, which is set by the highest losing bid, is 1. Therefore, all spectrum is sold at reserve price, but the market value is *exceeded*. The winning bidders have overpaid, relative to market value, by the difference between the reserve price and the highest losing bid. While this is a simplified example, it illustrates how the market value risks being overstated in countries where all spectrum was sold at the reserve price.

That said, we note that where stringent spectrum caps or other demand-constraining conditions (such as the exclusion of bidder) were applied, the highest losing bid does not necessarily reflect market value. The highest losing bid can only truly be considered to set the market value if all bidders are allowed to bid unconstrained. Where spectrum caps or other mechanisms prevent this, it may be that the price paid does not reflect market value.

However, the above is true for all auctions with caps or other demand constraints, not just those that finish at reserve price. Given that all European auctions within the time period being considered by Ofcom have been subject to caps and/or other bidding constraints, potentially none of them have achieved true market value.

In conclusion, one cannot tell in any auction where all spectrum sold at reserve and caps or other demand constraints were applied, whether the prices paid risk overstating or understating market value.

Two relevant examples are the auctions in Greece and Portugal, which both finished at reserve price. It is therefore possible that both auctions risk overstating market value.

5.2 Framework for the categorisation of auction benchmarks

In its consultation, Ofcom effectively classifies the auction benchmarks from the various European countries into three categories:

- Benchmarks that are excluded from the analysis – although we note that Ofcom is not explicit in this element of the categorisation.
- More important evidence – benchmarks on which Ofcom (in theory) places more weight when determining the lump-sum values.
- Less important evidence – benchmarks that carry less weight when Ofcom determines the lump-sum values (although, as discussed later in Section 6, we are circumspect regarding

whether these benchmarks carry much/any weight at all in the 1800MHz lump-sum value calculation).

The overarching principle used by Ofcom when classifying country benchmarks between more and less important is whether the *"circumstances of these auctions were likely to have led to prices which reflected the value of spectrum in the markets concerned"*.[35] Ofcom then gives two examples of such circumstances:

- Auctions where bidders did not have to outbid one another in order to acquire the spectrum they needed.
- Auctions where spectrum sold at reserve prices, but there were few bidders relative to the amount of spectrum available, in which case winners might have been able to acquire spectrum at prices below market value.

Note that as discussed in Section 5.1.3 we do not agree that spectrum selling at reserve price necessarily suggests that winners won spectrum below market value.

Ofcom then considers each country in turn and applies the above principle to determine whether the auction results from that country should be considered as more or less important evidence.

We agree with Ofcom's overarching principle that auction benchmarks differ in the amount and reliability of information that they provide for determining the lump-sum values in the UK. Therefore, different benchmarks should not necessarily all carry equal weight when determining the lump-sum values. However, in our opinion, Ofcom's categorisation of the benchmarks into more and less important evidence lacks objectivity and consistency, and as a consequence, the approach injects inaccuracy into the resulting lump-sum values. For example:

- Ofcom categorises the benchmarks from the Portuguese auction as less important evidence because spectrum was left unsold in both the 900MHz and 1800MHz bands. Yet at the same time, Ofcom considers Romanian relative benchmarks based on the 800MHz price as more important for the 1800MHz lump-sum value, even though some 800MHz spectrum was left unsold in this auction.
- Ofcom also categorises the German auction as less important evidence. Its rationale was that a lack of excess demand for spectrum in the 1800MHz band may have existed, caused by the auctioned spectrum being split by existing operator holdings, leading to the auction result not reflecting full market value. As discussed in Section 5.3.2, we disagree with this analysis. However, in any case, this rationale differs from those used by Ofcom to exclude other countries, and is specific for Germany.

35 Ofcom (2013), Annual licence fees for 900 MHz and 1800 MHz spectrum Consultation. Paragraph 4.31, Available at http://stakeholders.ofcom.org.uk/binaries/consultations/900-1800-mhz-fees/summary/900-1800-fees.pdf

We believe that the process of determining the lump-sum values would greatly benefit from a set of objective criteria, which could then be transparently and consistently applied. We would in fact recommend that two sets of criteria are applied: one to determine whether auction benchmarks should be included at all in the setting of the lump-sum values, and a second set of criteria which categorise the included benchmarks as either more or less important evidence.

Considering the first set of criteria, we recommend that countries are excluded from the 1800MHz lump-sum determination if:

- The 1800MHz band has not been auctioned within the relevant time period (as specified by Ofcom) – as clearly then little can be inferred about the value of 1800MHz spectrum.
- 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). This criteria is discussed in detail in Section 5.3.1. However, in summary, we disagree that package bid auction results should be entirely disregarded because band-specific prices cannot be inferred directly. Instead, Ofcom should infer as much information as is reasonably reliable from these auctions, even if the evidence has error margins associated with it.
- Certain bidders were excluded from the auction (especially incumbent operators) – clearly this would significantly constrain demand in the auction, leading to prices potentially being far from market value.
- There is no reliable[36] 800MHz or 900MHz benchmark from the country – this requirement is specific to the distance method, which ideally relies on benchmarks being available for the 800MHz, 1800MHz and 2.6GHz bands. However, in the absence of either 800MHz or 2.6GHz benchmarks, we think that it is valuable to use the 900MHz band as a proxy for the 800MHz band and/or zero as a proxy for the 2.6GHz band. Based on Ofcom's view that the value of 800MHz spectrum is higher than 900MHz spectrum, then the use of a 900MHz band price as a proxy for a 800MHz price would provide an upper bound for the value of 1800MHz spectrum using the distance method. Similarly, the use of zero as a proxy for a 2.6GHz price would also provide an upper bound for the value of 1800MHz spectrum.[37]

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36 In the same way as described for 1800MHz in the above bullet points, In particular, if bidders were excluded or reliable band-specific prices cannot be inferred from a package auction then we would consider that a reliable 800MHz or 900MHz benchmark is not available from the country.

37 As detailed in Section 4.4, the distance approach involves calculating the ratio of the values of 800MHz spectrum less 2.6GHz spectrum ('X' in Figure 4.7) and 1800MHz spectrum less 2.6GHz spectrum ('Y' in Figure 4.7), and then applying this ratio to the UK LRPs for 800MHz and 2.6GHz spectrum. Therefore the higher the ratio of $\frac{Y}{X}$ the higher the resulting evidence point for 1800MHz spectrum. In the case of using the 900MHz band instead of the 800MHz band, X is reduced whilst Y remains unchanged. Thus, $\frac{Y}{X}$ is higher than if an 800MHz value were available. Therefore, the use of the 900MHz band as a proxy for the 800MHz band produces an upper bound evidence point. In the case of using zero instead of the 2.6GHz band, both Y and X are increase by the same absolute amount. This again increases $\frac{Y}{X}$. Therefore, again the use of zero as a proxy for the 2.6GHz band produces an upper bound for the value of 1800MHz spectrum. The same is true if both proxies are used in combination.

Note that the above criteria have been defined such that only auctions that effectively provide no useful information regarding the value of 1800MHz spectrum are excluded from the analysis. As a general rule, we believe that as many data points as possible should be included in the analysis – even if some are more reliable than others – as this increases the overall accuracy of the derived lump-sum values. We note that due to the very selective nature of Ofcom's approach, its proposed lump-sum value for 1800MHz spectrum is heavily influenced by a small number of auctions, and in particular, the Italian and Greek auctions.

Therefore, this proposed approach is not more restrictive than Ofcom's, but it is more robust and transparent. Indeed, it leads to more evidence points contributing to the lump-sum values than Ofcom's approach.

Of course, as stated above, some countries provide more valuable benchmarks than others. We believe, like Ofcom, that this is most appropriately accounted for by giving them more weight in the final determination of the lump-sum values. However, we again believe that a clear and objective set of criteria should be used to determine which countries provide more and less important evidence. We recommend that countries are considered as less important if:

- Band-specific prices cannot be *directly* inferred– this would mean that benchmarks from package bid auctions would at best be considered as less important.
- A proxy is used for the 800MHz and/or 2.6GHz price when using the distance method (i.e. we use the 900MHz value or zero 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 – or indeed the 900MHz band, if used as a proxy) – such circumstances increase the likelihood that the auction did not result in true market value being paid, although, as discussed, in such cases the auction price may either be an over- or underestimate of the market price.
- There is a significant time gap between the auctioning of the three required bands (800MHz, 1800MHz or 2.6GHz – or indeed the 900MHz band if used as a proxy) – given the potential for the relative value of spectrum bands to evolve over time, this would likely lead to inaccuracies in the resulting 1800MHz benchmark.

Once applied, these criteria should identify those benchmarks which, although they provide some valuable information regarding the value of 1800MHz spectrum, are less reliable. The following section considers each of the European auctions that have occurred in the relevant time period considered by Ofcom and then categorises them as described above.

5.3 Assessment of individual European auctions

5.3.1 Package auctions

In the period covered by Ofcom's benchmarking, there were four European multi-band package bid auctions: the Swiss CCA in February 2012, the Romanian package clock auction in September 2012, the Dutch CCA and the Irish CCA, both in November 2012. In addition, since Ofcom published its consultation, two further multi-band package bid auctions have taken place – the Austrian CCA in October 2013 and the Norwegian sealed-bid auction in December 2013. Ofcom's approach to these package auctions appears to be highly inconsistent.

Ofcom clearly acknowledges that band-specific prices are not directly observable from package auctions. Notably, when considering the Swiss auction, Ofcom states *"that it is not possible to make reliable inferences about relative prices from these auction results, given the CCA nature of the auctions, and the non-linearity of the package prices."*[38]

Ofcom uses this logic to completely dismiss the Swiss auction from the evidence base for the ALFs. It also uses this logic to dismiss non-reserved band specific prices from the Dutch auction.

At the same time, it creates exceptions to include the Romanian and Irish auctions within the evidence base, and indeed considers evidence from these two auction as "more important". It also includes as "less important" evidence selective benchmarks from the Dutch auction (the price for the reserved 800MHz spectrum and the reserve price for the 1800MHz band), even though these provide very little information regarding the market value of 1800MHz spectrum.

This approach appears inconsistent. Why should some package bid auctions carry no weight in the evidence base, yet others play a pivotal role in the determination of the lump-sum values?

Furthermore, there appears to be an inconsistency in the process that Ofcom has followed to gain information regarding these auctions. Notably, Ofcom has been provided by Vodafone with information regarding the final clock-round prices in the Irish auction, which Ofcom verified with ComReg before then using to infer band-specific prices. We are not aware whether Vodafone has provided the final clock-round prices in other packages auctions (notably the Netherlands and Romania, where it participated in the auctions), nor are we aware whether Ofcom has gone to similar lengths to find final clock-round prices for the Swiss, Dutch and Romanian auctions.

In this section, we consider each of these six multi-band package bid auctions in turn and discuss what can and cannot reliably be inferred from them, before then concluding how we would recommend Ofcom treat these auctions when determining the lump-sum values.

[38] Page 25, footnote 38, *Annual licence fees for 900 MHz and 1800 MHz spectrum*, Ofcom, October 2013.

Irish 2012 CCA (800MHz, 900MHz, 1800MHz)

As discussed above, Ofcom bases its estimate of the band-specific prices from the Irish auction on the ratio of final clock-round prices as provided by Vodafone, which were then verified by ComReg. Given the nature of the opportunity-cost-based pricing algorithm in CCAs, final-round prices are not necessarily an accurate indicator of band-specific prices (as illustrated by the UK auction). Indeed, the prices paid by each bidder can be heavily influenced by bids in the supplementary round.

That said, given the constraints that primary-round bids place on supplementary-round bidding, bidders are incentivised to reveal their preferences across bands in the primary rounds. Therefore, although not perfect, we agree that using final-round prices to infer band-specific prices is of value. Furthermore, we note that it is difficult to infer band-specific prices reliably and with accuracy purely from information that is in the public domain.

However, given that this approach provides a proxy for band-specific prices, which cannot be inferred directly, we disagree with Ofcom that it should be categorised as "more important" evidence. Indeed, Ofcom's derivation of the band-specific prices from the final-round prices, as detailed in Annex 7 of its consultation, makes simplifying assumptions that introduce further error bounds to the benchmark. Notably, Ofcom combines all auction payments (including payments for standard lots in Time Slices 1 and 2 and payments for bidder-specific lots) and apportions them only to the standard lots in Time Slice 2. We also note that the Irish band-specific prices calculated by Ofcom differ from those calculated by DotEcon in their linear reference price report, even though both parties had the same information available to them and used a similar approach.[39] This illustrates the inherent margins for error in the calculation.

Given the difficulties in inferring band-specific prices, even with final-round prices, we believe that the evidence from the Irish auction should be categorised as less important.

Romanian 2012 package clock auction (800MHz, 900MHz, 1800MHz and 2.6GHz)

In its consultation, Ofcom decides that it is possible to infer band-specific prices from the Romanian auction, and therefore includes it within the evidence base. Ofcom's rationale is that the package prices were close to the sum of the reserve prices of constituent lots, therefore the reserve prices are likely to be a close approximation of the band-specific prices.

The auction results are provided in Figure 5.2 below.

[39] DotEcon (2013), *800MHz and 2.6GHz linear reference prices and additional spectrum methodology*, Page 24.

Figure 5.2: Results of the Romanian auction in 2×5MHz blocks[40] (with exception of 2.6GHz TDD lots which is in 15MHz blocks) [Source: Analysys Mason, Aetha, 2013]

Operator	800MHz	900MHz (short-term)	900MHz (long-term)	1800MHz (short-term)	1800MHz (long-term)	2.6GHz FDD	2.6GHz TDD	Price from primary rounds (EUR millions)	Price from assignment rounds (EUR millions)	Total price (EUR millions)
Orange	2	2.5	2	3	4	4		219.0	8.1	227.1
Vodafone	2	2.5	2	3	6		1	227.4	1.2	228.5
Cosmote	1		2		5	2		175.6	4.4	179.9
RCS&RDS			1					40.0	-	40.0
2K							2	6.6	-	6.6
Unsold	1						8			

The total price of all lots sold in the auction, including both primary and assignment rounds, was EUR682.1 million, which compares to the sum of the reserve prices for these lots of EUR659.8 million. So, in aggregate, the revenue from the auction was just 3.4% above reserve price. Therefore, we agree that using the reserve prices as a proxy for the band-specific prices is reasonable.

Ofcom states that there is a risk that the use of reserve prices may underestimate the band-specific prices as, in theory, all of the 3.4% of revenue above reserve price may have been concentrated in one band. However, we believe that this is a limited risk, and certainly represents a smaller error than those introduced through the translation of the auction result to a GBP equivalent.

One aspect of the Romanian auction result to note is that spectrum was left unsold in both the 800MHz and 2.6GHz bands. This may suggest that the reserve prices were set above market value.

The implication of this unsold spectrum is that there is a risk that relative 1800MHz benchmarks using either the 800MHz or 1800MHz prices may be understated, if the 800MHz/2.6GHz prices are above market value). This aspect means that there is also potential error margins in the use of the 'distance' method to calculate an 1800MHz benchmark from the Romanian result. Therefore, we believe that the Romanian auction should be classified as less rather than more important evidence in the way that Ofcom has chosen to do.

Swiss 2012 CCA (800MHz, 900MHz, 1800MHz, 2.1GHz and 2.6GHz)

In its consultation, Ofcom observes that *"band-specific prices are not directly observable"* from the Swiss auction. Therefore, it completely disregards ***all*** evidence from this auction.

[40] Short-term lots were available from January 203 to April 2014. The 900MHz short-term lots were 2×2.5MHz each.

We find this position inconsistent, given that it is not possible to directly observe band-specific prices from the Irish auction, even with the evidence provided by Vodafone. Yet Ofcom draws evidence that it classes as "more important" from the Irish auction.

Although we agree that it is not possible to pinpoint band-specific prices paid in the Swiss auction, in our opinion some valuable evidence can be gleaned.

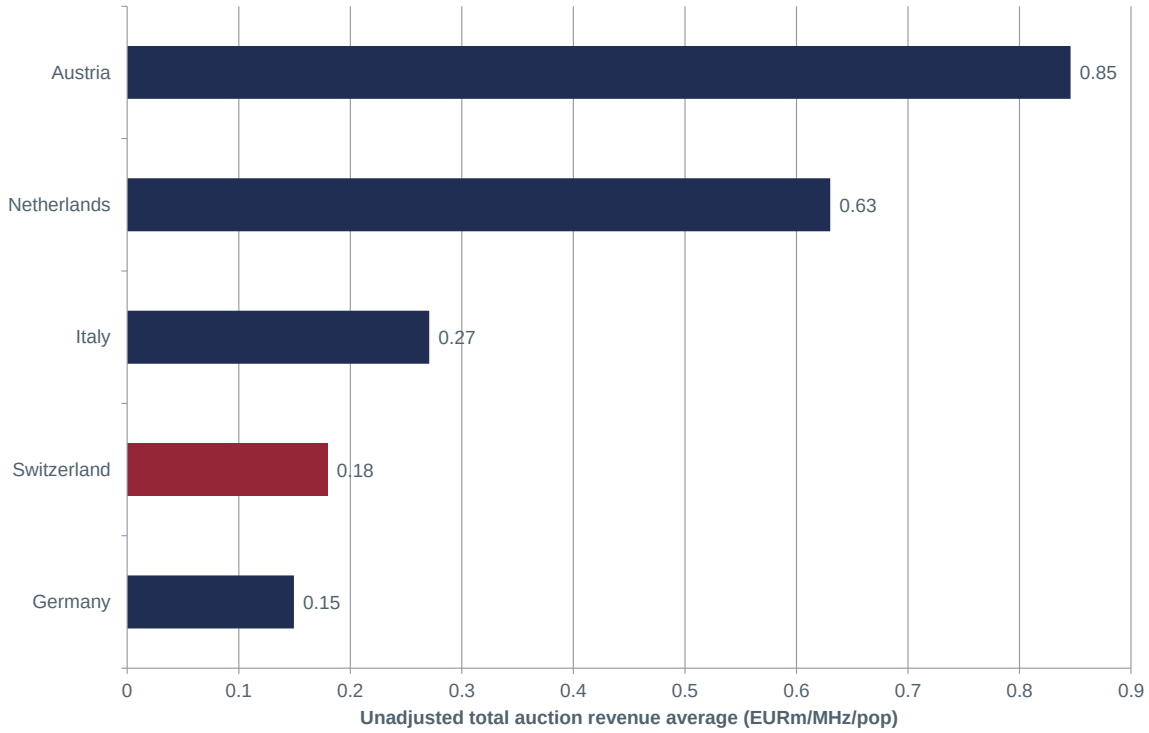
Figure 5.3 below provides the result of the Swiss auction.

Figure 5.3: Results of the Swiss auction in 2×5MHz blocks (with exception of 2.6GHz TDD lots which is in 15MHz blocks) [Source: Analysys Mason, Aetha, 2013]

Operator	800MHz	900MHz	1800MHz (avail. immediately)	1800MHz (from 2015/16)	2.1GHz (avail. immediately)	2.1GHz (from 2017)	2.6GHz FDD	2.6GHz TDD	Price (EUR millions)
Orange	2	1		5		4	4		128.4
Sunrise	2	3		4		2	5		399.8
Swisscom	2	3	2	4	3	3	4	3	298.6

The first observation from this auction is that overall the prices were relatively low. The average price paid across the whole auction was just EUR0.18 per MHz per population (unadjusted). As illustrated in Figure 5.4 below, this was at the lower end of benchmarks from other multi-band auctions of similar scale.

Figure 5.4: Unadjusted total auction revenue in relevant CCAs [Source: Analysys Mason, Aetha, 2013]



If we compare at a high level the result of the Swiss auction to that of the Irish auction (the evidence from which Ofcom considers to be "more important"), it is clear that the Swiss auction produced much lower prices overall. The total revenue raised in the Swiss auction was approximately 65% more than the Irish auction. However, this is despite:

- the population of Switzerland being 74% larger than Ireland
- the Swiss auction including almost twice as much spectrum as the Irish auction, although the additional spectrum was largely at high frequencies
- Switzerland being significantly more wealthy than Ireland (its GDP per capita is 72% higher than Ireland).

Using a relative approach (such as the distance approach suggested in this report), the absolute level of the prices is unimportant. However, were Ofcom to persist in using benchmarks of absolute-price levels, which we think is inappropriate, then the overall price levels from the Swiss auction should certainly be taken into account.

The second observation is that, although the differences in prices paid by the operators may to an extent have been caused by bidders setting asymmetric opportunity costs on each other, it is highly likely that the price of 900MHz spectrum was high in order to explain the stark differences in prices.

We can compare Orange's result to that of Sunrise. Sunrise paid EUR271 million more than Orange (more than three times). With the exception of the 900MHz band, there were the following differences between the packages that they won:

- Orange won one more lot in the 1800MHz band (five vs. four)
- Orange won two more lots in the 2.1GHz band (four vs. two)
- Sunrise won one more lot in the 2.6GHz band (five vs. four).

It is highly likely that the value of the three additional 1800MHz/2.1GHz lots won by Orange is more than the one additional 2.6GHz lot won by Sunrise. This would suggest that that EUR271 million (the total difference paid by the two operators) would be an underestimate for the price that Sunrise paid for the two additional 900MHz lots. This implies a minimum price for these marginal 900MHz lots of EUR1.74 per MHz per population.

We also note that Orange paid reserve price for its package;[41] and if you remove from Swisscom's package the additional lots it won compared to Orange (two lots in the 900MHz band, one 2×5MHz lot in the 1800MHz band, two lots in the 2.1GHz band, and three lots in the 2.6GHz TDD band) and removed the additional price it paid compared to Orange (EUR170 million), Swisscom also paid the reserve price for the remainder of its package.

Therefore, given this evidence, we believe that the following can be inferred from the Swiss auction with a reasonable amount of confidence:

[41] With the exception of EUR0.4 million it spent in the assignment round.

- The price for 900MHz spectrum was high: we certainly cannot understand why Ofcom states in its consultation: *"we do not consider this result can be explained by Sunrise winning more 900 MHz spectrum than Orange"*.[42]

- The price for 800MHz, 1800MHz and 2.6GHz spectrum was at or close to reserve price – given that:

  – one lot in the 2.6GHz band was left unsold
  – Orange paid reserve price for its package that included two lots of 800MHz spectrum, and the price differences between that paid by Orange and Swisscom/Sunrise cannot be explained by differing amount of 800MHz spectrum.
  – Orange paid reserve price for its package that included four lots of 1800MHz spectrum, and again the price differences between that paid by Orange and Swisscom/Sunrise are highly unlikely to be explained by differing amount of 1800MHz spectrum (although we note that Swisscom won one more 2×5MHz lot in the 1800MHz band).

- As an implication of the above two points, the price of 900MHz spectrum was (significantly) more expensive than 800MHz spectrum.

Therefore, we believe that it is reasonable to use the 800MHz, 1800MHz and 2.6GHz reserve prices to provide relative benchmarks for the value of 1800MHz spectrum in the UK, despite the 1800MHz and 2.6GHz reserve prices being set at the same level. Although given that band-specific prices cannot be inferred directly, we suggest that this evidence is categorised as less important.

Dutch 2012 CCA (800MHz, 900MHz, 1800MHz, 2.1GHz and 2.6GHz TDD)

Again, in its consultation Ofcom observes that *"band-specific prices are not directly observable"* from the Dutch auction. Therefore, it classifies evidence from this auction as less important. In particular, Ofcom uses a disaggregation of band-specific prices provided by New Street Research (NSR), which NSR itself states is "*only one of many mathematically plausible solutions*", as well as the reserve prices in this auction. In this section, we consider whether this is a justifiable approach.

The result of the Dutch multiband auction was as follows:

[42] Page 25, footnote 38, "Annual licence fees for 900 MHz and 1800 MHz spectrum", Ofcom, October 2013.

Figure 5.5: Results of the Dutch auction in 2×5MHz blocks[43] (with exception of 2.1GHz/2.6GHz TDD lots which is in 5MHz blocks) [Source: Analysys Mason, Aetha, 2013]

Operator	800MHz	900MHz	1800MHz	2.1GHz TDD	2.1GHz FDD	2.6GHz TDD	Price from primary rounds (EUR millions)	Price from assignment rounds (EUR millions)	Total price (EUR millions)
KPN	2	2	4		1	6	1350	2	1352
Vodafone	2	2	4		1		1381	0.01	1381
T-Mobile		3	6	3		5	911	0.1	911
Tele2	2						161		161

We agree that given the small number of evidence point available from the auction and the large number of variables, it is not possible to calculate reliable band-specific prices using a linear model. Therefore, as per our analysis regarding the Swiss auction, we have considered what information can and cannot be inferred reliably from the Dutch result.

One issue when considering the Dutch result is that there was a 2×10MHz reservation for entrants in the 800MHz band, which is unique among European 800MHz auctions. This means that it is not possible to directly infer a market price for 800MHz spectrum with 2×30MHz available, as was the case in the UK.

The price paid by Tele2 for the 2×10MHz reservation (EUR0.48 per MHz per population) is clearly an underestimate of the market value, as Tele2 only needed to outbid another entrant (Z4). T-Mobile, which was precluded from bidding for the reservation and ultimately failed to acquire any 800MHz spectrum, is likely to have had a higher valuation for this spectrum.

In theory, the prices paid by KPN and Vodafone for 800MHz spectrum should overstate the market value, due to the artificial scarcity resulting from the reservation. In any case, it is difficult to isolate the prices paid by KPN/Vodafone for this spectrum. Assuming that the price paid for 2.1GHz TDD, 2.1GHz FDD and 2.6GHz TDD was minimal (TDD spectrum has typically raised little revenue in European auctions, and the 2.1GHz licences had just four-year durations), the difference between the amounts paid by KPN/Vodafone and T-Mobile would represent a lower bound for the price paid by KPN/Vodafone for the 800MHz spectrum. This amount was EUR441–470 million (EUR1.31–1.40 per MHz per population). However, given T-Mobile also won an additional 2×5MHz in the 900MHz band and 2×10MHz in the 1800MHz band, the actual prices paid by KPN and Vodafone for the 800MHz spectrum are likely to have been significantly higher.

In summary, it is difficult to infer an 800MHz market price (assuming 2×30MHz available to all bidders) from the Dutch auction. The price paid by Tele2 is certainly a lower bound, but it is difficult to infer anything further with confidence.

[43] Short-term lots were available from January 203 to April 2014. The 900MHz short-term lots were 2×2.5MHz each.

It is also very difficult to infer a price for either 900MHz and 1800MHz spectrum. T-Mobile is likely to have paid an incremental amount for the additional 2×5MHz in the 900MHz band and 2×10MHz in the 1800MHz band over KPN/Vodafone's winning packages. However, it is very difficult to read how much.

In 2010, a 2.6GHz FDD auction was also held in the Netherlands. However, the auction raised just EUR2.7 million (EUR0.0013 per MHz per population), which was just above the low reserve price and well below any other 2.6GHz auction. The cause of the low price was spectrum caps placed on the three incumbent operators (KPN, Vodafone and T-Mobile), which restricted them to either 2×5MHz or 2×10MHz each, and 2×25MHz in aggregate. The rationale for these caps was to guarantee two entrants 2×20MHz each. However, the result was that there was no competition in the auction (other than for the preferred frequencies in the assignment round). Therefore, this auction result certainly underestimates the market value of 2.6GHz spectrum.

Given these difficulties in interpreting the outcome of the auctions in the Netherlands, we do not think that Ofcom's approach of using the New Street Research data provides a reliable evidence point. Ofcom also use the reserve prices for 900MHz and 1800MHz as evidence points. While we agree that this can be a reasonable approach in certain specific circumstances, as we have discussed for the Swiss auction above, we do not consider it to be appropriate in this case. This is because the revenue achieved in the Dutch multi-band auction significantly exceeds the figure that would have resulted if all spectrum had sold at reserve prices, and so it is very unlikely that the 900MHz and 1800MHz bands sold at reserve in the Netherlands.

In conclusion, given that it is very difficult to infer reliably 800MHz, 900MHz, 1800MHz or 2.6GHz prices from the Dutch auctions, we suggest that these auctions should not be used to calculate 'relative' benchmarks for either 900MHz or 1800MHz spectrum, even using the proposed distance approach.

Austrian 2013 CCA (800MHz, 900MHz, 1800MHz)

The Austrian multiband auction concluded in October 2013, after the publication of Ofcom's consultation. Therefore, Ofcom obviously could not have taken this auction into account when determining its lump-sum values. However, given the results are now available it is relevant to consider them.

The result of the auction was as follows:

Figure 5.6: Results of the Austrian auction in 2×5MHz blocks [Source: Analysys Mason, Aetha, 2013]

Operator	800MHz	900MHz	1800MHz	Price (EUR millions)
Telekom Austria	4	3	7	1030
T-Mobile	2	3	4	654
Hutchison 3G	-	1	4	330

Again, being a CCA, it is not possible to directly calculate band-specific prices. However, in its

post-auction communications Telekom Austria revealed the final clock-round prices.[44] As per the approach taken by Ofcom for the Irish auction, it is possible to use these final round prices to estimate band-specific prices.

The final clock-round prices were:

- 800MHz band: EUR89.7 million per 2×5MHz lot
- 900MHz band: EUR95.3 million per 2×5MHz lot
- 1800MHz band: EUR57.8 million per 2×5MHz lot.

We have no reason to suspect that these prices are incorrect, but Ofcom may wish to confirm them with the RTR.

Using the above clock-round prices we calculate the following prices per band (note that we use the exact process used by DotEcon to calculate the UK-equivalent prices from the Irish auction result):

Figure 5.7: Inferred prices per 2×5MHz lot and UK equivalents per MHz [Source: Analysys Mason, Aetha, 2013][45]

Band	Duration	Band-specific prices inferred from final clock-round prices (EUR millions)	Band-specific prices translated to UK equivalent (GBP millions per MHz)
800MHz	16 years	87.6	63.4
900MHz	19 years	92.2	32.458.0
1800MHz	17.3 years	56.2	20.738.1

In 2010, there was also a 2.6GHz CCA in Austria. Given that this was a single-band CCA, gaining a band-specific price is not problematic. In its consultation, Ofcom calculates the UK-equivalent price achieved in this auction to be GBP1.8 million per MHz.

As discussed elsewhere in this report, we do not think that it is appropriate to use absolute benchmarks in the evidence base for UK lump-sum prices. However, given the above two Austrian auctions provide us with benchmarks for the 800MHz, 1800MHz and 2.6GHz band, it is possible to calculate a UK benchmark for the 1800MHz band using the distance approach. This produces a value of GBP19.6million. We note that this value is above a linear interpolation of the UK 800MHz and 2.6GHz LRPs (GBP16.0 million). However, given that band-specific prices cannot be inferred directly from the Austrian auction, we categorise this evidence as less important.

Finally, we note that some of the Austrian bidders are legally challenging the result of the auction due to alleged irregularities with the auction procedure. One of the issues cited is that the inclusion

44 *Results of the Austrian Spectrum Auction*, Telekom Austria Group, 21st October 2013, available at www.telekomaustria.com/ir/news/TKA_acquires_austrian_spectrum_Presentation.pdf.

45 UK equivalent figures include annual fees. The duration of 1800MHz licences varied by block. A value of 17.3 years used in calculations is the average duration of licences sold.

of frequency-specific and time-specific 1800MHz lots in the primary-rounds/supplementary round led to strategic bidding and a high 1800MHz price. The high price of the Austrian 1800MHz value leads to a correspondingly high estimate of UK 1800MHz value using the distance method. We suggest that Ofcom monitors the developments of these challenges. If the Austrian auction were to be either annulled or demonstrated to have produced irregular prices, we would recommend that this benchmark is excluded from evidence base for the UK lump-sum values.

Norwegian 2013 first-price sealed bid auction (800MHz, 900MHz, 1800MHz)

At the time of the publication of Ofcom's consultation document, of the three bands relevant to the distance method only the 2.6GHz band had been auctioned in Norway (in 2007), and this was outside of the time period considered by Ofcom. Since the consultation publication the 800MHz, 900MHz and 1800MHz bands were auctioned in Norway in December 2013.

The auction format used was a first-price, sealed-bid combinatorial auction, the results of which were as follows.

Figure 5.8: Results of the Norwegian auction [Source: Analysys Mason, Aetha, 2013]

Operator	800MHz	900MHz	1800MHz	Price (NOK millions)
TeliaSonera	2×10MHz (coverage obligation)	2×5MHz	2×10MHz	626.7
Telco Data	2×10MHz	2×5.1MHz	2×20MHz	705.0
Telenor	2×10MHz	2×5MHz	2×10MHz	453.0

The prices are clearly non-linear, which is to be expected given the auction format. First-price, sealed-bid auctions incentivise bidders to 'shade' their bids below valuation in order to create a surplus. Clearly, if a bidder were to bid its valuation and then win, it would not be in any better financial situation than if it had lost. In other words, when bidding at valuation in a first price auction, the bidder will be agnostic as to whether or not it wins.

Bid shading has two implications:

- Firstly, the degree to which bidders shade can vary widely by bidder. Therefore, the price that a winning bidder pays is likely to be heavily influenced by its attitude to the risk of not winning. The influence of the size of the package won by each bidder on prices could easily be secondary to the effect of shading. This appears to especially be the case in the Norwegian auction, given that the similarity of spectrum packages won and the large implications if a bidder were not to win any spectrum.

- Secondly, it is unlikely that first-price, sealed bid auctions find the true market value of spectrum. If all bidders are risk averse and bid high to ensure that they do not lose, the

prices paid by all winners could be significantly above market value. Alternatively, if all bidders shade heavily it is possible that prices are below the true market value.

Given the combination of these two effects, there are likely to be large error bounds in any band-specific prices inferred from multiband, first-price sealed bid auctions, such as the Norwegian auction.

We note that these error bounds are likely to be greater than in a CCA, especially where final-round prices are known. The multi-round nature of the primary rounds in a CCA and the constraints that they provide on supplementary round bids, mean that bidders are much less likely to submit substantially inconsistent bids for similar packages.

The error bounds in inferring band-specific prices can clearly be seen from the Norwegian result. Assuming that the cost of the coverage obligation and the value of the extra 2×0.1MHz in the 900MHz band won by Telco Data are insignificant, it is possible to calculate a range of prices for the additional 2×10MHz of 1800MHz spectrum won by Telco Data over TeliaSonera and Telenor. Such an approach suggests a value of between NOK78 million and NOK252 million for this 2×10MHz. – i.e. there is a multiple of 3.2 between the low and high end of the range. The implication is that the price difference between Telco Data and TeliaSonera/Telenor is likely to have been heavily driven by differences in bid shading.

Furthermore, not only is it not possible to calculate a reliable band-specific price for the 1800MHz band, it is also not possible to disaggregate the price paid for the 800MHz and/or 900MHz bands. It is for these two reasons that we recommend that the Norwegian auction is excluded from the evidence base for the UK lump-sum values.

Conclusions regarding multi-band package bid auctions

As discussed in the introduction to this section, Ofcom's approach to package auctions appears inconsistent. In our opinion, if Ofcom wishes to remain consistent, it is faced with two options:

- It should exclude the results of ***all*** package auctions (including Ireland and Romania).
- It should infer as much information as is reliable from all package auctions, even if the evidence has error margins associated with it. It should then use all of this information, potentially giving the more accurate benchmarks more weight, when determining the lump-sum value for both the 900MHz and 1800MHz bands.

On balance, we would suggest that Ofcom should follow the latter approach. This is for three reasons:

- First, although the pricing in some package bid auctions is non-linear (e.g. CCAs), this is not a reason to completely discard them. Indeed, the UK package prices were non-linear, but it is still possible to infer some useful information about average prices.

- Second, although the amount of reliable information that can be inferred might vary by package auction, as demonstrated in this section it is possible to infer valuable information from all but the Dutch and Norwegian auctions. Therefore, it appears wasteful not to use this information.

- Third, package auction formats, and particularly the CCA, has become the leading auction format in recent years. Therefore, excluding package auctions from the evidence base significantly reduces the size of the evidence base.

That said, we fully acknowledge that there are error bounds in the calculation of benchmarks from multi-band package bid auctions, even using the 'distance' approach. Therefore, we would recommend that they are given less weight than other auctions where band-specific prices can be directly calculated (e.g. SMRA[46]s).

5.3.2 SMRAs and other awards

Belgium

Only the 2.6GHz band was auctioned in the timeframe considered by Ofcom. Since the publication of Ofcom's consultation document the 800MHz auction has also concluded in Belgium. However, as the results from these two auctions do not provide information about the value of the 900MHz and 1800MHz bands, we agree with Ofcom's initial assessment that Belgium does not provide any relevant benchmarks.

The results from the 2.6GHz auction are provided in Figure 5.9 below.

Operator	2.6GHz FDD	2.6GHz TDD	Price paid (EUR millions)
Belgacom	2×20MHz		20.2
Mobistar	2×20MHz		20.0
BASE	2×15MHz		15.0
BUCD BUVA	-	45MHz	22.5

*Figure 5.**9**: Results of the 2011 Belgian auction [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]*

Czech Republic

The 800MHz, 1800MHz and 2.6GHz SMRA in the Czech Republic concluded after the publication of Ofcom's consultation document. We include it here as an additional evidence point, as it provides a recent benchmark in which band-specific prices can be directly observed.

The outcome of the auction is summarised in Figure 5.10 below.

46 Simultaneous multiple-round ascending auctions

Figure 5.10: Results of the 2013 auction in the Czech Republic [Source: Analysys Mason, Aetha, 2013]

Operator	800MHz	1800MHz	2.6GHz	2.6GHz TDD	Price paid (CZK millions)
T-Mobile	2×10MHz	2×2MHz	2×20MHz	-	2614
Telefonica	2×10MHz	2×3MHz	2×20MHz	-	2803
Vodafone	2×10MHz	2×4MHz	2×20MHz	-	3113
Unsold	-	2×15.8MHz	2×10MHz	50MHz	-

As there were significant amounts of spectrum unsold in the 1800MHz and 2.6GHz bands, we consider the Czech auction a less important evidence point.

Denmark

In Denmark the 2.6GHz band was auctioned nearly two years after the 900MHz and 1800MHz bands at a price that was nearly ten times that of the 1800MHz band.

The prices of 900MHz and 800MHz spectrum were low because the three largest incumbents were prevented from bidding. Ultimately, given that no entrants participated in the auction, Hi3G acquired the available spectrum (2x5MHz of 900MHz and 2x10MHz of 1800MHz) at the low reserve price.

Although above reserve price, the 800MHz band auction also achieved a comparatively low price. This was in large part due to two of the incumbent operators, Telenor and Telia, bidding jointly, which reduced the number of bidders in the auction from what could have been four to three.

The 2.6GHz auction was significantly more competitive given all operators were allowed to bid and did so as individual entities. This led to 2.6GHz prices that were nearly as high as 800MHz values and significantly higher than 1800MHz values.

The auction results are provided in Figure 5.11, Figure 5.12, and Figure 5.13 below.

Operator	2.6GHz FDD	2.6GHz TDD	Price paid (EUR millions)
TDC	4	-	44.8
Telenor	4	2	44.8
Telia	4	3	45.2
Hi3G	2	5	1.0

Figure 5.11: Results of the 2.6GHz Danish auction in 2×5MHz blocks [Source: Analysys Mason, Aetha, 2013]

Operator	900MHz	1800MHz	Price paid 900MHz (DKK millions)	Price paid 1800MHz (DKK millions)
TDC	-	-	-	-
Telenor	-	-	-	-
Telia	-	-	-	-
Hi3G	1	1	4.0	8.0

Figure 5.12: Results of the 900MHz and 1800MHz Danish auction in 2×5MHz blocks for 900MHz and 2×10MHz blocks for 1800MHz [Source: Analysys Mason,

Operator	800MHz	Price paid 800MHz (DKK millions)
TDC	4	627.8
Telenor and Telia	1	111.5
Hi3G	-	-

Figure 5.13: Results of the 800MHz Danish auction in 2×10MHz blocks for Telenor and Telia and 2×5MHz blocks for TDC [Source: Analysys Mason, Aetha, 2013]

Given that bidders were excluded from the 900MHz and 1800MHz auction, leading to prices being significantly below market value, we recommend that evidence from the Danish auctions is excluded from the evidence base.

France

As there has not been an 1800MHz auction in France in the relevant time period, no relevant relative value can be calculated from the available evidence. Therefore, we are of the opinion that France should be excluded from the analysis.

The auction results are provided in Figure 5.14 below.

Operator	800MHz	2.6GHz	Price paid 800MHz (EUR millions)	Price paid 2.6GHz (EUR millions)
Orange	2×10MHz	2×20MHz	891.0	287.1
SFR	2×10MHz	2×15MHz	1065.0	150.0
Bouygues	2×10MHz	2×15MHz	683.0	228.0
Iliad	-	2×20MHz		271.0

Figure 5.14: Results of the 2011 800MHz and 2.6GHz French auction [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]

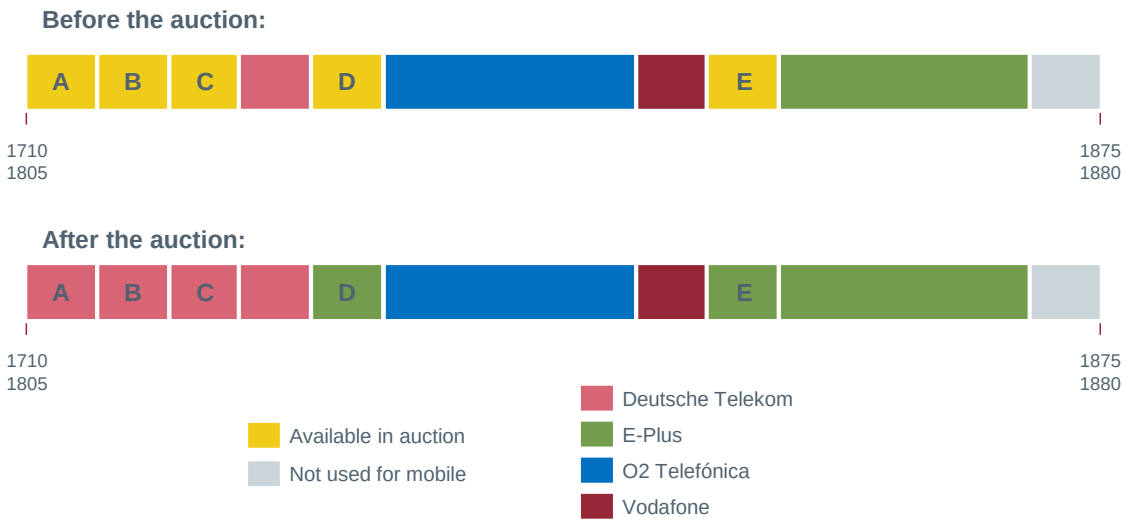
Germany

In its consultation, Ofcom categorises the German 2010 multi-band auction as less important evidence for deriving the ALF for the 1800MHz band. As discussed in Section 6 below, this appears to result in this auction having little, if any, bearing on the final choice of the 1800MHz lump-sum value.

Ofcom's rationale for this categorisation is that there was evidence of a lack of excess demand for spectrum in the 1800MHz band in this auction. According to Ofcom, this was caused by the five available 2×5MHz lots being split by existing holdings such that there were obvious contenders for the lots among the incumbent operators. Ofcom goes on to state that the German 1800MHz result, once adjusted to the UK, implies a value below the UK LRP for 2.6GHz spectrum, which it does not consider plausible.

First, we would challenge the notion that there were obvious contenders for the lots available in the 1800MHz band. Figure 5.15 below provides the band plan for the 1800MHz band both before and after the auction.

Figure 5.15: German 1800MHz band plan [Source: Analysys Mason, Aetha, 2013]



Although Ofcom is not explicit, we presume it considers the holders of the adjacent spectrum as the 'obvious contenders' for the auctioned lots. However, this is not substantiated by the auction result. Two of the five lots were 'sandwiched' by existing holdings: Lot D and Lot E. However, Lot D was eventually won by E-Plus, which was not an adjacent spectrum holder. Presumably it must have outbid the two adjacent holders (Deutsche Telekom and O2 Telefónica) for this lot. This suggests that the fragmented nature of the available spectrum did not materially impact demand.

The remaining three lots (A–C) were located at the bottom of band. These could be won as a contiguous 2×15MHz block, and indeed were by Deutsche Telekom. Although, it is possible that bidders may have reduced demand for isolated 2×5MHz lots (we note this is not substantiated by E-Plus winning Lot D), we expect that a 2×15MHz block would be sufficiently large to be of value to all bidders, not just adjacent bidders. Therefore, we see no reason why these lots would not have fetched market value.

Figure 5.16 below provides the prices raised for the individual lots in the 1800MHz band.

Figure 5.16: Prices raised for 1800MHz lots [Source: BNetzA, 2013]

Lot	Winner	Price (EUR millions)
A	Deutsche Telekom	20.7
B	Deutsche Telekom	20.7
C	Deutsche Telekom	19.9
D	E-Plus	21.6
E	E-Plus	21.5

Interestingly, the prices for Lots A–C (the contiguous lots) were all lower than both Lots D and E (isolated lots). This is further evidence that the isolation of Lots D and E did not materially impact demand for them.

Finally, we acknowledge that when translated into a UK-equivalent benchmark the German 1800MHz value is below the 2.6GHz LRP. However, as discussed in detail in Section 4, we do not believe that the use of absolute benchmarks is appropriate for setting the ALF in the UK, as they do not sufficiently take account of UK-specific factors that influence spectrum value. We do note, however, that Ofcom chooses not to estimate a relative benchmark from Germany because it considers the 1800MHz price "less important" evidence. Given our discussion above, we see no reason why this should be excluded. Even if Ofcom believes that the absolute 1800MHz result was too low to be classed as more important evidence, surely the relative value of the 800MHz, 1800MHz and 2.6GHz bands in Germany provide useful information about the relative values of these three bands in the UK.

As we disagree with Ofcom's assessment that there was a lack of excess demand in the German auction and instead consider it a useful benchmark for the relative values between bands, we in fact consider Germany to be more important evidence when considered in the context of applying the distance method.

Greece

Greece only provides absolute values for the 900MHz and 1800MHz bands. Nonetheless, it is possible to calculate an 1800MHz benchmark using the 900MHz price as a proxy for the 800MHz price and zero as a proxy for the 2.6GHz price. This approach implies a value of 44% of the distance between 2.6GHz and 800MHz. Of course, this is an upper bound. Therefore, given the use of proxies, we categorise the Greek results as less important evidence.

Finally, we note that Ofcom considers the values in the Greek auction to risk understating market value as spectrum was sold at reserve price. However, since there were no auction rules likely to constrain spectrum demand, we consider it likely that these values in fact risk overstating market value, as described in Section 5.1.3 above.

The auction results are provided in Figure 5.17 below.

Operator	900MHz	1800MHz	Price paid (EUR millions)
Cosmote	2×10MHz	2×10MHz	118.8
Vodafone	2×15MHz	2×10MHz	168.5
Wind Hellas	2×10MHz	-	93.2

Figure 5.17: Results of the 2011 900MHz and 1800MHzGreek auction [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]

Italy

We agree with Ofcom's assessment that there are no obvious reasons why market value might not have been achieved in this auction and that it therefore provides more important evidence.

However, the absolute value upon which Ofcom relies should not be used. Further, the two relative values used by Ofcom should be replaced by a single estimate based on the distance method.

Italy provides a good illustration of the flaws in Ofcom's relative value approach. Ofcom calculates relative values (UK equivalent) based on 1800MHz/800MHz of GBP9.6 million and based on 1800MHz/2.6GHz of GBP21.7 million. This difference is impossible to reconcile using Ofcom's approach, and the range so wide as to be rendered meaningless. The fact that the absolute value sits somewhere in the middle is a coincidence.

The distance method on the other hand uses all three evidence points to derive a single UK-equivalent relative value of GBP11.6 million. It is this evidence point which we believe should be classified as more important evidence.

The auction results are provided in Figure 5.18 below.

Figure 5.18: Results of the 2011 800MHz, 1800MHz, 2.1GHz, 2.1GHz TDD, 2.6GHz and 2.6GHz TDD Italian auction [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]

Operator	800MHz	1800MHz	2.1GGHz TDD	2.6GHz	2.6GHz TDD	Prices paid (EUR millions)
Telecom Italia	2×10MHz	-	-	2×15MHz	-	1300
Vodafone	2×10MHz	2×5MHz	-	2×15MHz	-	1300
Wind	2×10MHz	2×5MHz	-	2×20MHz	-	1100
3 Italia	-	2×5MHz	-	2×10MHz	30MHz	305
Unsold	-	-	15MHz	-	-	-

Portugal

We agree with Ofcom's assessment that Portugal provides less important evidence. This is because significant amounts of spectrum in the 900MHz, 1800MHz and 2.6GHz bands (amongst other bands) was left unsold.

The auction results are provided in Figure 5.19 below.

Figure 5.19: Results of the 2011 450MHz, 800MHz, 900MHz, 1800MHz, 2.1GHz TDD, 2.6GHz and 2.6GHz TDD Portuguese auction [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]

Operator	450MHz	1800MHz	900MHz	1800MHz	2.1GHz TDD	2.6GHz	2.6GHz TDD	Prices paid (EUR millions)
Vodafone	-	2x10 MHz	2x5 MHz	2x14 MHz	-	2x20 MHz	25MHz	146
TMN	-	2x10 MHz	-	2x14 MHz	-	2x20 MHz	-	113
Optimus	-	2x10 MHz	-	2x14 MHz	-	2x20 MHz	-	113
Unsold	2x1.25 MHz	-	2x5 MHz	2x15 MHz	10MHz	2x10 MHz	25MHz	-

Spain

Consistent with Ofcom's view, we believe that results of the Spanish auction should not be considered as part of the evidence base when considering relative benchmarks. This is because the three largest operators were not allowed to bid for 1800MHz spectrum. Consequently, it is unlikely that the market value was achieved for this band.

We note that a Spanish 1800MHz absolute benchmark was considered by Ofcom as less important evidence, although was ultimately ignored as it was below the UK 2.6GHz LRP. As stated above, we do not consider that absolute benchmarks are appropriate to use and would therefore suggest disregarding this evidence.

The beauty contest and auction results are in Figure 5.20, Figure 5.21 and Figure 5.22 below.

Figure 5.20: Results of the 2011 900MHz and 1800MHz Spanish beauty contest [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]

Operator	900MHz	1800MHz	Prices paid (EUR millions)
Orange	2x5MHz	-	126
Yoigo	2x5MHz	2x15MHz	42

Figure 5.21: Results of the 2011 800MHz, 900MHz, 2.6GHz and 2.6GHz TDD Spanish auction [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]

Operator	800MHz	900MHz	2.6GHz	2.6GHz TDD	Prices paid (EUR millions)
Movistar	2x10MHz	-	2x20MHz	-	668.3
Vodafone	2x10MHz	-	2x20MHz	-	517.6
Orange	2x10MHz	2x5MHz	2x20MHz	-	437.0
Regional Wholesalers	-	-	2x10MHz	-	-
Unsold	-	2x5MHz	Regional 2x10MHz	50MHz	-

Figure 5.22: Results of the 2011 900MHz and 2.6GHz TDD Spanish re-auction [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]

Operator	900MHz	2.6GHz	Prices paid (EUR millions)
Movistar	2x5MHz	-	169
Vodafone	-	20MHz	10.4
Orange	-	10MHz	5.2
Regional Wholesalers	-	10MHz	0.8
Unsold	-	10MHz	-

Sweden

In Sweden 2.6GHz prices are only available from an auction held in 2008. We note that this is outside of Ofcom's relevant time period. Nonetheless, this auction price is likely to give the best indication of 2.6GHz market value in Sweden, and in particular is likely to be more accurate than using a proxy of zero. Using this UK-equivalent value of GBP9.7 million and the UK-equivalent 800MHz price of GBP14.3 million, the distance method could potentially be applied.

However, in Sweden the 1800MHz UK-equivalent price is GBP9.1 million, which is below the 2.6GHz price. This is contrary to what we would normally expect. Given that there has been a period of three years between the two auctions, this suggests that the value of spectrum in Sweden fell in this time period. For these reasons, we categorise the resulting 1800MHz benchmark calculated from the distance method (which at GBP 1.7 million is below the UK lump-sum value for 2.6GHz) as less important evidence.

The auction results are shown in Figure 5.23 and Figure 5.24 below.

Operator	800MHz	Prices paid (SEK millions)
Teliasonera	2x10MHz	854
Tele2 and Telenor	2x10MHz	469
Hi3G	2x10MHz	431

Figure 5.23: Results of the 2011 800MHz Swedish auction [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]

Operator	1800MHz	Prices paid (SEK millions)
Teliasonera	2x25MHz	920
Tele2 and Telenor	2x10MHz	430
Hi3G	-	-

Figure 5.24: Results of the 2011 1800MHz Swedish auction [Source: Ofcom annual licence fees for 900MHz and 1800MHz spectrum consultation, 2013]

5.4 Categorisation of auctions

In the above section, we considered each country in turn and categorised them using the framework described in Section 5.2 as 'exclude', 'more important' or 'less important'.

Figure 5.25 below summarises our conclusions regarding whether each country should be included or excluded entirely from the analysis.

Figure 5.25: Result of categorisation to include/exclude countries [Source: Analysys Mason, Aetha]

Country	1800MHz not auctioned	No valuable band-specific price available	Bidders excluded from auction	No 800MHz or 900MHz benchmark	Conclusion
Austria					**Include**
Belgium	Yes				**Exclude**
Czech Republic					**Include**
Denmark			Yes		**Exclude**
France	Yes				**Exclude**
Germany					**Include**
Greece					**Include**
Ireland					**Include**
Italy					**Include**
Netherlands		Yes			**Exclude**
Norway		Yes		Yes	**Exclude**
Portugal					**Include**
Romania					**Include**
Spain			Yes		**Exclude**
Sweden					**Include**
Switzerland					**Include**

Figure 5.26 below summarises our conclusions regarding whether each included country should be categorised as more or less important.

Figure 5.26: Result of categorisation of included countries into more and less important evidence [Source: Analysys Mason, Aetha]

Country	Band-specific prices not directly inferred	Use of proxy for 800MHz and/or 2.6GHz	Unsold spectrum	Significant time gap between band auctions	Conclusion
Austria	Yes				**Less important**
Czech Republic			Yes		**Less important**
Germany					**More important**
Greece		Yes			**Less important**
Ireland	Yes	Yes			**Less important**
Italy					**More important**
Portugal			Yes		**Less important**
Romania	Yes		Yes		**Less important**
Sweden				Yes	**Less important**
Switzerland	Yes		Yes		**Less important**

6 Ofcom's conversion of benchmarks to lump-sum values

Using the analytical framework followed by Ofcom (evaluated in Section 4) and the pool of potential UK-equivalent evidence points arrived at and the level of importance assigned to the various benchmarks by Ofcom (described in Section 5), Ofcom's next step is to 'derive' lump-sum values for 1800MHz and 900MHz spectrum.

However, Ofcom does not seek to "*take a mechanistic approach*" and instead uses its "*regulatory expertise and judgement*"[47] in setting these proposed lump-sum values. In our opinion, this approach appears to bias the lump-sum values for 1800MHz upwards without any apparent justification.

In Section 6.1, we consider the implied weightings of benchmarks used by Ofcom in its non-mechanistic approach. In other words, we look at what any mechanistic approach designed to produce the same outcome would have to assume – finding that very extreme assumptions would be required.

In Section 6.2, we then go on to look at how Ofcom has treated 900MHz and 1800MHz differently in using its "*regulatory expertise and judgement*" and suggest an adjustment to the approach for 1800MHz to help improve consistency.

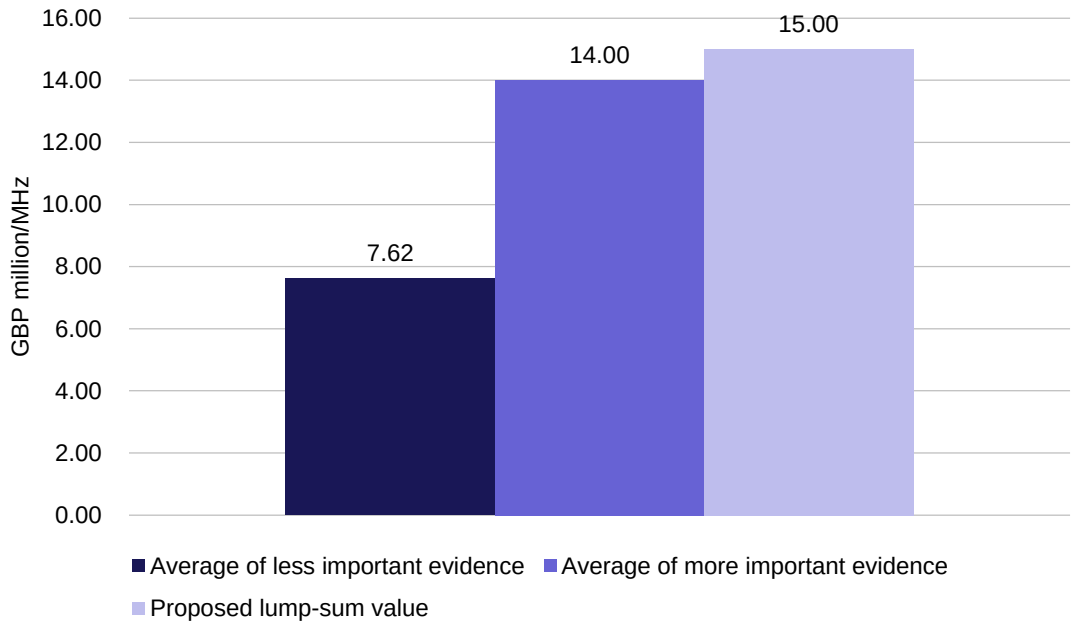
6.1 The implied weightings of benchmarks used by Ofcom

A more transparent approach would be to attach weightings to the more important and less important (and excluded) evidence points and then calculate a weighted average as the lump-sum value.

However, the lump-sum value proposed by Ofcom for the 1800MHz band is higher than the average of both the more important evidence and the less important evidence. This is shown in Figure 6.1 below. Therefore, no weighting for the more and less important evidence exists that would result in the GBP15 million per MHz proposed 1800MHz lump-sum.

[47] Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum Consultation.* Paragraph 4.51.

Figure 6.1: Ofcom's lump-sum value per MHz for the 1800MHz band (UK equivalent) relative to the averages of more important and less important evidence [Source: Ofcom, Analysys Mason, Aetha, 2013]



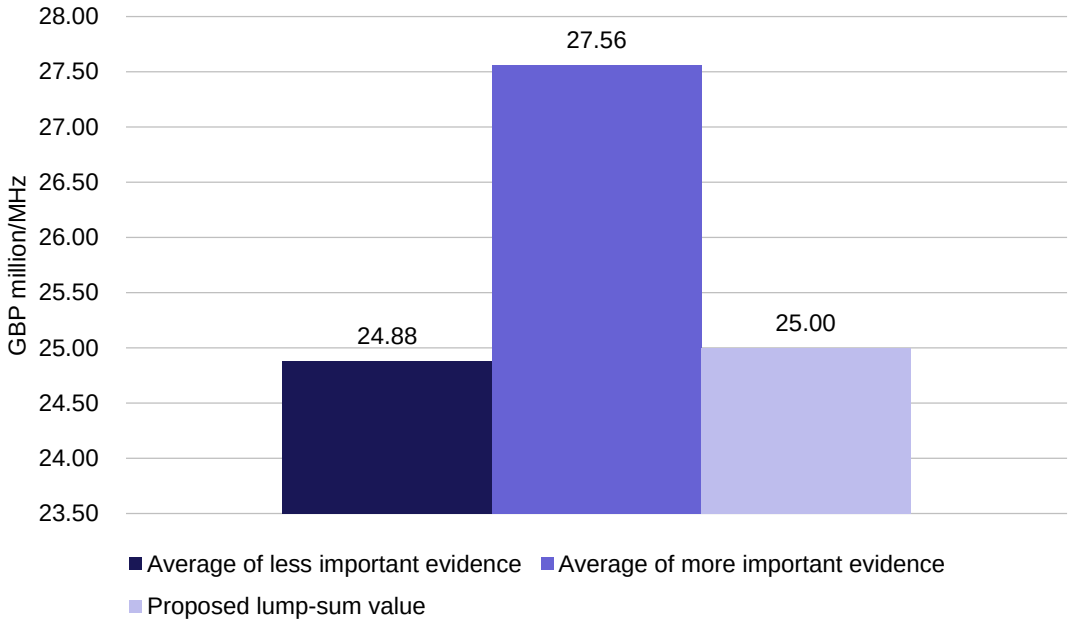
For example, if a weighting of 1 is applied to less important evidence and a weighting of 2 applied to the more important evidence, the weighted average would be GBP12.15 million per MHz. This is significantly less than the GBP15 million per MHz lump-sum value Ofcom proposes for the 1800MHz band.

Therefore, not only does one have to assume a zero weighting for the less important evidence, but in fact one has to assign higher weights to the higher value evidence points within the pool of more important evidence, to arrive at a figure of GBP15 million per MHz. Ofcom's approach lacks transparency, and it also seems to arrive at a result which requires extreme and seemingly unjustified assumptions, given the evidence points which Ofcom has collated.

6.2 Inconsistency in Ofcom's treatment of 900MHz and 1800MHz evidence

Ofcom is inconsistent in the treatment of its evidence points when determining the 1800MHz and 900MHz lump-sum values. While the proposed value for the 1800MHz band exceeds the averages of both more important and less important evidence points, as set out above, the proposed value for the 900MHz band is within these respective ranges. In fact, the proposed 900MHz value is close to the average of the less important evidence points and significantly below the average of the more important evidence points, as shown in Figure 6.2 below.

Figure 6.2: Ofcom's lump-sum value per MHz for the 900MHz band (UK equivalent) relative to the averages of more important and less important evidence [Source: Ofcom, Analysys Mason, Aetha, 2013]



If the proposed lump-sum of GBP25 million was a weighted average of the less and more important evidence, this would imply that the less important evidence has a weighting that is more than 21 times the weighting of the more important evidence. This would suggest that the less important evidence was in fact treated with *significantly* more importance than the 'more important' evidence.

Moreover, in assessing the 900MHz evidence points Ofcom applies a cap (the UK 800MHz LRP)[48] above which values are considered to be inconsistent with Ofcom's view that 900MHz is unlikely to have higher value than 800MHz. Conversely, for 1800MHz Ofcom applies a floor (the UK 2.6GHz LRP) below which values are considered to be inconsistent with Ofcom's view that 1800MHz is unlikely to have lower value than 2.6GHz.

However, values below the 1800MHz floor are automatically classified by Ofcom as less important evidence[49] but above the 900MHz cap they are not (and continue in many cases to be classified as more important evidence).[50]

In order to be consistent, Ofcom should:

- classify all values above the cap as less important evidence
- impose a cap for 1800MHz and a floor for 900MHz spectrum.

48 Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum consultation.* Paragraph 4.42.

49 Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum consultation.* Paragraph 4.45.

50 Ofcom (2013), *Annual licence fees for 900 MHz and 1800 MHz spectrum consultation.* Paragraph 4.57 d)

This would help to provide a more consistent approach to determining the 900MHz and 1800MHz lump-sum values. In the next section, we go on to consider the level at which such a cap for 1800MHz should be set. Any evidence points exceeding this cap should then be classified as less important evidence.

6.2.1 Upper bound for the 1800MHz lump-sum value

We consider one of the weaknesses of Ofcom's approach to be that it generates a large number of high and low outliers that subsequently need to be excluded using caps. The levels at which these caps are set adds a degree of arbitrariness to Ofcom's methodology. The distance method on the other hand does not require such caps to be set as it does not produce such extreme outliers. This is because, it is highly likely to result in values that are within the bounds of the UK 800MHz and 2.6GHz LRPs.

Nonetheless, should Ofcom persist in applying its absolute- and relative-value approaches instead of adopting the distance method, we suggest that a cap for the evidence for the 1800MHz lump-sum value could be set at the linear interpolation of values between 800MHz and 2.6GHz (i.e. GBP16 million per MHz).

The academic paper referenced in Section 4.3.2, suggests that the relationship between the frequency of spectrum and the price is inverse exponential; and as previously mentioned, we agree with this as a principle. As such, we would normally expect a linear interpolation between the 800MHz and 2.6GHz prices to represent an upper bound for the 1800MHz market value, as no inverse exponential relationship could return values higher than this. The simple average of 800MHz and 2.6GHz that is used by Ofcom as evidence sits above the upper bound described here, at GBP17 million per MHz, compared to GBP16 million per MHz calculated using linear interpolation.

We note that the cap set by Ofcom with regard to the 900MHz band, i.e. that the market value of 900MHz should be less than the UK 800MHz value, is exceeded in three of the auctions it has considered as more important evidence, namely Romania, Ireland and Greece. However, only one auction exceeds our proposed linear-interpolation-based cap for the 1800MHz market value, namely Austria, which suggests it is more applicable in that it eliminates fewer outliers.

7 Lump-sum value resulting from our recommendations

In this section we use the distance method described in Section 4.4 to determine a single 1800MHz benchmark from each country for which the required information is available. We use the UK-equivalent benchmarks provided by Ofcom in Figure 4.2 of the consultation document, as well as additional information for Austria, the Czech Republic and Norway[51] (where auctions have taken place subsequent to the publication of Ofcom's consultation) and Switzerland (for which Ofcom did not provide UK-equivalent value estimates).

For Austria, 800MHz, 900MHz and 1800MHz band-specific prices have been deduced using the methodology described in Section 5.3.1. For Switzerland, we use the reserve prices specified by the regulator as indicative of relative values between bands. Further detail on, and justification for, this approach is provided in the same section. In the Czech Republic an SMRA was used, which means that band-specific prices are readily available, as discussed in Section 5.3.2.

The distance-method benchmarks that result from each country are shown in Figure 7.1 below.

*Figure 7.1: Ofcom's UK-equivalent benchmarks and the resulting 1800MHz benchmark using the distance method [Source: Ofcom, Analysys Mason, Aetha: *UK equivalent benchmarks calculated by Analysys Mason and Aetha using Ofcom's methodology, 2013 ** Reserve prices]*

Country	Ofcom's UK equivalent benchmarks (GBP millions/MHz)				Distance method (GBP millions/MHz)
	800MHz	900MHz	1800MHz	2.6GHz	1800MHz
Austria	63.4*	58.0*	38.1*	1.8	**19.6**
Belgium				4.5	**not applicable**
Czech Republic	42.7*		5.6*	2.8*	**6.7**
Denmark	10.1	2.4	1.0	9.5	**not applicable**
France	34.3			5.2	**not applicable**
Germany	50.1		1.8	1.5	**5.1**
Greece		31.4	13.9		**16.0**[52]
Ireland	58.6	35.7	23.1		**14.8**
Italy	48.3		15.5	3.5	**11.6**
Netherlands	n/a	n/a	n/a	n/a	**not applicable**
Norway	n/a	n/a	n/a	n/a	**not applicable**
Portugal	36.1	24.1	3.1	2.4	**5.5**
Romania	21.8	24.9	6.2	2.5	**9.7**
Spain	31.4	25.4	2.9	3.1	**not applicable**

51 However, as the Norwegian auction results do not allow the determination of reliable band specific prices, Norway does not provide a distance method result.

52 No 800MHz and 2.6GHz values available, so we assume that the 800MHz is equal to 900MHz in value and the 2.6GHz has a value of zero to generate the distance method value. This value should be considered as an upper bound.

Sweden	14.3		9.1	9.7	**1.7**[53]
Switzerland	9.5**	Unknown	3.4**	3.4**	**5.0**

In the sub-sections below, we carry out three calculations for the lump-sum value of 1800MHz spectrum in the UK using the distance method benchmarks calculated above. In these calculations we apply three different sets of weightings to the evidence points:

- equal weighting on all evidence points (Section 7.1)
- weightings implied by Ofcom's analysis[54] (Section 7.2)
- weightings derived from our analysis of each European auction in Section 5. (Section 7.3).

We then go on to consider how sensitive the distance method is to these different weightings more generally in Section 7.4.

7.1 Distance method using equal weighting of evidence points

When applying equal weighting to all available distance method benchmarks we have only excluded those countries for which it was not possible to calculate a benchmark using the distance method. Figure 7.2 below summarises the weightings and provides country-specific comments. The simple average of the remaining benchmarks for the UK 1800MHz lump-sum is GBP9.6 million per MHz.

Figure 7.2: Distance method using equal weighting of evidence points [Source: Analysys Mason, Aetha, 2013]

Country	Distance method 1800MHz benchmarks (GBPm/MHz)	Weighting	Comments
Austria	19.6	1	800MHz, 900MHz and 1800MHz auction concluded after publication of Ofcom's consultation document. Given CCA format, band-specific prices cannot be directly inferred. However, we use the final clock round prices to infer band-specific prices
Belgium	not applicable	0	No 800MHz and 1800MHz values available
Czech Republic	6.7	1	Recent benchmark with band-specific prices as the auction format was SMRA. However, some unsold spectrum in 1800MHz and 2.6GHz bands suggests reserve prices may have exceeded market value in these bands.
Denmark	not applicable	0	900MHz and 1800MHz values not representative of market value, as three largest operators excluded

[53] The 2.6GHz price in Sweden was a UK equivalent of GBP9.7 million whilst the 1800MHz price was a UK equivalent value of GBP9.1 million. This combination results in a distance method value for Sweden which is below the UK 2.6GHz LRP.

[54] We note that in some cases judgement has been required because Ofcom has classified different relative evidence points from the same country as both more and less important.

			from bidding
France	not applicable	0	No 1800MHz value available
Germany	5.1	1	Reliable evidence
Greece	16.0	1	No 800MHz and 2.6GHz value available, so that we assume the 800MHz is equal to 900MHz in value and the 2.6GHz has a value of zero to generate the distance-method value
Ireland	14.8	1	Given CCA format, band-specific prices cannot be directly inferred. However, we use the final clock-round prices to infer band-specific prices for 800MHz and 1800MHz. 2.6GHz has not been awarded, so we assume value is zero
Italy	11.6	1	Reliable evidence
Netherlands	not applicable	0	No band-specific values available due to auction format
Norway	not applicable	0	This was a first-price auction, which incentivised bid shading, so that market value cannot be inferred from prices
Portugal	5.5	1	Reliable evidence
Romania	9.7	1	Reliable evidence
Spain	not applicable	0	We agree with Ofcom that Spain does not provide an insightful 1800MHz value, as the three largest operators were not allowed to bid in the auction
Sweden	1.7	1	2.6GHz is greater than 1800MHz value, which results in the distance-method calculation returning a number below the UK 2.6GHz LRP
Switzerland	5.0	1	Given CCA format, band-specific prices cannot be directly inferred. However, evidence suggests that the 800MHz, 1800MHz and 2.6GHz bands went for near reserve price. We therefore base our distance method estimate on reserve prices
Weighted average	**9.6**		

7.2 Distance method using weightings implied by Ofcom's analysis

Instead of using the same weighting on all of the applicable distance-method benchmarks, in this section we illustrate the value that would result if Ofcom's more important and less important classifications were given an explicit weighting. We assign more important evidence twice the weighting of less important evidence. However, we also consider weightings with a 3:1 and 10:1 ratio of more to less important evidence.

An exact application of Ofcom's classifications to the distance-method values is not possible, as Ofcom assigns different levels of importance to the absolute and relative values for 900MHz and 1800MHz values in the same country. However, in practice there is only one country for which different levels of importance are given to different evidence points. This is Romania, where the relative value of 1800MHz/2.6GHz is classified as less important evidence, while all other

evidence points are classified as more important evidence. Although not explicitly stated by Ofcom, this is probably because a significant amount of 2.6GHz went unsold in Romania. As the distance method relies on the 2.6GHz value we have assumed Ofcom's classification for Romania to be less important. The weightings for the remaining countries are shown in Figure 7.3 below.

Figure 7.3: Distance method using weightings implied by Ofcom's analysis [Source: Analysys Mason, Aetha, 2013]

Country	Distance method 1800MHz benchmarks (GBPm/MHz)	Weighting applied between more and less important evidence		
		2:1	3:1	10:1
Austria	19.6	0	0	0
Belgium	not available	0	0	0
Czech Republic	6.7	0	0	0
Denmark	not available	0	0	0
France	not available	0	0	0
Germany	5.1	1	1	1
Greece	16.0	2	3	10
Ireland	14.8	2	3	10
Italy	11.6	2	3	10
Netherlands	not available	0	0	0
Norway	not available	0	0	0
Portugal	5.5	1	1	1
Romania	9.7	1	1	1
Spain	not available	0	0	0
Sweden	1.7	2	3	10
Switzerland	5.0	0	0	0
Weighted average		**9.9**	**10.2**	**10.7**

The resulting weighted average given a 2:1 weighting is GBP9.9 million per MHz. Placing more weight on the more important evidence produce values that are slightly higher than this.

7.3 Distance method using weightings suggested by our analysis

As described in our country-by-country review in Sections 5.2 and 5.3.2, there are instances where we disagree with Ofcom's classification of evidence points. Therefore, below we show the weightings derived from our assessment. They are summarised in Figure 7.4 along with a summary of the reasons for our classification.

Figure 7.4: Distance method using weightings suggested by our own analysis [Source: Analysys Mason, Aetha, 2013]

Country	Distance method 1800MHz lump-sum (GBP millions/ MHz)	Weighting			Comments
		2:1	3:1	10:1	
Austria	19.6	1	1	1	Given CCA format, no band-specific prices can be directly inferred. We use the final clock round prices to infer band-specific prices. Therefore, we consider this evidence as less important.
Belgium	not applicable	0	0	0	No 800MHz and 1800MHz values available
Czech Republic	6.7	1	1	1	Recent benchmark with band-specific prices as the auction format was SMRA. However some unsold spectrum in 1800MHz and 2.6GHz bands suggests reserve prices may have exceeded market value in these bands.
Denmark	not applicable	0	0	0	900MHz &1800MHz values not representative of market value as three largest operators excluded from bidding
France	not applicable	0	0	0	No 1800MHz value available, so that we assume the 800MHz is equal to 900MHz in value and the 2.6GHz has a value of zero to generate the distance method value
Germany	5.1	2	3	10	As described in Section 5.3.2, we consider that the German auction was competitive and consider it to be more important evidence
Greece	16.0	1	1	1	No 800MHz and 2.6GHz value available
Ireland	14.8	1	1	1	Assumes 2.6GHz UK-equivalent value is zero. Therefore, we consider this evidence as less important.
Italy	11.6	2	3	10	We agree with Ofcom that this is more important evidence
Netherlands	not applicable	0	0	0	No values available
Norway	not applicable	0	0	0	In this case the band-specific market value cannot be reliably inferred from the prices paid, owing to the auction format
Portugal	5.5	1	1	1	We agree with Ofcom that this is less important evidence because there were spectrum caps (which may lead to lower than market value) and most spectrum sold at reserve (which could mean market value was exceeded)
Romania	9.7	1	1	1	Given that there was unsold lots in both the 800MHz and 2.6GHz band, a

					distance method calculated benchmarks for the 1800MHz band may be somewhat under- or overstated. Therefore, we consider this evidence as less important.
Spain	not applicable	0	0	0	We agree with Ofcom that Spain does not provide an insightful 1800MHz value, as the three largest operators were not allowed to bid in the auction
Sweden	1.7	1	1	1	2.6GHz is greater than 1800MHz value which results in the distance method calculation returning a number below the UK 2.6GHz LRP.
Switzerland	5.0	1	1	1	Given CCA format band-specific prices cannot be directly inferred we have used reserve prices for each band. Therefore, we consider this evidence as less important.
Weighted average		**9.4**	**9.2**	**8.8**	

Using our 2:1 weightings, the calculation result in a lump-sum of GBP9.4 million per MHz.

7.4 Significance of weightings applied to evidence points when using the distance method

The importance of the weightings chosen is reduced when using the distance method compared to Ofcom's approach. Irrespective of which weightings are selected, the weighted average is bounded by the average of the more important evidence points and the average of the less important evidence points. Figure 7.5 below shows that the range suggested by these limits is significantly reduced from GBP6.4 million per MHz to GBP4.2 million per MHz when moving from Ofcom's method to the distance method. Consequently, greater certainty can be attached to the distance method results. Furthermore, applying our classification of more and less important evidence, the range is reduced further to GBP1.5 million per MHz.

Figure 7.5: Importance of weightings using different approaches [Source: Analysys Mason, 2013]

	Average of more important evidence (GBP million/MHz)	Average of less important evidence (GBP million/MHz)	Range (GBP millions/MHz)
Ofcom's method with Ofcom's classification	14.0	7.6	6.4
Distance method with Ofcom's classification	11.0	6.8	4.2
Distance method with Analysys Mason/Aetha's classification	8.4	9.9	1.5

We have also conducted a sensitivity analysis on our suggested lump-sum value of GBP9.4 million per MHz (based on the distance method with Analysys Mason/Aetha's classification) to

illustrate the effect of excluding the highest or lowest benchmark values from our weighted average. This analysis is shown in Figure 7.6 below and results in a range of GBP7.7 million per MHz to GBP10.6 million per MHz with the two highest or the two lowest values excluded from the weighted average calculation.

Figure 7.6: Sensitivity analysis on our suggested value when excluding highest and lowest values [Source: Analysys Mason, 2013]

Sensitivity	Weighted average using distance method and Analysys Mason/Aetha weighting (GBP millions/MHz)
As in Figure 7.4 but excluding the two highest values (Austria and Greece)	7.7
As in Figure 7.4 but excluding the highest value (Austria)	8.4
As in Figure 7.4	9.4
As in Figure 7.4 but excluding the lowest value (Sweden)	9.8
As in Figure 7.4 but excluding the two lowest values (Sweden and Switzerland)	10.6

These sensitivities show that although a range of results can still be produced, depending on the exact weightings, classifications and benchmarks, the distance method produces a reliable and consistent set of results. These results are consistently well below the GBP15 million per MHz lump-sum value proposed by Ofcom.

8 Conclusions

There are several important flaws in Ofcom's proposed approach for determining the UK 1800MHz lump-sum value, both in the conceptual framework applied and in the gathering and application of available evidence to inform the UK-equivalent benchmark values.

In our view, Ofcom's conceptual framework is flawed because it bases its analysis on three categories of evidence points, none of which provide an accurate picture of the value of 1800MHz spectrum in the UK market.

- The *absolute*-value benchmarks used by Ofcom are not applicable to the UK market, as they fail to capture various country-specific factors that influence the absolute value of spectrum.
- The *relative*-value benchmarks used by Ofcom produce multiple evidence points per country, that fail to provide a consensus view of where between the 800MHz and the 2.6GHz band values the 1800MHz value should lie.
- The *simple average* of 800MHz and 2.6GHz LRPs used by Ofcom is arbitrary – especially as all available evidence suggests the 1800MHz lump-sum value should be significantly below this simple average.

A more robust alternative approach is available that provides a single, more insightful, evidence point per country by considering where in the range between the 2.6GHz value and the 800MHz value the 1800MHz value should lie. This approach places greater emphasis on the evidence which, according to the Government's Direction, Ofcom should have particular regard for: namely the 800MHz and 2.6GHz LRPs. As it focuses on relativities between the 800MHz, 1800MHz and 2.6GHz band values, this approach is less susceptible to the uncertainties introduced to each band's absolute value through conversion to UK-equivalent values. We have referred to this approach as the 'distance method'.

Notwithstanding the fact that we disagree with the conceptual framework that Ofcom has applied, if Ofcom were to persist in using it, there are significant errors that affect the absolute and relative benchmarks that should be fixed. These include the following:

1. In converting the available benchmark data to UK-equivalent values, there are inevitably several significant errors which are introduced, including through the choice of exchange rate, WACC, inflation rate, how to scale auction benchmarks for licences of a different duration to the UK and how to scale benchmarks to reflect differences in wealth/purchasing power between the UK and the benchmark country. This is exacerbated by the use of absolute auction values which are inherently uncertain. This supports our strong view that absolute benchmarks are not applicable to the UK market and should not form a part of Ofcom's analysis.

2. Ofcom comes to some curious conclusions in the way it classifies different auctions as more or less important evidence. Moreover, it completely omits potentially important information, such as benchmarks from the German auction. We have, on a country-by-country basis, suggested a more appropriate assessment of the available evidence points, including some which Ofcom ignored and reclassifying others as more or less important evidence based on a carefully considered analysis of the situation surrounding each benchmark.

3. In determining the UK 900MHz and 1800MHz lump-sum values Ofcom follows a non-transparent and inconsistent approach based on its judgement. This produces a proposed lump-sum for the 1800MHz band that is above all relevant benchmark values where band-specific prices can be directly inferred. This is partly a symptom of the flawed framework that Ofcom has chosen to apply. However, even within Ofcom's chosen framework, there appears to be an inconsistent treatment between the 900MHz and 1800MHz bands. In particular, the proposed 1800MHz lump-sum value cannot be obtained with any mechanistic weighting of the more and less important evidence points, as it is above even the (higher-value) more important evidence point average. Consequently, it appears that Ofcom gives no weight to most of the available evidence in the 1800MHz band, including all of the less important evidence. In contrast, to reach the 900MHz lump-sum value, one must assume the less important evidence receives a weighting of more than 21 times as high as the more important evidence, which appears contradictory.

Applying the more robust and transparent distance method, in combination with weightings that are based on our assessment of the importance of each available benchmark, we calculate that the lump-sum value for 1800MHz should be GBP9.4 million per MHz.

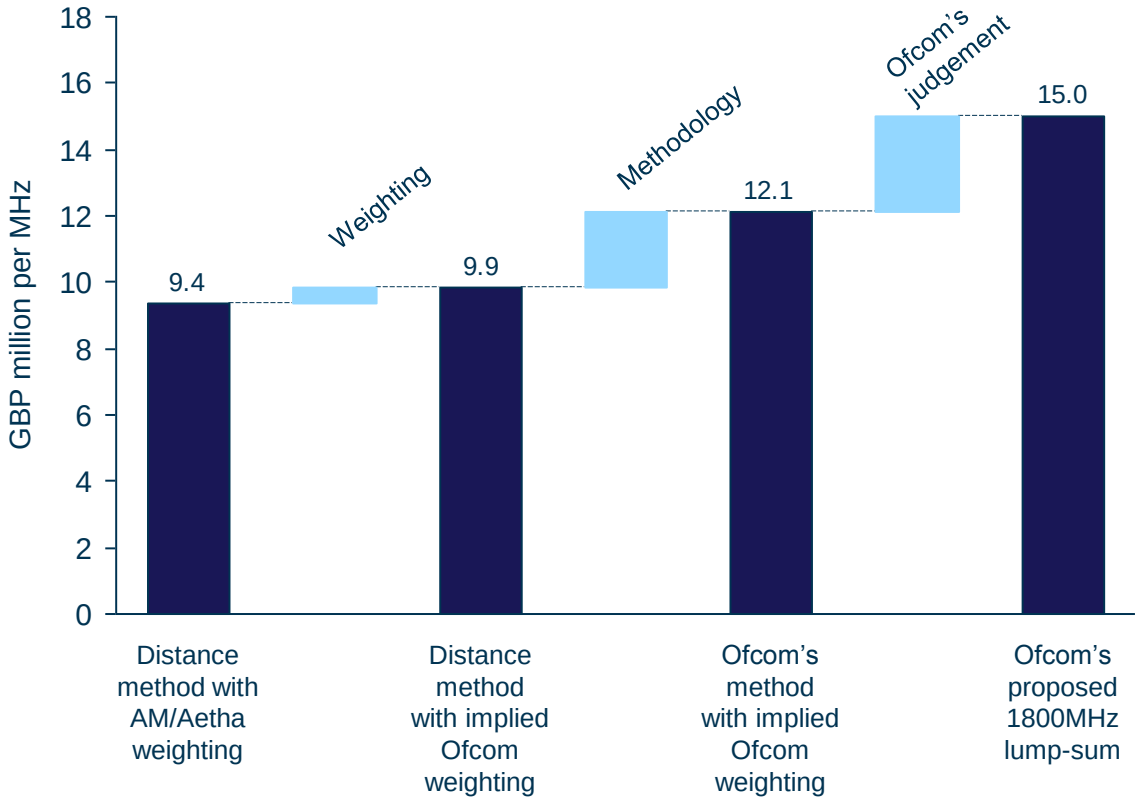
In Figure 8.1, we reconcile the difference between our proposed lump-sum value and Ofcom's proposed lump-sum value for 1800MHz. The distance method used with Analysys Mason and Aetha's weightings of benchmarks results in a lump-sum of GBP9.4 million per MHz, while the same method with Ofcom's implied weightings of more important and less important evidence results in a lump-sum of GBP9.9 million per MHz. Therefore a small difference can be explained by our adapted weightings.

Although Ofcom uses a non-mechanistic approach, we have attempted to disaggregate the remaining difference between the GBP9.9 million per MHz and Ofcom's proposed GBP15 million per MHz lump-sum into two parts. One of these shows what part of the difference can be explained through the use of different methodologies and the other shows how much of the difference must therefore be due to Ofcom's judgement.

We have interpreted the most likely mechanistic approach implied by Ofcom's categorisation into more and less important evidence to be a weighted average between more and less important evidence. In applying it we assume more important evidence to have a weighting twice as high as less important evidence. This is how the figure shown as 'Ofcom's implied method' in Figure 8.1 was calculated. It results in a lump-sum of GBP12.1 million per MHz, higher than both distance method calculations. While this illustrates a significant change due to the different methodology

used, there is still a large difference compared to the GBP15 million per MHz proposed by Ofcom, which cannot be arrived at by any mechanistic approach. The remaining GBP2.9 million per MHz difference results from Ofcom's judgement. As described throughout this report, Analysys Mason and Aetha do not consider there to be any evidence to suggest such an upward adjustment is reasonable to reflect the value of 1800MHz in the UK.

Figure 8.1: Summary of lump sum calculations and Ofcom's suggested value[55] *[Source: Ofcom, Aetha, Analysys Mason, 2013]*



In Section 3 we looked at Ofcom's conclusions at a high level. These immediately raised three important questions. Having analysed Ofcom's approach in detail, and proposed a more robust approach, we can now seek to answer these questions.

55 In determining the value for "Ofcom's method with implied Ofcom weighting" we have taken the arithmetic mean of the absolute and relative benchmarks Ofcom presents in Figure 4.5 of the consultation document. However, as explained above in footnote 21, the geometric mean should be used when averaging ratios. Consequently, an averaging methodology which takes the geometric mean of the relative ratios and then averages the resulting value with the absolute values using an appropriately weighted arithmetic mean is likely to be more robust. However, for simplicity in this example we have used an arithmetic mean across all data points. We note that since the geometric mean is always lower than (or equal to) the arithmetic mean, its use would result in a lower value, suggesting that more of the difference between the "Distance method with implied Ofcom weighting" and "Ofcom's proposed 1800MHz lump-sum" would be attributable to Ofcom's judgement.

1. **Is it reasonable for Ofcom to assume an 1800MHz lump-sum value that is above DotEcon/Aetha's benchmark range, when just 11 months ago the 800MHz/2.6GHz auction produced values at the middle/bottom of DotEcon/Aetha's benchmark ranges for those bands?**

   There are two relevant auctions where band-specific prices can be reliably inferred that have concluded in the 11 months since Ofcom's 800MHz/2.6GHz auction. These were held in Austria and the Czech Republic. Both of them concluded after the publication of Ofcom's consultation document and therefore could not have been taken into account by Ofcom in determining its lump-sum values. Nonetheless, these auction results now provide relevant evidence in answering our first question. Applying the distance method to these benchmarks results in a value of GBP19.6 million per MHz for Austria and GBP6.7 million per MHz for the Czech Republic. The average of these benchmarks is GBP13.2 million per MHz, which is significantly below the GBP15 million per MHz lump-sum value suggested by Ofcom. On a price per MHz per population basis this average figure is GBP0.210. While this is towards the upper end of the range of GBP0.146–0.219 per MHz per population provided by DotEcon/Aetha, it does not support exceeding the range. Furthermore, even if these evidence points had been available to Ofcom prior to publication of its consultation, we do not consider the use of only two benchmarks sufficiently robust to inform a change in conclusion. Even when considering absolute value benchmarks, which we do not agree with, whilst Austria's result is significantly above the DotEcon/Aetha range at GBP0.313 per MHz per population, the Czech Republic's result is significantly below it at GBP0.107 per MHz per population. Consequently, we do not consider it reasonable for Ofcom to select an 1800MHz lump-sum value that exceeds the DotEcon/Aetha range.

2. **Is it reasonable for Ofcom's approach to produce an 1800MHz lump-sum value that is higher than any prices raised in other European auctions where band-specific prices can be directly inferred? Clearly, historical auction prices should be adjusted to reflect the UK situation, but does Ofcom's approach have an inherent bias?**

   We have analysed Ofcom's misalignment with European prices. This misalignment, in large part, derives from the way Ofcom interprets the available evidence points. In using a non-mechanistic approach based on judgement, Ofcom's *selection* of an 1800MHz lump-sum is a value that is higher than both the average of its more important evidence points and the average of its less important evidence points. In contrast, we have set out a transparent and more robust *calculation* of the 1800MHz lump-sum value, that without an inherent bias results in a value of GBP9.4 million. This value reflects the fact that we do not consider there to be any UK-specific factors that affect the value of the 1800MHz band to the extent suggested by Ofcom and, therefore, there is nothing that would justify a value which exceeds all absolute benchmarks from which band-specific prices can be inferred. Furthermore, the evidence from the multiband package bid auctions should not be considered sufficient to justify a price above the auctions where a price can be directly inferred. Therefore, it appears unfounded for Ofcom's proposed value to do so.

3. **Is it reasonable for the proposed 1800MHz lump-sum value to be close to the straight-average of the 800MHz and 2.6GHz LRPs?**
   Given the available evidence base and the fact that the Direction highlights the importance of the UK 4G auction, we believe the right question to ask is where in the range between the 2.6GHz LRP and the 800MHz LRP should the 1800MHz lump-sum value lie? Ofcom's choice of a simple average of the 800MHz and 2.6GHz LRPs as a more important evidence point is completely arbitrary. We have provided a variety of sources that suggest the market value of 1800MHz is typically much closer to the value of 2.6GHz band than the value of the 800MHz band. Academic research indicates an inverse exponential interpolation is a more reasonable assessment of relative values. This is corroborated by the distance method result of GBP9.4 million, based on all available evidence. Consequently, we do not see any reason why a simple average would be informative in establishing where between the value of the 2.6GHz band and the value of the 800MHz band the 1800MHz value should lie.

In summary, the evidence presented in this report suggests Ofcom's proposed 1800MHz lump-sum value (GBP15 million per MHz) is too high. Therefore we recommend the use of the distance method in interpreting the available benchmark data. Based on our assessment of what is more and less important evidence, this approach results in a value of GBP9.4 million per MHz for the lump-sum value of the 1800MHz band in the UK.

Annex B Economic Insight report: Note on Ofcom's proposed ALF tax adjustment.

A note on Ofcom's proposed ALF tax adjustment

This note sets out our review and analysis of Ofcom's proposed tax adjustment to the Annual Licence Fee (ALF) for 900 MHz and 1800 MHz spectrum. We believe that Ofcom has not considered the differences in financing arrangements under the ALF and lump sum approaches and that, once this is incorporated, a small downwards tax adjustment should be made to the ALF.

Overview and context

In October 2013 Ofcom issued a consultation regarding its approach for deriving the Annual Licence Fee (ALF) with respect to radio spectrum in the 900 MHz and 1800 MHz bands. This was in response to the Government Direction, issued in December 2010, which specifically requires Ofcom to ensure that these rates reflect "full market value" (and where Ofcom was specifically required to have regard to the sums paid at the 4G Auction).

In order to set the ALF, Ofcom first had to estimate the 'lump sum' market value for spectrum and then convert this into an ALF amount. In converting the lump sum into annual amounts, Ofcom has sought to ensure that the present value of the stream of ALF payments is equal to the market value of the lump sum. The underlying economics principle of 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. This principle is well established in the academic economics and finance literature, where Miller and Upton (1976)[1] provide a comprehensive description of the relevant issues. These are further

[1] *'Leasing, buying, and the cost of capital services.' Miller and Upton, Journal of Finance 31, 761-786 (1976).*

considered by Schall (1974)[2] and Smith and Wakeman (1985).[3] As set out further subsequently, we believe that a key issue in ensuring value equivalence is to recognise that under both an ALF and lump sum approach, spectrum is an asset for which the financing costs must be borne by the MNOs (licensees). The only difference is that under the ALF approach, financing is provided by Government, whereas under a lump sum approach, the MNO (licensee) would need to raise *external finance.*

From a practical perspective, in order to convert the estimated 'lump sum' market value for spectrum into an ALF, Ofcom has had to consider: (i) what the appropriate cost of capital should be; (ii) whether it should be set in real or nominal terms; and (iii) whether it should be set on a pre or post-tax basis. Regarding this, in the Consultation Ofcom is proposing to:

- Set the cost of capital based on that used for the current charge controls for mobile call termination (MCT) – updated to reflect changes to corporation tax since those MCT controls were made.
- To set the cost of capital on a real, post-tax basis, reflecting Ofcom's view that bidders at the 4G Auction are likely to have formed their valuations based on expected returns *after tax.*

"A post-tax approach to determining the ALF is appropriate, as this reflects the fact that firms ultimately need to pay a share of their profits in taxation (in addition to remunerating debt and equity holders)."

We believe that a post-tax approach to determining the ALF is appropriate, as this reflects the fact that firms ultimately need to pay a share of their profits in taxation (in addition to remunerating debt and equity holders). However, were one to adopt a post-tax approach, a complication *may* arise in that differing tax treatments of 'lump sum' assets and annual licence payments could mean that the present value of the ALF (post-tax) would not be equal to the market value of the lump sum (unless one were to explicitly adjust for those differing tax treatments).

In light of these issues, under the First Competition Assessment[4] Ofcom's proposed approach was to apply a *pre-tax WACC.* Here, Ofcom's stated reasoning was that under a post-tax approach, the need to explicitly take account of differing tax treatments made the assessment more complex. However, in the Consultation Ofcom's position is now that because (as stated above) the bidders most certainly valued 4G spectrum from a post-tax perspective, like any other future investment project, it would therefore be correct to similarly adopt a post-tax WACC for setting the ALF; and to address the complication by quantifying the required tax adjustment to achieve value equivalence.

"Our underlying rationale for proposing the use of a real pre-tax cost of capital [in the First Competition Assessment] was that, when the likely tax advantage of annual licence fees compared to a lump sum payment was taken into account, using a real pre-tax cost of capital (and ignoring the different tax treatments) gave a similar result to using the real post-tax cost of capital. As this rationale ultimately depended on a calculation using the real post-tax rate, we now consider that it would be more transparent to do the calculation on a post-tax basis, and to make explicit our assumptions on the more favourable tax treatment of annual licence fees compared to a lump sum payment."[5]

We consider that Ofcom's revised approach, which is to be explicit and transparent regarding the assumptions it is making relating to tax treatments, is appropriate. In particular - and as noted above - it properly reflects the fact that a proportion of firm profits will be paid to tax authorities in addition to being distributed to debt and equity investors.

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[2] *'The lease-or-buy and asset acquisition decision.' Schall, Journal of Finance 29, 1203-1214 (1974).*

[3] *'Determinants of corporate leasing policy.' Smith, and Wakeman, Journal of Finance 40, 895-908 (1985).*

[4] *Which Ofcom refers to in relation to: 'Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues.' Ofcom (22 March 2011).*

[5] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Consultation.' Ofcom (2013). Para 5.51.*

In the above context, Ofcom has sought to quantify what it considers to be the appropriate upwards tax value adjustment to the ALF. Relatedly, Hutchison Three UK Ltd (Three) asked Economic Insight to examine and review Ofcom's proposed adjustment, and to set out our views as to its appropriateness and robustness from an economics perspective. A separate note, also prepared on behalf of Three, sets out our thoughts specifically in relation to the appropriate approach to determining the WACC for the purpose of setting the ALF.

Ofcom's proposed tax adjustment

As noted above, Ofcom believes that (on a post-tax basis) the NPV of the 'lump sum' and the ALF would not be equivalent. In particular, it believes that ALFs would receive a more favourable tax treatment than a lump sum. Consequently, in order to achieve equivalence in value terms on a post-tax basis, Ofcom argues that the value of the ALF should be adjusted upwards. In the following, we briefly summarise:

- the basis on which Ofcom believes the tax treatment would be more favourable under an annual fee amount; and
- Ofcom's methodology for calculating the adjustment.

Ofcom's rationale for the adjustment

Ofcom's view is that, were the spectrum purchased on a 'lump sum' basis, it would be treated as an intangible asset, recorded on a company's balance sheet; and then amortised on a straight line basis over the period of the licence.[6] Ofcom specifically references the 2002 IFA regime and International Accounting Standards 38 to support this view. Ofcom further states that, were this to be the accounting approach applied, then the impact of the spectrum on a firm's profit and loss account is that the firm's taxable profit would be reduced by the amortisation amount in each year.

In contrast, Ofcom believes that under an ALF approach, the cost of the annual fee would be treated as a revenue expense, and so would appear as a cost in the firm's profit and loss account in each year. Thus, under this approach, the firm's taxable profits would be reduced by an amount exactly equal to the licence fee in each year. Ofcom notes that such an accounting approach is allowable so long as the activity to which the licence relates *"is wholly and exclusively for the purposes of the trade [in question]."*

Ofcom then sets out two factors that explain why, under these two approaches, the NPV of the annual fee would differ from the value of the lump sum value of spectrum on a post-tax basis:

» ***Time value of money.*** Consistent with Ofcom's description of the differing accounting treatments set out above, the regulator notes that the tax impact under the lump sum approach is that taxable profit is lower by the amortisation amount in any given year. Given that this would most likely be on a straight line basis over the 20 year notional licence period, the amortisation charge that would appear in the profit and loss account would be 1/20th of the value of the lump sum. However, by definition, this approach does not reflect the opportunity cost of taxable profit, which by contrast, Ofcom explicitly takes in account in calculating the ALF. The result, according to Ofcom, is that the ALF is greater than the amortisation amount, and thus the reduction in taxable profit is greater under the annual fee than under a lump sum approach.

» ***Inflation.*** Ofcom states that, under the lump sum approach, the amortisation charge in the profit and loss account would be in nominal terms, and would not reflect general inflation. Therefore, in real terms, the value of the amortisation charge would decline over time. Consequently, in real terms, the total value of the amortisation charges would be less than the lump sum value. In comparison, Ofcom's calculation of the annual fee is explicitly set in real terms, and so reflects general inflation.

[6] *Where here straight line refers to dividing the asset value by the number of years over which the assets is expected to be used (Ofcom assumes a 20 notional licence period) so that the amortisation charge in the same in each year.*

Ofcom's methodology for calculating the adjustment

Given the above, Ofcom states that - in using a post-tax WACC to determine the value of the ALF - an explicit adjustment is required in order to ensure that the present value of the post-tax ALF is equivalent to the value of the lump sum. Specifically, Ofcom is of the view that an upwards adjustment of 11% should be applied to the ALF in order to achieve value equivalence. Ofcom's approach to calculating this adjustment is as follows:

- Ofcom has determined the adjustment by developing a spreadsheet model, which calculates the present value of the impact on taxable profits under the two approaches.[7]

- The key assumptions and calculation steps within the spreadsheet model are:
  - Ofcom assumes that under the lump sum approach, the spectrum is fully treated as an intangible asset – and so the taxable profit impact is the associated amortisation charge, based on 1/20th of the lump sum value in each year.
  - Ofcom assumes that under the annual fee approach, the spectrum is fully treated as a revenue expense, and so the taxable profit impact is the associated annual fee amount.
  - Ofcom has used the latest forecasts for the main rate of corporation tax – specifically 23% for 2013/14; 21% for 2014/15 and 20% for 2015/16 (and constant from then on).
  - Ofcom has assumed an inflation rate of 2.5% (defined in RPI terms), and the lump sum is spread over 20 years.
  - Ofcom further assumes that the value in question relates to the 20 year period post auction, and thus the calculation of the NPV is for the period 2013/14 to 2032/33.

- Given the above assumptions, Ofcom's spreadsheet model then 'solves for' the upwards adjustment to the ALF required for the present value of the tax impact to be equal under the 'lump sum' and ALF approach.

Our view of the key economics issues

If one accepts Ofcom's characterisation of the differing accounting treatments relating to the ALF and the 'lump sum,' then we agree that the 'in principle' need for an ALF tax adjustment exists. That is to say, absent such an adjustment (and subject to the assumption that the 'lump sum' would be fully treated as an intangible asset and amortised, whereas the ALF would be treated as a revenue expense through the profit and loss account) it is clearly the case that the NPV of the ALF would not necessarily be equal to the value of the lump sum post-tax. Consequently, the principle of value equivalence between asset ownership and leasing would not be met.

However, we consider that Ofcom's characterisation of the accounting treatments may not be complete. In particular, we think that Ofcom may not have fully considered: (i) the fact that under both the ALF and lump sum approaches, spectrum is an economic asset that must be financed; (ii) that critically, the sources of this finance would differ under the two approaches – with Government implicitly financing the ALF, whereas the lump sum would require the MNO to raise external finance (most likely debt, as discussed subsequently); and (iii) that as a consequence of not considering the differences in financing source, Ofcom has failed to factor in the possible debt tax shield that would arise under a lump sum approach.

An additional consideration is whether Ofcom's presumption regarding the differing accounting treatments of the ALF and lump sum approaches would necessarily reflect what firms might do in the real world in all instances. For example, with regard to finance leases (which under IFRS are defined as leases that *"transfer substantially all the risks and rewards incidental to ownership of an asset."*[8]) firms are required to capitalise the value of such leases and report them on their balance sheets, as though they were a fixed asset. In our view, the characteristics of the licences for 900 MHz and 1800 MHz spectrum could be considered to meet a number of the criteria used for defining finance leases. For example, whilst Ofcom has modelled a notional 20 year licence, in

[7] *See alf.xls Excel File, 'Calculation of annual licence fees for 900 MHz and 1800 MHz.' Ofcom (2013).*

[8] *'International Accounting Standard 17: Leases.' IFRS (2012).*

"Under both the ALF and lump sum approaches, spectrum is an asset that must be financed, one way or another."

practice the licences are of an indefinite term, which could be interpreted as conferring the rights and risks of ownership.[9] Furthermore, the joint FASB / IASB project to standardise the future accounting of leases proposes that operating leases should also be capitalised. Clearly, were firms to choose (or be required) to capitalise the ALF, then the accounting treatment could be equivalent to that of a lump sum approach. This is because in both instances there might typically be a financing/interest charge and a depreciation/amortisation charge reported in the P&L. However, differences in financing, as discussed above, would nonetheless remain and would need to be considered.

The above implies that, in practice, MNOs may have some flexibility as to whether they choose to record any ALFs as a revenue expense, or capitalise the value of those payments. Relatedly, firms may have a range of considerations that they take into account when determining what accounting approach they should adopt. Given this, it could be that Ofcom's characterisation of there being a clear distinction between the accounting treatments of the ALF relative to the lump sum is, to a degree, questionable. The annex to this note contains further details regarding the accounting treatment of leases.

In summary, we consider the key economics issues to be as follows:

- ***Under both the ALF and lump sum approaches, spectrum is an asset that must be financed.*** In an economics sense we consider that – regardless of whether the spectrum value is considered in terms of an annual payment or a lump sum amount – ultimately it should be regarded as an asset to the MNOs (the licensees) which must be financed.

- ***That critically, the key economics difference between the two approaches is that the sources of finance differ between the two.*** Implicitly, under the ALF approach, Government is providing financing as the opportunity cost of capital is itself embedded within the ALF as calculated by Ofcom (i.e. Ofcom is using a notional MNO WACC to convert the lump sum into an ALF). However, under a lump sum approach MNOs would typically need to raise external finance (which, on the basis of equivalence, would most likely be debt) in order to fund the purchase of the spectrum. The impact of these differences in financing source do not appear to have been considered within Ofcom's methodology.

- ***Once differing financing sources are recognised, one must factor in the potential tax shield that would arise under the lump sum approach.*** Once one considers that under a lump sum approach an MNO would need (or may choose) to raise external finance to fund the spectrum purchase, the tax implications of this finance must be included in any comparison of post-tax profits under the ALF and lump sum approaches. In particular, to the extent that corporate debt would be used to finance the lump sum, this would attract a tax shield with respect to the corresponding interest payments. In turn, this would lower taxable profit, reducing cash taxes paid by the firm, thus increasing the firms' total cash flows. Clearly, under an ALF approach in which corporate debt is not raised, this tax shield effect would not arise. Consequently, all else equal, including the impact of the debt tax shield under the lump sum approach would result in a *downwards* adjustment to the ALF to ensure equivalence between the ALF and lump sum approach. Having reviewed Ofcom's Consultation and corresponding ALF spreadsheet, we note that no offsetting tax shield effect has been incorporated within its calculation. We believe that this is an omission from Ofcom's analysis, and so the adjustment calculation should be amended accordingly.

In the following we expand further on the above issues.

[9] *This is not to say that the ALF could be classified as a finance lease per se, rather than it might be considered as being analogous to one.*

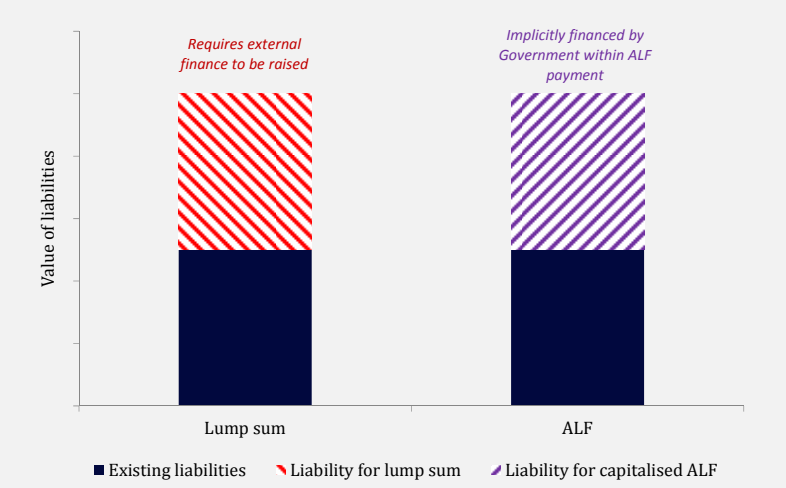
The need to explicitly recognise differences in financing sources

In considering the appropriateness – and level – of any potential tax adjustment, we consider it helpful to start from economics theory and first principles. These suggest that (putting tax treatments to one side initially) from the perspective of an MNO (licensee) the 900 MHz and 1800 MHz spectrum would be considered as an economic asset that needs to be financed, with a corresponding liability. Economically, this is true regardless of whether the MNO pays for the spectrum up front in the form of a lump sum payment, or in an annual stream of stream of payments under an ALF approach. In particular, and as illustrated in the diagram below:

- Under a lump sum approach, the spectrum represents a fixed intangible asset that would be reported on the firm's balance sheet, with a matching liability. Here the licensee would most likely need to raise external finance in order to support the purchase of the spectrum.

- Under an ALF approach, operators may have the option as to whether to capitalise and amortise the spectrum licence, like a lump-sum fee, or treat the ALF payment as a recurring revenue expense. In any event, either way, economically the capitalised value of the payments must necessarily be regarded as an asset with a matching liability. Here, however, the financing costs are implicitly embedded within the payments themselves – and so conceptually (and effectively), Government is financing the spectrum asset.

Figure 1: Illustrating the difference in financing sources



Source: Economic Insight

Why differing financing sources matter

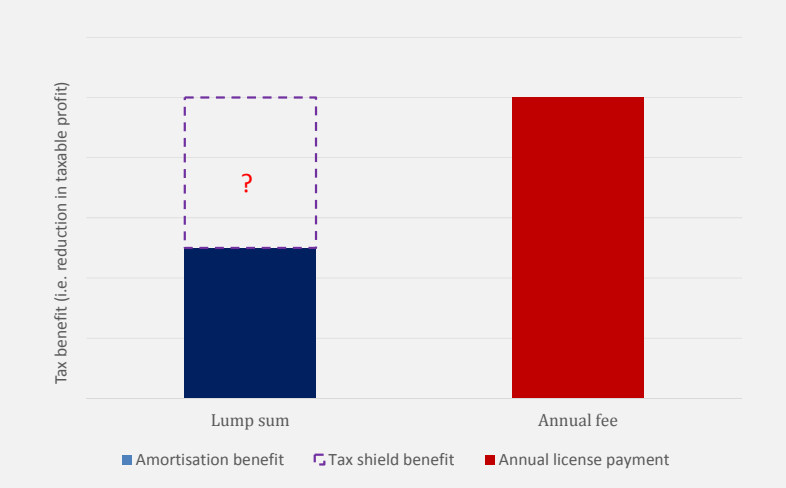
The fact that the present value of the ALF should be equivalent to the lump sum is, of course, non-contentious. Indeed, this is exactly the motivation for Ofcom's concern in the present case: namely that, due to differences in tax treatments, the present value of the ALF may be *lower* than the lump sum post-tax, so necessitating the need for an upward tax adjustment factor being applied to the ALF. This is also consistent with historical and future planned accounting guidelines and principles regarding the treatment of leases. In particular, under UK GAAP and IFRS standards finance leases must be capitalised and recorded on firm balance sheets. In other words, the accounting treatment of leases increasingly recognises the fact that, in many instances, they are an asset in an economic sense.

Of critical importance to the issues under consideration here is that the precise *form* of external finance used will itself in part determine taxable profits and cash flows under the lump sum approach. Consequently, in order to achieve equivalence between the lump sum and the ALF, one must accurately calculate taxable profit to the MNO (licensee) under the two approaches, taking financing sources and costs into account.

In particular, to the extent that under a lump sum approach, the spectrum would be financed through incremental corporate debt, then this would normally attract a tax shield on the corresponding interest payments. This, in turn, would lower taxable profit under the lump sum approach and so would act to offset the difference between the annual licence payments (under an ALF approach) and the amortisation charge (under a lump sum approach). Our review of Ofcom's Consultation and its corresponding ALF spreadsheet suggests that: (i) Ofcom has not apparently given consideration to the potential for the licensee to raise external debt finance to fund the spectrum under the lump sum approach; and so (ii) has not included the benefit the potential debt tax shield, which would accrue under this approach.

The below figure illustrates the difference between our proposed approach (which explicitly takes account of financing sources) and that used by Ofcom. In particular, Ofcom calculates the tax adjustment factor of 11% as being the difference between the reduction in taxable profit due to annual licence payments (the solid red bar below under the annual fee approach) and the amortisation charge that would arise under the lump sum approach (the solid blue bar). The key question, therefore, is what the difference in taxable profit would be under the two approaches once differing financing sources – and their respective tax shield effects – are taken into account, as shown by the dotted purple line.

Figure 2: Illustrating tax benefit under the lump sum and annual fee approach.



Source: Economic Insight

What the appropriate external financing source would be

For reasons set out above, in order to fully evaluate the difference in taxable profits to an MNO (licensee) under the ALF and lump sum approaches, it is essential to consider the *form* of external finance that would be used to fund the purchase of spectrum under a lump sum approach. This is because, to the extent that incremental corporate debt is raised, this could attract a tax shield that needs to be included in any comparative analysis of taxable profit under the two approaches. We think that there are three key considerations in this regard:

- the commercial incentives for raising debt finance;
- the ability of MNOs (licensees) to raise debt finance; and
- the likely cost of any corporate debt that would be raised.

Incentives for raising debt finance

Regarding the commercial incentives for raising incremental corporate debt to finance the lump sum, economic theory provides a range of relevant considerations. The natural starting point

would be Modigliani-Miller (1958)[10], who found that firm value is independent of capital structure absent the presence of taxation, bankruptcy costs, agency costs and information asymmetries. In practice, of course, factors such as taxation do apply, meaning that theories of optimal capital structures have been developed. Of particular relevance to the issues under consideration here is 'pecking order theory,' as proposed by Myers and Maijlu (1984),[11] which states that, due to adverse selection, firms firstly look to retained earnings, then to debt, and then only turn to equity finance in the absence of being able to make use of those sources. The most commonly expressed description of the adverse selection motivation for a pecking order is as follows: *"the key idea is that the owner-manager of the firm knows the true value of the firm's assets and growth opportunities. Outside investors can only guess these values. If the manager offers to sell equity, then the outside investor must ask why the manager is willing to do so. In many cases the manager of an overvalued firm will be happy to sell equity, while the manager of an undervalued firm will not."* Frank and Goyal (2005).[12]

Relating pecking order theory to the operation of mobile networks specifically, we note the following:

- Firstly, that in practice UK MNOs would rarely have sufficient cash to consider the financing of *significant* spectrum acquisition out of reserves, and so would always be reliant on external financing. In practice, this might usually take the form of an intra-group loan or equity but, conceptually, when considering financing from the perspective of a hypothetical *UK* MNO, the financing source is 'external' (evidence regarding corporate debt raising by MNOs is set out subsequently).

- The adverse selection problem that determines why debt may be preferred to equity could be more acute in industries where the external perspective is that internal management may have a particularly strong advantage in understanding the value of assets – which in complex and fast moving industries such as mobile telecoms, may be a consideration.

In addition to the above, wider reasons for generally favouring debt over equity finance – such as taxation– are also applicable to MNOs.

Ability to raise corporate debt

When considering the ability of MNO's to raise corporate debt to fund spectrum acquisition, a key issue is that the opportunity cost embedded with the ALF *could* (in a conceptual sense) be regarded as akin to paying the interest on corporate debt, had the spectrum been purchased as a lump sum. Relatedly, under the ALF approach the opportunity cost is inseparable from the overall payment, and so could be regarded as a 'senior' form of debt (i.e. the MNO has no option to forgo the repayment). The implication of this is that, if existing MNO debt holders believe that the firm would be financeable (and that their debt would not be unduly subordinated) in the event of the MNO having to pay an implicit financing cost under the ALF, then by definition they would also be accepting of the spectrum being entirely debt financed under a lump sum approach.

Notwithstanding the above, one must also address the practical considerations regarding the ability of MNOs (the licensees) to raise such finance. To examine this, in the first instance we calculated:

- the actual gearing levels of the UK MNO parent companies; and
- what the gearing would be if the parent companies 100% debt financed the UK 900 MHz and 1800 MHz spectrum (i.e. it does not show the impact on gearing of capitalising any non-UK spectrum).

The results of this are shown in the following figure.

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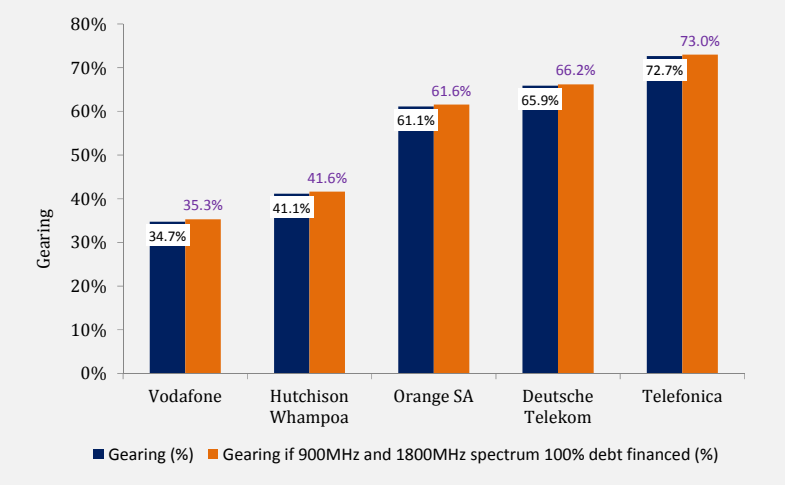
[10] 'The Cost of Capital, Corporation Finance and the Theory of Investment.' *American Economic Review 48 (3): 261–297, Modigliani, F.; Miller, M. (1958).*

[11] *'Corporate financing and investment decisions when firms have information investors do not have.' Journal of Financial Economics, 13, 187-221. Myers, S.C., and N.S. Majluf, (1984).*

[12] *'Trade off and Pecking Order Theories of Debt.' Centre for Corporate Governance Working Paper, Frank and Goyal (2005).*

Figure 3 MNO parent company gearing analysis



Source: Economic Insight analysis of Thomson Reuters and Ofcom data

Importantly, when considering the incentive and ability of MNOs to raise debt finance, it is appropriate to focus on the ultimate parent company as this is – in most instances – the entity against which external corporate debt finance would be raised. Here the key finding of our analysis is that, when assessed at a parent company level, the hypothetical impact of 100% debt financing the 900 MHz and 1800 MHz spectrum acquisitions in the UK would be immaterial to existing gearing levels. Consequently we would suggest that this implies:

- that the debt financing of the spectrum would have no impact on the credit ratings of the parent entities; and
- that the extent of debt required to finance the 900 MHz and 1800 MHz spectrum is so small relative to the overall size of corporate debt raised by the entities, that access to debt finance for this purpose would be straightforward.

Relating to the first of the above points, it is worth noting that – particularly in the current climate – low real interest rates mean that the parent companies are likely to have some headroom on key financial ratios relating to their leverage levels. To illustrate this we compared Vodafone Group's debt/EBITDA ratio (a key metric used by Moody's in its Telecommunications sector ratings) for 2012 against Moody's guidance – and then subsequently re-calculated the ratio assuming that 100% of the 900 MHz and 1800 MHz spectrum were debt financed. The results are shown in the table below.

Table 1: Debt / EBITDA ratio indicators for Vodafone Group PLC

	Vodafone actual 2012 ratio	Vodafone ratio adjusted to include 100% debt finance spectrum	Moody's guidance for Baa rating[13]
Debt/EBITDA	2.4	2.5	2.0x – 2.75x

Source: Economic Insight analysis of Thomson Reuters and Moody's data

The above shows that, based on 2012 data, Vodafone had some headroom against Moody's indicated range for a Baa rating specifically in relation to its debt / EBITDA ratio.[14] It further shows that the impact of 100% debt financing the spectrum would not result in any change to Moody's rating assessment with regard to this ratio.

[13] *See Moody's rating methodology: 'Global Telecommunications Industry.' Factor 5: Financial Strength table.*

[14] *In practice ratings agencies take a wide range of ratios and metrics into consideration when determining their overall corporate rating. Here we are specifically referring to Moody's guidance that with respect to the debt/EBITDA ratio for telecommunications firms, a ratio of 2.0-2.75 is consistent with a Baa rating.*

"There have been many examples in recent years of telecoms firms using deb t finance explicitly to support spectrum acquisition."

Consistent with both economic theory and the literature, there have been many examples in recent years of telecoms firms using debt finance explicitly to support spectrum acquisition. For example, in May this year Australia Telstra paid $1.3 (Aus) billion for 4G spectrum, which was entirely debt financed.[15] Similarly, in the US, T-Mobile plans to raise $2bn in order to purchase spectrum from a private party.[16] Telekom Austria very recently confirmed that it has paid €1.03 billion for 14 frequency blocks of 4G spectrum and confirmed that it would finance this out of a mixture of existing cash and new debt issuances.[17] More generally, access to debt finance currently appears to be good for large global MNOs – and corporate Groups have been able to raise billions of dollars' worth of debt in 2013. For example, on the 19th of February Vodafone Group issued a senior note worth $700m, and on April 2nd Orange issued a senior note worth $1.0bn.

Taking the above evidence into consideration, our view is that it is appropriate to assume that under a lump sum approach the spectrum would be externally financed through corporate debt; and that, furthermore, this spectrum would be 100% debt financed.

The appropriate cost of debt

For reasons of internal consistency, we consider that the appropriate start point for the cost of debt should be that assumed in the overall cost of capital used to convert the lump sum into the ALF in the first instance (expressed in real terms). In our analysis of the tax adjustment factor, we have initially assumed a real (pre-tax) cost of debt of 3.0%, as per Ofcom's MCT determination.[18] We have separately provided Three with a paper setting out our views regarding the appropriate cost of capital for setting the ALF. In our WACC paper we suggest that an appropriate real (pre-tax) cost of debt is 2.9%. We have also, therefore, calculated the implied tax adjustment using our assumed cost of debt.

The actual tax position of the UK MNOs

We are aware that, in practice, a number of the UK MNOs have made accumulated losses before tax in recent years. For example, both Vodafone UK and Everything Everywhere made losses in 2012 and 2011. Similarly, whilst Hutchison Three UK reported positive taxable profits in 2012, in 2011 and prior years it made tax losses. However, we consider this fact to be irrelevant to the setting of the appropriate ALF tax adjustment, as the associated WACC for the spectrum value conceptually relates to a hypothetically efficient, profit making, notionally geared, firm.

Our analysis of the appropriate ALF tax adjustment

In order to apply the methodology described above, we have developed our own version of Ofcom's ALF spreadsheet. Our analysis is consistent with Ofcom's in most respects, in that, in order to aid the comparability of our results with those of Ofcom, we firstly assume the following:

- all analysis is on a real post-tax basis;
- our assumed corporation tax rates are 23% in 2013/14, 21% in 2014/15 and 20% thereafter;
- our assumed post-tax real WACC is 4.2%;
- our assumed cost of debt is 3.0% (real); and
- our assumed inflation rate is 2.5%.

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[15] *Sydney Morning Herald 'Carriers pay $2 billion for spectrum.' 7th May 2013.*

[16] *http://www.ifre.com/us-hy-bonds-t-mobile-launches-us$2bn-bond-for-spectrum-buy/21120425.article*

[17] *Reported by Reuters 'UPDATE 1-Austria raises 2.01 bln euros in 4G telecoms auction.' October 21st 2013.*

[18] *The pre-tax real cost of debt is appropriate for determining the tax shield effect as we are seeking to address the benefit with respect to the impact on profits before tax.*

In relation to the above, it should be noted that these assumptions do not imply that we agree with Ofcom's assessment of the appropriate WACC for determining the ALF – and our views on this are set out in a separate note. We have also therefore calculated the implied tax adjustment that would arise under our assumed WACC parameters. Namely, a 2.9% pre-tax real cost of debt; a 3.8% post-tax real WACC; and an inflation rate of 2.4%.

The key difference between our approach and that applied by Ofcom is that we have explicitly included the benefit of the tax shield under the lump sum approach on the basis that the spectrum would be financed through external corporate debt. As per the discussion set out previously, we consider it reasonable to assume that the spectrum could be 100% debt financed, given the modest impact this would have on overall gearing and the clear commercial benefits that arise from such an approach.

Another key issue is the precise amortisation (and relatedly, debt) profile of the spectrum asset assumed under the lump sum approach. Here Ofcom assumes a straight line amortisation over 20 years, on the following basis:

"Under International Accounting Standards 38:

- *Intangibles are amortised based on the expected pattern of benefits. Where this is not readily identifiable, they are amortised on a straight line basis.*
- *Assets must be impaired where there is evidence to support impairment.*

Based on the accounting rules, we consider it reasonable to assume that the intangible asset to which the lump sum payment arose would be amortised on a straight line basis over the period of the licence. In this situation, the tax deduction in the calculation of profits chargeable to corporation tax would be equal to the amortisation in the accounts."[19]

We have reviewed the notes to the statutory accounts of the UK MNOs and find that current practice is generally to amortise spectrum on a straight line basis over its estimated useful economic life.[20] This, then, is consistent with the assumption that Ofcom has made.

Therefore, we have recalculated the ALF tax adjustment factor to include the debt tax shield effect assuming a straight line amortisation profile. In particular:

- The amortisation profile is based on equal annual payments in each year, where the payment is calculated as the lump sum value divided by the notional licence length assumed by Ofcom (20 years). This is deflated in each year by our assumed inflation index (described previously).

- The debt repayment profile also assumes a constant total nominal repayment amount (i.e. the sum of the principal and the interest payments is equal in nominal terms in each year, but the proportion of the payment that is principal and interest varies), where the debt is repaid at the end of the 20 year notional licence period. Interest payments on the debt are also deflated in each year by the inflation index.

Assuming that the incremental investment is 100% financed through corporate debt (which we consider to be appropriate) the ALF tax adjustment factor would be between -0.9% and -1.3% depending on whether Ofcom's, or our own, proposed WACC parameters are used. This compares to a tax adjustment factor of 11% as estimated by Ofcom, as shown in the following chart.

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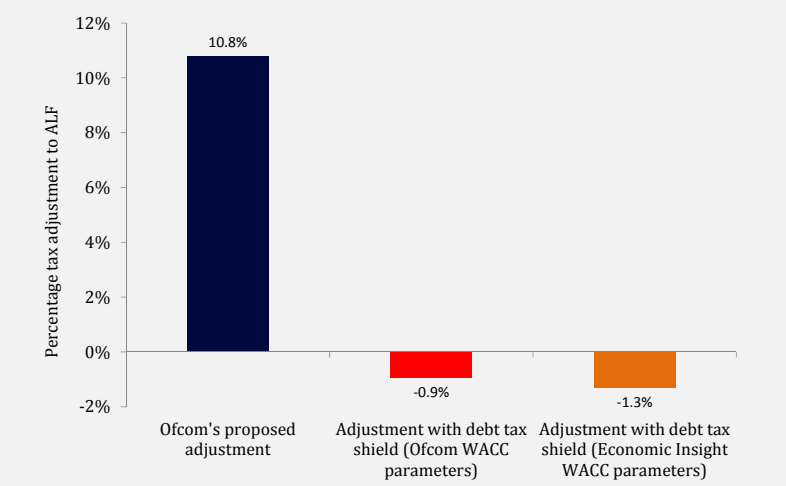
[19] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Consultation.' Ofcom (2013). Para 5.58.*

[20] *In particular, Note 1G to Three's 2012 accounts states that capitalised licenses were amortised on a straight line (although with respect to UMTS this has been treated as an indefinitely lived asset since 2011). Note 1 to O2's accounts states: ""UMTS licenses are depreciated or amortised on a straight line basis over their estimate useful lives." Note 1 to EE's accounts states: "value of the spectrum [is]… amortised through the consolidated income statement on a straight-line basis." Finally, Note 1 of Vodafone's accounts indicates that spectrum is: "amortised on a straight line basis over its estimated useful economic life."*

Figure 4 Implied ALF tax adjustment factors



Source: Economic Insight analysis

In relation to the above, the reason why the adjustment is not zero is because, under the lump sum approach, the reduction in taxable profit is (in part) a function of the amortisation amount as recorded in the P&L. This amortisation payment is independent of any assumed cost of capital, and so does not vary in any sense with the relative mix of debt and equity assumed under the lump sum.[21] Therefore, the above analysis indicates that there is a marginal tax benefit to a lump sum approach and, consequently, there should be a *downwards* tax adjustment applied to the ALF to ensure value equivalence.

Conclusions and recommendations

In summary our view is that the appropriate starting point for a consideration of the tax issue is that – regardless of whether it is paid for annually or as a lump sum – spectrum should be considered as an asset, for which MNOs (the licensees) must bear financing costs. Once one starts from this position, it is necessary to consider the differing sources of finance for the liability under the ALF and lump sum approach. In particular, under an ALF approach, financing is implicitly provided by Government, as the opportunity cost is itself embedded within the annual payment made by the MNOs. The corollary of this is that, under a lump sum approach, the MNOs (licensees) would need to raise *external finance* in order to fund the acquisition and would bear the cost of that external finance.

In our view, Ofcom's methodology does not recognise the difference in financing arrangements. This matters because differences in financing can impact the post-tax profits and cash flows of the licensee under the ALF and lump sum approaches, and so must be reflected in any tax adjustment calculation. In particular, under the lump sum approach, we suggest that the licensee would raise external corporate debt to fund the spectrum purchase, reflecting the economic advantages associated with this (such as the tax shield described below, but also the ability to avoid the adverse selection problems associated with equity finance under pecking order theory). The fact that existing debt holders would implicitly allow MNOs to bear financing costs under the ALF approach implies that those same debt holders could equally allow for 100% of the incremental spectrum to be debt financed under a lump sum approach. This view is supported by our analysis of the relevant MNO Group parent companies, which suggests that 100% debt financing of the incremental spectrum would be immaterial to overall leverage and financeability, and so is an appropriate assumption. Any incremental debt raised would attract a tax shield on the corresponding interest payments, which should be included within any comparison of post-tax

[21] *Whereas in contrast, both (i) the tax shied on the interest payments under the lump sum approach; and (ii) the size of the ALF payments under the ALF approach (which also determine the reduction in taxable profits under these approaches) are directly linked to the assumed cost of capital.*

profits and cash flows between the lump sum and ALF approaches. Once the debt tax shield effect is included, we find that the appropriate ALF tax adjustment is between -0.9% and -1.3%.

Annex A: accounting treatment of leases

As set out in the main body of this note, we consider that the appropriate start point for the tax adjustment issue is to recognise that, from an economics perspective, the spectrum should be regarded as an asset (with a corresponding liability) regardless of whether it is paid for annually, or via a lump sun.

Relating to the above, we note that relevant accounting guidelines and principles recognise the need to account for finance leases as though they were fixed assets. Furthermore, the joint FASB / IASB project to standardise the future accounting of leases proposes that operating leases should also be capitalised. In the remainder of this annex we summarise the key points of relevance.

Finance leases

UK GAAP defines a finance lease in the following terms (paragraph 15, SSAP 21):

"*A finance lease is a lease that transfers substantially all the risks and rewards of ownership of an asset to the lessee. It should be presumed that such a transfer of risks and rewards occurs if at the inception of the lease the present value of the minimum lease payments including any initial payment, amounts to substantially all (normally 90% or more) of the fair value of the leased asset.*"

UK GAAP states that where the above conditions are met, then only in "exceptional circumstances" would the payments not be regarded as a finance lease.[22]

Under IFRS accounting standards, finance leases are defined as follows:

"A finance lease is a lease that transfers substantially all the risks and rewards incidental to ownership of an asset. Title may or may not eventually be transferred."

The IFRS standard further sets out a list of criteria that are relevant to the definition:

"Whether a lease is a finance lease or an operating lease depends on the substance of the transaction rather than the form of the contract. Examples of situations that individually or in combination would normally lead to a lease being classified as a finance lease are:

a) *the lease transfers ownership of the asset to the lessee by the end of the lease term;*
b) *the lessee has the option to purchase the asset at a price that is expected to be sufficiently lower than the fair value at the date the option becomes exercisable for it to be reasonably certain, at the inception of the lease, that the option will be exercised;*
c) *the lease term is for the major part of the economic life of the asset even if title is not transferred;*
d) *at the inception of the lease the present value of the minimum lease payments amounts to at least substantially all of the fair value of the leased asset; and*
e) *the leased assets are of such a specialised nature that only the lessee can use them without major modifications."*[23]

We have further reviewed the notes to the statutory accounts of the UK MNOs and can confirm that the definition and treatment of finance leases applied in practice by the firms is consistent with the overarching accounting principles and standards set out above.[24]

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[22] *'BLM11200 – Lease accounting: lease classification: defining finance leases under UK GAAP.' HMRC (2012).*

[23] *'International Accounting Standard 17: Leases.' IFRS (2012).*

[24] *For example, Note 1(i) to Hutchison Three's 2012 statutory accounts states: "Where the Company has substantially all the risks and rewards of an asset subject to a lease, that lease is treated as a finance lease with the equivalent cost recorded as both a fixed asset and a liability." Similarly, Note 1 to Vodafone's (UK) statutory accounts reads: "Assets acquired under finance leases, which transfer substantially all the rights and obligations of ownership, are accounted for as though purchased outright." The remaining two MNOs also define and treat finance leases in a manner consistent with this.*

Accounting treatment of finance leases

Accounting standards and guidelines also set out how finance leases should be accounted for. Under IFRS the following principles are applied:

"At the commencement of the lease term, lessees shall recognise finance leases as assets and liabilities in their statements of financial position at amounts equal to the fair value of the leased property or, if lower, the present value of the minimum lease payments, each determined at the inception of the lease. The discount rate to be used in calculating the present value of the minimum lease payments is the interest rate implicit in the lease, if this is practicable to determine; if not, the lessee's incremental borrowing rate shall be used. Any initial direct costs of the lessee are added to the amount recognised as an asset.

…A finance lease gives rise to depreciation expense for depreciable assets as well as finance expense for each accounting period. The depreciation policy for depreciable leased assets shall be consistent with that for depreciable assets that are owned."[25]

Whether the ALFs would be regarded as finance leases

In our view, the characteristics of the licences for 900 MHz and 1800 MHz spectrum could be considered to meet a number of the criteria used for defining finance leases. In particular, whilst Ofcom has modelled a notional 20 year licence, in practice the licences are of an indefinite term, which we suggest means that they confer the rights and risks of ownership. Relatedly, whilst there is a revocation clause, the fact that it has been extended to 5 years is again consistent with the licensee to all intents and purposes baring the risks of ownership. This could, for example, be considered as analogous to a mortgage finance provider having the right to reclaim the asset in the event of default.

FASB IASB Joint Project

The IASB and IASB are jointly taking forward a project to standardise the accounting treatment of leases. Currently, a key recommendation of that project is:

"The lessee should recognise lease assets and liabilities for all leases, except those shorter than 12 months. Lease assets and liabilities are initially measured at the present value of the minimum lease payments, and subsequently measured on an amortised cost basis."[26]

The key implication of this is that, going forward, the distinction between finance and operating leases will no longer exist and, in the main, all leases will be treated as though they are an asset, which is consistent with the approach we have set out here.

[25] *'IFRS Technical Summary: IAS 17 Leases.' IFRS (2012).*

[26] *'Analysis of effects of proposals for lease accounting.' IFRS (2012).*

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Annex C Economic Insight report: Note on Ofcom's proposed WACC parameters.

A note on Ofcom's proposed WACC parameters for setting the ALF

This note sets out a range of evidence and analysis relating to determining the appropriate WACC parameters to use in setting the ALF (and relatedly, the appropriate inflation measure). Our view is that, rather than apply historical WACC parameters as used in the MCT decision, it would be more appropriate for Ofcom to use WACC parameters that reflect the latest available evidence. This would tend to suggest a somewhat lower WACC (and risk free rate) than currently proposed by Ofcom.

Introduction and context

Ofcom has published a consultation concerning its approach for determining the annual license fee (ALF) with respect to radio spectrum in the 900 MHz and 1800 MHz bands. This follows the December 2010 Government Direction, which specifically requires Ofcom to ensure that these rates reflect "full market value." This direction further requires Ofcom to have specific regard to the sums paid at the 4G Auction.

Setting the ALF requires Ofcom to first determine the 'lump sum' market value for spectrum and then convert this into an annual amount. In deriving the annual amount from the 'lump sum' valuation, Ofcom has ensured that the present value of the ALF payments (over 20 years) is equal to the market value of the lump sum.

From a practical perspective, in order to convert the estimated 'lump sum' market value for spectrum into an ALF, 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 relatedly, what the appropriate inflation measure should be); and (iii) whether it should be set on a pre or post-tax basis.

Regarding the above, in the Consultation Ofcom is proposing to:

- Set the cost of capital based on that used for the current charge controls for mobile call termination (MCT) – updated to reflect changes to corporation tax since those MCT controls were made.
- To set the cost of capital on a real, post-tax basis, reflecting Ofcom's view that bidders at the 4G Auction are likely to have formed their valuations based on expected returns after tax.

In the above context, Hutchison Three UK Ltd (Three) asked Economic Insight to consider Ofcom's decision to set the WACC using the parameters referenced in the MCT determination and provide our views as to: (i) what the appropriate approach should be to setting the WACC parameters (including providing our views as to the most appropriate inflation measure); and (ii) develop a range of evidence and analyses to inform what our proposed approach might imply in practice. In the remainder of this note we set out in turn:

- Ofcom's proposed approach for setting the WACC parameters for determining the ALF;
- the history of Ofcom's determination of WACC parameters for MCT;
- our assessment of the key issues relating to determining the appropriate approach to calculating the WACC for the purpose of setting the ALF; and
- recent evidence and analysis relevant to determining appropriate WACC parameters.

The wider question as to whether it is, in fact, a MNO WACC – rather than any alternative measure of discount rates, such as the risk free rate or the cost of debt – that is appropriate to the setting of the ALF is outside the scope of our work for Three. Our views here, therefore, merely relate to the appropriate basis for determining WACC parameters, were that deemed to be the appropriate measure.

Ofcom's proposed approach to setting the WACC for determining the ALF

Ofcom believes that, consistent with its First Competition Assessment[1], the WACC parameters it estimated in its March 2011 MCT determination remain the appropriate proxy for the discount rate that should be used to derive the ALF from the lump sum value. Ofcom has stated that this is for a number of reasons:

» As the MCT WACC was set in relation to a hypothetical UK MNO, it is likely to capture similar systematic risks to those of relevance to the ALF.

» The systematic risk associated with the 4G spectrum (which Ofcom, in part, used to determine the value of the lump sum) should also be consistent with the systematic risk of a hypothetical UK mobile-only operator.

» That although the MCT WACC was estimated for the purpose of a four year charge control period, Ofcom made use of long-term historical data to inform a number of parameters (for example, the ERP was based on historical data over 100 years). Therefore, Ofcom does not consider that it would take different evidence into account were it estimating a longer term WACC – and so the MCT WACC parameters are valid in the context of the ALF being set over a 20 year period[2] (although as noted below, Ofcom has used updated corporation tax rates).

» Ofcom believes that the date at which bidders estimated the value of the 4G spectrum provides an important reference point. Consequently, Ofcom is not minded to update the WACC to reflect more recent evidence. Ofcom further states that it has reviewed whether it should update the parameters of WACC, but believes that there has been no material changes in circumstances for the majority of the parameters from those relied upon in March 2011.

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[1] *Which Ofcom refers to in relation to: 'Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues.' Ofcom (22 March 2011).*

[22] *Note the licence has an indefinite term, but Ofcom's analysis to set the ALF assumes a 20 year notional term.*

Ofcom is, however, proposing to make two changes with respect to its approach relative to that set out in the First Competition Assessment. Firstly, Ofcom is now proposing to set the (real) WACC on a *post-tax,* rather than *pre-tax* basis. Ofcom's stated rationale for this is that it believes bidders will have valued spectrum on a post-tax basis. Ofcom has further stated that its previous position of using a pre-tax WACC reflected concerns regarding making adjustments for tax treatment under a post-tax approach to ensure value equivalence between the ALF and the lump sum. Ofcom now believes it can address these concerns by calculating the appropriate ALF tax adjustment (and this issue is dealt with in our separate paper prepared for Three). We agree with this approach, as it recognises that, in reality, firms must pay a proportion of their profits in taxation in addition to remunerating debt and equity holders. Secondly, Ofcom is proposing to update the WACC to reflect changes to the rate of corporation tax since the March 2011 MCT decision. In particular, the March 2011 MCT WACC incorporated a corporation tax rate of 24%. For setting the ALF Ofcom is proposing to use the lower rate of 20%, which will apply from 2015/16 onwards. The following table provides a summary of the key parameters assumed in Ofcom's proposed WACC for setting the ALF.

Table 1 WACC parameters proposed by Ofcom for ALF determination

WACC parameter	MCT (2011) value	Proposed ALF value (2013)
Real risk-free rate	1.5%	1.5%
Gearing	30%	30%
Equity risk premium	5.0%	5.0%
Asset beta	0.56	0.56
Debt premium	1.5%	1.5%
Overall real pre-tax cost of debt	3.0%	3.0%
Corporation tax rate	24%	20%
Inflation	2.5%	2.5%
Real pre-tax WACC	6.2%	5.9%
Real post-tax WACC	4.1%	4.2%

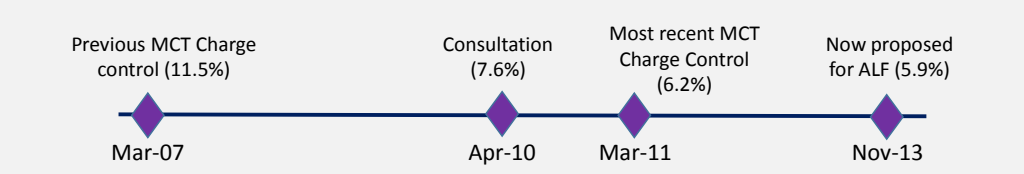
Source: Ofcom MCT determination and ALF consultation

Ofcom's determination of WACC parameters for mobile call termination

Given that Ofcom is proposing to base its WACC parameters for setting ALFs on the March 2011 MCT WACC, it is important firstly to understand the history and context to that MCT determination. In the following, therefore, we briefly set this out.

Firstly, it should be noted that Ofcom has created several iterations of cost of capital estimates for a hypothetically efficient UK mobile network operator in relation to MCT charge controls. Ofcom's final estimate for the *previous* charge control was in March 2007. It first consulted on the WACC for the *current* charge control in April 2010; and the latest estimate was in March 2011. The overall timeline for Ofcom's WACC determinations – and its estimates at each key milestone – is set out below.

Figure 1: Ofcom Mobile Operator Pre-Tax Real WACC Estimates Timeline



Source: Ofcom and Economic Insight analysis

The above illustrates two important points. Firstly, it shows that it, particularly in times of financial market and wider macroeconomic uncertainty, one's view as to what the appropriate WACC should be can vary materially over a relatively short period in time. Secondly, that whilst Ofcom ultimately set the MCT WACC in March 2011, this was part of a long and detailed process that began at a much earlier point in time. Therefore, in order to determine the suitability of the parameters used in the MCT decision to the setting of the ALF today, one must understand: (i) the overall context within which Ofcom reached its conclusions; and (ii) the data and evidence it relied upon.

"In times of financial market and wider macroeconomic uncertainty, one's view as to what the appropriate WACC should be can vary materially over a relatively short period in time."

At the time of the March 2011 MCT decision, Ofcom commented on the extent to which the WACC had changed (1.4% percentage points) relative to the April 2010 consultation. Ofcom specifically stated that most (1.0%) of this was due to changes in macroeconomic circumstances – lower interest and tax rates, with the remainder (0.4%) of the change being due to a perceived reduction in the risk profile of mobile telecoms relative to the market as a whole.[3]

In order to be able to consider the appropriateness of the MCT WACC to the setting of the ALF, it is also important to review: (i) precisely what data and information Ofcom relied upon for each individual WACC parameter; and (ii) over what time period that data was assessed. Key issues addressed by Ofcom of particular relevance to the analysis set out in this paper include:

- The extent of mean reversion that should be allowed for in the risk free rate (RFR) – Ofcom set a RFR of 1.5%, which was materially above prevailing spot rates at the time of the MCT decision.
- Betas and gearing for the hypothetical MNO were based on Vodafone data because Ofcom deemed its activities to most closely align to those of a pure MNO. We agree with the relevance of Vodafone, but evidence shows that betas and gearing can evolve relatively rapidly.
- The appropriate corporation tax rate. In the MCT decision Ofcom assumed a rate of 24%. However, for setting the ALF, Ofcom is proposing to use prevailing tax rates (we suggest there is a tension between this and Ofcom's decision not to update other WACC input parameters).

Further to the above, the following table (overleaf) provides a summary of the source information - and the periods over which it was assessed - in relation to Ofcom's final March 2011 MCT WACC determination.

[3] *'Wholesale mobile voice call termination Modelling Annexes.' Annex 8: Cost of Capital, Ofcom, paras A8.7 – A8.8 (March 2011).*

Table 2 Summary of evidence and assumptions relied upon by Ofcom in determining the March 2011 MCT WACC parameters

WACC parameter	MCT 2011 value	Source details
Risk-free rate (real)	1.5%	Primarily based on historical yields of 5 and 10 year government bonds (but with more weight on 5 year gilt) over a 10 year period. Ofcom's assumption of 1.5% was some way above prevailing risk free rates, but reflected its view that those levels were unsustainably low and that it was appropriate to take account of 'mean reversion'. Accordingly, Ofcom noted that the 5 year and 10 year yields on 5 year gilts were 1.3% and 1.7% respectively (in line with its 1.5% assumption). Ofcom also referenced the CC's risk free rate for Bristol Water of 1%-2%.
Gearing	30%	In the past Ofcom sought to identify an optimal level of gearing, based on a notionally efficient operator, which it assumed to be 10%. In the April 2010 consultation Ofcom used a range of 25%-35%. For the final March 2011 MCT determination Ofcom used 30%, which was based on the average gearing observed for Vodafone over the previous 2 years. Ofcom noted that this does not have any material effect on the overall WACC, as asset betas take into account gearing.
Equity risk premium	5.0%	Ofcom took into account evidence from respondents, market commentators, the Bank of England, and the Competition Commission to inform its review. In particular, research by Professors Dimson, Marsh and Staunton, who estimated the long-run ERP to be 5.2% (over the period 1900-2009) and the CC's determinations in relation to Bristol Water (2010) and the LLU Appeal (2009) where the ERP was determined to be 5.0%. One of the reasons cited for referencing the determinations by other regulators was *"how recent"* they were.
Beta	0.56	This is based on the mid-point of a range of averages for Vodafone over the following periods: 5 years to February 2011; 2 years to February 2011; 18 months to February 2011; and 1 year to February 2011. Vodafone is used because its lines of business are predominantly mobile (whereas the parent companies of other MNOs are engaged in a wider set of activities).
Debt premium	1.5%	Ofcom's debt premium estimate remained unchanged since its 2007 estimate. Its assumption of a 1.5% premium reflected yields on corporate debt with a 5 year redemption date (in line with its preference for 5 year gilts). Ofcom noted that recent yields on corporate bonds of the parent companies of UK mobile operators were in a range of 1–2% above risk-free rate. Ofcom further noted that the yield on Vodafone's 2017 GBP debt as of the middle of February 2011 was approximately 4.5%, around 1.5% above equivalent gilt yields.
Corporate tax rate	24%	For the March 2011 MCT decision, Ofcom took account of the Government's intention to reduce the corporate tax rate from 28% to 24% by 2014/15. As noted above, for the purpose of setting the ALF, Ofcom is proposing to use a rate of 20%, which will be effective from 2015/16.

Source: Review of Annex 8 of Ofcom March 2011 MCT Determination

The key issues regarding an appropriate approach to setting the WACC for determining the ALF

In the following we set out our assessment of the issues relating to what the appropriate approach should be for setting the WACC parameters to determine the ALF. In turn we address whether the MCT WACC is the appropriate reference point; and what regulatory best practice and the academic literature suggests in this regard.

Whether the MCT WACC parameters are the appropriate reference point

As described previously, Ofcom's rationale for applying the MCT WACC parameters to determine the ALF is based on its views that: (i) its overarching objective is to estimate a WACC that is consistent with its lump sum valuation; (ii) that the MCT WACC should be a 'reasonable proxy' for this; (iii) the systematic risk associated with 4G spectrum is likely to be consistent with that faced by a hypothetically efficient UK mobile-only operator; and (iv) that although the MCT WACC was

estimated for a 4 year charge control, Ofcom does not believe the fact that the ALF covers a 20 year period[4] would lead it to take a materially different view.

With regard to Ofcom's above rationale, we have the following observations.

- Firstly, it is important to note that the need to estimate the lump sum market value in the first instance arises from the Government's 2010 Direction that requires Ofcom ensure that licenses are set with respect to their *"full market value".* Furthermore, ultimately, these lump sum amounts are being used to set a revised ALF, which is anticipated as being effective from 2014. Relatedly, therefore, we would suggest that – given the Direction and the timing of the revised ALF – conceptually Ofcom's underlying objective must be to determine the *prevailing* market value of spectrum and thus the associated ALF. Irrespective of the nature of evidence used by Ofcom to inform its view as to the valuation therefore, this – we suggest – is the appropriate interpretation of its estimated lump sum values.

- The corollary of the above is that, taking 'today' as a start point, if the objective is to ensure that the present value of the annual stream of payments under the ALF is the same as the 'lump sum' value then, by definition, the appropriate discount rate for achieving this *must* be the one that reflects investor's current expectations. Related to this, Ofcom's own analysis indicates how quickly investor's views can evolve. For example, as recently as 2007 it determined that the appropriate MCT WACC was 11.5%; yet most observers would agree that it would be inappropriate to use this in order to derive a forward stream of payments today. Whilst clearly 'how quickly' investor expectations adapt (and therefore the extent to which mean reversion should be allowed for) is somewhat uncertain, by not using the latest available data the risk is that Ofcom is not making use of the best available evidence.

- We also note that Ofcom has accepted that – in principle – it might be appropriate to update its view of the WACC to reflect more recent data (at least up until the date of 4G bid submissions in December 2012). Indeed, Ofcom has stated: *"We have reviewed whether we should update the parameters used in the main assumptions and found no material change in circumstances, for the majority of parameters, from those estimated in March 2011 and the WACC estimated prior to bidder applications being submitted in December 2012."*[5] The implication of Ofcom's position is that (putting to one side whether one believes it is the 4G bid submission date, or the present that represents the appropriate reference point) ultimately there is a judgement as to whether certain parameters have changed sufficiently to merit a reconsideration of the WACC.

- Related to the above, there is some tension between Ofcom's proposal to use contemporaneous corporation tax rates in order to set the WACC and its position that: (i) it is the MCT determination or 4G bid submission date – rather than 'today' – that represent the appropriate reference point; and (ii) that the WACC input parameters do not need to be updated relative to those assumed at the MCT determination (given the length of time between the MCT determination and the 4G auction and the speed at which investor expectations can evolve).

- Ofcom has stated that, although the licence will be set over an indefinite term, it will consider undertaking reviews in future in circumstances where the evidence suggests key determinants of fees have changed significantly. Ofcom has further stated that it may set an initial period, during which no such review will be considered. Ofcom is (as part of the consultation) currently seeking stakeholder views as to these issues.[6] We suggest that the scope for potential future reviews provides further support to our view that somewhat more weight should be placed on contemporaneous, rather than historical, evidence in the determination of the appropriate WACC parameters.

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[4] *Note the licence has an indefinite term, but Ofcom's analysis to set the ALF assumes a 20 year notional term.*

[5] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Consultation.' Ofcom (2013), para 5.72.*

[6] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Consultation.' Ofcom (2013), paras 6.21 and 6.22.*

- Further to the preceding, Ofcom suggests that, because its lump sum value estimates are based on 4G auction values, it is appropriate to use a WACC estimate that reflects investor's expectations at the time of the auction, which Ofcom states is closely proxied by the MCT WACC. However, whilst Ofcom relied heavily on 4G auction prices to inform its view, in practice it also relied upon a range of evidence: *"We have not sought to take a mechanistic approach to deriving best estimates from the available evidence. Rather, we have considered the evidence for each band in the round, and used our judgement to decide how much weight to place on the various pieces of evidence to develop a best estimate for each band."*[7] In particular, we note that the evidence Ofcom used to inform its lump sum valuation also included:
  - benchmarking of auction values in other EU countries between 2010 and 2013;
  - ratios of values between different spectrum bands across countries; and
  - technical and other evidence – primarily a qualitative assessment of the underlying properties of spectrum and the commercial implications.

  Put simply, it is important to note that the lump sum values reflect Ofcom's estimate of the market value for 900 MHz and 1800 MHz spectrum (which is based in part on 4G auction values), rather than simply reflecting the historical 4G auction prices.

Our view is that the lump sum amounts estimated should be interpreted as representing the prevailing market value of spectrum, as this is consistent with Ofcom's objective and the timing of when the new ALF will be introduced. As a result, we consider that it may not necessarily be appropriate to link the setting of the WACC for the ALF to investor expectations from the time of the 4G auction. This view is further reinforced by the fact that Ofcom made use of a range of evidence when determining the lump sum values. Instead, we suggest that the appropriate WACC parameters for setting the ALF should be those consistent with prevailing market evidence and investor expectations.

Regulatory best practice and other evidence

Related to the above, we note that it is also generally regarded as regulatory best practice to make use of the latest available data and evidence when determining regulated rates of return and charges. In particular, we note that Ofcom stated that *"we favour using up to date estimates as far as possible"*[8] in relation to setting LLU and WLR charge controls. Similarly, in relation to determining the risk free rate, Ofgem has stated that *"we interpret this to mean that the Smithers Report advocates the use of the latest market data as the best indicator of the future cost of debt."*[9]

Consistent with this, academic research has found that best practice in business is also to use the latest available data for estimating the cost of capital. Burner et al. (1998)[10] surveys corporations and found that many re-estimate their cost of capital for significant events such as acquisitions and high-impact economic events. Truong et al (2006)[11] also find that corporates review their discount rate regularly and update it as conditions change, thus highlighting the importance that companies place on having up-to-date estimates of the cost of capital.

Recent evidence regarding key WACC input parameters

It is well established that it is appropriate to make use of the most recently available data and evidence when setting the cost of capital. In the following, therefore, we set out an assessment of the current evidence in relation to each WACC parameter in turn. This evidence relates both to: (i) financial market data, such as recent trends in the RFR; and (ii) relevant regulatory WACC determinations that have occurred since the March 2011 MCT WACC decision. In assessing what the latest data might imply with regards to the WACC, we have sought to broadly follow the same

[7] *'Annual licence fees for 900 MHz and 1800 MHz spectrum: Consultation.' Ofcom (2013), para 4.51.*

[8] *'Fixed access market reviews: Approach to setting LLU and WLR Charge Controls.' Ofcom, (Aug 2013).*

[9] *'TPCR4 Rollover: Initial Proposals.' Ofgem, (August 2011).*

[10] *'Best practices in estimating the cost of capital: survey and synthesis.' Burner et al., Financial Practice and Education, (1998).*

[11] *'Cost of Capital Estimation and Capital Budgeting Practice in Australia.' Truonh et al., (2006).*

approach adopted by Ofcom at the March 2011 MCT decision (i.e. we have reviewed the same types of evidence as that relied upon by Ofcom). However, we should note that - in practice - we cannot know precisely what weight Ofcom attached to each individual piece of evidence it referred to, and so we cannot necessarily infer that Ofcom would draw the same conclusions as us from this evidence.

A WACC for a hypothetically efficient, notionally geared, operator

In setting a WACC for the MCT determination, an important element of Ofcom's approach was that it sought to do so with respect to a *hypothetical*, efficient mobile network operator (MNO). Whilst Ofcom's gearing assumption was based on Vodafone Group's actual gearing, Ofcom stated that it was nonetheless being used as the reference point for an efficient operator.[12]

We agree that, in identifying a WACC for setting the ALF, it is appropriate to do so with respect to a hypothetically efficient, notionally geared, MNO. In particular, the use of notional gearing in setting any form of regulatory WACC recognises the fact that firm management is best placed to manage the risks associated capital structure and financing. Consequently, in setting out our views as to the key issues and considerations relating to WACC in the remainder of this paper, it should be noted that we are assuming that this relates to a hypothetical, notionally geared, firm.

A CAPM approach to the cost of equity

Consistent with Ofcom, we believe it remains appropriate to adopt a CAPM approach to determining the cost of equity. Given the instability and uncertainty that has characterised financial markets in recent years, various regulators have considered there to be merit in focusing on total equity returns, rather than developing a cost of equity 'bottom up' starting from the constituent parts of CAPM. For example, this issue has been raised recently by PwC in its report to Ofwat on an appropriate WACC methodology for the PR14 price control in the water and sewerage industry.[13] The rationale for a total equity approach arises from the fact that the individual CAPM parameters can be more volatile across the business cycle compared to overall returns (which are more stable).

Nonetheless, it ultimately remains necessary to separately identify an appropriate RFR, equity risk premium (ERP) and beta in order to determine the WACC for the purpose of setting the ALF. In this context, it is important to keep in mind how recent market conditions may have impacted these parameters, and the interlink-ages that exist between them. In particular, in periods of uncertainty investors may be more risk averse. Consequently the premium required for risky assets tend to increase, and assets that regarded as being safe – such as government bonds – receive inflows of capital. Therefore, as macroeconomic related risks increase, the ERP might be expected to increase, whereas the yield on government bonds falls. Relatedly, one would also ideally seek to assess evidence relating to both the RFR and ERP over similar time periods for reasons of internal consistency. In the current case, when evaluating how best to interpret recent evidence regarding key equity parameters (as set out below) in the context of determining a WACC for setting the ALF, a key consideration is the extent to which the data accurately captures investor expectations in a post financial crisis environment. Ultimately, this is somewhat subjective and requires a degree of judgement.

Risk free rate

Ofcom is proposing to apply a real RFR of 1.5%, consistent with its MCT decision. As noted in the previous summary table, the evidence Ofcom relied upon in reaching this view primarily consisted of: (i) an assessment of real yields on 5 and 10 year gilts; and (ii) the CC's determination with respect to Bristol Water. In evaluating this evidence, Ofcom attached more weight to 5 year gilts and the fact that prevailing yields were unusually low relative to long-term data. In particular,

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[12] *'Wholesale mobile voice call termination Modelling Annexes.' Annex 8: Cost of Capital, Ofcom, paras A8.7 – A8.94 (March 2011).*

[13] *'Cost of capital for PR14: Methodological considerations.' PWC (July 2013).*

Ofcom referred to the tendency towards mean reversion with respect to the RFR when determining an appropriate assumption for setting the WACC.

In the context of our view (set out above) that Ofcom should make use of the most recently available data for the purpose of setting the WACC (and therefore ALF), we have examined: (a) contemporaneous evidence regarding the RFR; and (b) a range of recent 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

- *CAA Gatwick & Heathrow (Oct 2013) 0.75 midpoint*
- *Ofcom LLU & WLR (Jul 2013) 1.3%*
- *ORR PR13 (June 2013) 1.65%*
- *Ofcom Business Connectivity Review (Mar 2013) 1.3%*
- *Ofcom Channel 3 & Channel 5 (Feb 2013) 1.3%*
- *Ofgem RII0 GDR (Dec 12) 2.0%*
- *Ofgem TPCR4 (Nov 11) 2.0%*

Source: Bank of England, Economic Insight analysis and regulatory determinations

As noted previously, 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 October 2013 inclusive are:

- for 10 year gilts, 1.0% over 10 years; and
- for 5 year gilts, 0.7% over 10 years.[14]

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.[15] 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 in its proposal to retain a RFR of 1.5% for the purpose of setting the WACC for the ALF, where it has noted that 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

[14] *Rounded to 1dp.*

[15] *'Wholesale mobile voice call termination Modelling Annexes.' Annex 8: Cost of Capital, Ofcom, paras A8.7 – A8.53 (March 2011).*

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 3 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%
CAA	Heathrow price control	Oct-13	0.75%
CAA	Gatwick price control	Oct-13	0.75%

Source: Review of regulatory determinations

The above table shows that, with the exception of the ORR PR13 decision, since 2013 regulators are assuming a RFR that is somewhat below the 1.5% currently being proposed by Ofcom. Indeed, we note that Ofcom itself has assumed a RFR of 1.3% in relation to its decisions regarding the Channel 3 and 5 licences, and the LLU and WLR charge controls. The average RFR across all regulatory determinations in 2013 is 1.2%.

"We suggest an appropriate range for the RFR might be 1.0%-1.3%. Our rationale is that the lower bound is consistent with the average yield over 10 years for 10 year gilts. The upper bound is consistent with Ofcom's more recent determinations for both the Business Market Review and the LLU and WLR charge controls."

Of the above, we suggest that the CCA's determinations for Heathrow and Gatwick are particularly useful, given how recently they were made (and noting that Ofcom's stated rationale for referencing the CC's Bristol Water decision at the time of the MCT was that it was 'recent'). For its October 2013 airport determinations, the CAA suggested that the appropriate range for the RFR lay between 0.5% and 1.0%, and assumed a mid-point of 0.75% in its WACC. In reaching this view, the CAA was mindful of balancing the need to reflect the latest information against the long-run RFR. However, the CAA noted that there the risk of paying too much attention to recent evidence is not one-sided, stating: *"…using long-run rates also has its difficulties as the basis for the estimation because it is not clear whether and when the economy might return to such rates."*[16] We think this is highly pertinent to Ofcom's concern regarding mean reversion. In particular, as the CAA's control ill apply over a 5 year period, effective from April 1st 2014, the regulator's assessment of the RFR reflects is view as to what RFR is currently appropriate over the medium-term.

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:

[16] *'Estimating the cost of capital: a technical appendix to the CAA's Final Proposal for economic regulation of Heathrow and Gatwick after April 2014.' CAA (October 2013).*

"appropriate… to reflect the continued fall in estimates of the real risk free rate to some degree."[17]

Overall we share Ofcom's view that it is important to take mean reversion into account when determining an appropriate RFR, particularly as the ALF is being set based on a 20 year notional license term and the fact that we are at the bottom of the interest rate cycle. However, we also think that this issue needs to be balanced against the need to ensure that the WACC accurately reflects current expectations. As such, we would suggest that the best currently available evidence – as indicted by recent regulatory determinations – would tend to support a RFR somewhat below the 1.5% proposed by Ofcom. In particular, we suggest an appropriate range for the RFR might be 1.0%-1.3% (with a midpoint of 1.15). Our rationale is that the lower bound is consistent with the average yield over 10 years for 10 year gilts. The upper bound is consistent with Ofcom's more recent determinations for both the Business Market Review and the LLU and WLR charge controls. This range reflects our judgement that there is a somewhat greater need to allow for mean reversion in the context of a long-term licence, relative to typical price control periods of 5 years.

Equity risk premium

In its March 2011 MCT determination, Ofcom assumed a point estimate for the ERP of 5.0%. This reflected a range of evidence – but in particular analysis by Professors Dimson, Marsh and Staunton, who examined ERP data over a period of over 100 years. Ofcom also took into consideration data from the Bank of England and the CC's determination in relation to Bristol Water (where an ERP of 5.0% was also assumed). Ofcom stated that the Bristol Water ERP was relevant because of 'how recent' the determination was, but also that the generic market-wide nature of the ERP meant that it was appropriate to consider determinations made elsewhere.

As set out previously, when considering what the appropriate ERP might be today, it is important to recognise that recent market conditions pose a number of challenges. Not least the fact that capital markets are heavily influenced by government macroeconomic policy and have been subject to an unusual amount of uncertainty and volatility. Notwithstanding this, given Ofcom's rationale for examining ERPs as determined in other sectors at the time of the MCT decision, we have similarly reviewed recent regulatory determinations in this regard, which are summarised in the following table.

Figure 3 Summary of ERP determinations

Regulator	Determination	Date	ERP
Ofgem	TPCR4 Rollover Final Proposals	Nov-11	4.50%
Ofgem	RIIO gas distribution final proposals	Dec-12	5.25%
Ofcom	Financial terms for the Channel 3 and Channel 5 licences	Feb-13	5.00%
Ofcom	Business connectivity market review	Mar-13	5.00%
ORR	PR13 draft determinations	Jun-13	5.00%
Ofcom	LLU and WLR Charge Controls	Jul-13	5.00%
CAA	Heathrow price control	Oct-13	5.75%
CAA	Gatwick price control	Oct-13	5.75%

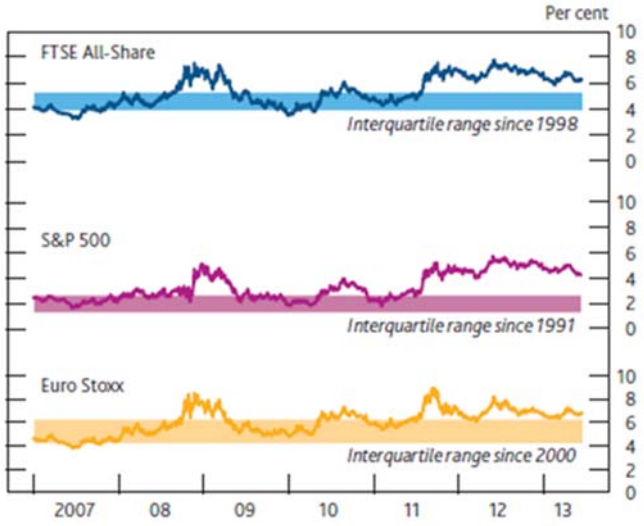
Source: Review of regulatory determination

[17] *'Business Connectivity Market Review: Annex 8.' Ofcom (July 2013).*

Across the regulatory determinations shown above, the average ERP is 5.2% (the average is slightly higher, at 5.3%, if we include only those determinations made in 2013). This, then, is somewhat above than the 5.0% being proposed by Ofcom.

Whilst it is commonplace to focus on historical data when considering the appropriate ERP, forward looking models can serve as a useful cross check. The most widely accepted approach for assessing equity returns on a forward looking basis is the dividend growth model (DGM). The underlying concept of the DGM is that the prevailing market price of assets reflects the expected discounted value of their future cash flows. The Figure below shows the Bank of England's ERP estimates as derived from its multi-stage DGM model.[18]

Figure 4: Bank of England ERP estimates



Source: Bank of England, *'Financial Stability Report', June 2013.*

The Bank of England's ERP estimates (as produced by its DGM model) are frequently relied upon in regulatory cost of capital determinations and submissions. For example, recently FTI's report for Ofgem in relation to the RIIO-T1 and GDI price controls[19] made explicit reference to this, as did NERA's report for Heathrow in relation to the CAA's 2013 price control.[20] Consequently, in relation to DGM based estimates of the ERP, the Bank of England's data is generally regarded to be a good source of evidence.

The above data shows that the FTSE 100 ERP's estimated by the Bank of England:

- have generally increased since 2010; and
- in recent years have consistently been above 6%.

In addition to historical data and future expected returns approaches, such as DGM evidence, investor surveys can also be used to provide evidence as to the prevailing ERP (and a number of such surveys exist). In June 2012 a survey of risk premiums in 82 countries was published, which shows that, for the UK, investor's required equity risk premium was 5.5%.[21] However, it is generally accepted that survey based estimates of the ERP should be treated with care, as (i)

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[18] *The Bank of England's DGM is a multi-stage model in which future expected cash flows are proxied by an assumed rate of dividend growth. Over the short-to-medium term, this is based on consensus data from surveys of investors' expectations of future earnings, as published by the Institutional Brokers' Estimate System (IBES). Long run growth is expected to be constant and in-line with the overall economy. The ERP is effectively the residual of the total market return and the RFR. For further details see: 'Interpreting equity price movements since the start of the financial crisis.' The Bank of England (2010).*

[19] *'Cost of capital study for the RIIO-T1 and GD1 price controls.' FTI report for Ofgem (2012). See page 34.*

[20] *'A Review of the CAA's Approach to Estimating the WACC at Q6: A Report for Heathrow.' NERA (2013). See pages 16-17.*

[21] *'Market Risk Premium used in 82 countries in 2012.' Fernandez, Aguirreamalloa and Corres. IESE Business School and World Finance Conference Paper (2012). UK estimate based on a sample of 171 responses.*

responses can be highly sensitive to recent stock price movements; (ii) respondent's may have differing interpretations of the questions and may have differing expectations of other relevant factors, such as the RFR; (iii) there is some evidence of individual response bias, including gender bias. There is a range of literature that discusses these issues further. For example, see Damodaran (2011).[22]

As indicated previously, it is important that both the ERP and RFR are considered holistically. In particular, if we believe that the RFR has fallen because equity has become more risky, or because investors are more risk averse, then we would normally expect an increase in the ERP to reflect this. Taking this into consideration, along with the most CAA regulatory determinations and DGM evidence, we consider that it would be appropriate to assume an ERP somewhat higher than that proposed by Ofcom. In the round, we suggest a range of between 5.50% and 5.75% (with a midpoint of 5.63) is reasonable in that:

- the upper bound is consistent with the latest CAA determinations and reflects higher expected returns to equity as implied by the DGM evidence;
- the lower bound reflects the fact that, for internal consistency with our proposed RFR range, we should assume an ERP somewhat higher than at the time of the MCT determination; and
- when viewed holistically with our assumed beta, this range implies total equity market returns that are consistent with long-run evidence (see later).

Equity and asset beta

As noted previously, Ofcom based its view as to what the appropriate asset beta and gearing should be on Vodafone Group data. In determining the beta, Ofcom made use of a range of estimation methods and periods, but placed more emphasis on the 2 year daily equity beta analysis, noting that: *"Our belief is that 2 year daily data affords the best compromise between sufficient datapoints to provide a statistically robust estimate, and the most up to date information."*[23] Ofcom's evidence included analysis undertaken by Brattle, which made use of data over 2 years up to and including October 2010. Ofcom's own internal analysis was updated to include data up to February 14th 2011, and it noted that this more recent period was less likely to be influenced by the credit crisis.

Brattle concluded from its analysis of Vodafone's beta (and other comparators) that a reasonable estimate of a UK mobile operator's asset beta would be around 0.5. In reviewing the evidence in the round, Ofcom concluded that it thought a range for asset betas of 0.5 – 0.61 was appropriate. Ofcom assumed a point estimate of 0.56, which is the midpoint (with an assumed gearing of 30%).

We are of the view that Vodafone remains a valid reference point for a hypothetical MNO (see later gearing discussion). We have, therefore, examined evidence regarding Vodafone's current equity beta, as estimated by Thomson Reuters. The estimation methodology applied by Thomson Reuters is based on using daily data over a 5 year trailing period, where equity volatility is assessed relative to the FTSE 100. As there are some methodological differences between the approach applied by Thomson Reuters and that used by Ofcom, we have assessed the data over a period of 4 years, as this allows us to make inferences regarding whether the beta is likely to have increased or declined since the March 2011 MCT decision. The following table shows our analysis of Vodafone Group's equity and asset betas (where actual gearing ratios have been used in each year for the conversion).

[22] *'Equity Risk Premiums (ERP): Determinants, Estimation and Implications – The 2011 Edition.' Damodaran, Stern Business School (2011).*

[23] *'Wholesale mobile voice call termination Modelling Annexes.' Annex 8: Cost of Capital, Ofcom, paras A8.7 – A8.105 (March 2011).*

Table 4 Vodafone Group betas

	2010	2011	2012	2013
Equity beta	0.75	0.76	0.65	0.56
Asset beta	0.55	0.56	0.46	0.37

Source: Thomson Reuters and Economic Insight analysis

"To be conservative, we would suggest a range for the asset beta of between 0.46 – 0.50, with a midpoint of 0.48. At an assumed gearing of 35% for the hypothetically efficient notionally geared UK MNO the midpoint implies an equity beta of 0.69."

Our estimated asset betas for 2010 and 2011 of 0.55 and 0.56 are consistent with the range reported by Ofcom at the time of the March 2011 MCT decision. Since then, the above data shows that Vodafone Group's beta has declined, such that our estimated asset betas for 2012 and 2013 are 0.46 and 0.37 respectively (and the corresponding equity betas fell to 0.65 and 0.56). We note that this downward trend is also consistent with Ofcom's previous analysis, where it was noted that: *"Brattle's work shows a steady decline in Vodafone's 2 year equity beta since at least 2004."*[24] We further note that, whilst this is a relatively sharp drop, Ofcom itself noted that Brattle's analysis also revealed steep declines in more recent years. Relatedly, we note that the continued decline in equity betas is consistent with an increase in the company's gearing (set out subsequently).

We think that it is appropriate to recognise the increase in Vodafone's gearing, to the extent that it is being used as a reference point for the notionally geared MNO. Accordingly, for reasons of internal consistency, it is also appropriate to assume a somewhat lower beta than that proposed by Ofcom. To be conservative, we would suggest a range for the asset beta of between 0.46 – 0.50, with a midpoint of 0.48. At an assumed gearing of 35% for the hypothetically efficient notionally geared UK MNO (see later) the midpoint implies an equity beta of 0.69. This translates to a total real (pre-tax) cost of equity of 6.8%, which is in line with long-run estimates of total equity market returns.

Cost of debt

The overall cost of debt for a notionally efficient UK MNO consists of both: (i) the RFR (as discussed previously); and (ii) an assumed debt premium. In order to reach a view on the appropriate premium for debt over the RFR, Ofcom examined the yield on corporate debt of the parent companies of the UK MNOs (i.e. Vodafone, Deutsche Telekom, France Telecom and Telefonica). Ofcom found that these were generally at a premium of between 1-2% in excess of its view of the appropriate RFR, indicating a debt premium of 1.5%.

To examine the current debt costs faced by the MNOs, we obtained details of all bonds issued by their respective parent companies, and calculated the average nominal rate paid. Using an assumed inflation rate of 2.4% (see subsequent discussion of inflation) and an assumed RFR of 1.0% – which is our lower bound – this would imply a current range for the debt premium of between 1.0% and 2.0%, as shown in the table below.

[24] *'Wholesale mobile voice call termination Modelling Annexes.' Annex 8: Cost of Capital, Ofcom, paras A8.7 – A8.118 (March 2011).*

Figure 5 Current debt costs

	Deutsche Telekom	Orange SA	Telefonica	Vodafone
Current nominal bond rates (%)	4.4%	4.6%	5.5%	4.8%
Real bond rates (%)	2.0%	2.2%	3.0%	2.3%
Assumed real RFR (%)[25]	1.0%	1.0%	1.0%	1.0%
Implied debt premium (%)	1.0%	1.2%	2.0%	1.3%

Source: Thomson Reuters and Economic Insight analysis

The average implied debt premium across all MNO parent companies is 1.4%, which is fractionally lower than the 1.5% premium assumed by Ofcom, indicating that there has been little change in this parameter since the MCT decision. However, as we are proposing a somewhat lower RFR than Ofcom previously determined, we consider it appropriate to use a slightly higher debt premium. In the round we propose that an appropriate range for the debt premium would be 1.5% to 2.0% in real terms (1.75% as a midpoint).

When considering the cost of debt in totality, it is important to keep in mind that prevailing market conditions mean that total embedded debt costs are likely to be low compared to forward looking debt costs. This must be taken into consideration when determining an appropriate rate for setting the ALF over a notional 20 year license period. In practice, the extent to which total debt costs are likely to rise depends on: (a) the maturity of existing debt, which drives the extent to which refinancing is required; and (b) the extent to which future investment will require new debt to be raised. This view is consistent with PwC's advice to Ofwat in relation to the forthcoming price control in the water industry: *"In the UK, there is a future market expectation of a gradual increase in interest rates (as implied from forward rates), although markets do not currently anticipate a quick return to historic average long-term debt interest costs."*[26]

Gearing

As noted previously, Ofcom based its view as to what the appropriate asset beta and gearing should be on Vodafone Group data, the rationale being that its activities were primarily mobile network related (whereas the other UK MNO parent companies undertook a wide range of activities). Given that for the purpose of setting the WACC, we are concerned with what the appropriate gearing should be for a notionally efficient MNO, we agree that – where possible – the evidence for input parameters should be closely related to the core activities that an MNO would be expected to undertake.

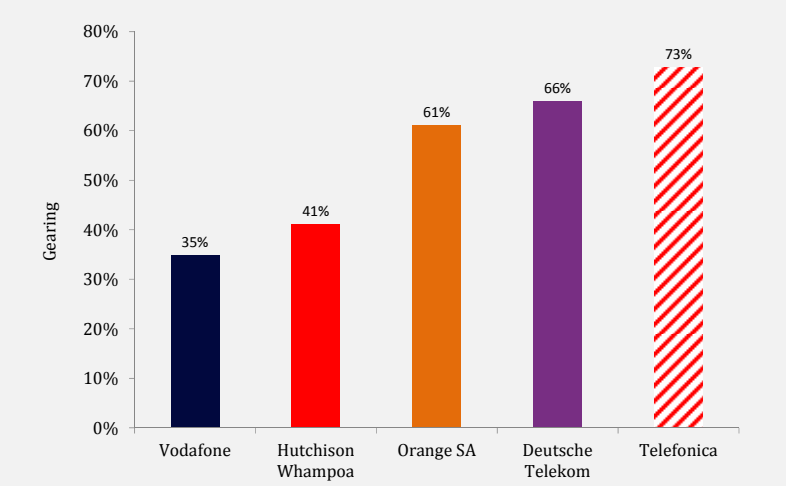
In the first instance, however, we nonetheless examined the latest data on gearing for the UK MNO parent companies. The results of this are shown in the following figure.[27]

[25] *The midpoint for our RFR range is 1.15%; 1.0% represents the low end for our RFR range and is used here to illustrate the implied Debt premium. Ultimately in any case we assume higher debt premium than implied by this data for reasons of internal consistency.*

[26] *Cost of capital for PR14: Methodological considerations.' PWC (July 2013), page 10.*

[27] *Gearing has been calculated using data from Thomson Reuters and reflects the ratio of net debt to capital employed, where net debt is long term liabilities + short term debt – cash and equivalents (where relevant short term debt is identified as being all interest bearing debt plus any short term debt classified as being a proportion of long term debt). Data relates to period ending December 2012.*

Figure 6: Gearing of MNO parent companies - 2012



Source: Economic Insight analysis of Thomson Reuters data

The above reveals that there is currently a considerable spread of gearing across the UK MNO parent companies, ranging from 35% (Vodafone) to 73% (Telefonica). In principle, this may imply that notional gearing for a hypothetical MNO could be somewhat higher than assumed by Ofcom. However, as noted previously, this turns on how relevant we consider the core activities of the parents to be, which are summarised in the following table.

Table 5 Summary of core activities of parent companies

MNO parent	Summary of activities
Deutsche Telekom	Deutsche Telekom AG is a Germany-based integrated telecommunications provider offering fixed-network lines, broadband lines, and mobile communication networks. As of June 2013, Deutsche Telekom had 31.7m fixed-network line customers and 143.6 mobile customers.[28] This indicates that 80% of its customer base relates to mobile.
Hutchison Whampova	Hutchison Whampoa Limited is an investment holding company. Its operations consist of six core businesses: ports and related services, property and hotels, retail, infrastructure, energy, and telecommunications.
Orange SA	Orange is a France-based company offering its customers a range of services covering fixed and mobile communications, data transmission, wireless telecommunication services, broadcasting services, Internet and multimedia and advertising services, among others. Approximately half of Orange's revenues are from mobile services[29]
Telefonica	Telefonica SA is a Spain-based company offering fixed telephony accesses, Internet and data accesses, mobile accesses and pay television. Approximately 60% of Telefonica's revenues are from mobile services[30]
Vodafone	Vodafone Group Plc (Vodafone) is a mobile communications company which provides mobile voice, messaging, data and fixed line services. Whilst its accounts do not segment revenues by area, we understand that it relates almost entirely to mobile.

Source: Economic Insight review of annual reports

Given the evidence set out above, we consider it reasonable to assume that Vodafone continues to represent a good reference point for considering the appropriate WACC input parameters for a hypothetical MNO. In this regard, at the time of its March 2011 MCT decision, Ofcom reported that

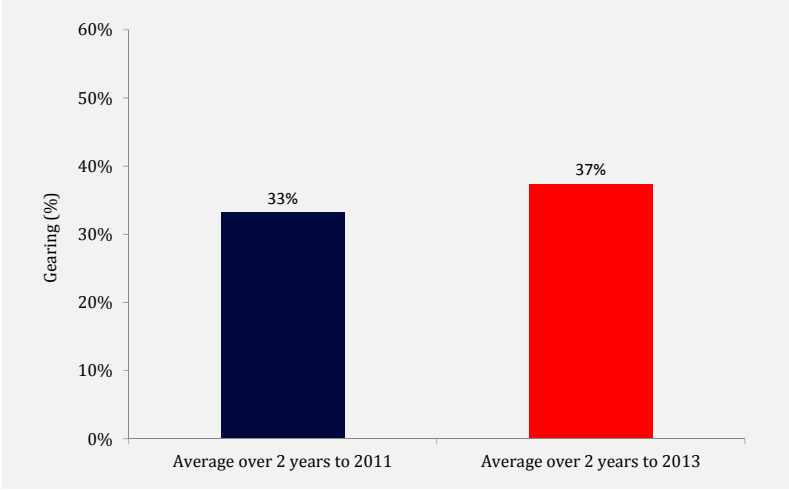
[28] *Deutsche Telekom Interim Group Report H1 2013*

[29] *Based on proportion of mobile services and mobile equipment sales of total revenue, as given by note 3 in Orange's first half 2013 financial report*

[30] *Based on the proportion of mobile revenues of total group revenue, as given on page 33 of Telefonica's 2012 financial report*

Vodafone Group's gearing had varied between 25% and 35% over the last two years and so it based its assumption on an assumed gearing of 30%. We have re-calculated Vodafone Group's average gearing for the last four years, as shown in the following chart.

Figure 7: Vodafone Group Plc Gearing



Source: Economic Insight analysis of Thomson Reuters data

Our analysis shows that, over the 2 years to December 2011 Vodafone's gearing was 33%, consistent with the ranges previously quoted by Ofcom. Over the 2 years to December 2013, however, Vodafone's gearing increased somewhat to an average of 37%. The relatively modest increase in Vodafone's gearing in recent years is consistent with the reported decline in its equity beta (as discussed previously).

In considering what an appropriate level of gearing might be today for a notionally geared, hypothetically efficient, MNO, it is important to take into account the low interest rate environment, which will have provided companies with a buffer on their debt service ratios. Therefore, consistent with us implicitly assuming debt costs that allow for some future increases, we think that a prudent approach would be to assume a level of gearing at the midpoint between the 2011 and 2013 two year averages. This implies a gearing of 35%.

Corporation tax rates

In line with our views set out previously, we consider that – as we are seeking to calculate an ALF that is consistent with a prevailing market value of spectrum – it is appropriate to use prevailing expectations of corporation tax rates when calculating a post-tax WACC. Consequently, we have assumed that, as per HMRC guidance, the tax rate will be 23% for 2013/14, 21% for 2014/15, and 20% for 2015/16 and thereafter. Over a 20 year period, this implies an average rate of tax of 20.2%.

In our view, there is some tension inherent in Ofcom's current proposed approach, as it is proposing to update its assumptions regarding tax, whilst leaving all other WACC input parameters unchanged from the time of the MCT determination.

Inflation

Ofcom is proposing to set the ALF so that it is constant in real terms. In other words, Ofcom will increase the nominal price of the ALF in each year to reflect inflation. Consequently, inflation affects Ofcom's methodology in two ways. Firstly, with regard to the annual adjustment to the nominal ALF. Secondly, it is used to determine the real WACC. In its ALF consultation, Ofcom is proposing to assume an RPI measure of inflation, at a rate of 2.5%, which is also consistent with its March 2011 MCT determination.

In principle there are a number of inflation measures that could be used to determine a WACC for setting the ALF, but in practice the RPI and CPI measures are of most relevance. There are a

number of differences between the measures, including: the basket of goods they include; the source of expenditure data used to estimate weights; and the formulae used to construct the indices. In our view, the appropriateness of these in the current context depends on: (i) whether the choice in any way affects the balance of inflation risk between the licensee and the licensor; and (ii) a more objective consideration of the relative merits of the inflation indices from an economics perspective (i.e. which measure best reflects the underlying cost drivers of the hypothetically efficient MNO).

With regard to the first issue, Ofcom has suggested that the choice of index does not affect the balance of inflation risk and that – so long as the same index is built into both the WACC and the ALF inflation adjustment – licensees should be indifferent as to whether RPI or CPI is used. In principle, we agree with Ofcom's statement as, from a net present value perspective, a licensee would be indifferent to the choice of index so long as it was properly incorporated into both the WACC and the nominal ALF payments (i.e. if the same inflation measure as used in the WACC was used to inflate the nominal ALF payment in each year). However, in practice this assumption could break down if: (a) it was more difficult to forecast one inflation index over another, such that the outturn rate of inflation used in the price index to adjust the nominal ALF differed, ex post, from that rate of inflation used in the WACC; and (b) if that divergence worked systematically to the advantage or disadvantage of the licensees. It is difficult to know with any certainty whether either of these factors is likely to arise in practice. However, to provide some indicative information we have reviewed a range of evidence.

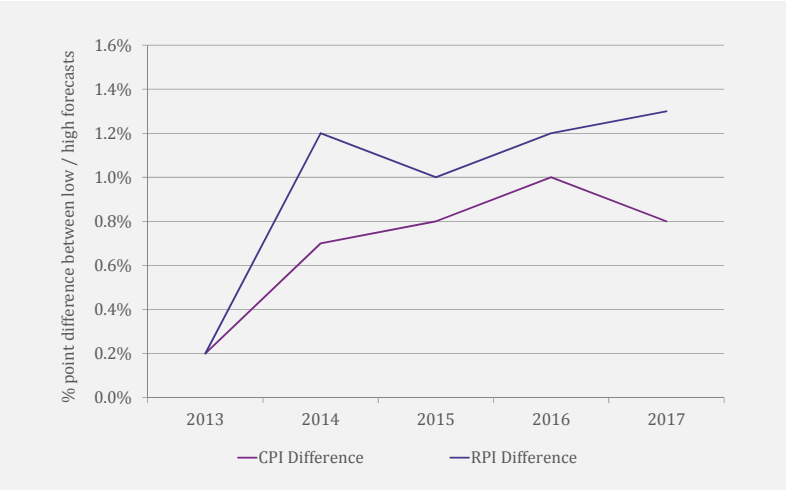
Firstly, we have examined *forecast* inflation rates for both CPI and RPI. This is because forecast data may provide us with information as to whether there are any inherent differences in uncertainty across the two measures (i.e. whether one measure is more likely to be subject to forecast error than the other). Regarding uncertainty more generally, analysis from the Centre for Policy Studies[31] shows that the Bank of England's ability to forecast inflation has generally deteriorated over time. From August 2001 to May 2004 the average error (in relation to CPI) was just +0.1 percentage points; from August 2004 to May 2007 the average error was +0.4 percentage points; and from August 2007 to November 2011 the average error was +1.4 percentage points. Therefore, putting to one side differences between the indices, forecasting errors have generally increased over time.

Of most interest to the current case, however, is whether there are any inherent differences in the accuracy of RPI and CPI forecasts. Relating to this, HM Treasury collates forecast data from independent institutions regarding both CPI and RPI projected over five years. Using the latest published forecast data[32], we have examined the percentage point 'wedge' between high and low forecasts for both measures. On average, over the five year forecast period, we find that the difference for CPI is 0.7 percentage points, and for RPI the difference is 1.0 percentage points. This would tend be consistent with there being somewhat more certainty regarding future CPI relative to RPI, although the difference in spread is relatively modest.

[31] *http://www.cps.org.uk/files/factsheets/original/120113142525-Factsheet6InflationforecastsUPDATE3.pdf*

[32] *https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/260252/201311_ForecastComparison.pdf*

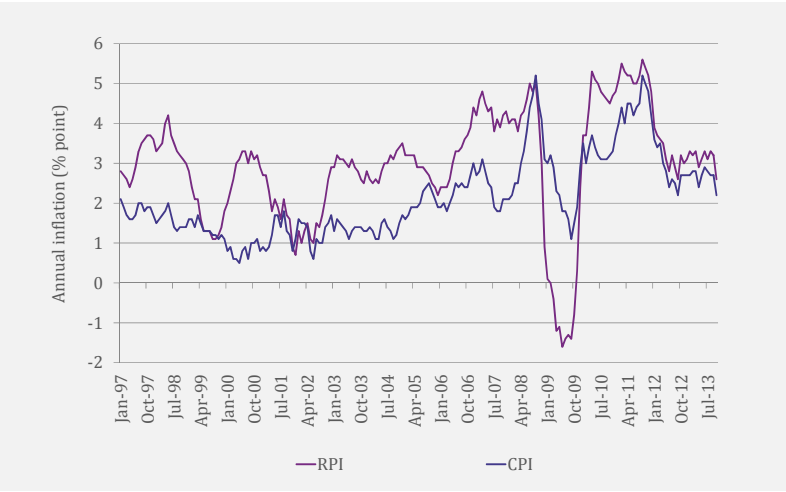
Figure 8: Percentage point spread between low/high RPI and CPI forecasts



Source: HM Treasury

Another way of considering the likelihood of forecasting errors (which, as noted above, determine the likely scope for divergence between the lump sum value and the present value of ALF payments ex post) is to look at the volatility of both measures over a long period of time. We have therefore examined trends in the RPI and CPI back to January 1997, as published by the ONS. These are shown in the following figure.

Figure 9: Long-term volatility in RPI and CPI measures



Source: ONS

Based on this we find that the long-term average rate of inflation is:

- 3.0% for RPI; and
- 2.1% for CPI.

We further calculated the standard deviations for both measures over the same time period and found that these to be:

- 1.4 for RPI; and
- 1.0 for CPI.

Put simply, and consistent with the slight difference in forecasting spreads shown earlier, historical data tends to indicate that CPI is a more stable measure than RPI. This is consistent with there being less scope for divergence between the lump sum value and the (ex post) present value of the stream of ALF payments under a CPI, rather than RPI, form of indexation.

With regard to the second issue: an objective consideration of the relative merits of RPI versus CPI, we note the following.

- ***The official status of RPI has been removed.*** There have in recent years been an increasing number of concerns raised regarding the underlying robustness of the RPI measure. In particular – and as referenced by Ofcom in its LLU and WLR Charge Controls, in January 2013 the ONS announced that RPI *"does not meet international standards"* and recommended that a new index be published. In March 2013 the designation of RPI as a National Statistic was cancelled. However, it will continue to be published - not least because of its importance to index-linked government bonds (and relatedly, the extent of corporate debt that is index linked to RPI).

- ***Regulators, including Ofcom, are now actively considering CPI.*** As part of its RPI-X@20[33] review of energy network regulation, Ofgem considered the replacement of RPI indexation with CPI indexation. With the Bank of England switching to the CPI measure in 2003, and it becoming an increasingly accepted measure of inflation, a case was seen to move from RPI – although ultimately Ofgem retained RPI. Similarly, in its Consultation on setting LLU and WLR charge controls,[34] Ofcom propose to use CPI as the default inflation index for that charge control and future ones. A number of factors were taken into consideration (official status of the index; cost causality; exogeneity; availability of independent forecasts; regulatory predictability) and, largely as a result of the declassification of RPI, Ofcom has favoured CPI.

- ***An assessment of cost causality indicates CPI may be preferable.*** From an economics perspective we are primarily interested in which index best reflects the underlying cost drivers of a hypothetical MNO. In this regard, we note that one reason for Ofgem's decision to retain RPI was that its use in corporate and government index-linked bonds meant that it played a critical role in the determination of a fair return on assets. Relatedly, ORR's decision to retain RPI reflected the fact that it fundamentally drives Network Rail's actual cost of debt (half their debt is RPI linked).[35] In our view, however, the index-linked debt issue is more pertinent to ex-ante price regulated, capex intensive, natural monopoly type industries. Whilst we have not undertaken a detailed review of cost causality for the purpose of our work, we note that the RPI basket includes a number of items that we consider to be irrelevant to the cost drivers of a notional MNO, including: mortgage interest payments, house depreciation and house purchase costs. Furthermore, ONS analysis indicates that these housing cost items explain a material proportion of the differences between the RPI and CPI measures.[36] It is likely, therefore, that a full cost causality analysis would show CPI to be the more appropriate metric.

On balance, we think that a CPI measure is most appropriate to the setting of a WACC for determining the ALF.

Further to the above, and consistent with our view that it is appropriate to base the WACC parameters on prevailing investor expectations, we think that the average of the latest 5 year forecasts as published by HM Treasury represent a reasonable source of data. This indicates that an appropriate rate of CPI inflation to assume in determining the WACC is 2.4%. Were an RPI measure to be retained instead, the HM Treasury consensus forecasts would indicate an inflation rate of 3.3%.

Whether the WACC should be set on a pre or post-tax basis

Ofcom's proposed WACC for setting the ALF has been determined on a post-tax basis. As noted above, Ofcom's stated rationale for this is that it believes such an approach is consistent with the basis on which the MNO's valued 4G spectrum in the first instance – noting that 4G auction prices were themselves an input into Ofcom's determination of the market value of the spectrum lump

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[33] *https://www.ofgem.gov.uk/ofgem-publications/51901/rpi-xrecommendations.pdf*

[34] *http://stakeholders.ofcom.org.uk/binaries/consultations/llu-wlr-cc-13/summary/LLU_WLR_CC_2014.pdf*

[35] *http://www.rail-reg.gov.uk/pr13/PDF/pr13-draft-determination.pdf*

[36] *For example, see 'Differences between the RPI and CPI Measures of Inflation.' ONS (2010).*

sum. Ofcom further states that its prior position of proposing a pre-tax WACC reflected the complication in differing tax treatments between the ALF and the lump sum, which would need to be adjusted for under a post-tax approach (see our separate note on the ALF tax adjustment).

We consider that Ofcom's revised approach, which is to be explicit and transparent regarding the assumptions it is making relating to tax treatments, is appropriate. This is because it properly reflects the fact that a proportion of firm profits will be paid to tax authorities in addition to being distributed to debt and equity investors. We therefore agree that the WACC should be determined on a post-tax basis.

Conclusions

A key issue to the determination of the ALF is that it should reflect the prevailing market value of spectrum. We therefore believe that, conceptually, Ofcom's estimated lump sum values should be interpreted accordingly. Taking this as a given, we suggest that in deriving the ALF from the lump sum by reference to a WACC, it is appropriate to do so using the most up-to-date evidence that is available. Such an approach is consistent both with best regulatory practice and the academic literature. In addition, we are of the view that: (i) it is appropriate to set the WACC on a post-tax basis (reflecting the fact that firm profits must be distributed to tax authorities as well as to equity and debt holders); and (ii) that a CPI measure of inflation should be applied, as there is less scope for ex-post discrepancies between the present value of the ALF and the lump sum value of spectrum compared to an RPI measure (which is more volatile).

The analyses set out here show that, once contemporaneous evidence is taken into account, the appropriate WACC for determining the ALF is likely to be somewhat lower than that proposed by Ofcom (4.2% real post tax). Indeed, based on the midpoints identified for each WACC parameter outlined in this paper, the latest evidence would tend to suggest a real post-tax WACC of 3.8%. Our assumed parameters, which underpin this view, are summarised in the table below.

Table 6 WACC parameters for ALF consistent with latest evidence

WACC parameter	Ofcom's proposed ALF values	Values consistent with latest evidence (based on midpoints, shown to 1dp)
Real risk-free rate	1.5%	1.2%
Gearing	30%	35%
Equity risk premium	5.0%	5.6%
Asset beta	0.56	0.48
Debt premium	1.5%	1.8%
Overall real pre-tax cost of debt	3.0%	2.9%
Corporation tax rate	20.0%	20.2%
Inflation	2.5%	2.4%
Real pre-tax WACC	5.9%	5.4%
Real post-tax WACC	4.2%	3.8%

Source: Economic Insight

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Annex D Technical evidence shows that 1800MHz is much closer in value to 2.6GHz than to 800MHz.

Ofcom uses technical evidence to inform its 1800MHz UK lump-sum value, finding that 1800MHz has "*substantially better*" propagation characteristics and is a closer substitute for 800MHz than 2.6GHz.[46]

Ofcom concludes from this that 1800MHz cannot be less valuable than 2.6GHz in the UK.[47] The view that propagation characteristics deteriorate with frequency may also explain Ofcom's conclusion that the value of 1800MHz spectrum is about half-way between that of 800MHz and 2.6GHz spectrum.

However, in Three's view the technical analysis shows that 1800MHz is much closer in value to 2.6GHz than to 800MHz. The use of 1800MHz is categorically for capacity and its deployment scenario is similar to 2.6GHz. Neither frequency offers new market opportunities over a 2.1GHz network. However LTE 800MHz (even with 5MHz bandwidth), offers a large new market opportunity, due to the significantly increased coverage compared to a 2.1GHz network.

This Annex compares the relative coverage and capacity benefits of different spectrum bands. We first demonstrate that the area covered by 1800MHz is only marginally greater than that covered by 2.1GHz spectrum, which is particularly true when path loss differences are accounted for.

We then go on to establish how, even for a very large number of sites, propagation differences between 800MHz and 1800MHz result in significant and business changing population differences in all-important indoor locations, particularly where deep indoor penetration is concerned.

Next, we show that the value of 1800MHz spectrum in providing incremental capacity on an existing 2.1GHz network is the same as the value of 2.6GHz used for the same purpose, due to the ability of operators to efficiently load-balance their networks.

Finally we provide a high level illustration of the relatively high incremental value derived from low frequencies such as 800MHz, and demonstrate that the value derived from high frequency spectrum (1800MHz or 2.6GHz) is much lower than 800MHz.

[46] Paragraphs 4.43-4.44
[47] Paragraphs 4.45

Therefore, from a technical standpoint, analysis of how each frequency can actually be used in the real world demonstrates that the value of 1800MHz is very similar to the value of 2.6GHz, and significantly lower than the value of 800 MHz spectrum.

The coverage area of 1800MHz is only marginally greater than that of 2.1GHz, and much smaller than 800MHz.

Three agrees with Ofcom's advice to Government on the consumer and competition issues relating to liberalisation of 900MHz and 1800MHz spectrum for UMTS.[48] This stated that, unlike 900MHz, 1800MHz provides no material coverage advantage over 2.1GHz. The 1800MHz band is used for capacity.

> ***"1800 MHz liberalisation***
>
> ***1.16*** *Our analysis in February 2009 showed that use of liberalised 1800MHz spectrum for 3G provided no material advantage relative to 2100MHz spectrum for providing improved mobile broadband services, in terms of speed or coverage. Although liberalising the 1800MHz band for 3G could in principle offer significant extra capacity to T-Mobile and Orange (as they were then), in practice there was a lack of momentum in relation to compatible equipment, and operators had other options for increasing capacity such as acquiring the right to use additional spectrum in other bands and deploying more base stations".*

In our response to the second Ofcom consultation on the 800MHz and 2.6 GHz spectrum Auction, Three showed that the coverage of 800MHz is significantly greater than that of 1800MHz, 2.1GHz and 2.6GHz.[49]

The coverage differences between different frequencies are demonstrated below:

[48] Ofcom consultation - 13 Feb 2009; "Application of spectrum liberalisation and trading to the mobile sector
A further consultation"; [http://stakeholders.ofcom.org.uk/consultations/spectrumlib/advice-to-government/]

[49] "Three response to Ofcom second consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues"; Confidential response; Corrected version – re-submitted 26 March 2012

Figure 1: Coverage and bandwidth for each frequency layer

Source: Three.

According to [✂] the cell range and coverage area differences between different frequencies in an urban environment are shown in the following table.

Table 1: Frequency band and relative footprint size

Band	Cell range (km)	Area (km2)
2.6GHz	[✂]	[✂]
2.1GHz	[✂]	[✂]
1800MHz	[✂]	[✂]
800MHz	[✂]	[✂]

Source: COST 231.

This shows that the coverage area of 1800MHz is[✂]).

This cell range calculations can be compared with the values in the Real Wireless report commissioned by Ofcom in April 2012.[50]

[50] Real Wireless; "Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030"; April 2012; Version 1.16, page 93.

The report estimates the cell ranges for different frequency bands in different environments.

In Table 2 below we use the values from the Real Wireless report and compare cell range and coverage areas for each frequency in an urban environment.

Table 2: Real Wireless' relative footprint size.

Band	Cell range (km)	Area (km2)
2.6GHz	0.80	2.00
2.1GHz	-	-
1800MHz	1.12	3.93
800MHz	3.52	38.9

Source: Real Wireless.

The Real Wireless report confirms that there is a significant difference between 800MHz and 1800MHz cell range and coverage areas. Real Wireless estimates that the area coverage of 800MHz is 9.89 times larger than that of 1800MHz. This independent analysis therefore demonstrates [✂]

This calculation does not consider the device sensitivity difference between the two frequency bands. The following sub-section describes the difference between 1800MHz and 2.1GHz path losses.

The small coverage advantage of 1800MHz over 2.1GHz reduces when path loss differences are accounted for.

[✂]

Figure 2: Effect of sharper filter roll-off vs. duplex difference between 1800MHz and 2.1GHz bands.

[redacted]

Source: Three.

[redacted].[51][redacted]

[redacted].[52][redacted]

There are large differences in deep-indoor population coverage between 800MHz and 1800MHz.

Today, [redacted].[53]

[redacted]

[51] [redacted]
[52] [redacted]
[53] [redacted]

Figure 3: [✂]

[✂]

Source: Three.

[✂].[54] [✂]

[54] [✂]

Figure 4: [✂]

[✂]

Source: Three.

Figure 5 shows [✂]

Figure 5: [✂]

[✂]

Source: Three.

Table 3 presents [✂]

Table 3: [✂]

Source: Three.

The capacity value of 1800MHz on an existing 2.1GHz network is the same as the capacity value of 2.6GHz.

The averaged cell throughput for a medium loaded network for each frequency band varies as follows:

Table 4: Averaged cell throughput at different bands.

Band	Cell Throughput (Mbps)
800MHz	[✂]
1800MHz	[✂]
2.1GHz	[✂]
2.6GHz	[✂]

Source: Three, simulated results.

[✂]

Table 5: [✂][55].

[✂]

Source: Three.

Table 5 above shows that [✂]

[55] [✂]

The value that an operator derives from high frequency spectrum (1800MHz or 2.6GHz) is much lower than from 800MHz.

This section illustrates how the incremental EBIT benefit provided by the incremental coverage, capacity and speed of 1800MHz is small relative to the incremental value of 800MHz.

[✂]

Table 6: Net Present Value by band.

[✂]	[✂]
[✂]	[✂]
[✂]	[✂]

Source: Three.

Using this approach, [✂]

Conclusion: from a technical perspective, 1800MHz is much closer in value to 2.6GHz than to 800MHz.

In summary, 1800MHz and 2.6GHz should only be considered as efficient capacity offload bands for network traffic from a 2.1GHz layer. Conversely, 800MHz use is optimal as a coverage enhancement band offering new market opportunities.

In conclusion, 1800MHz and 2.6GHz layers are optimally used as efficient frequency bands from a technical capacity offload point of view. Hence, they should be treated similarly from a valuation standpoint for the purposes of the ALF considerations.

Annex E Statistical comparison of different benchmarking methods.

This Annex contains further details on the methods used to estimate 1800MHz value discussed in the main report, and a statistical analysis of the accuracy of those methods.

The estimation methods are summarised in the table below:

Table 5: Methods used to estimate UK 1800MHz value.

Method	Description
Ofcom absolute method	Observations of 1800MHz value are used to directly infer UK 1800MHz value
Ofcom combination of values method	A simple average of observed 800MHz and 2600MHz values
Ofcom relative method	The observed ratios of 1800:800Mhz, and 1800:2600MHz value in benchmark countries are applied to UK 800MHz and 2600MHz value to infer UK 1800MHz value
Corrected relative method	Three has developed an alternative method to estimate UK 1800MHz values using relative ratios (described below)
Distance method	The distance of 1800MHz value between 800MHz and 2600MHz values in benchmark countries is used to infer the distance of UK 1800MHz value between UK 800MHz and 2600MHz values

Source: Ofcom, Three.

We have compared two statistics in our analysis of the accuracy of each of the five methods above – the standard deviation of the UK estimated 1800MHz values for each method and the average absolute error for the predicted 1800MHz values among the benchmark countries.

With respect to the first statistic, we have calculated an estimate of UK 1800MHz value implied by each benchmark country for each estimation method. We then compare the standard deviation of the implied UK values given by each method to compare the extent of variation that each method gives.

With respect to the second statistic, we have tested the predictive power of each method by comparing their predictions of 1800MHz value in recent EU auctions against the actual 1800MHz price achieved in those awards. This allows us to rank the different methods based on the average absolute estimation error generated.

These summary statistics by method are presented in the table below:

Table 6: Observed spectrum values (UK-normalized, in £m/MHz).

Method	UK 1800MHz estimate	Standard deviation of UK estimates	Average absolute error
Ofcom absolute	12.0	10.8	8.5
Ofcom combination of UK values	16.7	NA	10.6
Ofcom relative	14.8	22.7	7.9
Corrected relative	9.2	16.0	6.7
Distance	9.3	5.1	7.0

Source: Three.

Key elements of approach to analysis in this Annex

There are a number of key assumptions in the analysis in this Annex that need to be highlighted:

– The group of comparator countries in this Annex differs from the benchmark countries presented in Ofcom's main report. The group includes all countries that have auctioned 1800MHz in Figure 4.2 of Ofcom's consultation (excluding Denmark and Spain)[56] and results from recent awards in Austria and the Czech Republic, which have become available since Ofcom's consultation.

[56] In Denmark and Spain, three incumbents were not allowed to bid for 1800MHz, so the resulting price does not represent market value.

– For the purposes of estimating UK 1800MHz value, both Three and Ofcom have categorised benchmarks as more and less important. In its estimate of UK 1800MHz value, Three has applied different weightings to the different categories. For the analysis that underpins this Annex, Three has assumed each of the benchmark countries has an equal weighting. Three has separately tested the sensitivity of the results presented in this Annex to changes in relative weightings and found that the impact of such changes was not material.
– We do not use the UK 800MHz value presented in Ofcom's consultation of £29.85m. This value includes the full contribution to DMSL. Rather, for the purposes of this Annex, we assume a 50% DMSL contribution. This gives a UK 800MHz value of £28.35m

The remainder of this is annex is structured as follows:
– a statistical analysis of the absolute method;
– a statistical analysis of the Ofcom combination of UK values method;
– a statistical analysis of the Ofcom relative method;
– a consideration of key characteristics of relative spectrum value ratios;
– a description of the corrected relative method and our statistical analysis of this method; and
– a statistical analysis of the distance method.

The Ofcom absolute method.

Observed 1800MHz spectrum values directly inform estimates of 1800MHz value under the Ofcom absolute method.

The group of comparator countries and their associated 800MHz, 1800MHz and 2600MHz UK-normalized spectrum values are shown in the table below.

Table 7: Observed spectrum values (UK-normalized, in £m/MHz).

Country	Country code	800MHz	1800MHz	2600MHz
Austria	AT	63.4	38.1	1.8
Czech Republic	CZ	42.7	5.6	2.8
Germany	DE	50.1	1.8	1.5
Greece[57]	EL	31.4	13.9	0
Ireland[58]	IE	58.6	23.1	0
Italy	IT	48.3	15.5	3.5
Portugal	PT	36.1	3.1	2.4
Romania	RO	21.8	6.2	2.5
Sweden	SE	14.3	9.1	9.7
Switzerland	CH	9.5	3.4	3.4
UK	UK	28.4		5.0
Average		**36.8**	**12.0**	**3.0**

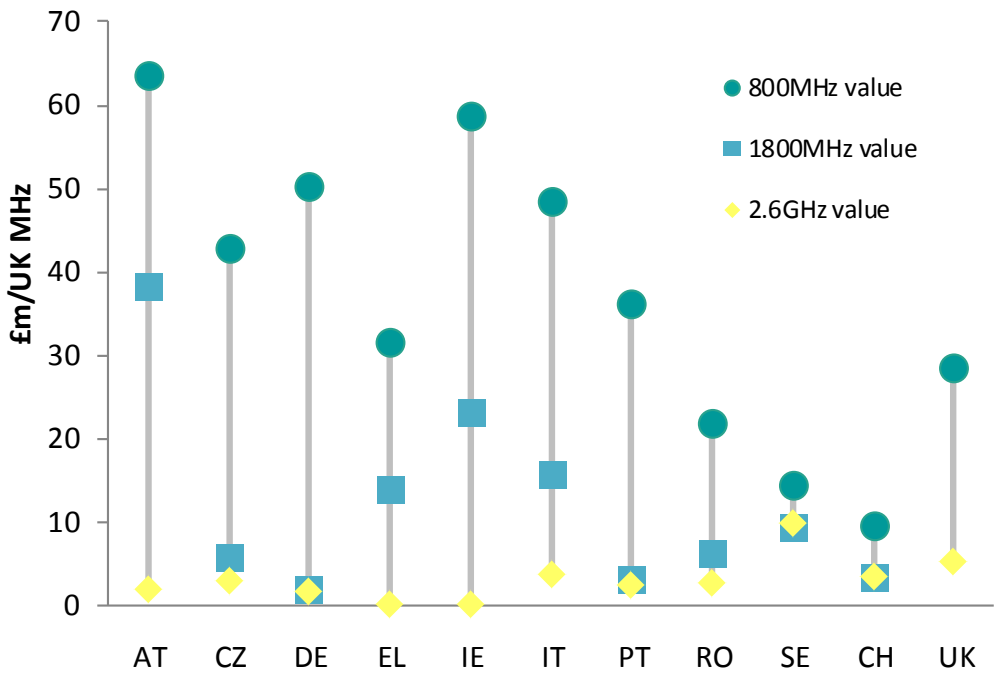
Source: Analysys Mason/Aetha Consulting.

These values are shown in the chart below:

[57] In Greece there have not been auctions for 800MHz or 2.6GHz spectrum. However, for the purposes of this analysis, we have assumed that in Greece the value of 800MHz spectrum is equal to the value of 900MHz spectrum (there has been an auction for 900MHz spectrum), and that the value of 2.6GHz spectrum is zero.

[58] In Ireland there has been no auction for 2.6GHz spectrum. As with Greece, we have assumed that the value of 2.6GHz spectrum in Greece is zero.

Figure 11: Observed spectrum values (UK-normalized, in £m/MHz).



Source: Three.

Ofcom absolute method estimates of UK 1800MHz value

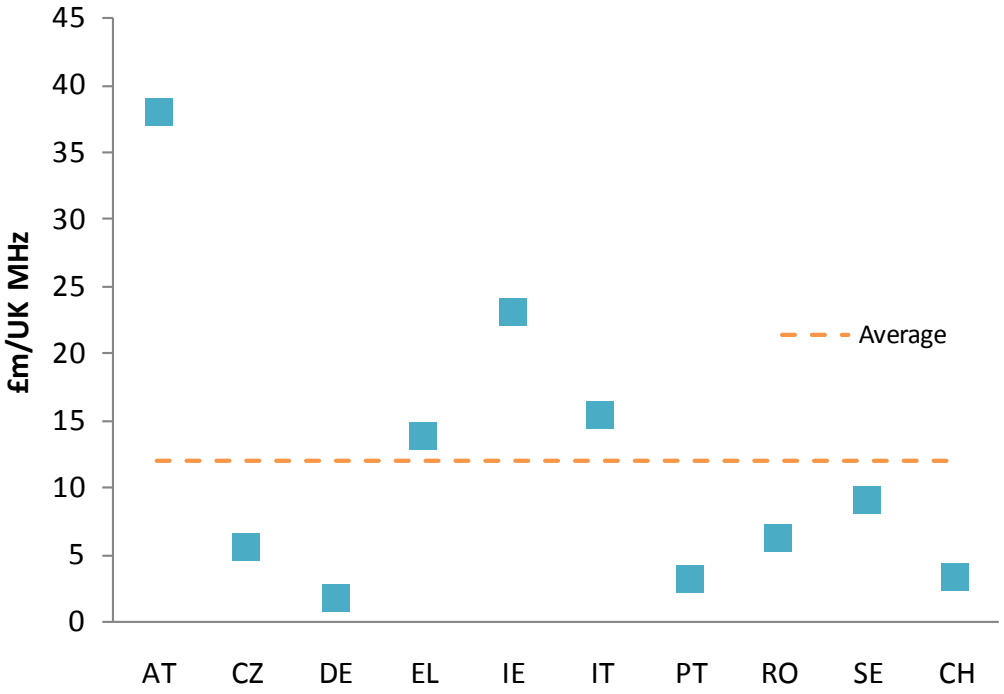
The implied UK 1800MHz value using the Ofcom absolute method is based only on the observed (UK-normalized) absolute 1800MHz values in the group of comparator countries (it does not take account of 800MHz or 2600MHz values). The implied UK value by benchmark country is equal to the observed 1800MHz value in the benchmark country. This is shown in the table and chart below:

Table 8: Ofcom absolute method estimation of UK 1800MHz value.

Country	Implied UK 1800MHz value
Austria	38.1
Czech Republic	5.6
Germany	1.8
Greece	13.9
Ireland	23.1
Italy	15.5
Portugal	3.1
Romania	6.2
Sweden	9.1
Switzerland	3.4
Average	**12.0**
Standard deviation	**10.8**

Source: Three.

Figure 12: Ofcom absolute method estimates of UK 1800MHz value by benchmark country.



Source: Three.

Ofcom absolute method estimates of benchmark countries 1800MHz value.

To test the predictive power, our estimation of 1800MHz values in each of the comparator countries according to the Ofcom absolute method is equal to the simple average of the 1800MHz across all countries within the comparator group. As stated in Table 7 above, this is equal to £12.0m per MHz. This method gives an average absolute error in predicted value across the group of benchmark countries of £8.5m.

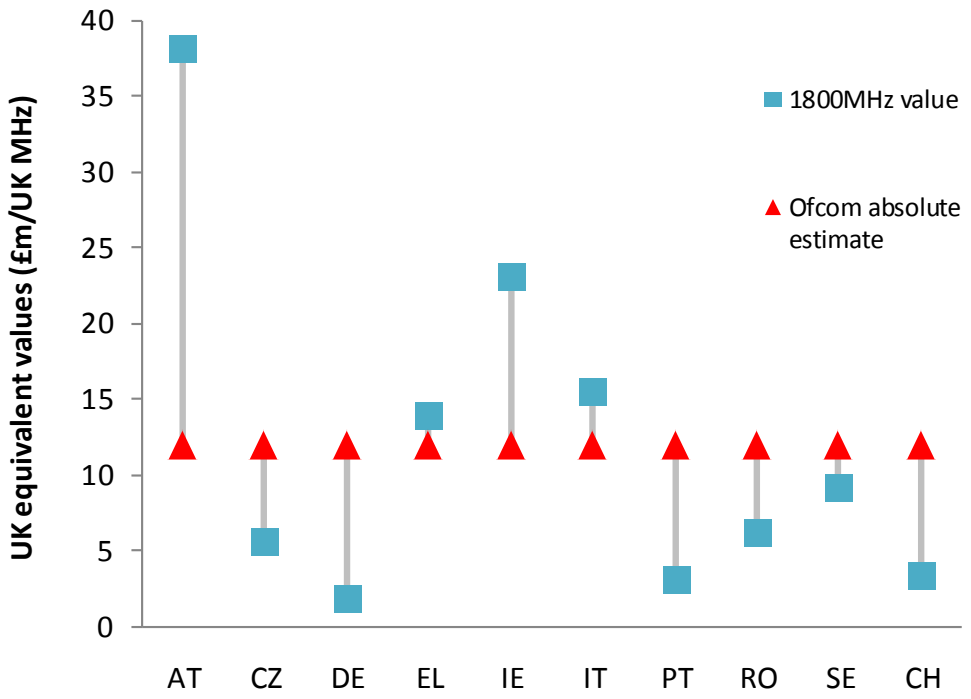
The Ofcom absolute method estimated 1800MHz value by benchmark country and the observed 1800MHz value are plotted in the table and chart below.

Table 9: Ofcom absolute method estimate of benchmark country 1800MHz value (UK-normalized, in £m/MHz)

Country	Estimated 1800MHz value in benchmark county
Austria	12.0
Czech Republic	12.0
Germany	12.0
Greece	12.0
Ireland	12.0
Italy	12.0
Portugal	12.0
Romania	12.0
Sweden	12.0
Switzerland	12.0
Average absolute error	**8.5**

Source: Three.

Figure 13: Ofcom absolute method estimates of benchmark country 1800MHz value (UK-normalized, in £m/MHz).



Source: Three.

The chart above shows that the observed 1800MHz values in each country are, in general, very different to the implied 1800MHz values using the Ofcom absolute method. The chart also highlights the key fundamental flaw with the Ofcom absolute method, which is that it takes no account of country specific factors (hence it does not vary at all by country, despite the fact that spectrum values across all bands do vary by country). As discussed in the main paper, Three considers that this flaw with the Ofcom absolute method means it should not be used to estimate UK 1800MHz value.

Ofcom combination of UK values method.

Ofcom has considered combinations of UK 800MHz and 2600MHz values to infer UK 1800MHz values. Specifically, it has considered the simple average, the linear interpolation and the exponential fit of those

two methods as a proxy for the 1800MHz value. For the purposes of this annex, we consider only the simple average approach.

Clearly, since the combination of UK values does not consider spectrum values from other countries, it does not generate estimates of UK value by benchmark country, and hence it is not possible to calculate the standard deviation of individual estimates of UK 1800MHz value given by the benchmark countries.

It is however possible to test the predictive power of this method amongst the group of benchmark countries. This is done by taking the average of the 800MHz and 2600MHz values in a given benchmark country to infer an estimate of 1800MHz value in that country. This estimate can then be compared to the observed value to test the predictive power of the method.

The table below shows the simple average of 800MHz and 2600MHz values by benchmark country (where available)[59] and the average absolute error of these estimates.

[59] Since 2600MHz spectrum values are unavailable for Greece and Ireland we do not produce estimates for these countries or include them in the calculation of average absolute error in this analysis.

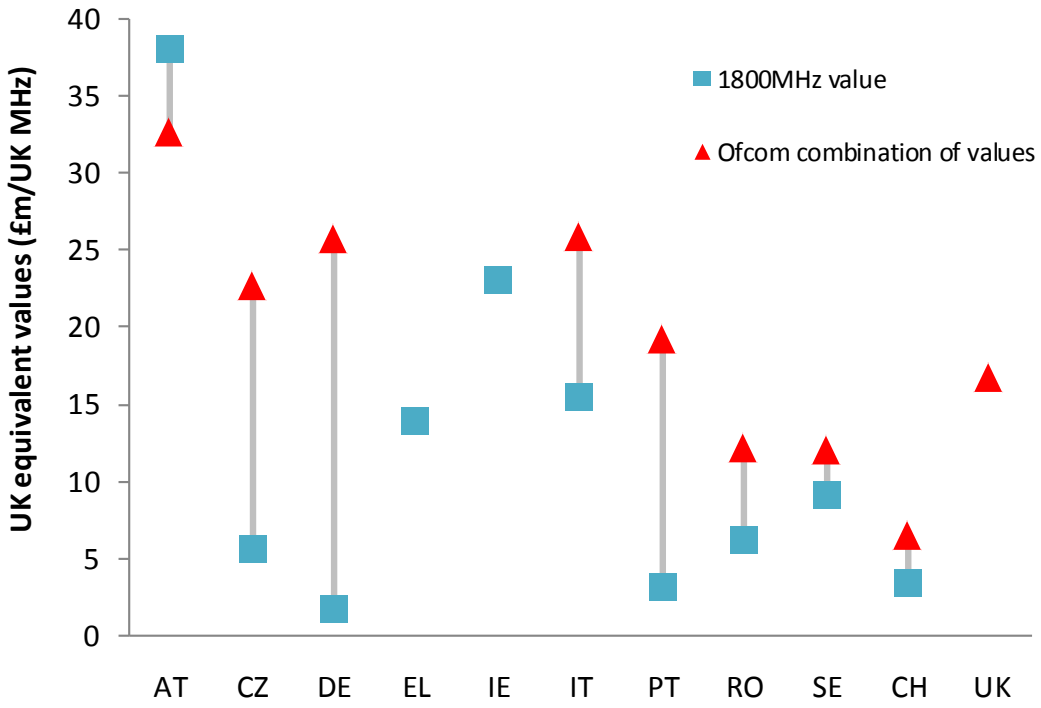
Table 10: Ofcom combination of UK values estimates of benchmark country 1800MHz value (UK-normalized, in £m/MHz).

Country	Average of 800MHz and 2600MHz
Austria	32.6
Czech Republic	22.8
Germany	25.8
Greece	NA
Ireland	NA
Italy	25.9
Portugal	19.3
Romania	12.2
Sweden	12.0
Switzerland	6.5
Average absolute error	**10.6**

Source: Three.

The chart below plots these 1800MHz estimates along with the observed 1800MHz values in the benchmark countries.

Figure 14: Ofcom combinations of UK value estimates of benchmark country 1800MHz value (UK-normalized, in £m/MHz).



Source: Three.

The table and chart above illustrate that the Ofcom combination of values method has a high level of error. Furthermore, the chart above shows that the method tends to significantly overestimate 1800MHz value when compared to observed 1800MHz value. In seven out of the eight benchmark countries in which we were able to replicate the Ofcom combination of UK values method, the method overestimated 1800MHz value, in some cases significantly.

Ofcom relative method.

Ofcom relative estimates of UK 1800MHz value.

The Ofcom relative method uses 1800:800 and 1800:2600 ratios from the benchmark countries. Estimates of UK 1800MHz value are derived

by multiplying observed UK 800MHz and 2600MHz values by the relevant ratio to give two relative estimates of UK 1800MHz value per benchmark country.[60]

We have defined the two estimates of UK 1800MHz value as:
- Z_{UK1} is the estimate of UK 1800MHz value in the UK using the 1800:800 ratio in the benchmark country; and
- Z_{UK2} is the estimate of UK 1800MHz value in the UK using the 1800:2600 ratio in the benchmark country.

In order to compile the various benchmark estimates of UK spectrum value to produce a single estimate of UK 1800MHz value, it is necessary to average the benchmark estimates. Ofcom has not explicitly averaged the benchmarks it has calculated using relative ratios, but for the purposes of this analysis, we use an arithmetic average of the implied UK values by benchmark.

Estimates of Z_{UK1} and Z_{UK2} and their arithmetic averages are presented in the table below:

[60] Note that in the cases of Greece and Ireland, no 2600MHz value is available, so the relative methods only produces one estimate of UK 1800MHz value in these countries (using the 1800:800 ratio).

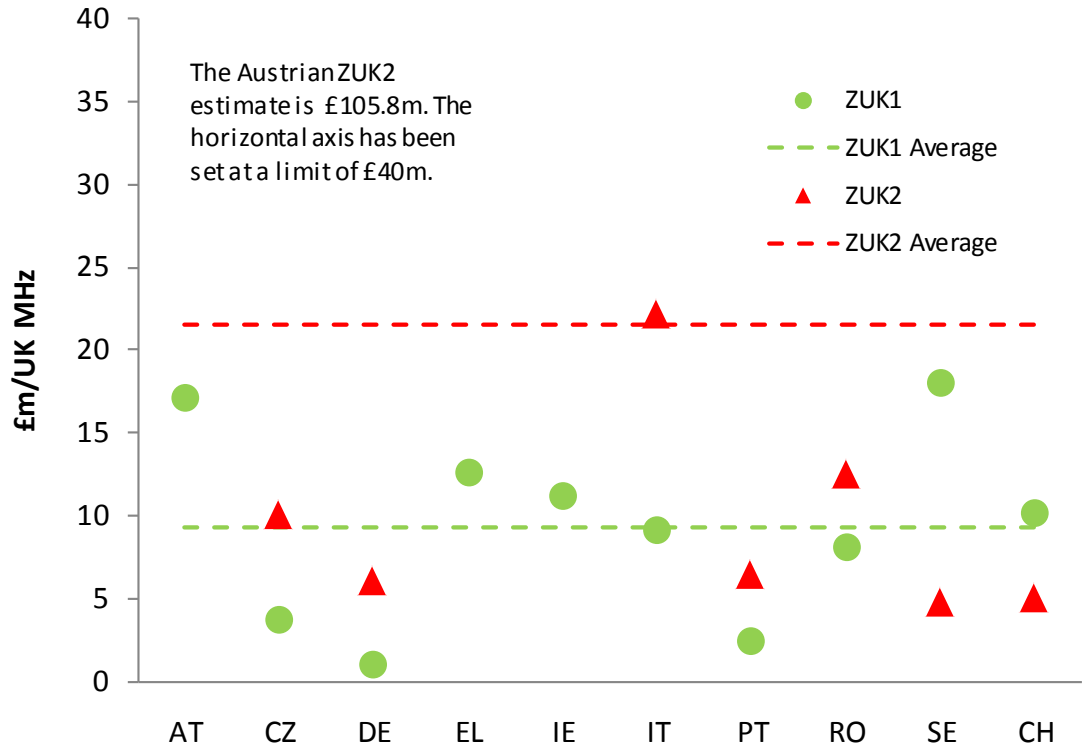
Table 11: Ofcom relative estimates of UK 1800MHz value.

Country	Z_{UK1}	Z_{UK2}
Austria	17.0	105.8
Czech Republic	3.7	10.0
Germany	1.0	6.0
Greece	12.5	NA
Ireland	11.2	NA
Italy	9.1	22.1
Portugal	2.4	6.5
Romania	8.1	12.4
Sweden	18.0	4.7
Switzerland	10.1	5.0
Arithmetic average	**9.3**	**21.6**
Average of all estimates	**14.8**	
Standard deviation of all estimates	**22.7**	

Source: Three.

The chart below plots all the points in the table above, along with arithmetic averages of the implied values which represent the estimate of UK 1800MHz value by ratio:

Figure 15: Ofcom relative estimates of UK 1800MHz value by benchmark country.



Source: Three.

Since Ofcom uses both ratios to present estimates of UK 1800MHz value, the relevant standard deviation is not the standard deviation of Z_{UK1} or Z_{UK2} estimates in isolation, rather it is the standard deviation of all the Z_{UK1} and Z_{UK2} estimates in combination. This gives a standard deviation of the Ofcom relative method of 22.7. Under this logic, the relevant average to give a single UK 1800MHz estimate under the Ofcom relative method is the average of all the estimates in the table above. This gives a value of £14.8m.

Ofcom relative method estimates of benchmark countries' 1800MHz value.

To test the predictive power of the Ofcom relative method, we have adapted the method slightly. Instead of applying spectrum valuation

ratios from individual countries, we take the average valuation ratios across the group of benchmark countries. That is, the 1800:800 ratio we use to estimate 1800MHz values in each of the benchmark countries is the average 1800:800 ratio across the group of comparator countries. Again, this average is the arithmetic average.

We have also made an additional change to the methodology for the purposes of calculating the predictive power of the Ofcom relative method. The Ofcom method as described above would result in two distinct estimates of 1800MHz value per benchmark country (one estimate for each of the relative ratios). In order to test the predictive power of the Ofcom relative method, it is necessary to calculate a single point estimate of 1800MHz value by benchmark country. In order to do this, we have averaged the two implied spectrum values by benchmark country to calculate a single 1800MHz estimate for the benchmark country.

Specifically, the estimates of 1800MHz values in country *i* are:

- $B_{OR1i} = \overline{X_A} \times 800_i$
- $B_{OR2i} = \overline{Y_A} \times 2600_i$

Where:

- $\overline{X_A}$ is the arithmetic average 1800:800 ratio across the group of comparator countries;
- $\overline{Y_A}$ is the arithmetic average 1800:2600 ratio across the group of comparator countries;
- 800_i is the value of 800MHz spectrum in country *i;* and
- 2600_i is the value of 2.6GHz spectrum in country *i*

The average of the relative estimates of 1800MHz in country *i* is then equal to:

$$\overline{B}_{ORi} = (0.5 \times \overline{X_A} \times 800_i) + (0.5 \times \overline{Y_A} \times 2600_i)$$

The table below presents the estimated 1800MHz values using the Ofcom relative method by benchmark country, and the average absolute error of these estimates compared to the observed 1800MHz values in the benchmark countries.

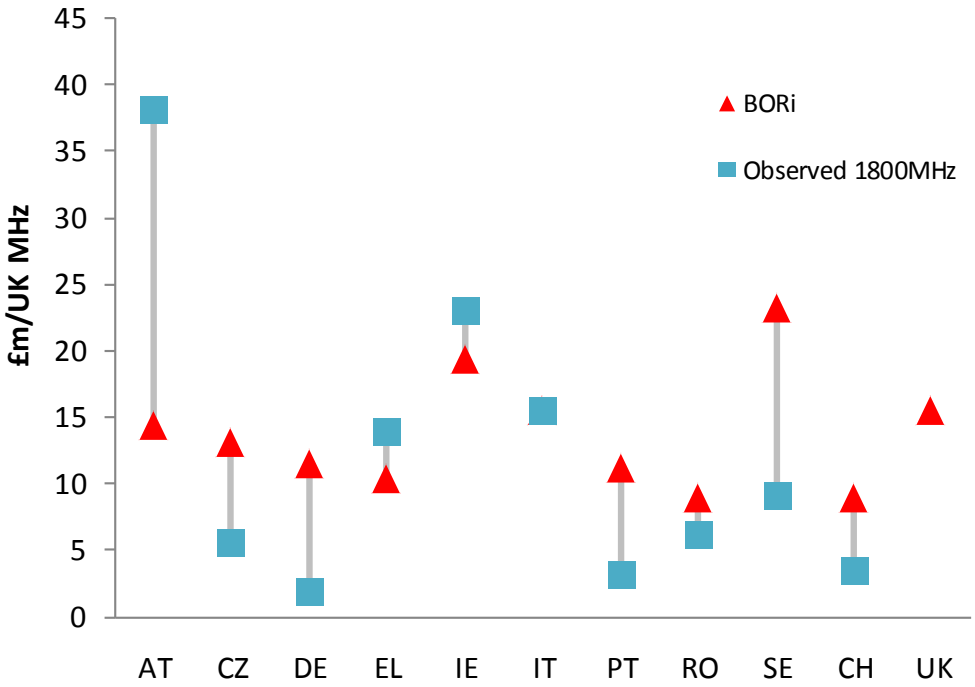
Table 12: Ofcom relative estimates of benchmark country 1800MHz values (UK-normalized, in £m/MHz).

Country	B_{OR1i}	B_{OR2i}	$\overline{B}_{ORi}$
Austria	20.9	7.8	14.3
Czech Republic	14.0	12.1	13.1
Germany	16.5	6.5	11.5
Greece	10.3		10.3
Ireland	19.3		19.3
Italy	15.9	15.1	15.5
Portugal	11.9	10.4	11.1
Romania	7.2	10.8	9.0
Sweden	4.7	41.8	23.3
Switzerland	3.1	14.7	8.9
Average absolute error of method	**6.3**	**12.2**	**7.9**

Source: Three.

The chart below plots $\overline{B}_{ORi}$ and observed 1800MHz values in the benchmark countries:

Figure 16: Ofcom relative estimates and observed 1800MHz values in benchmark countries (UK-normalized, in £m/MHz).



Source: Three

A consideration of the key characteristics of relative ratios means the Ofcom relative method should be adapted.

Our analysis of the characteristics of relative ratios has highlighted a number of flaws with Ofcom's use of relative ratios. These are explained below, along with the corrected relative method that Three has developed to estimate 1800MHz values using relative ratios.

Ofcom's application of relative ratios is not robust and gives rise to a wide variation in estimated UK 1800MHz values.

In the Ofcom relative method, UK 1800MHz values are estimated using the ratio of either 1800:800 or 1800:2600 values from individual countries, and applying these ratios to the UK 800MHz or 2600MHz value as appropriate.

As we show in Section 2 of our response, using the two ratios from individual benchmark countries (as Ofcom has done) gives rise to significantly different estimates of UK 1800MHz value for a given country depending on which ratio is used. The algebraic proof for this effect is laid out below:

Where:

- 800_i = 800MHz value in country *i*;
- 2600_i = 2600MHz value in country *i*;
- 1800_i = 1800MHz value in country *i;*
- k is the ratio of 800MHz value (800_B) to 2600MHz value (2600_B) in the benchmark country and is a factor used to express 800MHz value (800_B) in terms of 2600MHz value (2600_B) in the benchmark country
- c is the ratio of 800MHz value (800_{UK}) to 2600MHz value (2600_{UK}) in the UK, and is used in the proof below to express 800MHz value (800_{UK}) in terms of 2600MHz value (2600_{UK})

It follows that the estimated 1800MHz values in the UK are defined:

- $Z_{UK1} = ({}^{1800_B}/_{800_B}) \times 800_{UK}$
- $Z_{UK2} = ({}^{1800_B}/_{2600_B}) \times 2600_{UK}$

Defining 800MHz values in both the benchmark country and the UK as a function of 2600MHz values in the respective countries gives:

- $Z_{UK1} = ({}^{1800_B}/_{k2600_B}) \times c2600_{UK}$

Therefore, for the two relative ratios in the benchmark country to provide an equal estimate of the UK 1800MHz value (i.e. $Z_{UK1} = Z_{UK2}$), the following condition must hold:

- $({}^{1800_B}/_{k2600_B}) \times c2600_{UK} = ({}^{1800_B}/_{2600_B}) \times 2600_{UK}$

Solving shows that for the two relative ratios to provide equal estimates of UK 1800MHz values, c must equal k, or in other words the relative ratios of 800:2600 value must be equal in the UK and the benchmark country.

In cases where $c \neq k$:

– $Z_{UK1} > Z_{UK2}$ if $c > k$
– $Z_{UK1} = Z_{UK2} \times c/k$

For instance, if the 800:2600 ratio in the UK (c) is twice that in the benchmark country (k), then Z_{UK1} will be twice Z_{UK2}. A comparison of the 800:2600 spectrum ratios across the group of benchmark countries with the 800:2600 spectrum ratio in the UK along with the factor difference (c/k) in UK 1800MHz values that the relative ratios will give is shown in the table below:

Table 13: Difference in 800:2600 relative ratios in UK and benchmark countries.

Country	800:2600 MHz	c/k
Austria	35.2	0.2
Czech Republic	15.3	0.4
Germany	33.4	0.2
Greece	NA	NA
Ireland	NA	NA
Italy	13.8	0.4
Portugal	15.0	0.4
Romania	8.7	0.7
Sweden	1.5	3.8
Switzerland	2.8	2.0
UK	**5.7**	

Source: Three calculations.

From the ratio *c/k* in Table 13 above and the values of Z_{UK1} and Z_{UK2} in Table 11 above, the following can be seen.

– in almost all instances the 800:2600 ratio was greater in the benchmark country than in the UK (the exceptions are Sweden and Switzerland);

– the difference in this ratio gives rise to very large differences in UK 1800MHz values depending on which ratio is used (represented by the factor *c/k*). In Austria and Germany, this difference is more than fivefold; and
– in most cases Z_{UK2} is much higher than Z_{UK1} reflecting the fact that the 800:2600 ratio is lower in the UK than the benchmark countries (the reverse is true using data from Sweden and Switzerland).

The wide dispersion in estimated UK 1800MHz values using the two ratios is evidence of a number of key features of implied spectrum values using relative ratios:

– firstly, that using two relative ratios in isolation from a given country will result in inconsistent estimates of UK 1800MHz values from that benchmark country;
– secondly, that the magnitude of these inconsistencies is very significant; and
– thirdly, when selecting a subset of relative UK 1800MHz values, from a group of benchmark countries, the implied UK 1800MHz value will vary significantly depending on the countries included in that subset.

The implication of this is that to minimise the variation in estimates, both relative valuation ratios should be incorporated in the estimate of UK 1800MHz value from a given benchmark country. This would reduce the variation in estimates as it partly controls for the respective difference in 800:2600 ratio between the benchmark country and the UK.

A further implication of the large variation in implied values is that as many data points should be included in the analysis as possible (this is consistent with the approach we have adopted for the distance method).

In contrast, in its use of relative ratios, Ofcom fails to control for the difference in the 800:2600 ratios between the benchmark countries and the UK, giving rise to very inconsistent estimates of UK 1800MHz value.

Ofcom then compounds this inconsistency by selecting a small subset of the implied valuations from the benchmarks, rather than taking an average across the group of benchmarks. As discussed above, the UK 1800MHz values implied by a subset of the wider group of

benchmarks can vary hugely depending on which countries are included in that subset.

When using relative ratios geometric means rather than arithmetic means should be used.

In our assessment of the predictive power of the Ofcom relative method described above, we have used the same principles as Ofcom, but have adapted the approach somewhat. Instead of applying spectrum valuation ratios from individual countries, we take the average ratios across the group of countries. That is, the 1800:800 ratio we use to estimate 1800MHz values is the average 1800:800 ratio across the group of comparator countries.

When calculating the average of the ratio across a number of countries, it is important to consider whether scaling impacts means the geometric average rather than the arithmetic average should be used. If the scaling for each ratio is different, then a geometric mean should be used.

When considering the possible range of the two ratios (assuming 800MHz is greater in value than 1800MHz, and 1800MHz is greater in value than 2600MHz), the scales for the two ratios are as follows:
– the range for the 1800:800 ratio is 0-100%
– the range for the 1800:2600 ratio is 100% to infinity.

The implication of this is that a proportionate change in either ratio can result in a very different absolute value change, and would therefore have a very different impact on an arithmetic average.

This is illustrated in the example below:

A first benchmark country (B1) has the following spectrum values:
– 800MHz = £40m
– 1800MHz = £10m
– 2600MHz = £3m

A second benchmark country (B2) has the same 800MHz and 2600MHz values, but an 1800MHz value that is twice B1's (i.e. £20m). The relative ratios and implied UK values given by each ratio are shown in the table below:

Table 14: Illustration of ratio scaling effects.

	1800:800	1800:2600	UK (1800:800)	UK (1800: 2600)
B1	25%	333%	7.5	16.7
B2	50%	667%	15.0	33.3
Proportionate difference (B2/B1)	200%	200%	200%	200%
Absolute difference (B2 – B1)	25 percentage points	333 percentage points	£7.5m	£13.3m

Source: Three calculations.

From the table, the following observations can be made:

– the proportional difference in relative ratios and implied UK 1800MHz values between B1 and B2 is equal to the difference in 1800MHz value between B1 and B2 (i.e. double);
– however the absolute difference is very different for both the ratios (in terms of percentage points) and for implied spectrum values (in £m); and
– therefore, the impact of the difference in 1800MHz value between the two countries on an arithmetic average of the relative ratios or the implied UK spectrum value would be very different depending on whether the 1800:800 or 1800:2600 ratio was being considered.

The difference in impact on the arithmetic mean is due to the difference in scales discussed above. In contrast, if a geometric mean is applied, the difference in scales is controlled for. Therefore, in contrast to the arithmetic mean, a given proportionate increase in the relative ratios/values would have the same proportionate impact on the geometric mean for the 1800:800 and 1800:2600 ratios.[61]

[61] A similar analysis on the individual ratios (either the 1800:800 or 1800:2600), also shows that the geographic mean has to be used. In the case of the individual ratios, the 1800:800 ratio should be invariant to the 1/800:1800 ratio (similarly, the 1800:2600 ratio should be invariant to the 1/2600:1800 ratio). However, the difference in scales of the two ratios (1800:800 has a range of 0-100%, but 800:1800 has a range of 100%+) means that the invariance condition does not hold when using arithmetic means. In contrast the invariance condition does hold when using the geometric mean.

Furthermore, if rather than averaging relative ratios, the implied spectrum values are averaged, then the same issue arises and geometric averages should be utilised. To see this consider the difference in scales of 1800MHz estimates:

– Z_{UK1} has an upper limit equal to the value of 800MHz spectrum
– Z_{UK2} has no upper limit.

Three notes that of the other methods considered, neither the Ofcom absolute method, Ofcom combination of values method or the distance method suffers from the issue with scale that affects the relative method and that therefore, using arithmetic averages is appropriate in those instances.

Corrected relative method: Correctly applying benchmark relative spectrum values.

In summary, our above analysis indicates that when using relative ratios, three important characteristics have to be captured:

1 Both the 1800:800 and 1800:2600 ratios must be used, as differences in the 800:2600 ratio between benchmark countries and the UK can lead to large differences in estimated UK 1800MHz value by relative ratio;
2 Relative ratios from individual countries can give very different estimates of UK 1800MHz value by country. Therefore as many countries as possible should be included in the derivation of lump sum 1800MHz value; and
3 When averaging across countries, geometric means rather than arithmetic means should be used (whether it is relative ratios or implied 1800MHz values that are being averaged).

Corrected relative method: Estimating UK 1800MHz values

Under the corrected relative methods two changes are made to the application of the Ofcom relative method presented above.

Firstly, instead of calculating two estimates of UK 1800MHz value per benchmark country using each of the relative ratios, the two estimates are combined in an average. That is:

– $1800_{UKCRi} = (Z_{UK1i} + Z_{UK2i})/2$

Where:

- 1800_{UKCRi} is the estimate of UK 1800MHz value implied by country i under the corrected relative method
- Z_{UK1i} is the estimate of UK 1800MHz value implied by country i using the 1800:800 ratio in country i
- Z_{UK2i} is the estimate of UK 1800MHz value implied by country i using the 1800:2600 ratio country i

Secondly, when all estimates of UK 1800MHz value under the corrected relative method are combined to provide a single estimate of UK 1800MHz value, geometric averages are incorporated as follows:

- a geometric average of all values of Z_{UK1i} is calculated
- a geometric average of all values of Z_{UK2i} is calculated
- a simple average of these two geometric averages is taken to calculate the final estimate of UK 1800MHz value under the corrected relative method.[62]

The table below presents the estimates of the corrected relative data points discussed above:

[62] Since values of 1800_{UKCRi} are calculated using a combination of two ratios with different scales, it would be incorrect to take a geometric average of these values. Hence the need to take separate geometric averages of Z_{UK1i} and Z_{UK2i} and combine these using a simple average to get a single estimate of UK 1800MHz value under the corrected relative method.

Table 15: Corrected relative estimates of UK 1800MHz value.

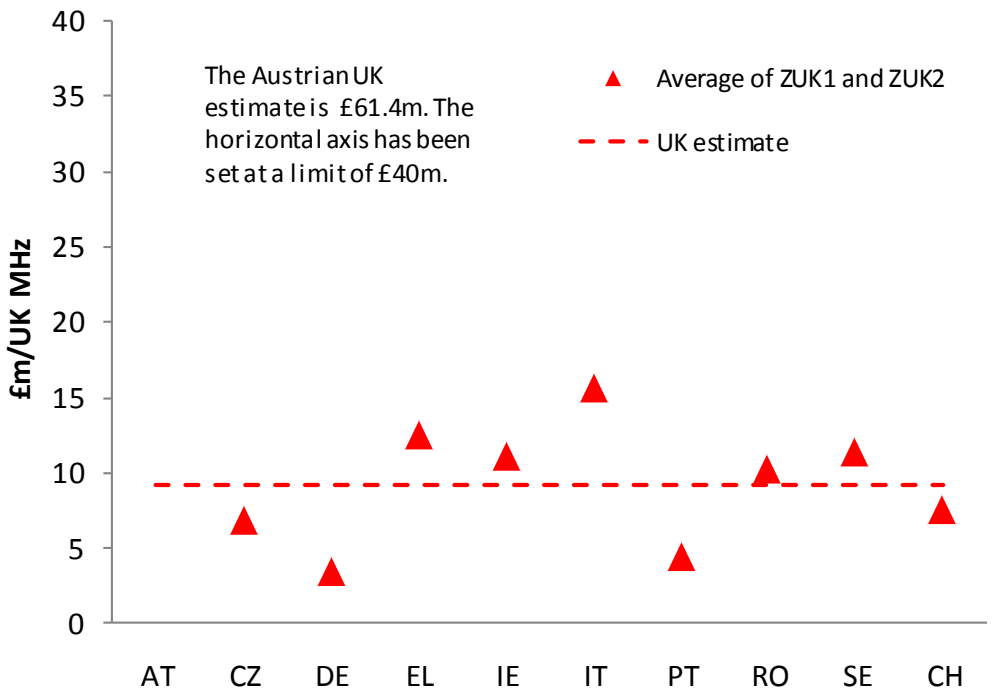
Country	Z_{UK1i}	Z_{UK2i}	1800_{UKCRi}
Austria	17.0	105.8	61.4
Czech Republic	3.7	10.0	6.9
Germany	1.0	6.0	3.5
Greece	12.5		12.5
Ireland	11.2		11.2
Italy	9.1	22.1	15.6
Portugal	2.4	6.5	4.4
Romania	8.1	12.4	10.2
Sweden	18.0	4.7	11.4
Switzerland	10.1	5.0	7.6
Standard deviation	**5.5**	**32.3**	**16.0**
Geometric average	**7.0**	**11.3**	**NA**

Source: Three.

Taking the simple average of the two geometric averages in the table above (£7.0m and £11.3m), gives a single estimate of UK 1800MHz value under the corrected relative approach of £9.2m.

The individual country estimates of UK 1800MHz value using the corrected relative method are plotted in the chart below.

Figure 17: Corrected relative method: Estimates of UK 1800MHz value.



Source: Three.

Corrected relative method: Estimating benchmark 1800MHz values

Incorporating these characteristics, we have calculated the estimate of 1800MHz values in the UK and all other benchmark countries under the corrected relative method. Specifically, the estimates of 1800MHz in country *i* using the corrected relative method are equal to:

- $1800_{CR1i} = \overline{X_G} \times 800_i$
- $1800_{CR2i} = \overline{Y_G} \times 2600_i$
- $1800_{\overline{CR}i} = (0.5 \times \overline{X_G} \times 800_i) + (0.5 \times \overline{Y_G} \times 2600_i)$

Where:

- $\overline{X_G}$ is the geometric average of the 1800:800 ratios across the group of comparator countries;

– $\overline{Y_G}$ is the geometric average of the 1800:2600 ratios across the group of comparator countries;
– 800_i is the value of 800MHz spectrum in country *i;* and
– 2600_i is the value of 2600MHz spectrum in country *i*

The table below presents the respective 1800:800 and 1800:2600 spectrum valuation ratios, across the group of comparator countries as well as the benchmark group geometric average:

Table 16: Relative spectrum ratios.

Country	1800:800	1800:2.6
Austria	60%	2117%
Czech Republic	13%	200%
Germany	4%	120%
Greece	44%	NA
Ireland	39%	NA
Italy	32%	443%
Portugal	9%	129%
Romania	28%	248%
Sweden	64%	94%
Switzerland	36%	100%
Geometric average	***25%***	***226%***

Source: Three calculations.

In the first two columns of the table below, the average ratios calculated above are applied to each country's 800MHz and 2600MHz values to derive estimates of $1800_{3\mathrm{PR1i}}$ and $1800_{3\mathrm{PR2i}}$. In the final column, the table shows the 1800MHz using the (equally) weighted average of these two valuations as per the formula above to give $1800_{\overline{3\mathrm{PRi}}}$.

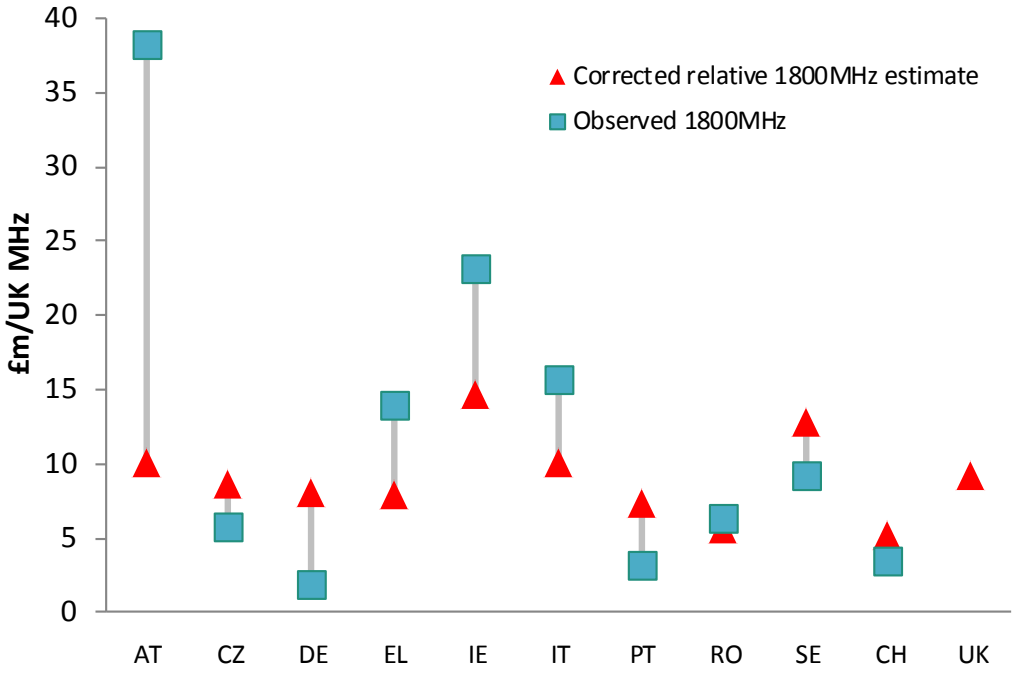
Table 17: Corrected relative method estimate of benchmark country 1800MHz value (UK-normalized, in £m/MHz).

Country	1800_{3PR1i}	1800_{3PR2i}	$1800_{\overline{3PRi}}$
Austria	15.7	4.1	9.9
Czech Republic	10.6	6.3	8.5
Germany	12.4	3.4	7.9
Greece	7.8		7.8
Ireland	14.5		14.5
Italy	12.0	7.9	9.9
Portugal	9.0	5.4	7.2
Romania	5.4	5.6	5.5
Sweden	3.5	21.9	12.7
Switzerland	2.4	7.7	5.0
UK	7.0	11.3	9.2
Average absolute error (UK not included)	**6.9**	**8.0**	**6.7**

Source: Three calculations.

The chart below plots the estimates of 1800MHz value according to the corrected relative method in the benchmark countries and the observed 1800MHz values in those countries.

Figure 18: Corrected relative method: Estimates and observed 1800MHz values in benchmark countries (UK-normalized, in £m/MHz).



Source: Three.

This table and chart illustrate the difference that using geometric averages makes, compared to using arithmetic averages.

Calculating the UK 1800MHz value using the 1800:800 ratio:
– Ofcom's relative method (arithmetic averages) gives: £9.3
– Corrected relative method (geometric averages) gives: £7.0m

Calculating the UK 1800MHz value using the 1800:2600 ratio:
– Ofcom's relative method (arithmetic averages) gives: £21.6
– Corrected relative method (geometric averages) gives: £15.4m

The single point UK 1800MHz value under the two approaches is:
– Ofcom's relative method (arithmetic averages) gives £14.8m
– Corrected relative method (geometric averages) gives: £9.2m

The distance method.

Three has developed an alternative method for estimating the 1800MHz UK value – namely, considering the value of 1800MHz in relation to both 800MHz and 2600MHz together, or "distance" method.

The distance method measures the distance ratio D as the difference between the 1800MHz and 2600MHz values in recent EU auctions, as a proportion of the distance between the 800MHz and 2600MHz values in those awards. The method then applies D to the 800MHz and 2600MHz values in the UK to generate an estimate of 1800MHz UK value.[63]

The distance method: estimating UK 1800MHz value

The table below shows the calculated D by benchmark country, and the implied UK 1800MHz value by benchmark country.

[63] i.e. D equals (1800 price-2.6 price)/(800 price -2.6 price) in the auction in question. The absolute difference between the 800MHz and 2.6GHz values in the UK is multiplied by D and added to the 2.6GHz value to arrive at the 1800MHz UK estimate

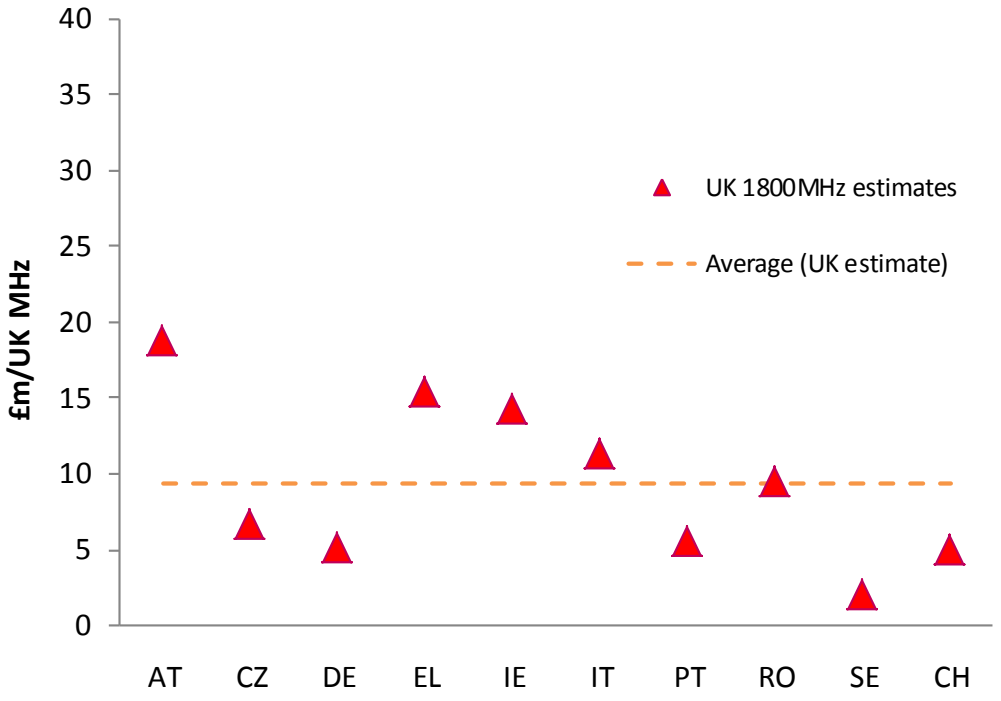
Table 18: Distance method parameter ("D") and implied 1800MHz value (UK-normalized, in £m/MHz).

Country	D	Implied UK 1800MHz value
Austria	59%	18.8
Czech Republic	7%	6.6
Germany	1%	5.1
Greece	44%	15.3
Ireland	39%	14.2
Italy	27%	11.3
Portugal	2%	5.5
Romania	19%	9.5
Sweden	-13%	2.0
Switzerland	0%	5.0
Arithmetic average	19%	9.3
Standard deviation		5.1

Source: Three calculations.

The following chart plots UK 1800MHz values implied by the distance method.

Figure 19: The distance method UK 1800MHz value estimates.



Source: Three.

The distance method: estimating benchmark country 1800MHz value

Our test of the predictive power of the Distance method takes the average distance (the "D") of the 1800MHz value between the 800MHz and 2600MHz values across the group of comparator countries, and applies this average "D" to the 800MHz and 2600MHz values in each benchmark country. The implied 1800MHz value in the benchmark countries using the average "D" (19%), and the average absolute error of these estimates is shown in the table below:

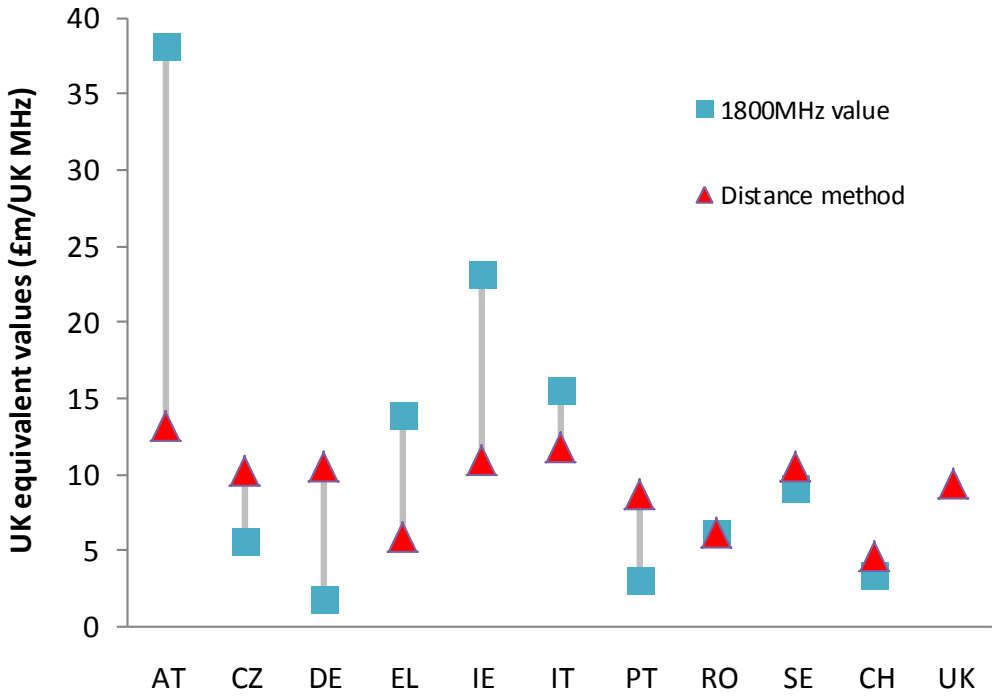
Table 19: Distance method implied benchmark 1800MHz values (UK-normalized, in £m/MHz).

Country	1800MHz estimate
Austria	13.2
Czech Republic	10.2
Germany	10.5
Greece	5.8
Ireland	10.9
Italy	11.8
Portugal	8.6
Romania	6.1
Sweden	10.6
Switzerland	4.5
UK	9.3
Average absolute error (UK not included)	7.0

Source: Three calculations.

The chart below plots each benchmark country's distance method implied 1800MHz value, and the observed 1800MHz value by benchmark country.

Figure 20: Observed and distance method implied 1800MHz spectrum values in benchmark countries



Source: Three

Conclusion: The Ofcom absolute and Ofcom relative methods should be discounted, while the corrected relative and distance method provide valid estimates of UK spectrum value. The distance method is more statistically robust than the corrected relative method, but both give similar estimates of UK 1800MHz value.

The table below summarises our statistical analysis of the various estimation methods:

Table 20: Observed spectrum values (UK-normalized, in £m/MHz).

Method	UK 1800MHz estimate	Standard deviation of UK estimates	Average absolute error
Ofcom absolute	12.0	10.8	8.5
Ofcom combination of values	16.7	NA	10.6
Ofcom relative	14.8	22.7	7.9
Corrected relative	9.2	16.0	6.7
Distance	9.3	5.1	7.0

Source: Three.

As we have discussed above, we consider that the issues associated with the Ofcom absolute method and Ofcom combination of values methods means they should be discounted as a method for estimating UK 1800MHz value. Therefore, for the remainder of this Annex we concentrate on the two relative methods and the distance method.

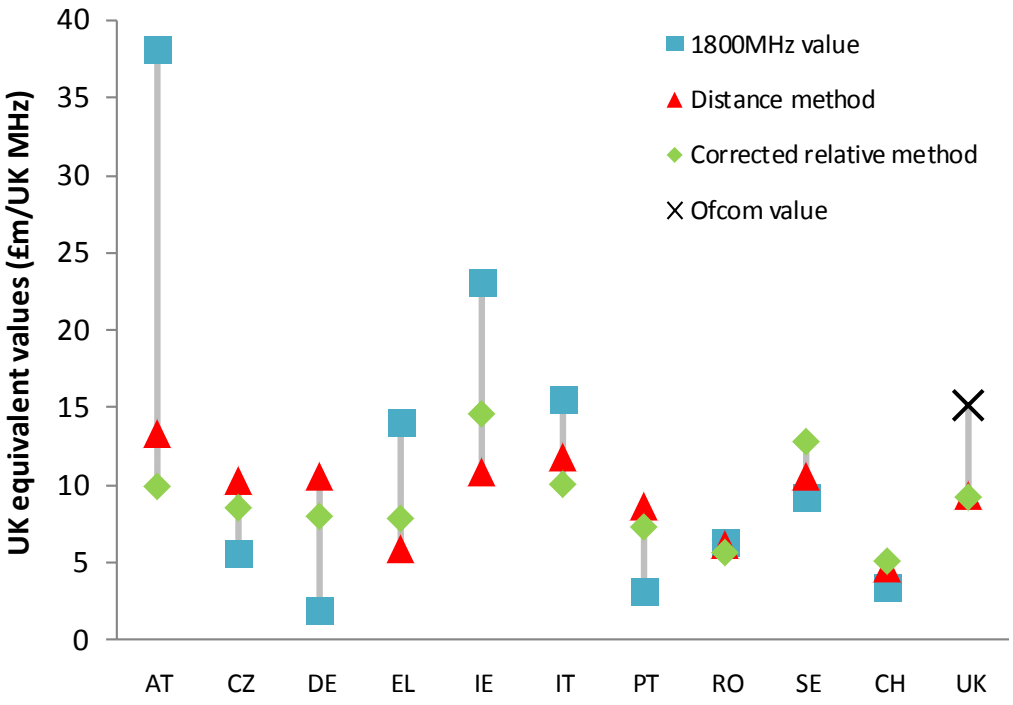
When using the relative ratios relevant to the UK 1800MHz value, a number of key characteristics must be considered and incorporated in the estimation methodology. These characteristics mean that Ofcom's use of relative ratios – the Ofcom relative method – is flawed.

In order to apply relative ratios correctly to the estimation of 1800MHz values, Three has developed the corrected relative method. Our statistical analysis supports the assertion that the corrected relative method is more robust than the Ofcom relative method (the standard deviation of UK estimates and average absolute error is lower with the corrected relative method). Three therefore considers that if relative ratios are to be used for the estimation of UK 1800MHz values, the corrected relative method rather than the Ofcom relative method should be used.

On this basis, the key question is whether the distance or corrected relative method is the most appropriate for estimating UK 18000MHz value.

The chart below compares the estimates of 1800MHz value in the benchmark countries produced by the distance and corrected relative method.

Figure 21: Comparison of corrected relative and distance method predictive power



Source: Three

From this chart it is apparent that the distance method estimates of 1800MHz value are closer to observed 1800MHz values in five out of ten instances, while the corrected relative method also gives a more accurate prediction in five out of ten instances. A comparison of the average absolute errors of the 1800MHz estimates given by the two methods also shows little difference.

However, a comparison of the standard deviation of UK 1800MHz estimates shows that the distance method gives a lower variation in estimates than the corrected relative method, indicating that the distance method is preferable to the corrected relative method.

In conclusion, when deciding between the corrected relative method and distance method, although one of the statistical tests is inconclusive (the absolute error of benchmark predictions), our other statistical test (the standard deviation of UK estimates) suggests the distance method is preferable. In any event, we consider the proximity of the estimates of UK 1800MHz value implied by both methods to be supportive evidence of the values implied by both methods.

Annex F Ofcom's classification of its data raises the average 1800MHz value from £8.7m to £15m per MHz.

Section 3 explains that Ofcom's classification of its benchmark evidence progressively increases its 1800MHz UK value from the £8.7m per MHz average produced by its three methods to the final £15m per MHz.

In particular, Ofcom's methods yield (up to) three different value estimates from each benchmark country. This generates 30 estimates of 1800MHz UK value from 11 countries, including the UK. Ofcom handles this evidence as follows:

– Ofcom omits 10 out of the 30 potential 1800MHz UK values;
– of the remaining 20 data points, Ofcom classifies 11 observations as more important and 9 as less important;
– finally, Ofcom arrives at its 1800MHz UK value based on the range of values derived for each category.

Table 1 below documents the individual data points, Ofcom's classification and the average values in each category.

Table 1: Ofcom's assessment of its 1800MHz values.

	All	More and less important	More important only
Netherlands NSR	18.8	18.8	
Netherlands reserve	1.6	1.6	
Netherlands 1800/800	7.1[64]		
Ireland 1800	23.1	23.1	23.1
Ireland 1800/800	11.8	11.8	11.8
Germany 1800	1.8	1.8	
Germany 1800/800	1.1		
Germany 1800/2.6	5.9		
Italy 1800	15.5	15.5	15.5

[64] Ofcom disregards New Street Research's 800MHz value. NSR values 800MHz in the Dutch auction at $1.8/MHz/pop, which may be used to calculate the relative 1800/800 value.

Italy 1800/800	9.6	9.6	9.6
Italy 1800/2.6	21.9	21.9	21.9
Portugal 1800	3.1	3.1	
Portugal 1800/800	2.6		
Portugal 1800/2.6	6.4		
Spain 1800	2.9	2.9	
Spain 1800/800	2.8		
Spain 1800/2.6	4.6		
Romania 1800	6.2	6.2	6.2
Romania 1800/800	8.5	8.5	8.5
Romania 1800/2.6	12.3	12.3	
Sweden 1800	9.1	9.1	9.1
Sweden 1800/800	19.0	19.0	19.0
Sweden 1800/2.6	4.6		
Greece 1800	13.9	13.9	13.9
Denmark 1800	1.0	1.0	
Denmark 1800/800	3.0		
Denmark 1800/2.6	0.5		
UK simple average	17.4	17.4	17.4
UK linear interpol	16.0	16.0	
UK inverse exp	11.0	11.0	
Average	**8.7**	**11.2**	**14.2**

Source: Three, based on Figures 4.2 and 4.5 of the Consultation.

Annex G Ofcom should carry out a proper Impact Assessment.

Ofcom must consider the impact of its ALF proposals on competition, future investment or consumer retail prices.

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

An impact assessment (or "IA") is required by s.7 of the Communications Act 2003 ("2003 Act") where the proposal appears to Ofcom to be "important". In practice, Ofcom will undertake one in relation to the great majority of its policy decisions, according to its Better Policy Making Guidelines (the "Guidelines").[65]

Section 7(4) of the 2003 Act states:

> "*An assessment under subsection (3)(a) must set out how, in OFCOM's opinion, the performance of their general duties (within the meaning of section 3) is secured or furthered by or in relation to what they propose*."

The issues listed are aspects of Ofcom's general duties under both s.3 of the 2003 Act and other relevant statutory duties. The relevant provisions are:

1. **Competition**: Framework Directive, Article 8(2)(b); 2003 Act, s. 3(1)(b), 3(4)(b), 4(3)(a); Wireless Telegraphy Act 2006 ("2006 Act"), s. 3(2)(d);
2. **Promoting future investment**: 2003 Act, s.3(4)(d), s.4(8)(aa); 2006 Act, s.3(2)(c);
3. **Consumer retail prices**: Framework Directive Article 8(2)(a); 2003 Act s.3(1)(a), s.3(5), s.4(5), s.4(8)(b).

Ofcom is therefore under statutory duty to set out how the performance of these duties would be secured or furthered "by or in relation to what they propose" in the Consultation.

The Guidelines set out Ofcom's approach to IAs and were relied upon in, for example, Vodafone [2008] CAT 22 (see paras 47, and 91 on IAs generally) and Hutchison 3G [2008] CAT 11 (para 181)). The relevant paragraphs are set out below:

[65] Better Policy Making: OFCOM's approach to Impact Assessment, issued on 21 July 2005 ("the Guidelines") para 4.1

"2.1. … Subject to the principle of proportionality, an Impact Assessment will generally:

- *identify the impacts of each option on the interests of particular groups of stakeholders [this could include the potential impact on their ability or willingness to make future investments];*
- *identify any impacts which each option would have on competition;*
- *identify and, where possible, quantify the costs and benefits flowing from the impacts which each option would have;*
- *assess the key risks associated with each option.*

2.2. In making regulatory decisions, we should select the option most closely aligned with Ofcom's principal duty, which is to further the interests of citizens in relation to communications matters and to further the interests of consumers in relevant markets, where appropriate by promoting competition.

3.3. At the outset we should identify the issue to be addressed and the options available to us. In doing so, we should continue to bear in mind the need for options to be linked with our statutory duties…

3.9. Producing an Impact Assessment also helps make transparent the consideration of the impact of our policies on the interests of different groups of stakeholders. Given Ofcom's principal duty, it is particularly important for us to identify the impact of options on the interests of citizens and consumers, including particular groups of citizens and consumers…

5.4. Producing an Impact Assessment will normally involve six stages:

- *defining the issue we need to consider and identifying the citizen or consumer interest (stage 1);*
- *defining the policy objective (stage 2);*
- *identifying the options (stage 3);*
- *identifying the impacts on different types of stakeholders (stage 4);*
- *identifying any impacts on competition (stage 5);*
- *assessing the impacts and choosing the best option (stage 6).*

> *5.10. …As mentioned above, the objective should always be linked to our statutory duties, both to our principal duty to further the interests of citizens and consumers …*
>
> *5.32. A related issue is that of possible unintended consequences. In selecting and assessing the different options, our aim will be to think widely about the possible impacts, taking account of possible knock-on effects across the communications sector, including other parts of the value chain, and on existing regulation*" (emphasis added).

Ofcom clearly recognises that it is under such a duty in the Consultation.[66] However, in Three's view Ofcom has not conducted a proper assessment of these matters. We discuss below the treatment of the impact on competition, future investment and consumer retail prices in the Consultation.

Ofcom has not discharged its duty to consider the impact on competition.

As far as Three can ascertain, the impact on competition is not directly considered or assessed in any detail anywhere in the Consultation. Ofcom's ALF proposals were first presented in its 4G auction consultation, specifically in the First Competition Assessment (March 2011), Second Competition Assessment (January 2012) and July 2012 Statement.

These documents set out Ofcom's competition assessment for the 4G auction (see Sections 5, 4 and 4 respectively). The sections on ALFs for 900MHz and 1800MHz (Sections 8, 10 and 12 respectively) were concerned with the interpretation of the Government Direction and on the approach that would be taken to calculating revised ALFs. They did not contain any detailed analysis of the potential impact on competition of the proposed options for revising ALFs.

Paragraph 6.10 of the current Consultation, discussing the options in relation to the introduction of ALF, states:

> "*There is the potential for such a payment separation to have an effect on competition although, given the scale of the differential*

[66] Paragraph 2.21 states that the analysis in the Consultation, in particular in Sections 4, 5 and 6 and Annex 9, constitutes an impact assessment. Paragraph 3.35 then states that in making its proposals Ofcom has considered its principal and other duties

> *effect compared to the size of operators' relevant business, any such effect may be limited*."

There is no further discussion of how this may impact on competition, why the effect may be limited, the scale of the potential problem or the likelihood of it materialising.

Ofcom does not consider the impact on future investment.

Similarly, Ofcom discusses the potential impact of its proposals on future investment indirectly and in the context of other (unrelated) discussions. This is clearly insufficient to discharge its duty.

In its assessment of the duration of the revised ALF fees, Ofcom states:[67]

> "… *Elsewhere, when spectrum fees are introduced, or changed, so as to make them reflective of opportunity cost, we would normally expect to set out a period during which we would not expect to carry out a further review. As was explained in the SRSP, the purpose of this is to provide a degree of certainty about the future level of fees when licensees take investment decisions or consider options for trading*."

Paragraph 6.22 then invites respondents to express a view on how long such a period should be. No further assessment is made of the likely impact on future investment of different possible periods.

The only other discussion of the impact of ALFs on future investment is in the context of Ofcom's assessment of the risks of setting fees too high or too low. By and large, the discussion simply states that i) ALFs could affect investment decisions;[68] and ii) although setting ALF too high or too low could fail to incentivize efficient investment decisions, there is no clear reason to expect that risk to be asymmetric.[69]

Paragraph A9.45 then concludes as follows in relation to the risk of setting ALF above or below market value:

> "*Spectrum prices have an important role in informing efficient investment decisions and encouraging efficient use of spectrum. In this context, we do not consider that there are material*

[67] Paragraph 6.21 of the Consultation
[68] Paragraphs A 9.6 and A9.14 of the Consultation
[69] Paragraph A 9.4 and A9.6 6 of the Consultation

> *sources of asymmetry as between the effects of ALFs being set too high or too low. That is, in terms of incentivising efficient use of spectrum compared to alternative inputs such as network investments, ALFs that are too low and ALFs that are too high both have the potential to distort efficient choices by sending the wrong price signals*."

No assessment is made as to the impact that ALFs which are set too high or too low may have on investment decisions or of the likelihood of this occurring. As far as Three can ascertain, nowhere else in the Consultation is the impact on future investment directly considered.

Ofcom does not consider the impact on consumer retail prices.

Finally, Ofcom's discussion of the impact on retail prices is also insufficient to discharge its duty to consider the impact of their proposals on the interests of (1) citizens in relation to communications matters; and (2) of consumers in relevant markets, in particular in relation to their impact on consumer retail prices.

Again, Ofcom's discussion of these issues is only indirect and in the context of its assessment of the relative risks of setting fees too high or too low. In the relevant parts, the discussion merely points out that to the extent that ALF affects consumer prices, setting ALF too low could distort downstream price signals, because this could lead operators to seek more spectrum at the expense of other users.[70]

The conclusion of that section is that: [71]

> "*In summary, whilst there are risks to the efficiency of use by current licence holders, we see no clear reason why there should be an asymmetry in this regard as between (inadvertently) setting ALFs that are above true market value and (inadvertently) setting ALFs that are below true market value*."

These passages do not adequately address the impact of Ofcom's proposals on consumer retail prices. There is no assessment of the likely impact on consumer prices of Ofcom's actual ALF proposals. No explanation or analysis is given of the likelihood that setting ALFs too low may distort downstream market signals. No evidence is given for

[70] Paragraphs A 9.5 and A 9.46 of the Consultation
[71] Paragraph A 9.47 of the Consultation

the conclusion that there is no asymmetry between the two types of risk.

The possible impact on consumers of failing to phase-in the ALF increases is identified. This is not explored in any detail but relates more to the potential impact on delivery of services to consumers rather than on retail prices. Ofcom concludes that any detrimental impact is unlikely to materialise.[72]

The impact on consumer retail prices is not directly considered or assessed in any detail anywhere else in the Consultation.

[72] Paragraphs 6.17-6.20 of the Consultation

Annex H Response to Ofcom consultation questions.

Q1: Do you agree with the approach that we propose to deriving a lump sum estimate of spectrum value for 900MHz and 1800MHz spectrum?

No. Three does not agree with Ofcom's proposed approach to deriving a lump sum estimate for 900MHz and 1800MHz spectrum.

In particular, this is because Three considers that Ofcom's lump-sum values do not reflect full market value (as required by the Government Direction), as:

- other country evidence shows that 1800MHz is much closer in value to 2.6GHz than to 800MHz;
- Ofcom's benchmarking methodologies contain major flaws;
- Ofcom's classification of the benchmarks contains large inconsistencies;
- a proper benchmarking approach produces a much lower 1800MHz lump-sum value; and
- Ofcom's proposed 1800MHz lump-sum value does not adequately reflect technical and other evidence.

Please see Sections 1-5 of Three's response plus related Annexes (A, D, E, F and I) for further details.

Q2. Do you have any comments on our assessment of the lump sum value of (a) a licence for 900MHz spectrum; or (b) a licence for 1800MHz spectrum?

Yes. Please see Sections 1-5 of Three's response plus related Annexes (A, D, E, F and I).

Q3. Do you agree with our approach to annualising the proposed lump sum value, including the cost of capital which we propose to use?

Three agrees with Ofcom's general approach to annualising the proposed lump value.

Three nevertheless disagrees with Ofcom's calculation of the proposed annual fees, as:

- Ofcom's proposed discount rate should be the risk-free rate, not the cost of capital; and
- Ofcom's proposed tax adjustment is invalid.

Please see Sections 6 and 7 of Three's response, plus related Annexes B and C.

Q4. Do you agree that fees should be specified in constant real terms and should be adjusted annually in the light of changes to RPI?

Three agrees that the fees should be specified in constant real terms.

Three nevertheless disagrees that the fees should be adjusted annually in the light of changes to RPI. The fees should be adjusted in the light of changes to CPI, not RPI. Please see Section 8 and Annex C of Three's response for further detail.

Q5. Do you agree that revised fees should be implemented in a manner which has an effect such that all licences are charged higher fees simultaneously even though payment dates of individual licensees may vary?

Yes, Three agrees that revised fees should be implemented in a manner which has the effect such that all licensees are charged higher fees simultaneously. Please see Section 9 of Three's response for further details.

Q6. Do you agree it is appropriate that revised fees should be payable in full as soon as practicable after revised fee regulations are made.

No. Three agrees only that the fees should be payable in full subject to the Government Direction, Licence Charges Regulations and statutory requirement for Ofcom to carry out an Impact Assessment.

Three considers that Ofcom's current proposals are inconsistent with the Licence Charges Regulations and Government Direction, and that Ofcom has not carried out a proper Impact Assessment. Please see Section 9 and Annex G of Three's response for details.

Q7. Do you have any views about the minimum period that should elapse before we should consider revising fees again?

Yes. In the interest of certainty, Three considers that there should be a minimum period of three years before Ofcom should consider revising fees again.

Three notes that there can rapid changes in the full market value of spectrum, reflecting market, economic and technological changes. Three therefore considers that Ofcom should implement an explicit mechanism for licensees to request a review of fees, in the event of material changes in the value of spectrum.

Ofcom would then have to conduct a review or show why no such material change in the value of spectrum had occurred. This would be similar to the interim review type mechanism in regulated industries, whereby regulated companies can request an interim review determination in the event of material unexpected market changes.

Annex I [✂]