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

Analysys Mason Limited
St Giles Court
24 Castle Street
Cambridge CB3 0AJ
UK
Tel: +44 (0)1223 460600
Fax: +44 (0)1223 460866
cambridge@analysysmason.com
www.analysysmason.com
Registered in England No. 5177472

Aetha Consulting Limited
Terrington House
13–15 Hills Road
Cambridge CB2 1NL
UK
Phone: +44 (0)1223 755 575
Fax: +44 (0)20 7183 3716
enquiries@aethaconsulting.com
www.aethaconsulting.com
Registered in England No. 7716768

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.

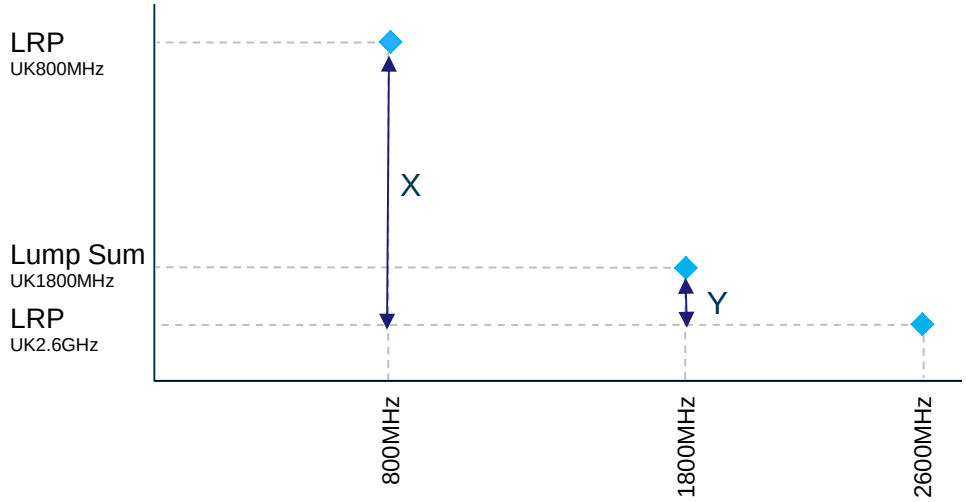
This leads us to propose a simpler, more robust approach that results in a single relative value for each benchmark country, which takes into account the relativities to both the 800MHz and the 2.6GHz benchmarks: the 'distance method'. We describe this method and why it is superior to Ofcom's relative-value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



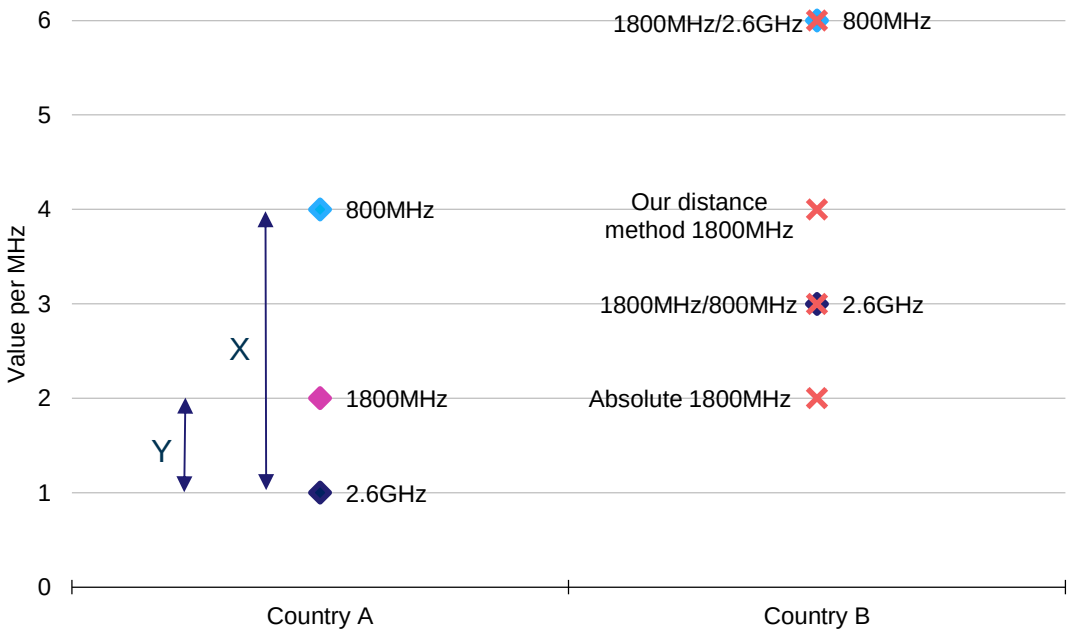
The following example explains why the distance method yields a more accurate value for the 1800MHz band than the absolute-value- or relative-value-based approaches used by Ofcom. We consider two countries, A and B, that are in essence identical (e.g. same population, currency, licence conditions) and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

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 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.

---

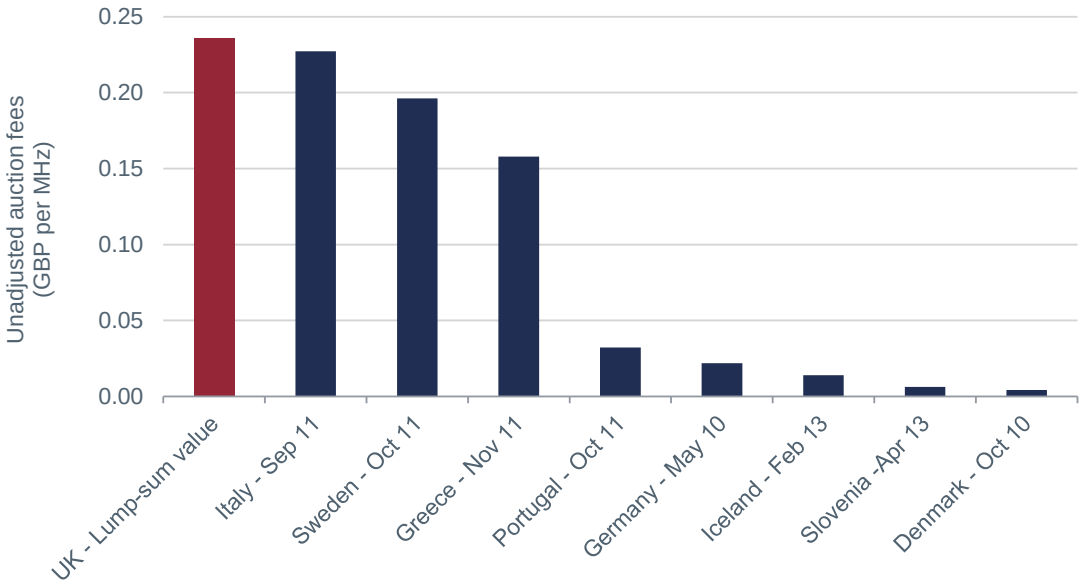
10 DotEcon and Aetha (2012), *Spectrum value of 800MHz, 1800MHz and 2.6GHz*, Executive Summary.

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]

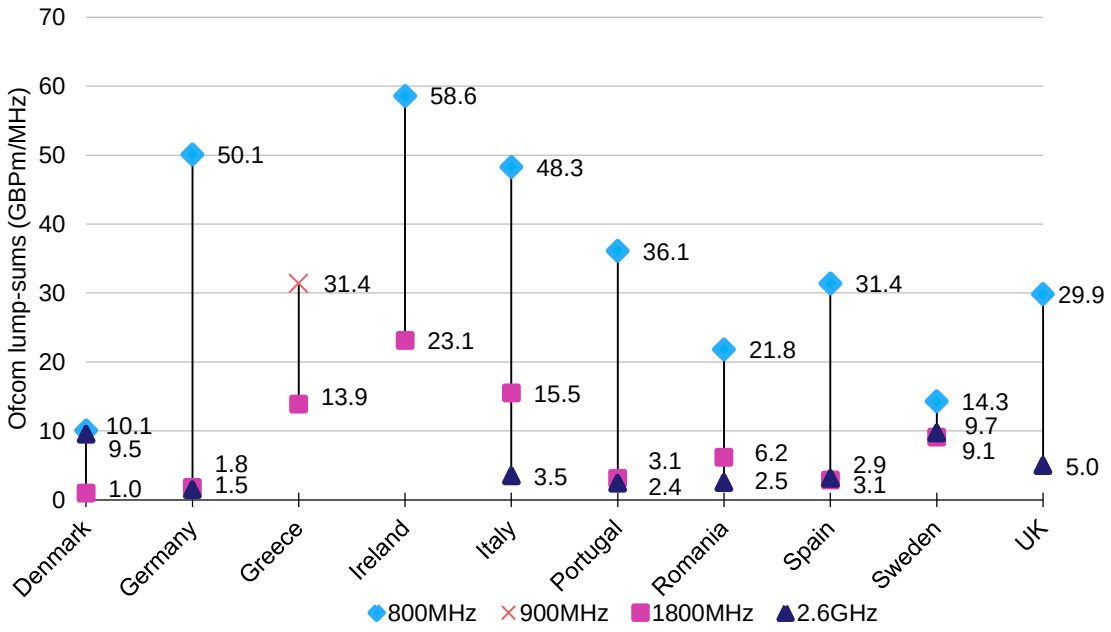


4. The proposed 1800MHz lump-sum value is only slightly below a simple average of the 800MHz and 2.6GHz LRPs; yet the results of recent European auctions overwhelmingly show that the value of 1800MHz spectrum is much closer to the value of 2.6GHz than 800MHz, as shown in Figure 3.2 below.[15]

[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.

---

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.

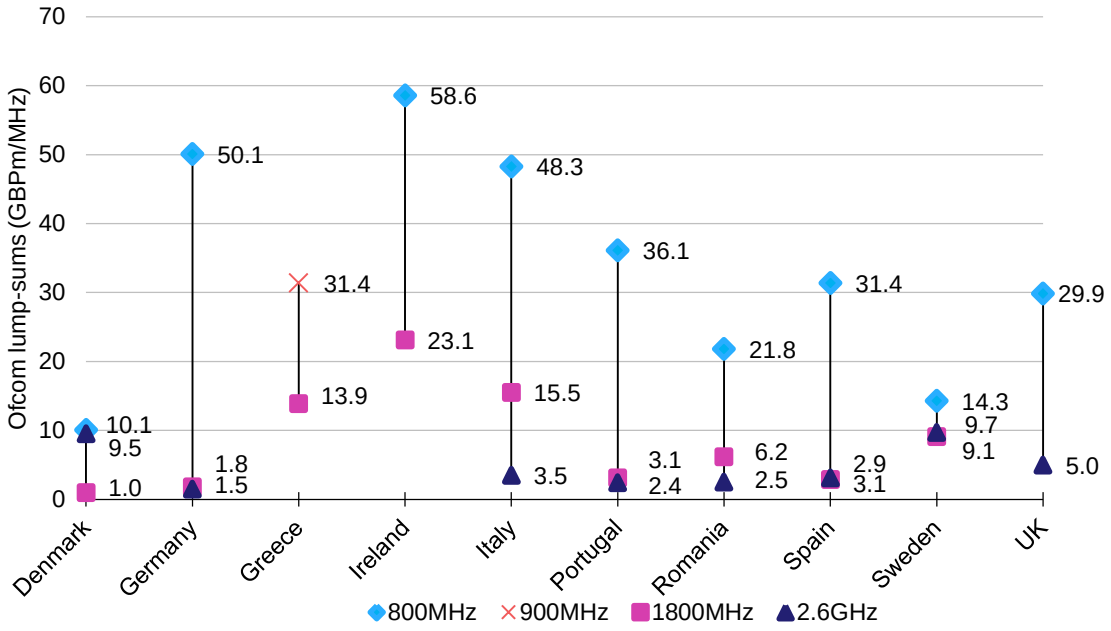
23 As discussed in later sections, it may be the case that not all of these benchmarks should be considered as reliable evidence. However, for the purposes of this cross-check we include them. Conversely, we do not include benchmarks in the above cross-check which were not available to Ofcom at the time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

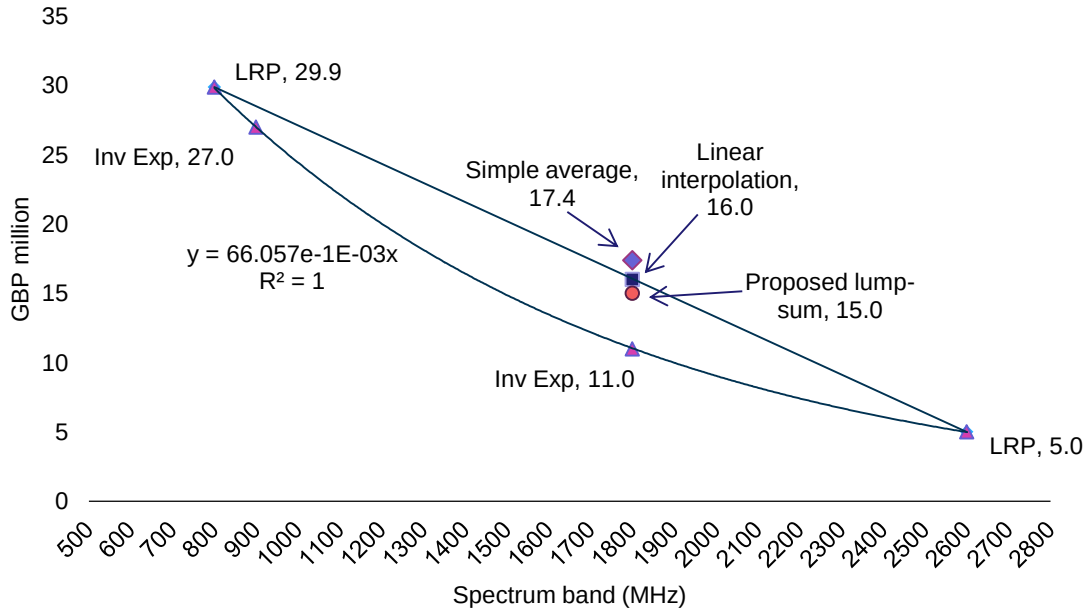
4.3.2 Evidence from academia

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.

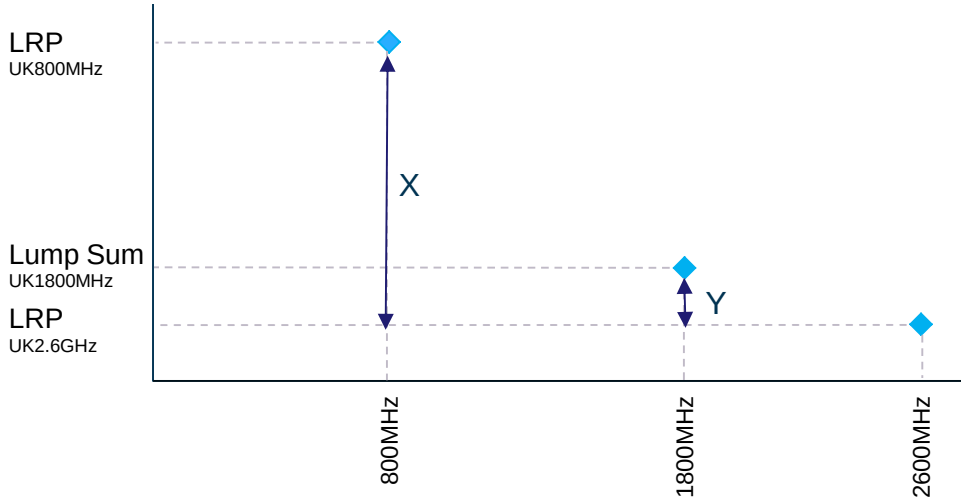
This is due to the inherently superior propagation characteristics of the 800MHz band, compared to higher frequency bands, which allow for operators to realise much greater network cost savings. Typically, the better quality of service provided by networks using 800MHz spectrum also allows for increased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

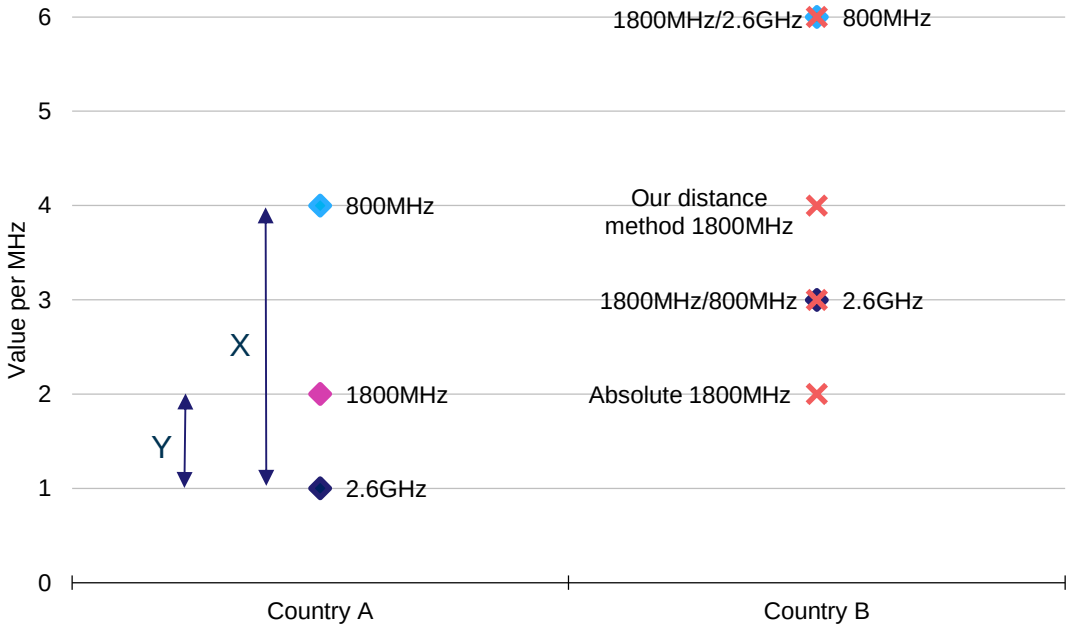
The following example explains why the distance method yields a more accurate value for the 1800MHz band than the absolute value or relative value based approaches used by Ofcom. We consider two countries, A and B, that are in essence identical (e.g. same population, currency, licence conditions) and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

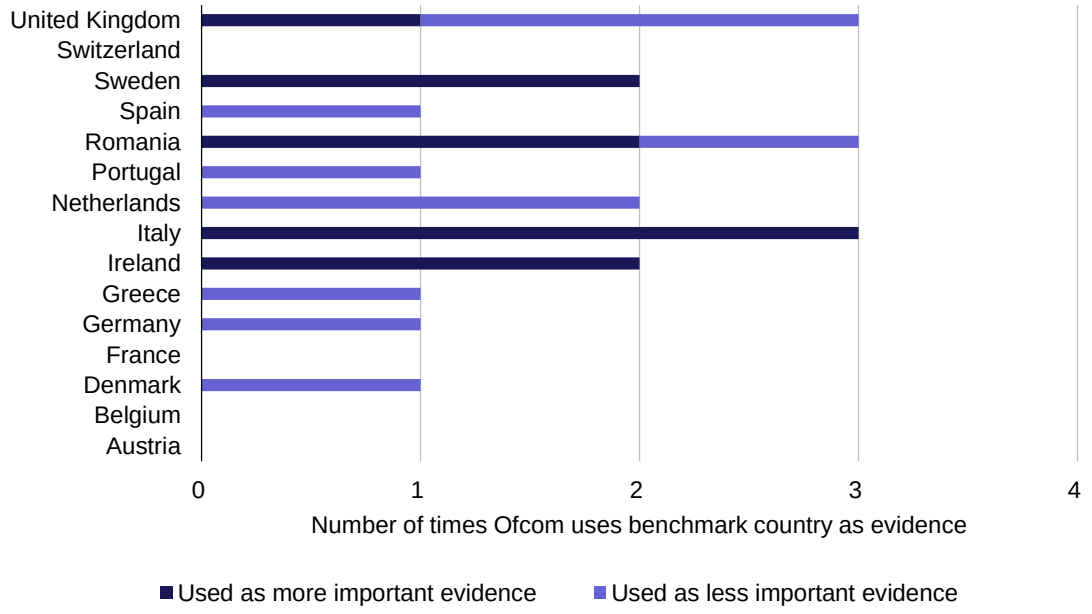
The relative values of 1800MHz/800MHz and 1800MHz/2.6GHz for Country B produce two very different values. The 1800MHz/2.6GHz relative value provides a figure that is equal to the 800MHz band in Country B. The 1800MHz/800MHz relative value, on the other hand, provides a value equal to the 2.6GHz price. 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

---

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.

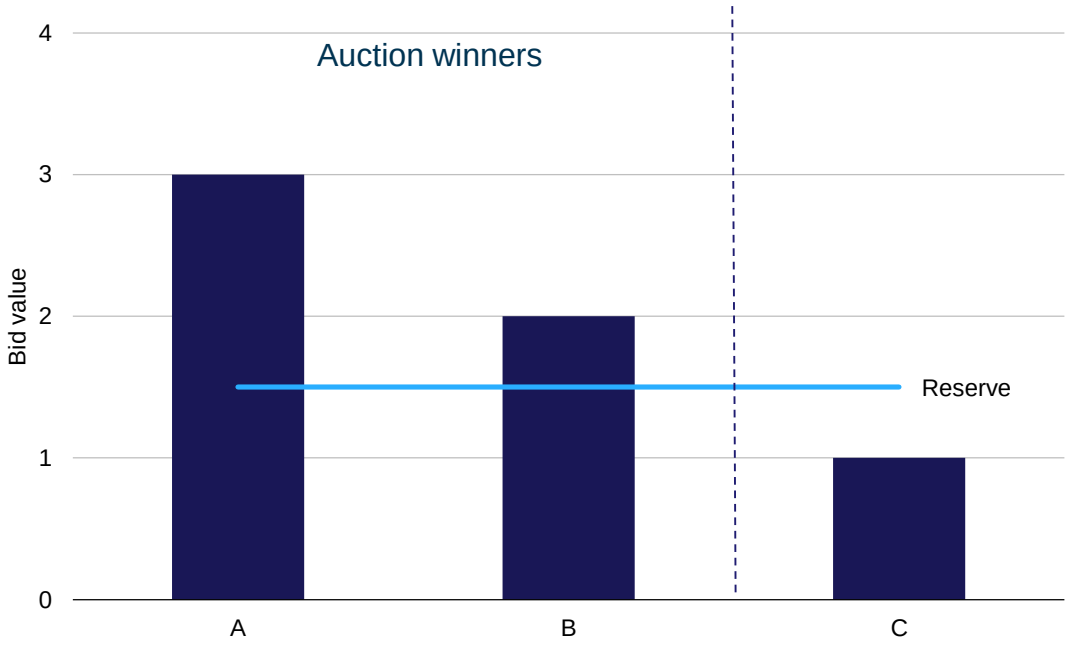
check. This is because the adjustments used in normalising the benchmarked values are only able to capture some country-specific factors that affect the value of spectrum in different countries. The Directive highlights the UK 4G auction outcome as the most important evidence. Therefore we consider it 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]

---

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.

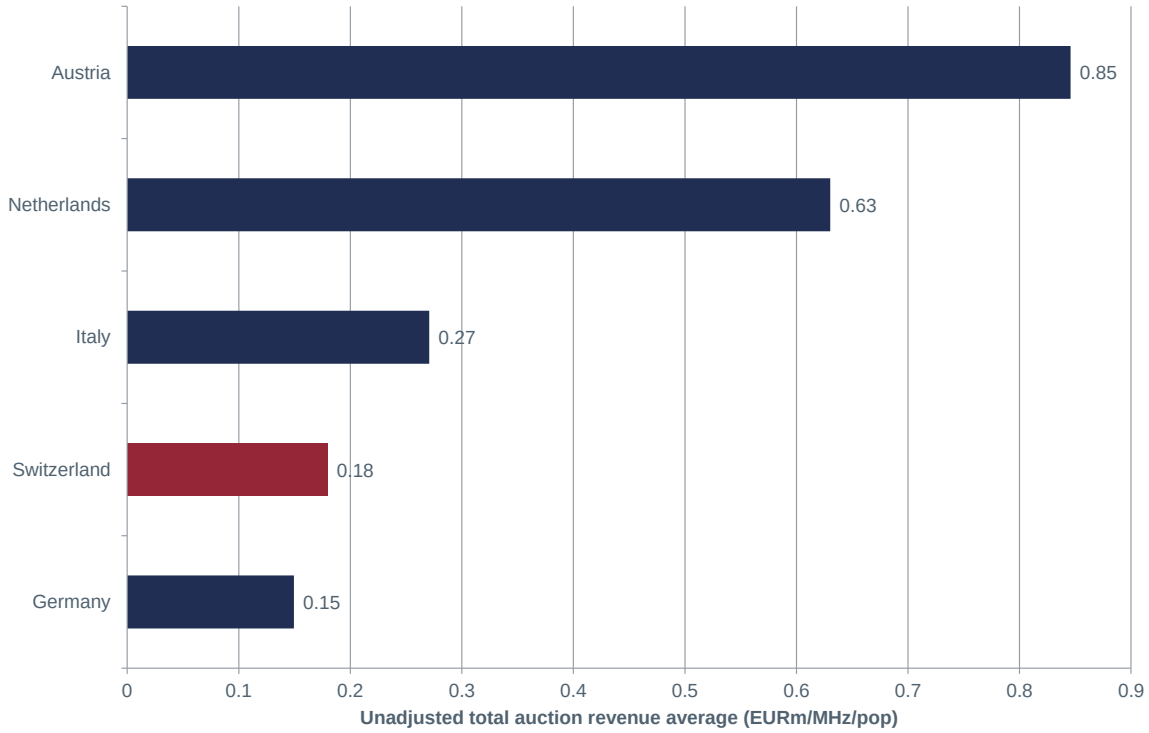
Figure 5.3 below provides the result of the Swiss auction.

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]

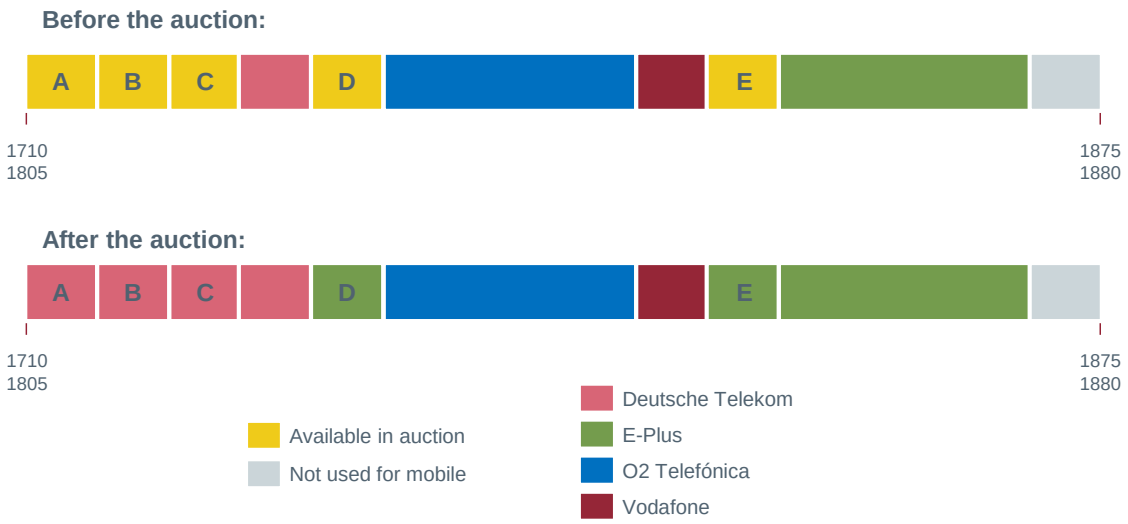
Germany

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.

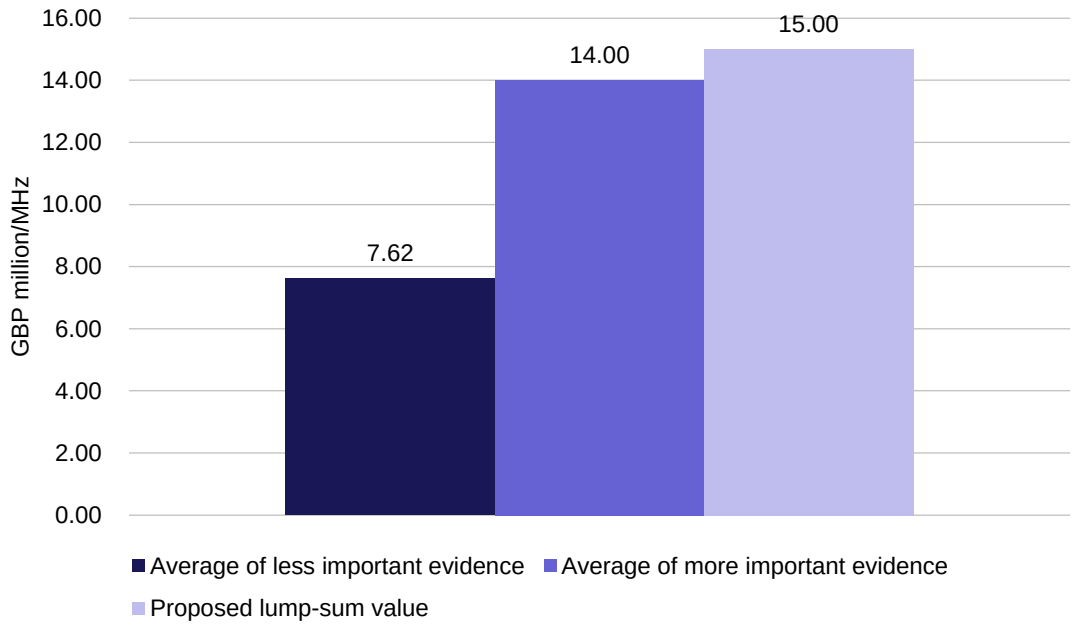
6.1 The implied weightings of benchmarks used by Ofcom

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]



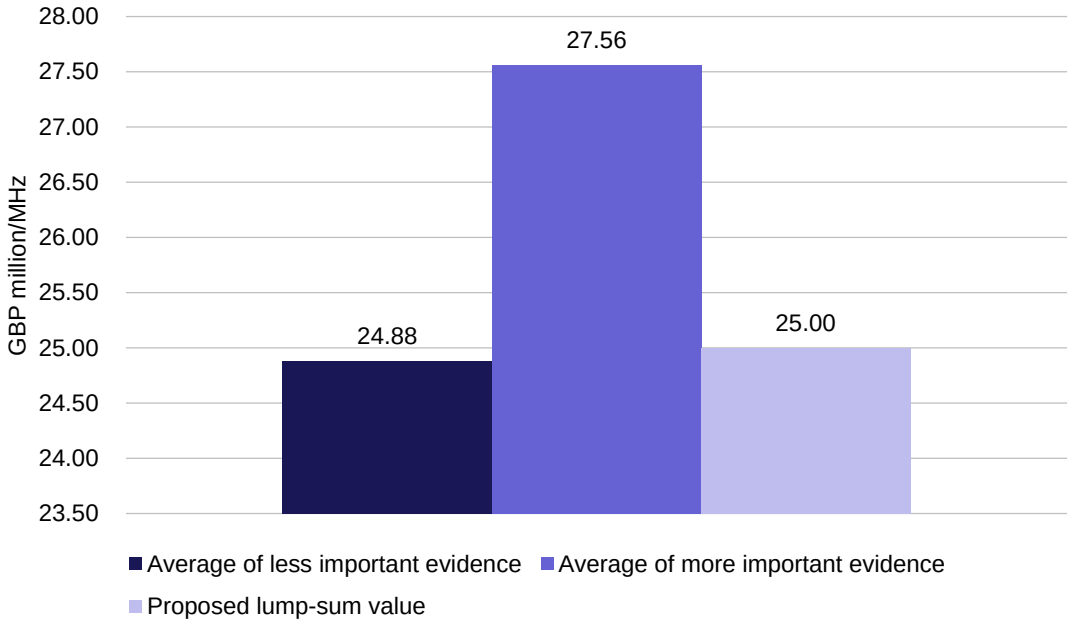
For example, if a weighting of 1 is applied to less important evidence and a weighting of 2 applied to the more important evidence, the weighted average would be GBP12.15 million per MHz. This is significantly less than the GBP15 million per MHz lump-sum value Ofcom proposes for the 1800MHz band.

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.

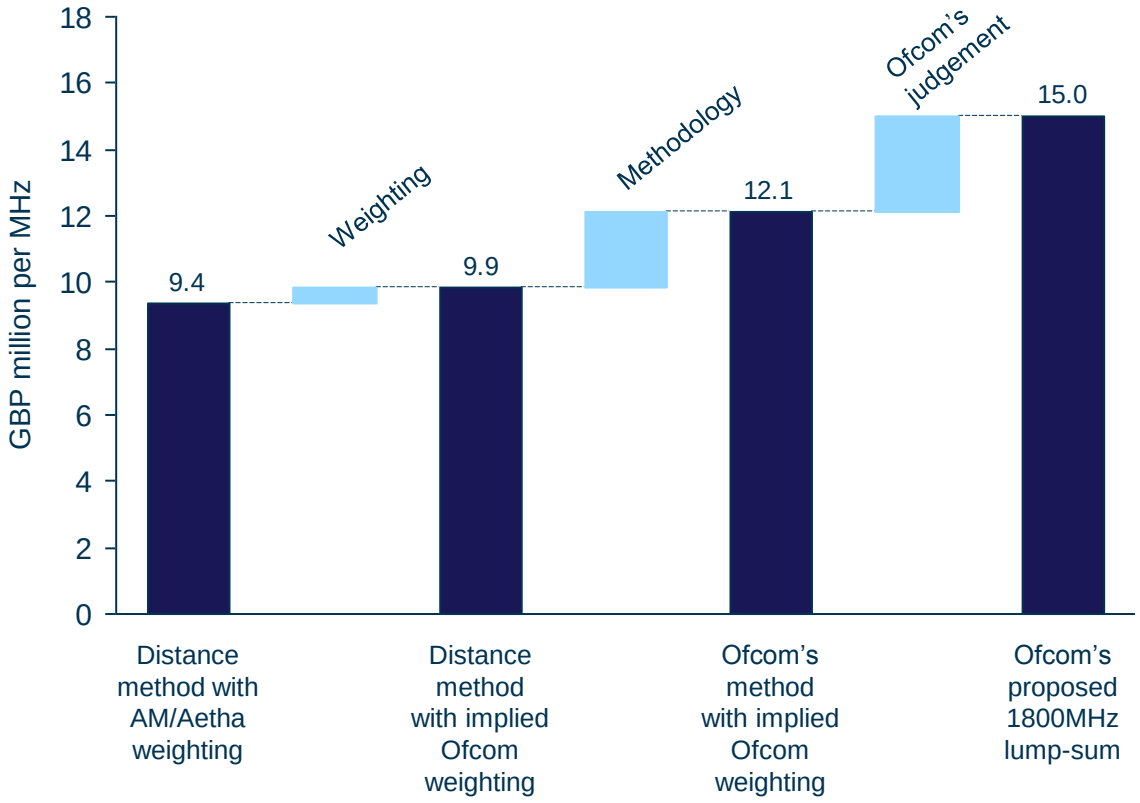
In Figure 8.1, we reconcile the difference between our proposed lump-sum value and Ofcom's proposed lump-sum value for 1800MHz. The distance method used with Analysys Mason and Aetha's weightings of benchmarks results in a lump-sum of GBP9.4 million per MHz, while the same method with Ofcom's implied 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.