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Final report for Three and EE

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

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1 Executive summary

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

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

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

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

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

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

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

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

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

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

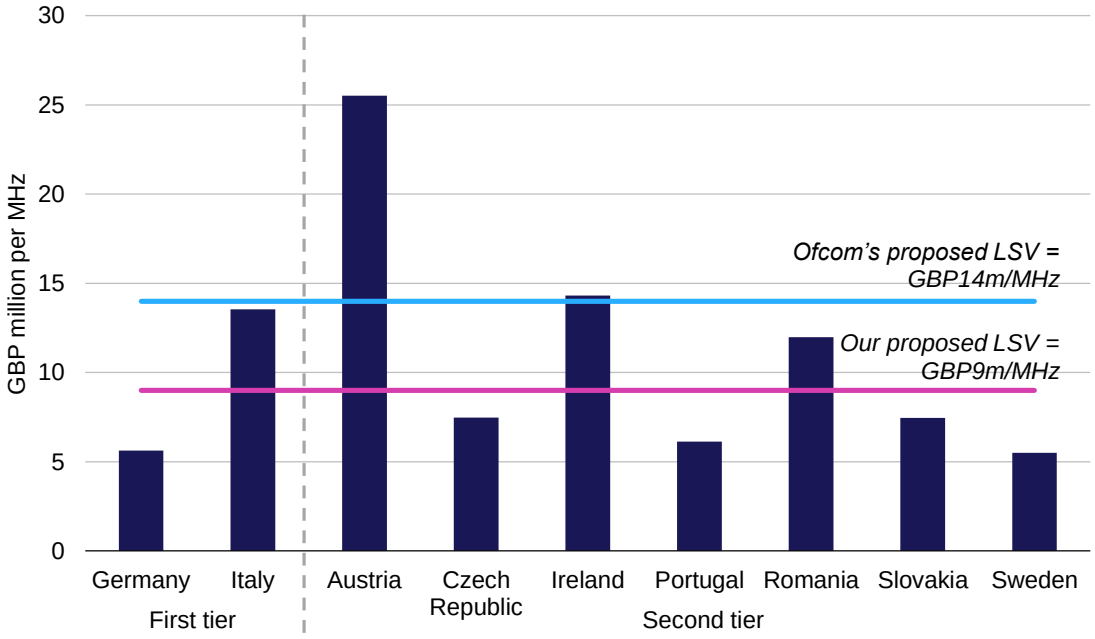
- Ofcom does not conduct any rigorous sensitivity analysis. Consequently, it appears unaware that its tiering and weighting approach produces an extreme outcome for 1800MHz spectrum, and that its decision to include a proxy for the value of 2.6GHz spectrum in Sweden has such a substantial impact on the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

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

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

Figure 1.1 below presents the 1800MHz distance method benchmarks.

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



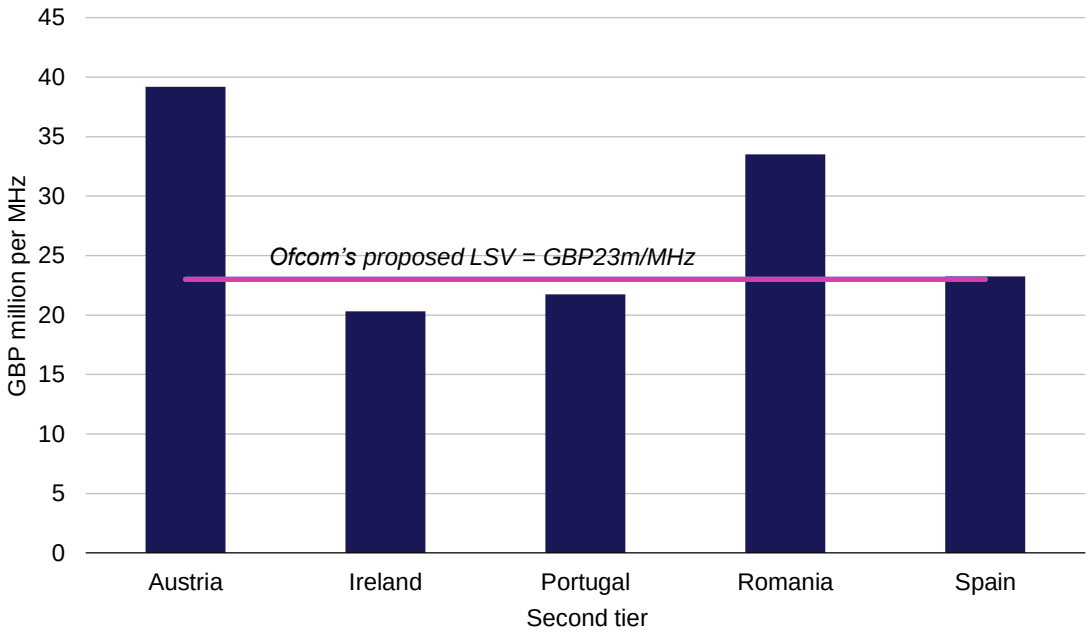
With corrected tiering and input data it becomes clear that Ofcom's proposed lump-sum value of GBP14 million per MHz is much too high. It is not only higher than both of the Tier 1 benchmarks, it is higher than five of the seven Tier 2 benchmarks.

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

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

Figure 1.2 below presents the 900MHz benchmarks.

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



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

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

2 Introduction

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

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

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

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

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

The remainder of this report is laid out as follows:

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

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

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

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

The report also contains three annexes providing supporting information:

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

3 Issues with Ofcom's tiering and weighting approach

3.1 Overview of Ofcom's approach to tiering and weighting

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

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

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

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

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

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

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

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

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

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

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

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

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

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

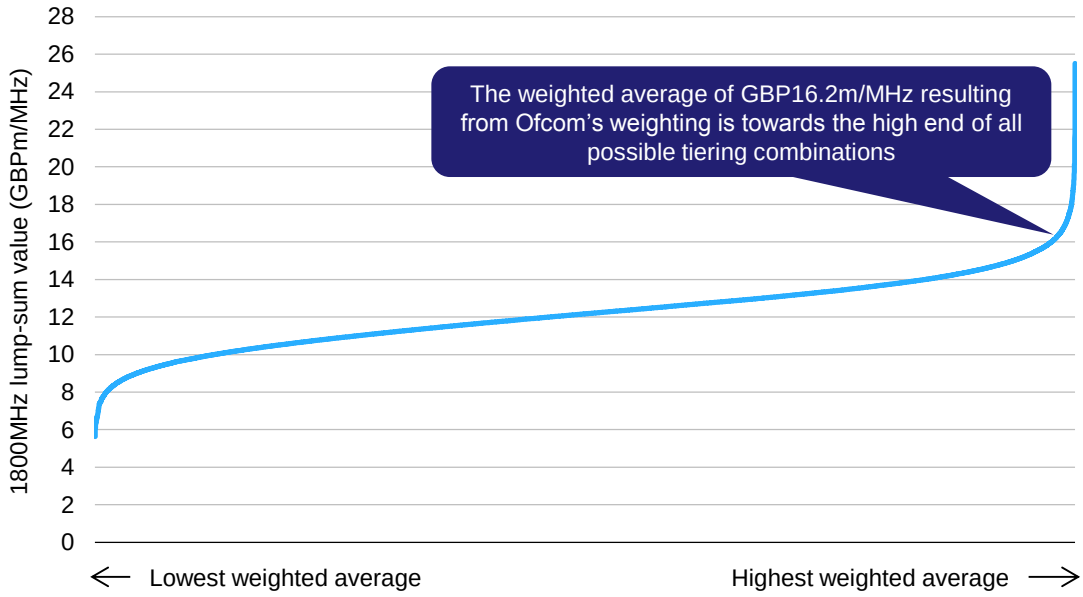
In contrast, for 900MHz, the unweighted average of Ofcom's benchmarks is GBP27.6 million per MHz,[5] compared to an average using Ofcom's proposed weightings of GBP27.3 million per MHz.

3.2 Sensitivity analysis of Ofcom's tiering approach

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

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

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



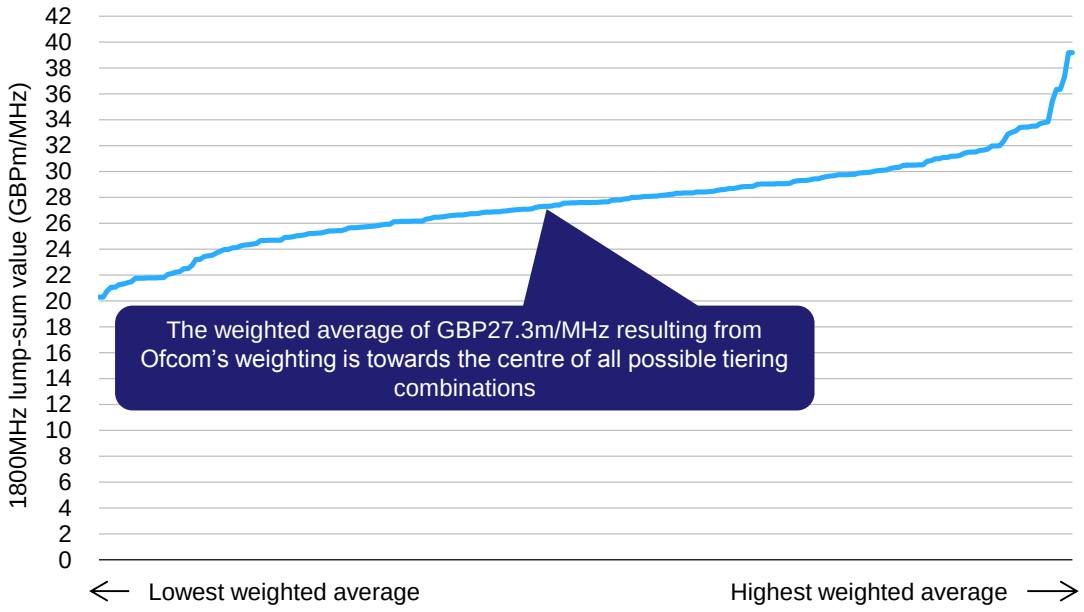
5 This figure excludes Denmark, to which Ofcom assigns a weighting of zero. We agree that Denmark should be excluded since incumbent operators were not able to bid for 900MHz spectrum.

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

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

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

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



3.3 Ofcom itself acknowledges the uncertainty

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

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

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

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

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

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

3.4 Concerns with Ofcom's approach to tiering and weighting

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

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

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

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

3.4.1 Ofcom's effectively excludes Tier 3 benchmarks

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

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

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

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

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

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

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

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

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

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

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

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

3.4.3 Some of Ofcom's criteria are highly questionable

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

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

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

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

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

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

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

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

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

3.4.4 Ofcom excludes key criteria from its framework

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

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

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

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

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

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

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

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

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

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

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

4 Our proposed solutions to the tiering and weighting issues

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

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

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

In practical terms, this means using a framework that:

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

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

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

1800MHz spectrum

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

900MHz spectrum

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.2 The results of our suggested solution

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

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

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

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

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

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

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

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

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

4.3 Sensitivity analysis

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

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

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

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

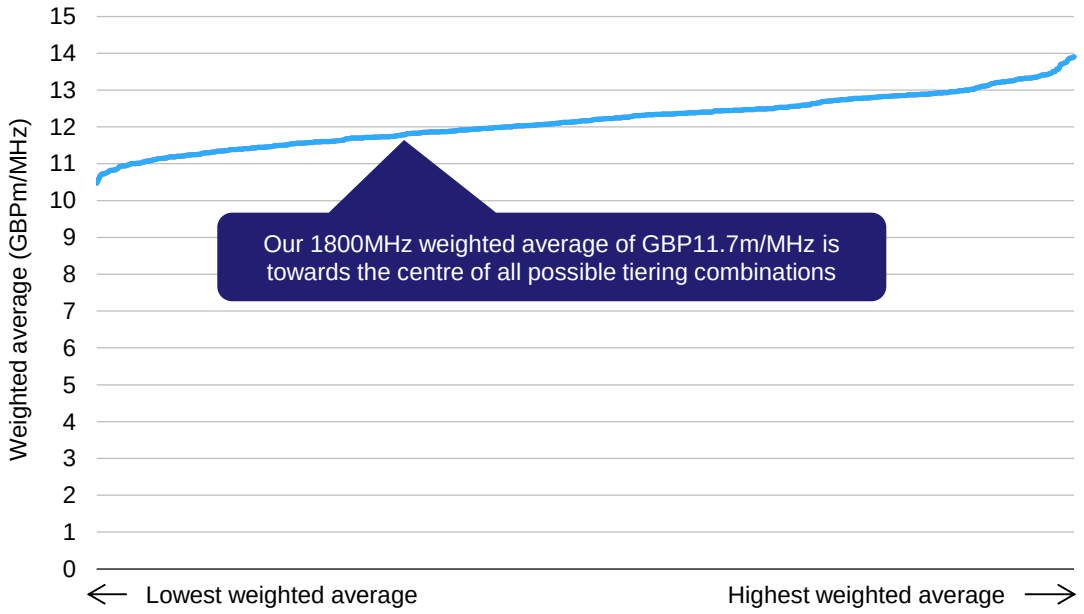
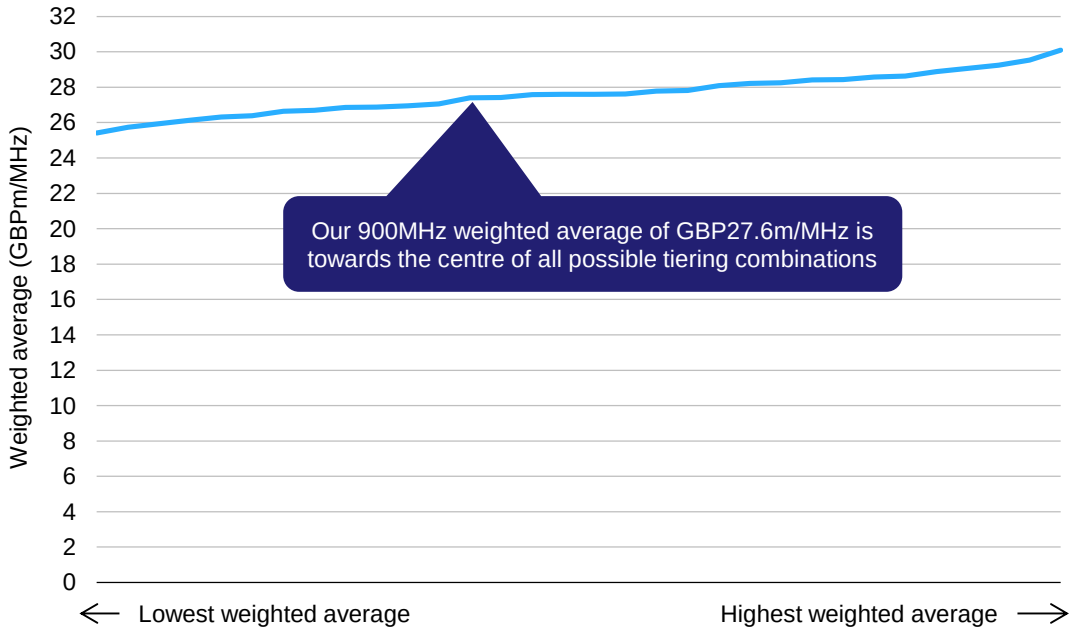


Figure 4.5 shows that the range of possible weighted averages in our suggested framework is much narrower than Ofcom's framework (see Section 3.2). This is because our framework is more inclusive in terms of the evidence points considered. It therefore avoids extremes in the resulting weighted average.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

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

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

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



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

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

5 Input data issues

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

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

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

5.1 Approach to averaging lot values in benchmark countries

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

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

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

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

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

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

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

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

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

5.2 The use of proxies for 2.6GHz benchmark values

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

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

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

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

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

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

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

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

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

5.2.1 Sweden

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

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

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

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

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

5.2.2 Ireland

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

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

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

5.2.3 Greece

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

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

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

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

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

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

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

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

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

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

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

5.4 Impact on the 900MHz and 1800MHz results

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

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

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

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

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

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

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

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

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

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

6 Our proposed selection of lump-sum values

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

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

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

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

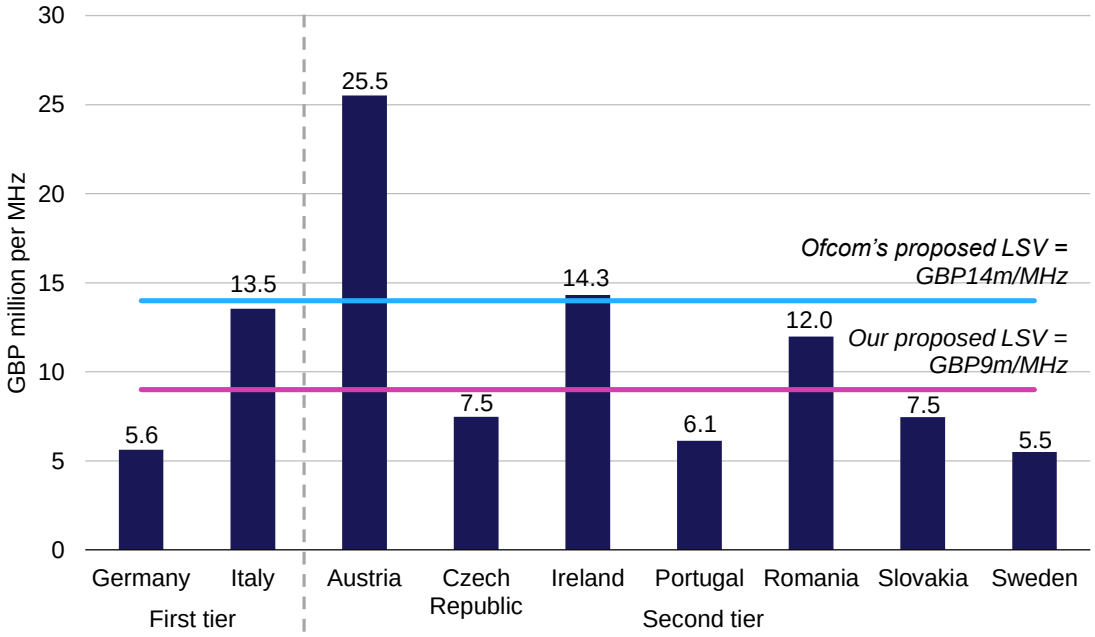
6.1 Lump-sum values assuming Ofcom's UK values for 800MHz and 2.6GHz spectrum

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

6.1.1 1800MHz spectrum

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

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



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

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

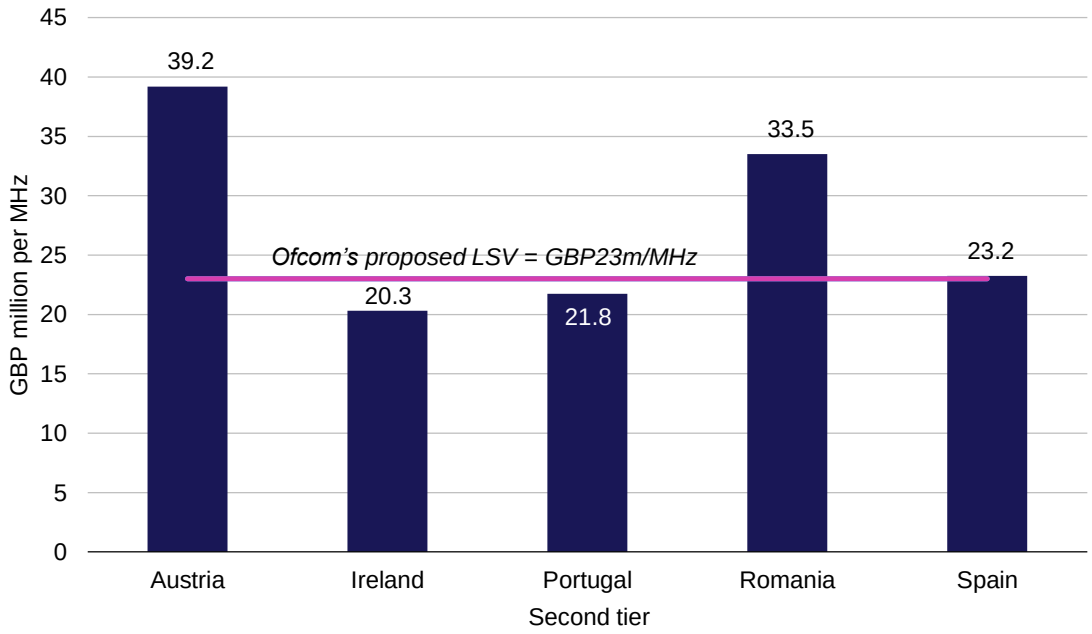
Considering the Tier 2 benchmarks, we note that there is a large range of values, from GBP5.5 million per MHz (Sweden) to GBP25.5 million per MHz (Austria). Four of the seven Tier 2 benchmarks are below the Tier 1 average of GBP9.6 million per MHz; but at GBP11.2 million per MHz, the average of the Tier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

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

6.1.2 900MHz spectrum

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

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



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

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

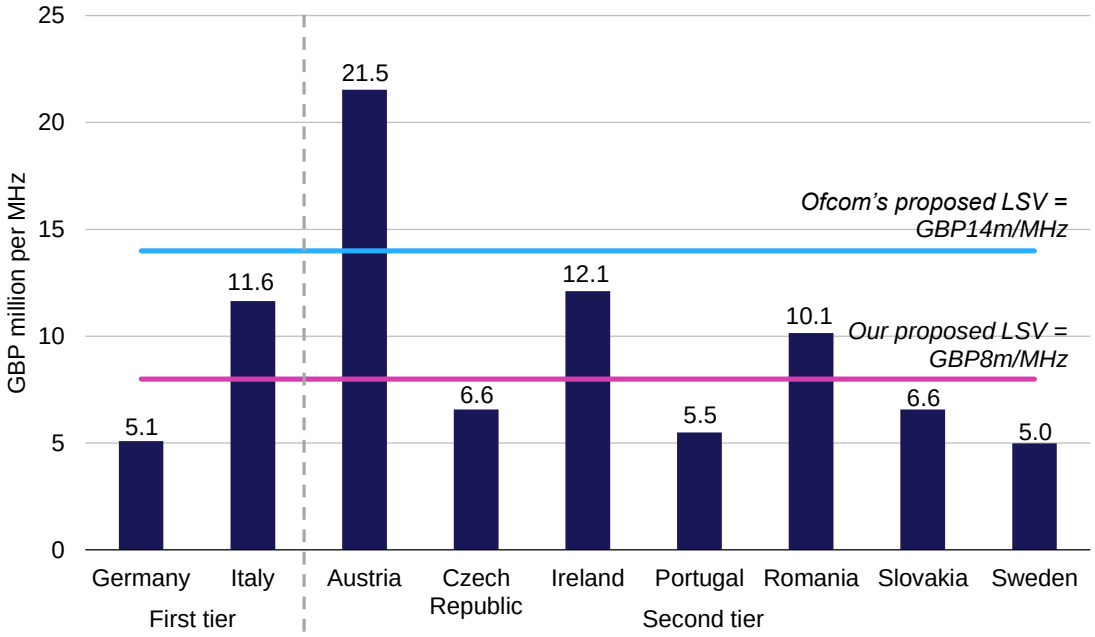
6.2 Lump-sum values assuming EE's UK values for 800MHz and 2.6GHz spectrum

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

6.2.1 1800MHz spectrum

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

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



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

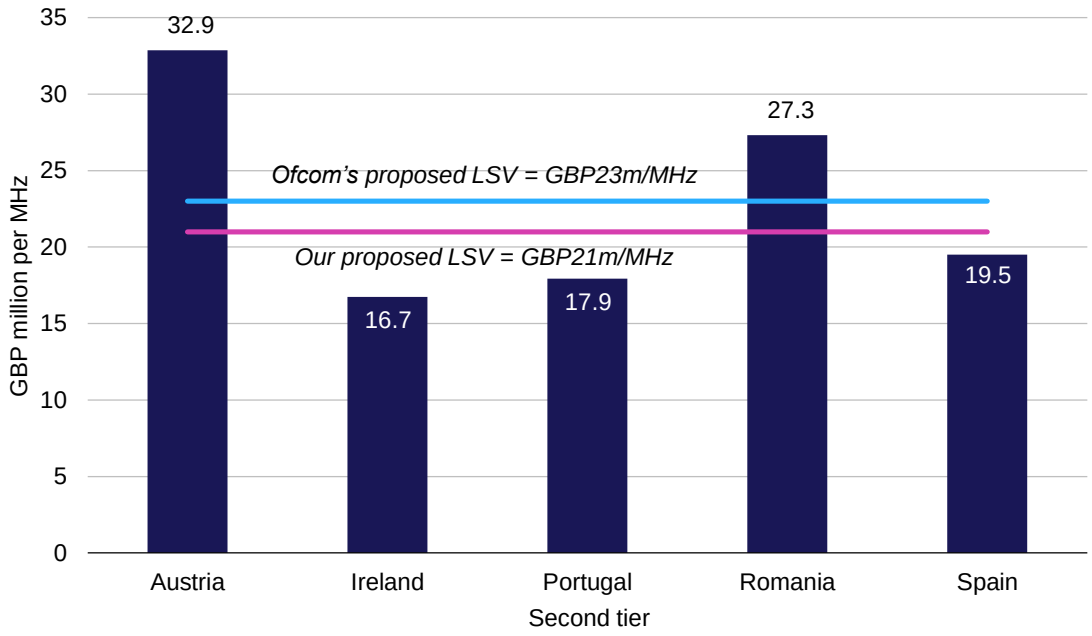
The average of the Tier 1 benchmarks is GBP8.4 million per MHz, whilst for the Tier 2 benchmarks it is GBP9.6 million per MHz. Therefore, in order to be conservative, we believe that the lump-sum value should be set at a small discount to the average of the Tier 1 benchmarks.

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

6.2.2 900MHz spectrum

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

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



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

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

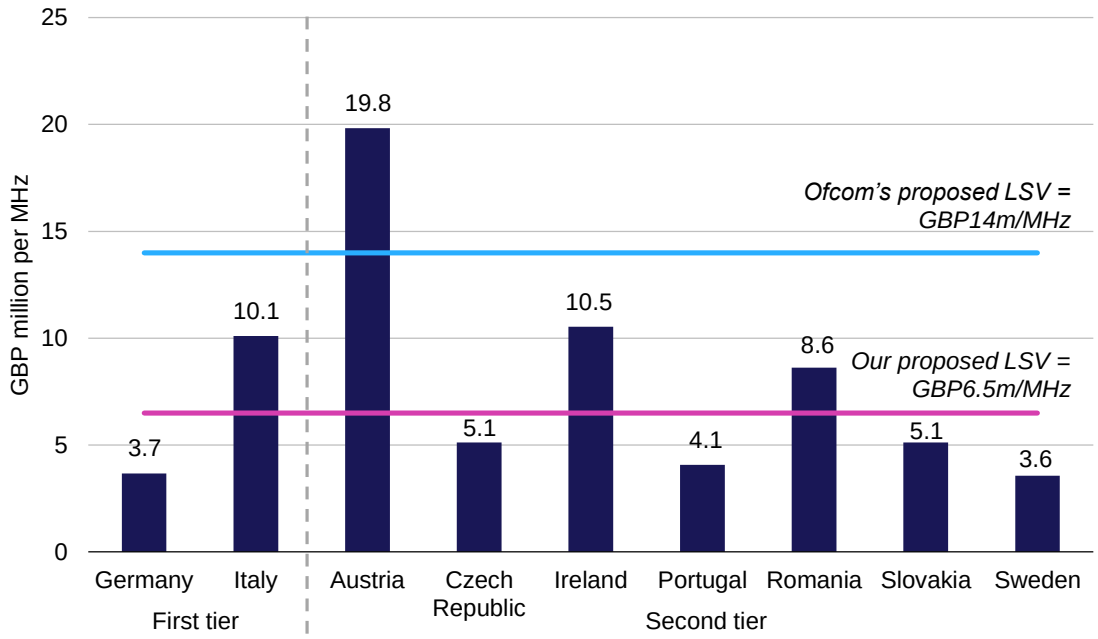
6.3 Lump-sum values assuming Three's UK values for 800MHz and 2.6GHz spectrum

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

6.3.1 1800MHz spectrum

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

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



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

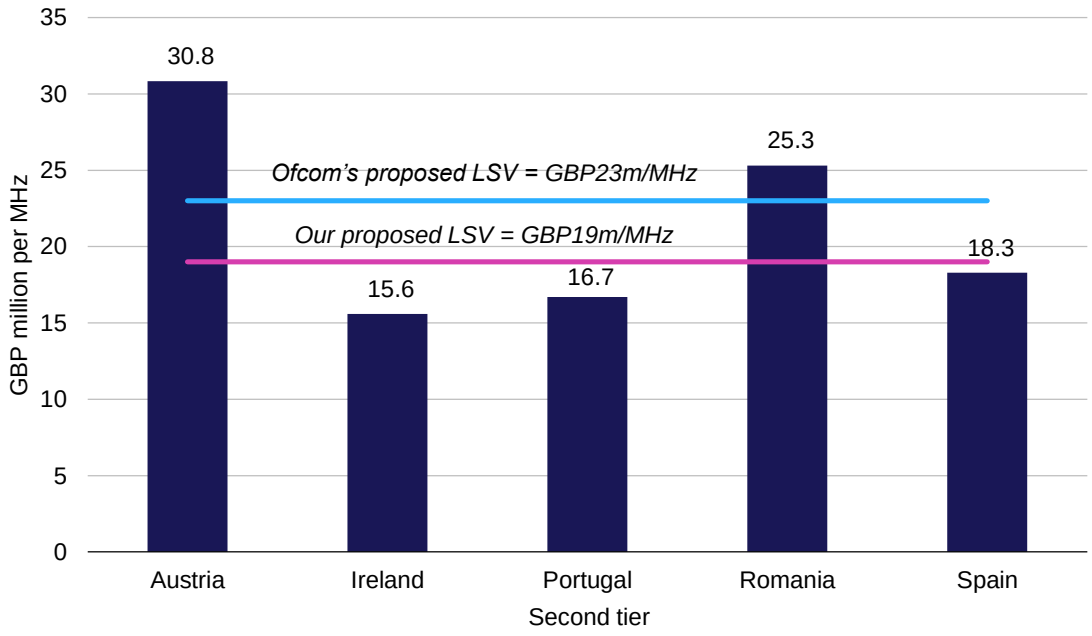
The average of the Tier 1 benchmarks is now GBP6.9 million per MHz, whilst for the Tier 2 benchmarks it is GBP8.1 million per MHz. Therefore, in order to be conservative, we again believe that the lump-sum value should be set at a small discount to the average of the Tier 1 benchmarks.

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

6.3.2 900MHz spectrum

Figure 6.6 below presents the 900MHz benchmarks assuming Three's UK values for 800MHz and 2.6GHz spectrum.

Figure 6.6: 900MHz benchmarks assuming EE's UK values for 800MHz and 2.6GHz [Source: Ofcom, Three, Analysys Mason and Aetha, 2014]



With the revised UK 800MHz and 2.6GHz values, Ofcom's proposed lump-sum value again appears too high. The mean of the benchmarks is now GBP21.3 million per MHz and the median is GBP18.3 million per MHz.

On balance, assuming Three's UK values for 800MHz and 2.6GHz spectrum, we therefore consider that **GBP19 million per MHz** is an appropriate estimate of the UK lump-sum value for 900MHz spectrum.

6.4 Weighted average cross-check of the lump-sum values

In Sections 4 and 5, we presented our view of the lump-sum values as calculated using weighted averages of the available benchmarks. These are presented in Figure 6.7 below and compared to the lump-sum values selected above.

Figure 6.7: Comparison of our selected and weighted average lump-sum values [Source: Analysys Mason and Aetha, 2014]

	1800MHz	900MHz
Assuming Ofcom's UK values for 800MHz/2.6GHz		
Weighted average lump-sum value	10.6	27.6
Selected lump-sum value	9.0	23.0
Discount to the weighted average	15%	17%
Assuming EE's UK values for 800MHz/2.6GHz		
Weighted average lump-sum value	9.2	22.9
Selected lump-sum value	8.0	21.0
Discount to the weighted average	13%	8%
Assuming Three's UK values for 800MHz/2.6GHz		
Weighted average lump-sum value	7.7	21.3
Selected lump-sum value	6.5	19.0
Discount to the weighted average	16%	11%

Our selected lump-sum values represent a small discount to the corresponding weighted averages, which is consistent with Ofcom's aim of setting the lump-sum values conservatively. We also note that, in its second consultation, Ofcom selects lump-sum values that have similar discounts to its calculated weighted averages (16% for 900MHz and 14% for 1800MHz).

7 1800/900MHz cross-check

In its second consultation, Ofcom includes a comparison of the ratio of its proposed 1800MHz to 900MHz lump-sum values to equivalent ratios in the benchmark sample. We welcome this comparison as a valuable cross-check of the proposed lump-sum values. However, we believe that Ofcom interprets the results incorrectly and thus derives misleading conclusions.

As shown in Figure 7.1, six European countries have auctioned both 900MHz and 1800MHz spectrum.[20]

Figure 7.1: 900MHz and 1800MHz UK equivalent values, in GBP million per MHz [Source: Ofcom, Analysys Mason and Aetha, 2014]

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

The ratio of Ofcom's proposed 1800MHz and 900MHz lump-sum values is 61% (GBP14 million per MHz divided by GBP23 million per MHz). This is right at the upper end of the range of benchmarks, and therefore suggests that Ofcom's proposed 1800MHz lump-sum value is too high compared to its proposed 900MHz lump-sum value.

However, when interpreting the results of this cross-check, Ofcom completely disregards all of the benchmarks except for Ireland and Austria – which provide the two highest benchmark ratios (by a considerable margin). Ofcom's rationale is that it has earlier categorised Ireland and Austria as Tier 1 countries, whilst it categorised either one or both of the 900MHz and 1800MHz values in the remaining countries as Tier 3.[21] Therefore, Ofcom states that it should place *"very little weight on them"*. In reality it appears to place no weight on them at all.

In Section 3, we reviewed Ofcom's approach to its tiering and concluded that:

- It is far from robust

[20] Although both 900MHz and 1800MHz spectrum have been awarded in Spain, 1800MHz spectrum was only awarded via a beauty contest. Therefore, consistent with Ofcom's analysis, we have excluded it from the 1800/900MHz cross-checks.

[21] In fact Ofcom categorises Spain's 900MHz benchmark as Tier 2 and its 1800MHz benchmark as Tier 3. We presume that Ofcom defaults to a country's lowest tier category, although this is not explicitly stated.

- Ofcom excludes too many data points, largely due to effectively excluding the Tier 3 benchmarks, and therefore relies on too few data points

- The inclusion of Austria and Ireland as Tier 1 data points is highly questionable, given:
  - the inevitable error bounds in calculating band-specific prices from CCAs – even when an LRP calculation is conducted using the bid data or final-round prices are known
  - the fact that Ofcom completely disregards all other multiband CCAs from the analysis because no reliable information regarding band-specific prices can be gleaned.

The shortcomings of Ofcom's tiering are then inevitably evident in this cross-check using the ratio of 1800MHz and 900MHz values. Indeed, the manner in which Ofcom conducts this cross-check provides no new information at all:

- Ofcom's 900MHz lump-sum value is heavily influenced by the Austrian and Irish benchmarks – which constitute the only two Tier 1 benchmarks out of the four benchmarks that are effectively considered (given that Ofcom places no weight on the Tier 3 benchmarks)

- Ofcom's 1800MHz lump-sum value is also heavily influenced by the Austrian and Irish benchmarks – which constitute two of the three Tier 1 benchmarks (Ofcom also considers two Tier 2 benchmarks, Germany and Sweden, but these do not affect its conclusion of the appropriate 1800MHz lump-sum value)

- Therefore, it is a mathematical inevitability[22] that the ratio of Ofcom's proposed 1800MHz and 900MHz values is very close to the equivalent Austrian and Irish benchmarks.

In practice, therefore, Ofcom's supposed cross-check does not check anything.

Ofcom should instead have used this cross-check to verify that the approach it has taken to determine the lump-sum values, and particularly the weightings that it places on each benchmark country, is reasonable. On this measure, the evidence clearly suggests that Ofcom's approach is in fact seriously flawed.

Giving each 1800MHz to 900MHz ratio benchmark equal weighting and assuming that the benchmarks follow a normal distribution curve, we calculate that the ratio of Ofcom's proposed 1800MHz and 900MHz lump-sum value (61%) is on the 97th percentile.[23] This result implies that for Ofcom's ratio to be valid, the actual distribution of European 1800MHz to 900MHz ratios must be vastly different from that suggested by the above six benchmarks. For Ofcom to believe that this is the case, it must be very confident that its tiering and weighting is robust. As discussed in Section 3, however, this is clearly not the case.

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22 To the extent that Ofcom's *selected* lump-sum values are similarly discounted from the weighted average cross-checks, which we established was indeed the case in Section 6.

23 Using the six 1800MHz to 900MHz price ratios, we calculate a standard deviation of 11%, and that the ratio between Ofcom's proposed 1800MHz and 900MHz LSVs (61%) is 1.9 standard deviations above the geometric mean of 40%. Our 97th percentile result is based on the cumulative density function at the 61% level.

Therefore, in our opinion, the correct interpretation of this cross-check is that Ofcom's proposed 1800MHz lump-sum value is very high compared to its proposed 900MHz value.

In comparison, the ratio of our suggested 1800MHz and 900MHz lump-sum values is either 34%, 38% or 39% (depending on whether Three, EE or Ofcom's proposed UK 800MHz and 2.6GHz values are assumed). These are all very close to the geometric mean of the benchmark ratios, suggesting that our calculations are more robust than Ofcom's to the assumptions used.

8 Conclusions

In our opinion Ofcom's revised lump-sum value for 1800MHz spectrum of GBP14 million per MHz remains unduly high. In contrast, the proposed lump-sum value for 900MHz spectrum of GBP23 million per MHz appears more reasonable. This outcome is the product of serious shortcomings in Ofcom's revised approach:

- Ofcom's tiering and weighting framework is over-complicated and relies on too many subjective criteria. The framework appears to look for reasons to exclude data points, whereas a more inclusive approach designed to incorporate as much evidence as possible would be far more robust. The result is that Ofcom relies on too few data points in reaching its conclusions.

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

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

- Ofcom's cross-check using benchmark 1800MHz to 900MHz value ratios is flawed, as it excludes all benchmarks other than the two highest. A more robust analysis of these benchmark ratios shows that Ofcom's approach to tiering and weighting the various benchmarks must be erroneous and so produces an extremely high lump-sum value for 1800MHz compared to 900MHz.

In this report, we have proposed revisions to Ofcom's tiering and weighting, as well as corrections to some of Ofcom's input data set. Using the same approach to select the lump-sum values as Ofcom (firstly selecting a value, then conducting a cross-check using weighted averages), and also adopting Ofcom's aim to use a *"conservative approach when interpreting the evidence"* (which Ofcom adopts in its second consultation), we propose that the following lump-sum values are appropriate estimates of UK market value:

Figure 8.1: Our proposed lump-sum values, GBP million per MHz [Analysys Mason and Aetha, 2014]

	1800MHz	900MHz
Assuming Ofcom's UK values for 800MHz/2.6GHz	**9**	**23**
Assuming EE's UK values for 800MHz/2.6GHz	**8**	**21**
Assuming Three's UK values for 800MHz/2.6GHz	**6.5**	**19**

Annex A Using the distance method for 900MHz

A.1 Introduction

As discussed in Section 2, whilst we believe that the distance method is the most robust method for determining the 900MHz lump-sum value, we do not have material concerns with Ofcom's chosen approach of using benchmarks of the relative value of 900MHz to 800MHz. This is because both approaches produce similar results, as we demonstrate in this annex.

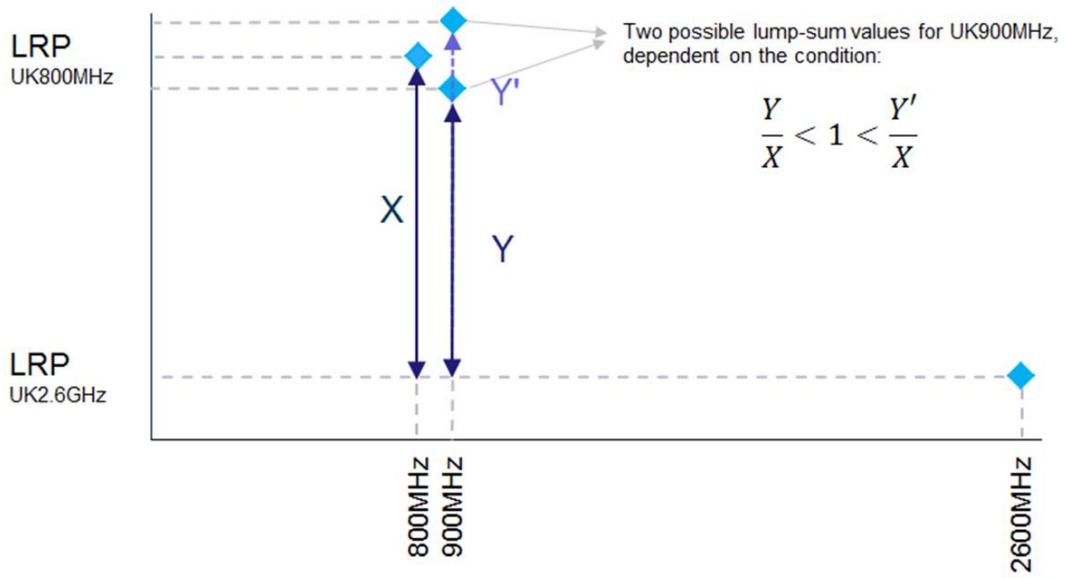
A.2 The application of the distance method for the 900MHz band

Given the clear benefits of the distance method, we note that there are no reasons, *a priori*, why the same methodology should not be applied to the calculation of lump-sum values for 900MHz spectrum. We note that unlike for the 1800MHz band, Ofcom uses only 800MHz auction prices to determine relative values for 900MHz spectrum. Therefore, an opportunity is missed to also use 2.6GHz price information from the UK auction to inform the 900MHz value.

The distance method can be applied to 900MHz spectrum using exactly the same formula as for 1800MHz spectrum. One additional point to note, however, is that the value of $\frac{Y}{X}$ may not necessarily be less than 1, since in some cases 900MHz spectrum has achieved higher auction values than 800MHz spectrum (e.g. in Romania and Austria). This is analogous to the value of $\frac{Y}{X}$ not necessarily needing to be greater than zero for 1800MHz spectrum, in particular when the benchmark for 1800MHz is lower than the benchmark for 2.6GHz in a particular market.[24]

[24] There was one such example, Sweden, in our distance method calculation for 1800MHz – using our corrected benchmark values calculated in Section 4 rather than a proxy for 2.6GHz.

Figure A.1: Illustration of the distance method as applied to the 900MHz band [Source: Analysys Mason and Aetha, 2014]



We are not of the opinion that the 800MHz value is necessarily an upper limit on the value of 900MHz. The 900MHz band is critical for the immediate, ongoing delivery of GSM services, and a substantial ecosystem for UMTS/HSPA+ at 900MHz is already in place. We understand that both Telefónica and Vodafone have deployed UMTS900 in the UK. Furthermore, although the 800MHz band is the leading low-frequency band for LTE, the device ecosystem for LTE900 is progressing rapidly (e.g. included in the specification for the iPhone 5s).

A.3 What objective criteria should be applied to the selection of benchmarks?

As discussed in Section 4, we previously set out criteria to determine whether benchmarks from different countries should be included or excluded in the analysis and whether they should be classified as more or less important (Tier 1 or Tier 2 in the context of this document). We suggested that, in line with our criteria for determining a relevant sample for 1800MHz benchmark analysis, countries are excluded from the 900MHz lump-sum determination if:

- The 900MHz band has not been auctioned within the relevant time period (as specified by Ofcom)
- For package bid auctions, no reliable information regarding the 900MHz prices can be inferred from publicly available information
- Certain bidders were excluded from the auction (particularly incumbent operators), as this would significantly constrain demand in the auction
- There is no reliable 800MHz benchmark – a requirement for the distance method calculation for 900MHz spectrum. In the absence of a 2.6GHz benchmark, a proxy could be used.

We continue to believe that these criteria are appropriate. These criteria are broadly consistent with Ofcom's approach in its second consultation, with the exception that Ofcom includes Denmark, despite incumbent operators being excluded from the Danish 900MHz auction. We therefore recommend that Denmark is excluded from Ofcom's set of benchmark countries.

Furthermore, we now suggest that, if using the distance method, countries are considered as Tier 2 if any of the following apply:

- Band-specific prices cannot be *directly* inferred (i.e. CCA/package auction benchmarks)
- A proxy is used for 2.6GHz price when using the distance method
- There is unsold spectrum in any of the three bands relevant for the distance method (800MHz, 900MHz or 2.6GHz)
- There is a significant time gap between the auctioning of the three required bands (800MHz, 900MHz or 2.6GHz)
- Spectrum in either of the three relevant bands (800MHz, 900MHz or 2.6GHz) was sold at its reserve price.

We therefore conclude that all 900MHz benchmarks should be classified as Tier 2, as set out in Figure A.2 below. As none of the 900MHz benchmarks is entirely without fault we therefore believe it is most informative to give each benchmark the same weighting.

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

Country	Band-specific prices not directly inferred?	Use of proxy for 2.6GHz?	Unsold spectrum?	Significant time gap between band auctions?	Auction finished at reserve price?	Conclusion
Austria	Yes			Yes		Tier 2
Ireland	Yes	Yes				Tier 2
Portugal			Yes			Tier 2
Romania	Yes		Yes			Tier 2
Spain					Yes	Tier 2

A.4 Results of the application of the distance method for the 900MHz band

Applying the distance method calculation for the above countries yields five estimates for the lump-sum value of the 900MHz band in the UK, as summarised in Figure A.3 below.

Figure A.3: Results of the application of the distance method for the 900MHz band [Source: Analysys Mason and Aetha, 2014]

Country	800MHz	900MHz	2.6GHz	Tier	UK 800MHz price used[25]	Distance method result for 900MHz UK lump-sum value
Austria	72.2	79.4	1.9	2	35.63	38.7
Ireland	63.5	39.6	6.8[26]	2	32.63	21.2
Portugal	37.3	24.9	2.5	2	32.63	22.9
Romania	43.9	47.3	10.6	2	31.08	33.7
Spain	40.4	26.4	1.9[27]	2	35.63	24.2
AVERAGE						**28.1**

This produces a weighted average result of GBP28.1 million per MHz for the lump-sum value for 900MHz spectrum in the UK.

A.5 Conclusion

The result of GBP28.1 million per MHz for the lump-sum value of the 900MHz spectrum using the distance method is only slightly higher than the figure of GBP27.3 million per MHz that was calculated using Ofcom's 900MHz to 800MHz ratio benchmarking method. As such, whilst we still believe that the distance method is the most robust method for determining the 900MHz lump-sum value, we do not have strong objections to Ofcom's use of the 900MHz to 800MHz ratio method to determine this value, although we note that it adds a further element of conservatism to the result.

25 In our calculations we have used the UK 800MHz value as indicated by Ofcom in Tables 3.2 and 3.3 of its second consultation.

26 Here we use a proxy value of GBP6.8 million per MHz as calculated by Ofcom.

27 This value is the one attained after a weighted average was taken into account, as discussed in Section 5.1.

Annex B Summary of criteria used by Ofcom for categorising benchmarks into tiers

As described in Section 3.1, Ofcom adopts a framework for categorising the benchmarks into tiers, which is based on the extent to which Ofcom considers the benchmark to be "informative of UK market value". Ofcom develops several criteria, which are cited in the analysis of individual countries, to explain its view of whether a benchmark is firstly representative of the market value in that country and secondly whether it is relevant to the UK. In this annex we list these criteria and provide a brief summary of each.

Criteria relating to whether a benchmark represents market value

► *Lot sizes too small for LTE*

Ofcom argues that where the lot sizes of at least some lots available in the auction (generally those available to incumbents) are not suitable for LTE (i.e. are smaller than 2×5MHz) then the benchmark may be less representative of market value.

► *Incumbents prevented from bidding*

Ofcom considers that where incumbent operators are prevented from bidding, the benchmark may be less representative of market value.

► *Unsold lots*

Ofcom suggests that where lots are unsold this may indicate that market value was not achieved because the prices were not set by bids.

► *Spectrum selling at reserve price*

Similarly, where spectrum sells at reserve price Ofcom argues that the price is not set by bidding and therefore the benchmark may be less representative of market value.

► *Too few bidders imply market value was not achieved*

Ofcom mentions on one occasion (for Sweden) that for an auction with fewer bidders (1800MHz) than other auctions in the same country (800MHz) there may have been less competition for the spectrum, resulting in the benchmark being less representative of market value.

► *Spectrum caps prevented competitive bidding*

Ofcom argues that tight spectrum caps can prevent an auction from revealing market prices if potential bidders are prevented from bidding their valuation due to the caps.

► *Non-contiguity of blocks created obvious contenders for certain lots*

This criterion only applies to Germany. Ofcom argues that the fact that T-Mobile already held block 4 in the 1800MHz band before the auction made it an obvious contender for blocks 1, 2 and 3, as it was the only operator capable of creating a 2×20MHz carrier out of this spectrum.

Criteria relating to whether a benchmark is relevant to the value in the UK

► *2G heavy markets*

For Romania, Ofcom argues that high 900MHz prices are a reflection that prices were driven to a large extent by the much greater importance of 2G in Romania compared with the UK.

► *1800MHz or 2.6GHz benchmark from before 2011*

Ofcom argues that where 1800MHz or 2.6GHz spectrum was auctioned before the eco-system for LTE in the 1800MHz band was as developed as it is today (i.e. prior to 2011), there may have been an impact on operators' relative valuations of these two bands.

► *Not the whole band was auctioned*

Ofcom considers whether the whole band was available for auction in one go, noting that where this was not the case this represents a difference from the UK situation.

► *Spectrum sold in separate awards*

This criterion only applies to Sweden, where the 800MHz and 1800MHz bands used to calculate the distance method result were auctioned in March and October 2011 respectively.

Annex C Discussion of individual countries

In this annex we provide a country-by-country discussion of our recommended classification in support of Section 4.

C.1 Austria

Ofcom uses the Austrian benchmark in the selection of both the 900MHz and the 1800MHz lump-sum values.

All spectrum in the Austrian CCA sold above reserve prices.

As discussed in Section 3, we do not agree with Ofcom's inconsistent treatment of package auctions. The auction in Austria was a CCA auction, which makes it difficult to infer band-specific prices from the available evidence. Nonetheless Ofcom categorises this benchmark as Tier 1. In contrast, Switzerland is excluded from Ofcom's benchmark set entirely, on the grounds that no reliable information is available regarding band-specific prices. Whilst there may be some differences between the results of the Swiss and Austrian auctions which mean that band-specific prices are harder to infer in Switzerland, there is still some evidence that can be gleaned from it – for example, that the price of 900MHz was clearly relatively high. However, if Switzerland is excluded due to reliable band-specific prices not being available, then it seems inconsistent for this issue to be completely ignored for other CCAs such as Austria. In other words, it is not consistent that Swiss band-specific prices are considered totally unreliable to the point that they should be completely excluded, but at the same time for no consideration to be given to lack of reliability of band-specific prices in Austria, and hence for Austria to considered as Tier 1 evidence.

A further reason to question Ofcom's decision to consider Austria as Tier 1 evidence is the fact that some bidders are legally challenging the auction result due to alleged irregularities with the auction procedure. Therefore the auction result may yet be subject to revision. Given that Ofcom's 1800MHz benchmark relies on only three countries and Austria makes such a material difference to its value, what would happen if the Austrian auction result was overturned after Ofcom has set ALF? Would Ofcom then need to re-calculate the 1800MHz ALF (using just two data points)?

Finally, as shown in Section 3.3 above, according to Ofcom, the likelihood, scale and direction of any risk of overstating or understating market value in Austria are not known. Therefore, taking this fact in conjunction with the arguments above, we do not consider Austria to be a benchmark with sufficient certainty to be classified as Tier 1. We believe that it should instead be classified as Tier 2 under our proposed framework and note that, other concerns notwithstanding, the lack of band-specific prices should be sufficient for the Austrian award to be downgraded to Tier 2.

C.2 Czech Republic

Ofcom uses the Czech benchmark in the calculation of only the 1800MHz lump-sum value.

The Czech auction was an SMRA comprising the 800MHz, 1800MHz and 2.6GHz bands. Five bidders entered the auction, but only the three incumbents won spectrum. There was unsold spectrum in the 1800MHz, 2.6GHz FDD and 2.6GHz TDD bands. Nonetheless, in both the 800MHz and 1800MHz bands spectrum sold above reserve prices, whereas the 2.6GHz band did not. The 1800MHz blocks won by incumbents were less than the minimum carrier size for LTE (i.e. less than 2×5MHz).

Conversely, as Ofcom notes in paragraphs A8.72 and A8.73 of the second consultation document,[28] the unsold spectrum in the 1800MHz band could mean that the reserve price was set too high and therefore exceeded market value, though the fact that incumbents were not allowed to bid for the unsold spectrum may also mean that full market value was not reached. Ultimately however, the spectrum that was sold was not influenced by the reserve price, as it sold for more.

In summary, there are a number of reasons why the Czech Republic may overstate or understate market value. As these reasons are likely to at least partly offset one another, we believe that the 1800MHz price can nonetheless provide some valuable evidence and should be considered as Tier 2 evidence under our proposed framework and in Ofcom's calculation of a weighted average 1800MHz lump sum value.

C.3 Denmark

Ofcom uses the Danish benchmark in the calculation of only the 900MHz lump-sum value.

As three of the incumbent operators were not allowed to bid in the 900MHz and 1800MHz auction in Denmark, Ofcom give this benchmark a weighting of zero in the calculation of the 900MHz weighted average lump-sum value (by classifying it as Tier 3). While, as mentioned previously, we do not agree with the approach of giving any tier a weighting of zero, we agree with the ultimate exclusion of Denmark. We do not consider that it provides valuable evidence on full market value of the 900MHz spectrum for the above reason and therefore recommend excluding it from the analysis.

C.4 Germany

Ofcom uses the German benchmark in the calculation of only the 1800MHz lump-sum value.

All spectrum sold above reserve prices in the auction.

In paragraphs A8.113 to A8.118 of Annex 8 of the second consultation, Ofcom speculates as to bidders' strategies in the 1800MHz band in some detail. Nonetheless, Ofcom arrives at the

[28] Ofcom (2014), *Annual licence fees for 900MHz and 1800MHz spectrum – Further consultation*.

conclusion that "[…] *there are possible reasons why the price of 1800 MHz spectrum might understate or overstate market value in Germany* […]".[29]

Our view is that Ofcom's interpretations are merely one possible explanation of the bids that were made and do not constitute reliable evidence for a non-competitive auction outcome. That notwithstanding, we comment on Ofcom's observations below. These are based on the auction outcome shown in Figure C.1 below.

Figure C.1: Spectrum holdings in the German 1800MHz band after the auction [Source: Analysys Mason and Aetha, Ofcom, 2014]

Ofcom comments on the first point made in our first report (that there were not 'obvious contenders' for all blocks) by arguing that E-Plus had the intention of only winning block E, and not block D. Ofcom argues that E-Plus was faced with the option of either:

a) bidding slightly higher on block D and probably winning it; or
b) not bidding higher on block D, definitely not winning it but probably having to pay for its withdrawn bid for it.

If Ofcom's assumption is correct, the price of block D may have been higher than E-Plus initially intended to bid for it. However, in this case the increase in the price paid by E-Plus is likely to be just a single bid increment, which is unlikely to materially change the price raised for this block, let alone the payment for the average lot.

Ofcom comments on the second point raised in our first report (that 2×15MHz lots are sufficiently large to be of value to all bidders, and not just those holding adjacent spectrum) by suggesting that T-Mobile was possibly the obvious bidder for blocks A, B and C, as it was the only bidder which could make a 2×20MHz carrier with these three blocks. Having access to a 2×20MHz carrier is important to mobile network operators as it allows them to offer and therefore advertise the fastest available peak speed on LTE to their customers. However:

[29] Ofcom (2014), *Annual licence fees for 900MHz and 1800MHz spectrum – Further consultation*, Annex 8, Paragraph 8.118.

a) All operators except E-Plus won 2×20MHz in the 2.6GHz band and are therefore able to advertise the fastest peak speeds in any case (although at an arguably lower coverage level). They would have been aware of the likelihood of this outcome, as 2×70MHz were available to the four operators in this band

b) 2×15MHz of 1800MHz delivers a comparable incremental capacity to operators with and without a further contiguous 2×5MHz. Consequently the capacity benefit, which is the other significant source of value, would have been similar for T-Mobile and the other operators

c) Telefónica, which following Ofcom's logic would have been the obvious bidder for block D, did not end up winning this block of spectrum

d) With intra-band carrier aggregation on the horizon (at the time of the German auction) and long licence durations, operators may not have placed as much importance as Ofcom implies on holding all 2×20MHz of spectrum in a contiguous block.

Therefore we do not consider that Ofcom's argument clearly demonstrates that T-Mobile was the obvious winner and that other operators did not bid up the price of blocks A, B and C to competitive levels.

For these reasons we do not consider the German benchmark to be significantly affected by the types of bidding behaviour which Ofcom suggests. As a result, we consider Germany to provide one of the best available benchmarks for 1800MHz and we classify it, according to the rules proposed by our framework, as Tier 1 evidence.

C.5 Ireland

Ofcom uses the Irish benchmark in the calculations of both the 900MHz and the 1800MHz lump-sum values.

All spectrum in the Irish auction sold above reserve prices.

As we described in Section C.1 regarding Austria, we do not consider it consistent to exclude Switzerland on the grounds that no band-specific prices can be reliably inferred from its auction but to categorise Ireland, another CCA, as Tier 1 evidence.

Furthermore, in the calculation of the Irish distance method benchmark for 1800MHz, Ofcom uses a proxy for the 2.6GHz band, as the 2.6GHz band was not auctioned in Ireland. This reduces the accuracy of the distance method benchmark and should also mean that the benchmark cannot be considered as Tier 1 evidence.

Furthermore, not only does the lack of a 2.6GHz price benchmark mean that one of the inputs to the distance calculation is not available for this benchmark, but it also means that 1800MHz prices are likely to have been inflated, as the band can be considered a substitute for the unavailable

2.6GHz spectrum. Therefore the 1800MHz band prices in Ireland risk overstating market value in the UK.

For these reasons we do not agree with a classification of Ireland as Tier 1 evidence and recommend that Ofcom should reclassify it as Tier 2 evidence, according to the criteria set out under our proposed framework.

Finally, we stand by the comments we made in our first report on the process followed for obtaining the Ireland benchmark. Vodafone selectively provided this benchmark to Ofcom, but we understand that it has not provided other similar benchmarks from other auctions that Vodafone Group was involved in. This is understandable from Vodafone's perspective, since it is in Vodafone's interests to provide a low 900MHz benchmark, whilst having less regard for the value of the accompanying 1800MHz benchmark. We are aware that Ofcom has validated the benchmark with the Irish regulator, ComReg, but the fact remains that without Vodafone's intervention Ofcom would not be using a benchmark from Ireland (as ComReg declined Ofcom's request to conduct LRP analysis on the bid data). To our mind this introduces a bias to the process, favouring the interests of a stakeholder which selectively provided Ofcom with the additional benchmark.

C.6 Italy

Ofcom uses the Italian benchmark in the calculation of only the 1800MHz lump-sum value.

We agree with Ofcom's assessment that Italy provides a Tier 1 evidence point, as there are no substantial arguments why this benchmark would not have provided market value in the relevant bands. We note that only 2×15MHz of spectrum was awarded in the 1800MHz band but agree with Ofcom that this should not be a reason for the benchmark not to be classified in Tier 1. As set out in our proposed framework criteria, this principle should be applied consistently in all benchmark countries.

C.7 Portugal

Ofcom uses the Portuguese benchmark in the calculations of both the 900MHz and the 1800MHz lump-sum values.

In the Portuguese auction all spectrum was sold at reserve prices, which in isolation could mean that the benchmark overstates market value. This is because the highest losing bid, which sets the price if there had been no reserve price, would have been lower than the reserve price. However, as we described in our first report,[30] the presence of spectrum caps may mean that despite spectrum selling at reserve prices the market value was not achieved. That is because a bidder that was prevented from bidding could in theory have submitted a bid higher than the reserve price that

[30] Analysys Mason and Aetha (2013), *Review of Ofcom's benchmarking of the value of the 1800MHz bands to determine annual licence fees,* Section 5.1.3.

would have become the highest losing bid and therefore the price paid. Because spectrum in Portugal sold at reserve prices and stringent spectrum caps were in place, we cannot be sure whether market value is understated or overstated for this benchmark. However, we see no reason to exclude it entirely and therefore recommend that Ofcom should classify it as Tier 2 benchmark, in accordance with our proposed framework.

C.8 Romania

Ofcom uses the Romanian benchmark in the calculations of both the 900MHz and the 1800MHz lump-sum values, classifying it as Tier 3 in both cases.

We agree that Romania is not a perfect benchmark since:

a) It was a package auction, which makes it difficult to determine band-specific prices, despite the fact that in this instance reserve prices can be used as a proxy for band-specific prices
b) There was unsold spectrum in the relevant bands.

However, as discussed in Section 3.4.3, we do not agree with Ofcom's assessment that the greater importance of 2G in Romania makes it a less relevant benchmark, as no market is a perfect representation of UK circumstances and this criterion only excludes a single benchmark. Therefore we recommend that Romania is classified as a Tier 2 benchmark, in accordance with our proposed framework.

C.9 Slovakia

Ofcom uses the Slovakian benchmark in the calculation of only the 1800MHz lump-sum value.

The auction in Slovakia was a CCA. However, we agree with Ofcom that it is possible to disaggregate prices in a meaningful way using reserve prices. Nonetheless, as discussed in Section C.1 above, we do not consider any disaggregation of CCA payments reliable enough to avoid relegation out of Tier 1. At the same time, however, we do not consider that the Slovakian benchmark should be excluded entirely.

Ofcom considers a number of reasons why the 1800MHz and 800MHz prices in Slovakia may risk overstating or understating market value in each case. It is argued that the 1800MHz reserve price could be higher than market value, as it was paid (subject to inaccuracies in the disaggregation of prices by band) by all winners. However, prices may also have been depressed due to the fragmentation of the available lots. Similarly, the 800MHz price was not pushed beyond reserve price through competition, but some operators argued that the reserve price was above market value.

The reserve price was used for the 2.6GHz value, which Ofcom suggests could have a risk of understating market value, but by an unknown amount.

Given this inconclusive evidence we do not agree with Ofcom's assessment that the distance method result will necessarily understate market value. We do not therefore see any objective reason to weight Slovakia differently from any other Tier 2 benchmark and therefore we recommend that Ofcom should classify it as such under our proposed framework.

C.10 Spain

Ofcom uses the Spanish benchmark in the calculation of only the 900MHz lump-sum value.

We are only considering the November 2011 auction for deriving a benchmark for Spain (i.e. not the preceding beauty contest). The caps in the 900MHz auction in 2011 effectively precluded some incumbents from bidding and therefore Spain is excluded from our benchmarks as per the framework we propose and describe in Section 4.

The November 2011 auction had spectrum caps set sufficiently high such that all incumbents could compete. The spectrum sold at its reserve price. Therefore it is possible that the benchmark could overstate the market value to some extent. However, we also note that only 2×5MHz of 900MHz was auctioned, and depending on the value that operators assigned to having contiguous spectrum lots of greater than 5MHz, it is also possible, although probably less likely, that the benchmark could understate market value. Consequently, overall we do not consider there to be clear evidence that Spain is overestimating or underestimating market value. On balance we therefore recommend that Ofcom should categorise it in Tier 2 under our proposed framework.

C.11 Sweden

Ofcom uses the Swedish benchmark in the calculation of only the 1800MHz lump-sum value.

In both the 800MHz and the 1800MHz auctions spectrum sold above reserve prices.

In Section 5.2.1 we discussed our view that an adjustment to the actual 2.6GHz price should be used, rather than a non-market-specific proxy as Ofcom suggests. Nonetheless, we agree with Ofcom's current classification of Sweden as a Tier 2 benchmark because:

a) We do use a proxy (albeit a different one) for the 2.6GHz band price by setting it equal to the 1800MHz band price
b) There is a time gap between the 800MHz and 1800MHz auctions.

Therefore, we do not recommend a change to the classification of Sweden from Ofcom's proposed Tier 2, and consider Tier 2 to also be the most appropriate categorisation under our proposed framework. However, in line with our arguments in Section 5.2.1 we strongly recommend that the Swedish benchmark is corrected both to use a more reasonable proxy and for the weighted averaging of lots described in Section 5.1.