OFCOM'S UPDATED INTERNATIONAL BENCHMARKING ANALYSIS

A REPORT PREPARED FOR VODAFONE

September 2014

Vodafone ALF August consultation

Figures and Tables

Executive Summary

In August 2014, Ofcom published a further consultation document on annual licence fees (ALF) for 900 MHz and 1800 MHz spectrum[1]. This included Ofcom's revised approach to treating international benchmarking evidence from other EU auctions of 900 MHz and 1800 MHz spectrum. This report sets out Frontier's review of this revised approach.

In summary, Ofcom's updated approach is broadly consistent with the methodology proposed by Frontier Economics and taking into account comments of other stakeholders. Ofcom now focusses on relative values from benchmark countries, using absolute values of 900 MHz and 1800 MHz spectrum only as a cross-check. Specifically:

- estimates of the 900 MHz spectrum value are now based on relative 900/800 MHz valuations from benchmark countries; and
- estimates of the 1800 MHz spectrum value are based on "distance ratios" from benchmark countries, that is, the ratio between the 1800 MHz and the 800 MHz values, both net of the 2.6 GHz value.[2]

Nevertheless, some shortcomings in Ofcom's methodology still remain, and these increase the risk of overestimating the true market value for 900 MHz and 1800 MHz spectrum in the UK.

In particular, the appropriate treatment of the available benchmarking evidence indicates that the results from the Austrian auction are likely to be a poor indication of relative market value of spectrum in the UK, as the estimated value of 900 MHz spectrum in Austria exceeds the value of 800 MHz spectrum, which is inconsistent with Ofcom's position that the value of 800 MHz spectrum should be expected to be higher. Austria should therefore be given minimal or no weight by Ofcom when deriving the market value of spectrum in UK, in line with the weight Ofcom attaches to Romania, the only other benchmark country indicating that 900 MHz is more valuable than 800 MHz spectrum.

Taking this into account, we come to a view that a reasonable range for the relative value of 900 MHz spectrum in the UK is between 62% (Ireland) and

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1 Ofcom, *Annual Licence Fees for 900 MHz and 1800 MHz spectrum – Further Consultation*, August 1, 2014, hereinafter "the August consultation".

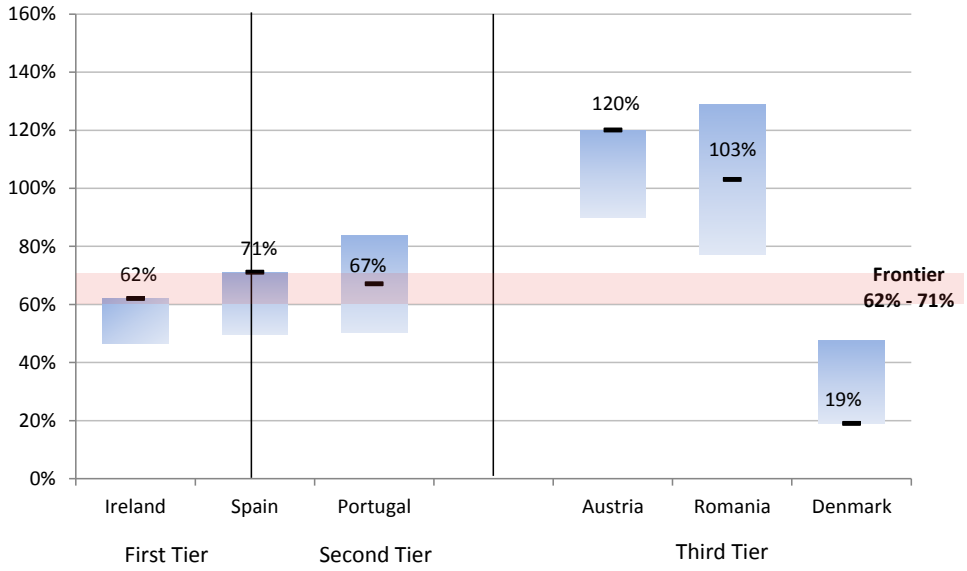
2 See Annexe 2 for more details on deriving 1800 MHz values based on distance ratio.

Figures and Tables

71% (Spain) ratios, with the appropriate value likely being closer to the 62% ratio from Ireland, which is a more reliable 900/800 benchmark[3], see **Figure 1** below.

While Ofcom's current proposal is within what we consider a reasonable range for relative 900 MHz value, its proposed 70%[4] ratio is at the upper end of the range and there is therefore a risk it could lead to overestimating the true market value of 900 MHz spectrum.

Figure 1. Range for 900 MHz relative value



Source: Frontier elaboration based on Ofcom data and August consultation, Figure 3.2

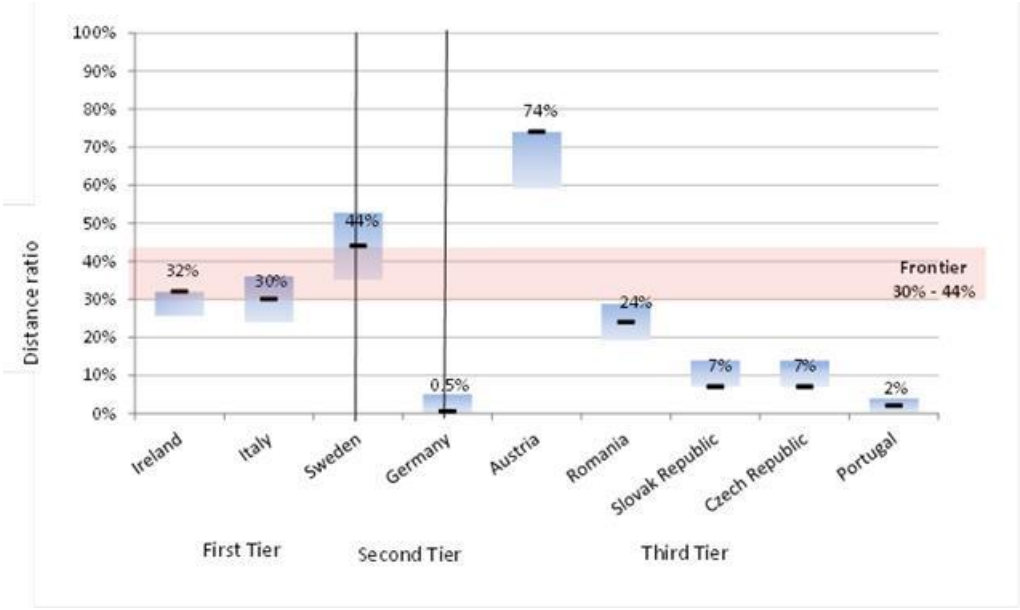
Similarly, we consider that a reasonable range for the relative value of 1800 MHz in the UK is between 30% (Italy) and 44% (Sweden) distance ratios, with the appropriate value likely being closer to more reliable benchmarks at the lower end of this range, namely Italy (30%) and Ireland (32%), see **Figure 2** below.

3 This value should be applied to the relevant comparator 800 UK value, i.e. excluding coverage obligation and any co-existence costs. It should also be noted that the appropriate range is derived taking into account Ofcom's current estimate of UK 800 value. If this estimate changes, the appropriate range of relative 900 and 1800 values will also be affected, as explained in Annexe 3.

4 In order to derive a consistent comparator with our recommended 62%, Ofcom's proposed 900 MHz value of £23m per MHz has been divided by Ofcom's estimate of UK 800 MHz value excluding coverage obligation and any co-existence costs.

Figures and Tables

Figure 2. Range for the 1800 MHz relative value



Source: Frontier elaboration based on Ofcom data and August consultation, Figure 3.3

Ofcom's current proposal of distance ratio of 31% is consistent with what the benchmarking evidence indicates is the appropriate relative value of 1800 MHz spectrum in the UK.

These relative ratios should be applied to a correctly derived estimate of UK 800 MHz value, excluding co-existence cost or coverage obligation.[5]

[5] This is because the relative ratios presented throughout this report have already been adjusted to reflect whether co-existence cost / coverage obligation have been incorporated in bidders' valuation of 800 MHz spectrum in a given auction (see Annexe 3 for more detail).

1 Ofcom's revised approach to international benchmarking

Our review of Ofcom's August consultation document, and of the underlying calculations within the Benchmarking Model, reveals that Ofcom has substantially improved its original analysis of international benchmarking evidence, broadly in line with the methodology proposed by Frontier Economics. Here we provide an overview of Ofcom's revised approach, describing the technical aspects in Annexe 2.

1.1 Methodological improvements

The main improvements of Ofcom's approach concern the following areas:

1.1.1 The importance of relative spectrum values

Ofcom recognises the issues raised in our response to its original consultation[6] on the use of absolute values of 900 MHz and 1800 MHz spectrum from other countries in deriving the UK values.

Ofcom now focusses on relative values:

- The value of the UK 900 MHz spectrum is now estimated based on relative 900/800 MHz valuations from international benchmarks. For each benchmark country, a relative 900/800 MHz value is obtained and multiplied by the UK 800 MHz value to compute a UK 900 MHz estimate. The final 900 MHz value is obtained through a qualitative assessment of the available estimates.

- The value of the UK 1800 MHz spectrum is estimated using international evidence on the value of the 1800 MHz spectrum relative to 800 MHz and 2.6 GHz bands. This evidence is used to compute a "distance ratio" for each benchmark country. Estimates of the UK 1800 MHz value are obtained for each benchmark employing the distance ratio, the value of the UK 800 MHz spectrum, and the value of the UK 2.6 GHz spectrum. The final 1800 MHz value is obtained through a qualitative assessment of the available estimates.

6 Frontier Economics, *Critique of Ofcom's International Benchmarking Analysis – A Report Prepared for Vodafone*, January 2014, hereinafter "Frontier's January response".

1.1.2 The appropriate treatment of auctions that cleared at reserve prices

Ofcom now treats auctions where spectrum cleared at reserve price as less relevant (Second Tier or Third Tier) evidence, accepting that these are likely to overestimate the true market value of spectrum[7].

1.1.3 The more careful assessment of factors driving spectrum value

Ofcom now takes into account some country- and auction-specific factors which may imply that auction benchmarks are not reflective of UK market values:

- Ofcom acknowledges that market profitability, demand for 2G spectrum and demand for mobile data[8] may have an impact on the spectrum value, but that the direction of this impact is inconclusive.
- Ofcom accepts that low urbanisation levels are likely to increase the value of low frequency spectrum in the country[9].
- Ofcom accepts that strategic valuations relating to the ability to weaken the market position of other bidders by preventing them from acquiring spectrum or strategic bidding, aimed at increasing the prices other bidders pay, may lead to auction outcomes that overstate the appropriate market value of spectrum[10].

1.1.4 The revised conversion of spectrum prices into UK equivalent values

Ofcom now computes the value of spectrum in benchmark countries by discounting payments at cost of debt, rather than weighted average cost of capital. Moreover, values are adjusted for deferred availability of spectrum, where relevant. In Annexe 2, we provide further detail on Ofcom's revised approach.

1.2 Evidence base

We now turn to analysing Ofcom's consideration of international benchmarks for the 900 MHz and 1800 MHz spectrum values. We compare Ofcom's

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7 Ofcom has however been inconsistent in its analysis of the UK auction, where prices also reflected reserve prices. In the UK Ofcom estimates that market values are above the prices paid.

8 August 2014 consultation, Annexe 7, paras. A7.62-74.

9 August 2014 consultation, Annexe 7, paras. A7.75-78.

10 August 2014 consultation, Annexe 7, para. A7.87.

allocation of benchmarks to one of three "tiers" in order of importance to our judgement expressed in previous responses[11], also based on three categories.

1.2.1 Evidence from 900 MHz auctions

Table 1 below provides a summary of Ofcom's assessment of the quality of 900/800 from selected EU auctions, in comparison with Frontier's as expressed in our previous responses. Ofcom's and Frontier's views are broadly consistent, with key differences in the treatment of Austria and Spain, and a discrepancy in the treatment of Romania.

11 Frontier's January response and Frontier Economics, *Critique of Ofcom's International Benchmarking Analysis – Response to Ofcom's Document "Update on European Auctions since Ofcom's Consultation on Annual Licence Fees for 900 MHz and 1800 MHz spectrum"*, June 2014, hereinafter "Frontier's June response".

Table 1. Comparison of Ofcom's and Frontier's assessment of international benchmarks for the 900 MHz spectrum

Country	Ofcom	Frontier	Key reasons for difference in treatment
Austria			Frontier considers the Austrian 900/800 MHz relative value to overstate UK market value, because of strategic behaviour in the 900 MHz band, and the high private value attached by operators to that band compared to the 800 MHz frequency. Ofcom recognises a risk of strategic behaviour driving auction values in Austria, but considers the direction and scale of this risk unknown.
Ireland			N/A
Spain			According to both Ofcom and Frontier, the 900 MHz auction outcome overstates market value in Spain, because spectrum sold at reserve price. However, Frontier considers auction outcomes from Spain as "Important evidence", because the 900/800 MHz relative value is judged to be reflective of the UK value.
Portugal			N/A
Denmark			N/A
Romania			Ofcom envisages a risk that the 900/800 MHz relative value may not be reflective of market value in Romania. Frontier considers it unclear. Both Frontier and Ofcom recognise that 900 MHz sold at reserve prices, and that there were 800 MHz lots unsold.

Legend:  First Tier / Important Evidence;  Second Tier / Less Important Evidence;
 Third Tier / Not Relevant Evidence

Based on this assessment of international benchmarking evidence, Ofcom uses an implied relative 900/800 MHz valuation of 70%[12]. Table 1 above shows this relative valuation in comparison to the evidence from each of the benchmarks considered by Ofcom, ordered according to the weight assigned to them in the August consultation. All ratios are adjusted to consistently reflect the relative

12 Computed as the ratio between Ofcom's valuation of the 900 MHz spectrum, £23 million, and Ofcom's valuation of the 800 MHz spectrum net of co-existence costs or coverage obligations, £32.63 million.

Ofcom's revised approach to international benchmarking

value of 900 MHz based on the value of 800 MHz spectrum net of co-existence costs and absent any coverage obligation.[13]

Ofcom's proposed relative 900/800 MHz valuation of 70% is within the range estimated in Frontier's January and June responses, 61% to 81%.

This range was obtained with the relative 900/800 valuation from Ireland as the lower bound, and the relative 900/800 valuation from Spain as the upper bound, given the estimates of 900 and 800 MHz spectrum provided by Ofcom in the October consultation. Data provided by Ofcom as part of the August consultation now shows relative values of 62% for Ireland and 71% for Spain[14]. Having reviewed Ofcom's approach and data[15], we accept these updates.

13 This adjustment depends on the size of co-existence and coverage obligation costs as a proportion of the value of UK 800 MHz spectrum net of co-existence costs and absent any coverage obligation. For the purpose of this report, in order to obtain relative valuations comparable with those used by Ofcom, we use Ofcom's UK 800 MHz figures, although, as explained in Vodafone's response on the UK auction, these include inflated estimates of the value of the UK 800 MHz spectrum. See Annexe 3 for further detail on the calculation of adjusted relative ratios.

14 These changes appear to be due to updates in the approach to calculating absolute values. See Annexe 2 for further detail.

15 August consultation, Annexes 7 and 8, and underlying calculations provided by DotEcon.

Ofcom's revised approach to international benchmarking

1.2.2 Evidence from 1800 MHz auctions

Table 2 below provides a summary of Ofcom's assessment of the quality of 900/800 from selected EU auctions, in comparison with Frontier's as expressed in our previous responses[16]. Ofcom's and Frontier's views are broadly consistent, with a key difference in the treatment of Austria, and discrepancies in the treatment of Germany, Romania, Slovak Republic, and Sweden.

16 Frontier Economics, January and June responses.

Ofcom's revised approach to international benchmarking

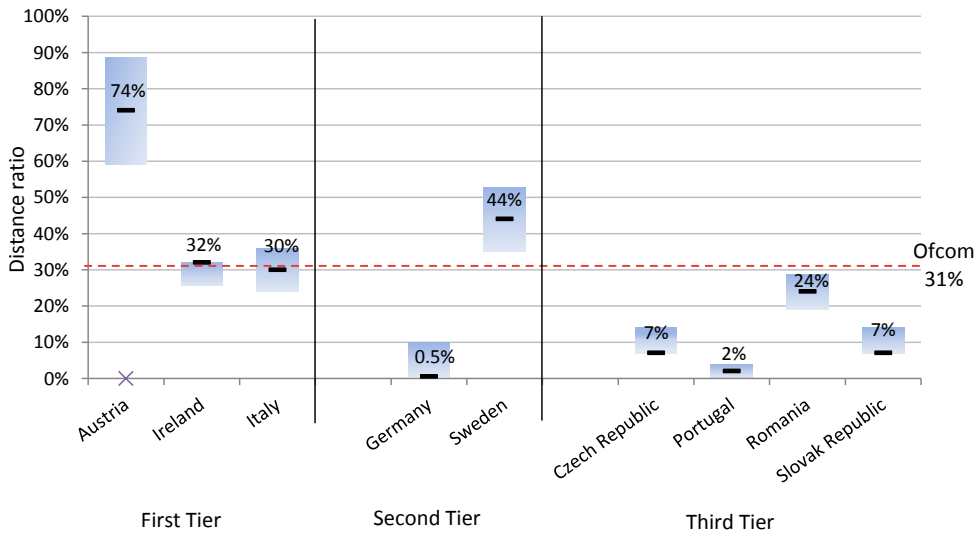
Table 2. Comparison of Ofcom's and Frontier's assessment of international benchmarks for the 1800 MHz spectrum

Country	Ofcom	Frontier	Key reasons for difference in treatment
Austria	🟢	🔴	Frontier considers the Austrian 1800/800 MHz relative value to overstate UK market value, because of strategic behaviour in the 1800 MHz band, and the high private value attached by operators to that band compared to the 800 MHz frequency. Ofcom recognises a risk of strategic behaviour driving auction values in Austria, but considers the direction and scale of this risk unknown.
Czech Republic	🔴	🔴	N/A
Germany	🟡	🔴	Ofcom considers the prices paid for the 1800 MHz spectrum not to be reflective of market value in Germany, because of strategic behaviour in that auction. Frontier considers German evidence “not relevant” because it potentially suggests a UK 1800 MHz value below the 2.6 GHz value.
Ireland	🟢	🟢	N/A
Italy	🟢	🟢	N/A
Portugal	🔴	🔴	N/A
Romania	🔴	🟡	According to Ofcom, auction outcomes are likely not to reflect market value in Romania, because the 1800 MHz spectrum sold at reserve price. According to Frontier, this is not clear, since prices paid in Romania for the 800 MHz spectrum are also likely to be distorted by high reserve prices.
Slovak Republic	🔴	🟡	Ofcom considers the 1800 MHz auction to have cleared at reserve prices. Frontier estimates the clearing prices as above reserve prices. Moreover, Ofcom considers the fragmentation of spectrum in the 1800 MHz auction to be a potential reason why Slovak auction outcomes may not reflect UK market values.
Sweden	🟡	🟢	Ofcom considers the prices paid for the 1800 MHz spectrum to be potentially understating market value in Sweden, because of the joint venture between Tele2 and Telenor. According to Frontier, the joint venture does not necessarily imply that Swedish outcomes are not reflective of market value.

Legend: 🟢 First Tier / Important Evidence; 🟡 Second Tier / Less Important Evidence; 🔴 Third Tier / Not Relevant Evidence

Based on its assessment of international benchmarking evidence, Ofcom uses an implied distance ratio of 31%[17] to estimate the UK 1800 MHz value. **Figure 3** below shows this relative valuation in comparison to the evidence from each of the benchmarks considered by Ofcom, ordered according to the weight assigned to them in the August consultation.

Figure 3. Summary of Ofcom's assessment of benchmarking evidence on 1800 MHz spectrum in the August 2014 consultation



Note: All relative ratios based on 800 MHz value net of co-existence costs and without coverage obligation

Source: Frontier elaboration based on Ofcom data and August consultation, Figure 3.2

The implied 1800/800 MHz relative valuation proposed by Ofcom is 43%[18]. This is consistent with the range estimated in Frontier's January and June responses of 32% to 64%, with relative observation from Italy representing the lower bound (32%) and Sweden being the upper bound (44%).

In the following sections, we analyse the shortcomings in Ofcom's current benchmarking approach.

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17 Computed as the ratio between i) Ofcom's valuation of the 1800 MHz spectrum, £14 million, minus the value of the UK 2.6 GHz spectrum, £5.5 million, and ii) Ofcom's valuation of the 800 MHz spectrum excluding co-existence costs, £32.63 million, minus the value of the UK 2.6 GHz spectrum, £5.5 million.

18 Computed as the ratio between Ofcom's valuation of the 1800 MHz spectrum, £14 million, and Ofcom's valuation of the 800 MHz spectrum excluding co-existence costs and coverage obligations, £32.63 million.

Ofcom's revised approach to international benchmarking

2 Key shortcomings of Ofcom's updated approach to international benchmarking

While Ofcom's updated approach to evaluating the international benchmarking have improved significantly since the original consultation, we believe that there are still shortcomings in Ofcom's methodology, which could lead to overestimating the true value of ALF for 900 MHz and 1800 MHz spectrum in the UK. In particular Ofcom treats some of the international benchmarking evidence in an inconsistent way, in particular relative valuations derived from the auction in Austria. We discuss this in more detail below.

2.1 Ofcom treats benchmarking evidence in an inconsistent and biased way

2.1.1 Austria

Ofcom treats the relative values of 900 MHz and 1800 MHz spectrum derived from the Austrian auction as First Tier (more important) evidence for estimating the value of 900 and 1800 MHz spectrum in the UK. As explained in our previous submission[19], we believe that the LRP results of the Austrian auction provide only limited information about the true value of spectrum in the UK.

- First, the fact that 900 MHz LRP in Austria was above 800 MHz implies that Ofcom cannot treat relative value of 900/800 spectrum as more important evidence for deriving UK market value of 900 MHz spectrum while being internally consistent.

- Second, it is not clear that the LRP estimates from the Austrian auction reflect the true relative market value of spectrum in Austria.

- Third, even if the LRP estimates reflect the market value in Austria, the relative value of 900 and 1800 spectrum is not reflective of relative market value in the UK.

As a result, Ofcom should put only a minimal or no weight to the Austria evidence when deriving the market value of spectrum in the UK, in line with its approach in treating Romania, the only other benchmark indicating 900 MHz is

19 Frontier Economics, June Response

more valuable than 800 MHz spectrum.[20] This is particularly relevant given that Ofcom now works with a smaller sample of benchmarks, which implies the available evidence needs to be treated even more cautiously.[21]

We discuss these points in more detail below.

The fact that 900 MHz LRP in Austria was above 800 MHz implies that Ofcom cannot treat relative value of 900/800 spectrum as more important evidence for deriving UK market value of 900 MHz spectrum while being internally consistent

In the original consultation, Ofcom made it clear that it considers the market value of 800 MHz in the UK to be a likely upper bound of 900 MHz value in the UK.

> *"On this basis, we consider on balance that 900 MHz is unlikely to have a higher value than 800 MHz spectrum in the UK, i.e. the value of the 800 MHz spectrum in the UK is likely to set an upper limit on the value of 900 MHz in the UK."*[22]

In the current consultation, Ofcom does not provide any additional evidence or explanation indicating that it has changed its position on this important issue. Therefore, if Ofcom is still of the view that 900 MHz value in the UK is equal or below 800 MHz value, it cannot use 900/800 ratio from Austria of 120% to reliably derive 900 MHz market value in the UK, while remaining internally consistent and conservative in its approach.

In other words, 900/800 ratio which is above 100% cannot reflect the relative market value of spectrum in the UK. There are a number of reasons why the relative LRPs in Austria may not reflect relative values in the UK:

- either there has been strategic bidding in the Austrian auction that pushed 900 MHz prices above 800 MHz value in Austria, which would

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20 In our June Response, we included the relative value from Austria in our sensitivity analysis and we treated it as Second Tier evidence. This was primarily to ensure internal consistency (i.e. the relative 900/800 from Austria (110%) was below what we defined as an upper bound value of 900 MHz spectrum in the UK, which was based on the UK 800 value gross co-existence costs). We note that a consistently derived relative value from the Austrian auction at 120% (see Annexe 3 for more details on deriving adjusted 900/800 values) would likely be above this upper bound of 900 MHz value in the UK, further indicating that Austria should be treated as Third Tier evidence.

21 For instance, in the 900 MHz sensitivity analysis presented as a part of June Response, we consider all available observations, both absolute and relative, implying that the relative valuation from Austria was only one out of 17 observations. Therefore, the results were less sensitive to how much weight is given to this observation. This is not the case under Ofcom's updated approach, where Austria is one of 6 observations considered in the sample, and the risk of deriving biased results is much higher.

22 Ofcom, October consultation, para 4.42.

Key shortcomings of Ofcom's updated approach to international benchmarking

overestimate true value of 900 MHz in the UK (if we apply 900/800 ratio from Austria to UK 800 value); or

- the true value of 900 MHz in Austria is indeed above 800 MHz value, due to specific market circumstance, which makes it incomparable comparable to the UK and 900/800 ratio would overestimate the true market value of 900 MHz in the UK; or
- both of these statements are valid, which further undermines the relevance of 900/800 ratio from Austria for the purposes of deriving the true market value of 900 MHz in the UK.

In fact, as discussed below, there is evidence that there might have been strategic biding in the Austrian auction that might have inflated overall prices paid in the auction but also distorted relative 900/800 valuations. In addition, we show that there are significant differences in the characteristics of the mobile markets in Austria and the UK, which could lead to inflated 900/800 ratio.

We note that the only other auction in Ofcom's benchmarking sample where the relative 900/800 value indicates 900 MHz spectrum is more valuable than 800 MHz spectrum is Romania. As further discussed below, Ofcom treats Romania as Third Tier evidence, does not consider it when deriving the value of 900 MHz and 1800 MHz spectrum in the UK and does not even take this observation into account when undertaking its sensitivity analysis. Ofcom provides the following reasoning:

> *"The price of the 900 MHz band in the Romanian auction was higher than the price of the 800 MHz band. This reflected the relativity of the reserve prices that were set by the regulator. Moreover, despite having a lower reserve price, there was unsold 800 MHz spectrum in Romania, but no unsold 900 MHz spectrum. The evidence indicates that the higher price of 900 MHz compared to 800 MHz was driven to a large extent by the much greater importance of 2G in Romania compared with the UK. We regard this as so different to the key drivers of the relative value of these bands in the UK that we consider Romania to be a third-tier benchmark for 900 MHz."*[23]

In other words, Ofcom accepts that there are significant differences between the UK and Romanian market, which are driving the value of 900 MHz spectrum above the value of 800 MHz spectrum, and therefore make the auction outcomes from Romania less relevant for estimating the market value in the UK. At the same time, Ofcom ignores that fact that there must be specific factors in the Austrian auction, which are driving the value of 900 MHz above the value of 800 MHz spectrum in Austria, thus making the outcomes of the Austrian auction less relevant for deriving the true market value of spectrum in the UK.

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23 Ofcom, August consultation, para 3.36.

It is not clear that the LRP estimates from the Austrian auction reflect the true market value of spectrum in Austria

The LRP decomposition of the package prices does not provide market clearing prices for individual blocks of spectrum[24]. Ofcom itself is proposing to depart from the use of LRP for the UK auction, reflecting the limitations of the methodology. This is of particular concern in the Austrian auction where the lack of transparency in the application of the LRP methodology means that stakeholders, including Ofcom, cannot adequately assess the robustness of the decomposition. Nor can anyone determine what other drivers of value, such as strategic value, may have impacted the auction outcomes, the values of losing bids, and the LRP calculations.

There is indeed evidence that strategic valuations paid a key role, as explained in more detail below. We also understand that the Austrian auction results are the subject of on-going legal challenges by operators.[25]

Even if the LRP estimates reflect the operators' valuation in Austria, the relative value of 900 and 1800 spectrum is not reflective of true market value in the UK

There is evidence that the prices in Austria were influenced by 'exclusionary' and/or 'price setting' strategic bids (mainly in the supplementary round of the auction), which may indicate that prices paid in the auction may reflect the potential value of converting a three-operator market into a two-operator market, or the value of a third operator trying to maintain its existence (and relative competitiveness) in the market versus competitors trying to push it out. A combination of strategic bidding and high private values for existing spectrum could therefore have led to the price of 900 and 1800 MHz spectrum being bid up above a market clearing level, thus further distorting relative valuations and any sensible comparison with the UK.

A combination of the timing of the auction, the current use of some of the spectrum being auctioned and the timing of potential reassignment of the spectrum could have inflated the spectrum value and distorted any comparison with the UK. As explained in our previous submission, the combination of these effects means that the some bidders may have significant private value attached

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24 Frontier's analysis of the UK auction (Annexe 2 to Vodafone's response to Ofcom's original consultation on Annual Licence Fees for 900 MHz and 1800 MHz spectrum dated January 2014)), hereinafter 'UK auction analysis', shows that the LRP method does not give band specific market clearing prices.

25 See for instance a Reuters article from 26 November 2013: *H3G joins T-Mobile Austria in telco auction appeal,* available online at http://uk.reuters.com/article/2013/11/26/us-austria-telecoms-auction-idUKBRE9AP13620131126

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to the 900 and 1800 bands, but the same did not hold for newly released 800 MHz spectrum.[26] The high private value attached by current holders of 900 and 1800 spectrum is therefore likely to inflate the private value of this spectrum compared to the clear 800 spectrum, where no operator will have significant private value.

Finally, as discussed in our previous submission, there is evidence that spectrum suitable for delivery of mobile data services is likely to be more valuable in Austria than in the UK. In particular, the overall importance of mobile broadband access; and ii) the importance of dedicated mobile broadband devices[27] is higher in Austria than the EU in general, and the UK in particular. The need to meet demand of these data heavy mobile broadband users would likely increase the value of mobile data spectrum in Austria, compared to the UK. In addition, it is possible that the relative value of spectrum used to serve existing mobile broadband customers (in particular 900 MHz and 2100 MHz spectrum suitable for delivery of 3G services) was higher than the value of spectrum that was newly offered in the Austrian auction 800 MHz spectrum.

Therefore, in order to be internally consistent, we conclude that Ofcom should put no or only minimal weight on this observation when deriving the market value of 900 MHz spectrum.

2.1.2 Other countries – 900 MHz

As shown in Table 1 and Table 2, there are other cases besides Austria where our treatment of benchmarking evidence in previous responses differs from Ofcom's. Here, we focus on differences on 900 MHz evidence with respect to Spain and Romania as well. We analyse these two cases in turn.

Ofcom treats auction outcomes from **Spain** as Second Tier (less important) evidence, while we considered them to be more important (First Tier) evidence.

- Ofcom's treatment is based on the judgement that the 900/800 MHz ratio is likely to overestimate the value of 900 MHz spectrum in Spain. This is because the November 2011 900 MHz auction cleared at reserve price, while the 800 MHz auction outcomes are reflective of market value. In our responses, we recognised this overestimation risk[28], i.e. the 900/800 ratio is likely to be an upper bound of the true value as the 900 valuation is inflated. However, we treated evidence from Spain as more important (First Tier),

26 In particular the high private value attached by current holders of 900 and 1800 spectrum, given the possibility to re-farm this spectrum prior to it being re-assigned in 2016.

27 Mobile data cards, modems, key and dongles.

28 Frontier Economics, June Response, Case Study Annexes, pages 109-121.

because the 900/800 MHz relative valuation is likely to control for country-specific factors when comparing Spain to the UK. In this note, we consider Spain as a borderline case: we treat evidence from Spanish auctions as First Tier evidence in our main estimates, but within our sensitivity analysis we also provide estimates based on considering Spain as a Second Tier benchmark.

Ofcom treats **Romania** as Third Tier (less relevant) evidence, while we included it as less important (Second Tier) evidence in our previous submission.[29]

- Ofcom considers the relative 900/800 MHz valuation to be at risk of not reflecting market values in Romania. We recognised this risk, resulting from the 900 MHz auction clearing at reserve prices and the 800 MHz leaving 2x5MHz blocks unsold. However, because both 900 MHz and 800 MHz spectrum may not reflect market value, the effect on the 900/800 ratio is unclear[30].

- In this note, taking into account Ofcom's view, and our considerations of the Romanian market with respect e.g. to the demand for 2G services, recognised by Ofcom in the August consultation[31], we accept Ofcom's treatment of Romania as a Third Tier benchmark is more appropriate.

- This is particularly relevant given the smaller size of the benchmarking sample based only on relative values and the increased risk of overestimating the true market value of 900 MHz spectrum if too much weight is put on observations that are clearly not reflective of relative market value of spectrum in the UK, i.e. given that the results indicate 900 MHz spectrum is more valuable than 800 MHz spectrum.

2.1.3 Other countries – 1800 MHz

Our treatment of 1800 MHz international benchmarking evidence in previous responses differs from Ofcom's in the cases of Sweden, Germany, Romania, and the Slovak Republic. We analyse these in turn.

Ofcom treats auction outcomes from **Sweden** as Second Tier (less important) evidence, while we considered them to be more important (First Tier) evidence.

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29 In our previous submission, we included the relative value from Romania in the sensitivity analysis and we treated it as Second Tier evidence primarily to ensure internal consistency (i.e. the relative 900/800 was within what we defined as a plausible range of 900 MHz values), while recognising that the benchmarking sample was sufficiently large to ensure our overall findings are robust to whether Romania is treated as Second Tier or Third Tier evidence.

30 Frontier Economics, June Response, Case Study Annexes, pages 101-109.

31 Ofcom, August consultation, Annexe 8, paras. A8.269-271.

Key shortcomings of Ofcom's updated approach to international benchmarking

- Ofcom's key reason for its treatment of Sweden is the judgement that outcomes from the 1800 MHz auction may understate market value, because of joint bidding by Tele2 and Telenor in that auction. However it is not clear to what degree market structure should affect the marginal opportunity cost of spectrum, given that consolidation will not alter the overall level of traffic on networks. Ofcom has not taken into account elsewhere other structural issues such as network sharing or the number of operators, when assessing the appropriateness of benchmarks.

- For the purposes of our analysis, we consider Sweden as a borderline case. In our main estimates, we treat it as First Tier evidence. However, within our sensitivity analysis, we also provide estimates based on considering Sweden as a Second Tier benchmark, consistent with Ofcom's assessment.

Ofcom treats auction outcomes from **Germany** as Second Tier (less important) evidence, while we considered them to be less relevant (third tier) evidence.

- Relying on the 1800/800 MHz relative valuation from Germany would yield an estimate of the UK 1800 MHz value below the UK 2.6 GHz value. This is inconsistent with Ofcom's own view[32] that the 1800 MHz value should be above the 2.6 GHz value. However, Ofcom's updated approach also takes into account evidence on 2.6 GHz from Germany, and uses the UK value of 2.6 GHz spectrum as a floor for estimates of the 1800 MHz value[33]. As a consequence, in our analysis, we consider Germany as a borderline case. In our main estimates, we treat it as Third Tier evidence, but we also investigate the impact of treating as Second Tier, consistent with Ofcom's approach, within our sensitivity analysis.

Ofcom treats **Romania** as third tier (less relevant) evidence, while we included it as less important (second tier) evidence.

- Ofcom considers auction outcomes to be at risk of not reflecting market values in Romania. We recognised this risk, resulting from the 1800 MHz auction clearing at reserve prices and the 800 MHz leaving 2x5MHz blocks unsold. However, because both 1800 MHz and 800 MHz spectrum may not reflect market value, the effect on the 1800/800 ratio is unclear[34]. In our analysis, we accept Ofcom's treatment of Romania as a Third Tier benchmark, taking into account:

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32 As expressed in Ofcom, October consultation, para. 4.32, and implicit in the distance method employed in the August consultation.

33 See Annexes 1 and 2 for further detail.

34 Frontier Economics, June Response, Case Study Annexes, pages 101-109.

- Ofcom's view on relative values from Romania;
- the fact that Ofcom also considers evidence from the 2.6 GHz auction, where some blocks were unsold;
- our considerations on the peculiarity of the Romanian market with respect e.g. to the demand for 2G services, recognised by Ofcom in the August consultation[35].

Ofcom treats auction outcomes from the **Slovak Republic** as Third Tier (less relevant) evidence, while we included them as less important (Second Tier) evidence.

- As part of the August consultation, Ofcom provides further evidence that the 1800 MHz auction in the Slovak Republic effectively cleared at reserve price. Based on this additional evidence, we accept Ofcom's treatment of the Slovak Republic as a Third Tier benchmark.

35 Ofcom, August consultation, Annexe 8, paras. A8.269-271.

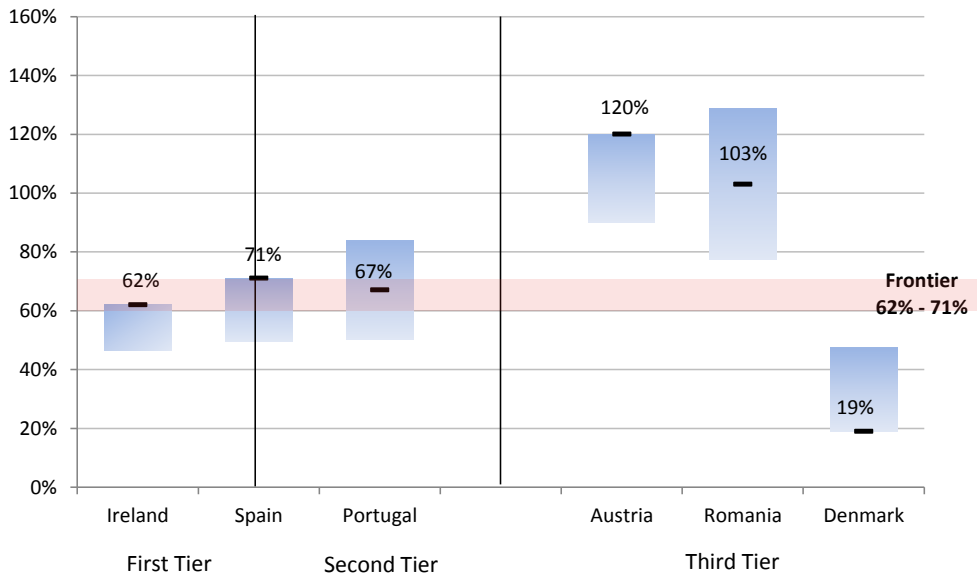
Key shortcomings of Ofcom's updated approach to international benchmarking

3 Correcting for main shortcomings in Ofcom's approach to estimate relative values of 900 MHz and 1800 MHz spectrum

3.1 900 MHz

We first present Ofcom's approach looking at relative values only, but putting appropriate weight on Austria and other relevant 900 MHz evidence. **Figure 4** below presents our assessment of the appropriate weights for the benchmarking evidence considered by Ofcom.

Figure 4. Summary of Frontier's assessment of 900 MHz benchmarking evidence considered in Ofcom's August 2014 consultation



Note: All relative ratios based on 800 MHz value net of co-existence costs and without coverage obligation

Source: Frontier elaboration based on Ofcom data and August consultation, Figure 3.2.

We have already explained why Austria cannot be considered a First Tier benchmark for the value of 900 MHz spectrum in the UK.

We accept Ofcom's concerns that the Spanish auction outcomes may not be reflective of market value in that country. Therefore, we consider Spain as a borderline case between First and Second Tier benchmark when deriving the appropriate range of relative 900 MHz values. For our main estimate, we treat Spain as First Tier benchmark. As part of our sensitivity analyses, we also show

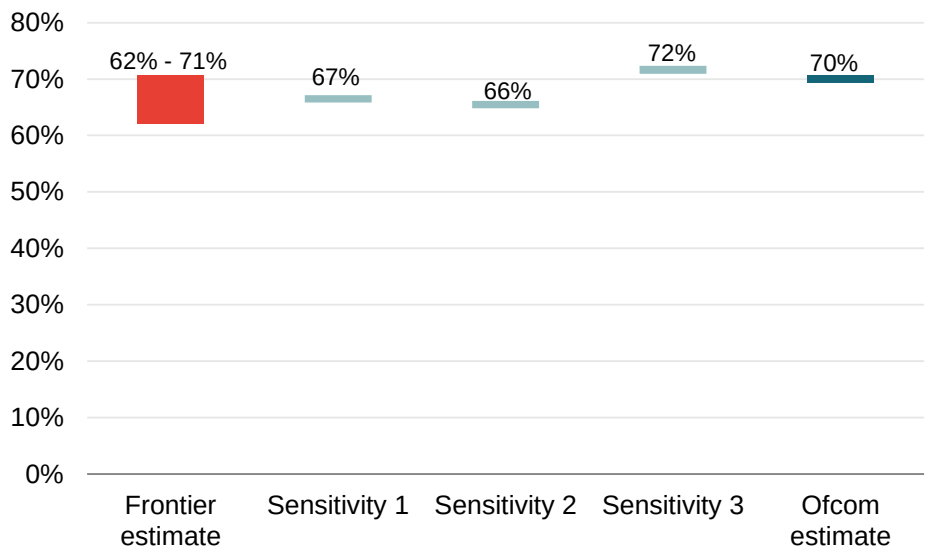
the impact of treating Spain as Second Tier evidence, in line with Ofcom's classification.

Based on this, we come to a view that a reasonable range for the relative value of 900 MHz spectrum in the UK is between 62% (Ireland) and 71% (Spain) ratios, with the appropriate value likely being closer to the 62% ratio from Ireland[36], which is the only true First Tier benchmark in the sample of relative 900 MHz benchmarks.

While Ofcom's current proposal is within what we consider a reasonable range for relative 900 MHz value, its proposed 70%[37] ratio is at the upper end of the range and there is therefore a risk it could lead to overestimating the true market value of 900 MHz spectrum.

Analysing the sensitivity of our estimate to the weights assigned to benchmarking evidence confirms that a range of 62% - 71% is broadly consistent with the sensitivity estimates. Ofcom's proposed 70% ratio is towards the upper end of the range of sensitivity estimates, as shown in **Figure 5** below.

Figure 5. Sensitivity analysis of 900/800 MHz relative values



Source: Frontier elaboration based on Ofcom data and August consultation.

36 This value should be applied to the relevant comparator 800 UK value, i.e. excluding coverage obligation and any co-existence costs.

37 In order to derive a consistent comparator with our recommended 62%, Ofcom's proposed 900 MHz value of £23m per MHz has been divided by Ofcom's estimate of UK 800 MHz value excluding coverage obligation and any co-existence costs.

Correcting for main shortcomings in Ofcom's approach to estimate relative values of 900 MHz and 1800 MHz spectrum

Table 3 below presents the results of our sensitivity analysis in detail.

Table 3. Sensitivity of 900/800 MHz ratio to weighting of benchmarking evidence

Country	900 / 800 MHz ratio	Weights – Sensitivity 1	Weights – Sensitivity 2	Weights – Sensitivity 3
Ireland	62%	100%	100%	100%
Austria	120%	0%	0%	50%
Portugal	67%	50%	50%	75%
Spain	71%	100%	50%	75%
Denmark	19%	0%	0%	50%
Romania	103%	0%	0%	50%
Implied 900/800 value – using UK 800 with no co-existence cost or coverage obligation		**67%**	**66%**	**72%**

Source: Frontier elaboration based on Ofcom data and August consultation.

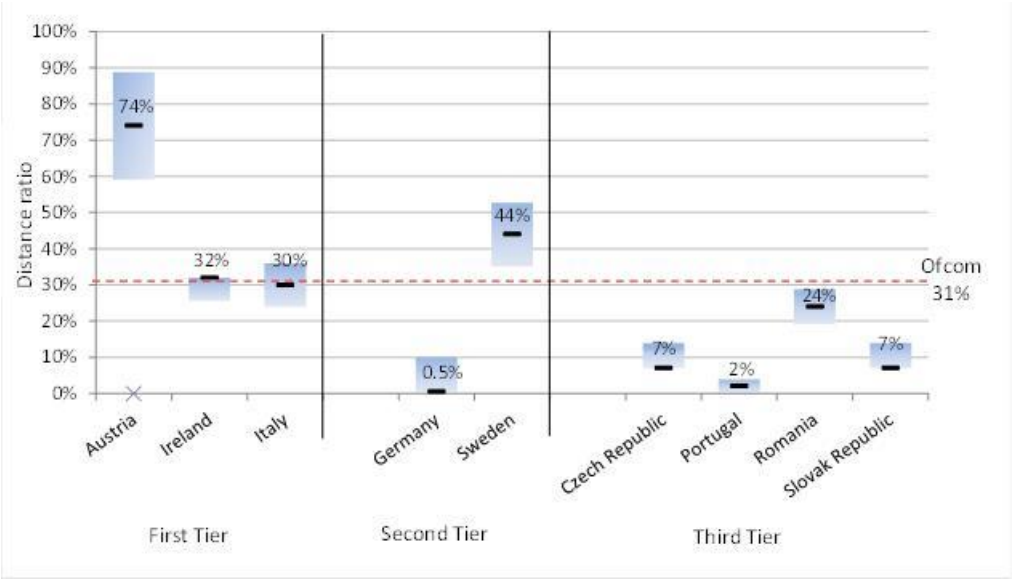
In our first sensitivity, we compute a point estimate of the 900/800 MHz range as a weighted average of First and Second Tier benchmarks. In Sensitivity 2, we show the impact of classifying Spain as a Second Tier benchmark, consistent with Ofcom's assessment. Then, in Sensitivity 3, we take into account Third Tier benchmarks as well, still using Ofcom's assessment of Spain as Second Tier evidence.

3.2 1800 MHz value

Figure 6 below presents our assessment of the benchmarking evidence considered by Ofcom. As outlined in our review of the key shortcomings in Ofcom's current approach, we maintain that evidence including 1800 MHz values from Austria cannot be considered as First Tier for the purpose of deriving UK spectrum values. We take into account the distance ratio obtained from the Austrian auction outcomes as Third Tier evidence.

Correcting for main shortcomings in Ofcom's approach to estimate relative values of 900 MHz and 1800 MHz spectrum

Figure 6. Summary of Frontier's assessment of 1800 MHz benchmarking evidence considered in Ofcom's August 2014 consultation



Note: All relative ratios based on 800 MHz value net of co-existence costs and without coverage obligation

Source: Frontier elaboration based on Ofcom data and August consultation, Figure 3.3.

Auction outcomes from Sweden could be considered as First Tier evidence. Although we recognise Ofcom's concerns that the joint venture between Tele2 and Telenor reduced demand for 1800 MHz spectrum, it is not clear that structural differences should influence the assessment of Sweden as a benchmark. As a result, we consider Sweden as a borderline case between First and Second Tier benchmark. In order to derive the appropriate range for relative 1800 MHz valuation, we treat it as First Tier evidence. As part of our sensitivity analyses, we show the impact of treating it as Second Tier evidence, in line with Ofcom's classification.

Similarly, auction outcomes from Germany could be considered as Third Tier, rather than Second Tier, because of strategic behaviour prevailing in the German 1800 MHz auction. Taking into account Ofcom's argumentation, we however consider Germany as a borderline case between Second and Third Tier benchmark, treating it as Third Tier in our main estimates, and as Second Tier in our sensitivity analyses.

As discussed, based on additional evidence presented by Ofcom, we accept the categorisation of Slovak Republic and Romania as Third Tier benchmarks.

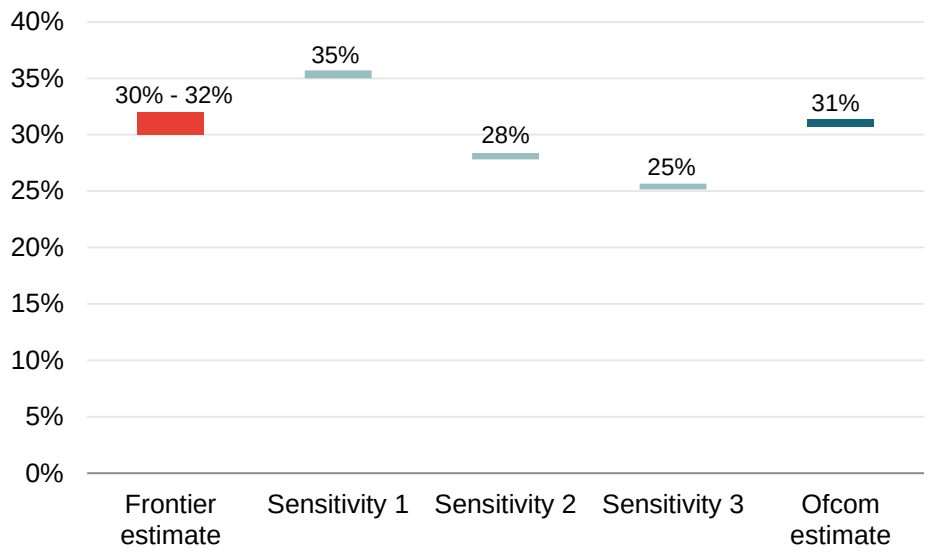
Based on this we consider that a reasonable range for the relative value of 1800 MHz in the UK is between 30% (Italy) and 44% (Sweden) distance ratios, with the appropriate value likely being closer to more reliable benchmarks at the lower end of this range, namely Italy (30%) and Ireland (32%).

Correcting for main shortcomings in Ofcom's approach to estimate relative values of 900 MHz and 1800 MHz spectrum

Ofcom's current proposal of distance ratio of 31% is consistent with what the benchmarking evidence indicates is the appropriate relative value of 1800 MHz spectrum in the UK.

Analysing the sensitivity of the above range to the weights assigned to benchmarking evidence confirms that our conclusion is broadly consistent with the range of sensitivity estimates (25% to 35%). Ofcom's proposed 31% ratio is near the middle of the range of sensitivity estimates, as shown in **Figure 7** below.

Figure 7. Sensitivity analysis of 1800 MHz relative values



Note: for the purposes of the sensitivity analysis, Frontier estimate represents the mid-point of the appropriate range of First Tier evidence of 30% and 32%.

Source: Frontier elaboration based on Ofcom data and August consultation.

Table 4 below presents the results of our sensitivity analysis in detail. In our first sensitivity, we compute a point estimate of the distance ratio as a weighted average of First and Second Tier benchmarks. In Sensitivity 2, we show the impact of classifying Sweden and Germany as Second Tier benchmarks, consistent with Ofcom's assessment. Then, in Sensitivity 3, we take into account Third Tier benchmarks as well, still using Ofcom's assessment of Sweden and Germany.

Table 4. Sensitivity of 1800 MHz distance ratio to weighting of benchmarking evidence

Country	Distance ratio	Weights – Sensitivity 1	Weights – Sensitivity 2	Weights – Sensitivity 3
Austria	74%	0%	0%	50%
Czech Republic	7%	0%	0%	50%
Germany	0.5%	0%	50%	75%
Ireland	32%	100%	100%	100%
Italy	30%	100%	100%	100%
Portugal	2%	0%	0%	50%
Romania	24%	0%	0%	50%
Slovak Republic	7%	0%	0%	50%
Sweden	44%	100%	50%	75%
Implied distance ratio – using UK 800 MHz value without co-existence or coverage obligation)b		**35%**	**28%**	**25%**

Source: Frontier elaboration based on Ofcom data and August consultation.

Correcting for main shortcomings in Ofcom's approach to estimate relative values of 900 MHz and 1800 MHz spectrum

4 Conclusion

In summary, we conclude that Ofcom's updated analysis is broadly in line with the methodology proposed by Frontier Economics and taking into account comments of other stakeholders. Ofcom now focusses on relative values from benchmark countries, using absolute values of 900 MHz and 1800 MHz spectrum only as a cross-check.

We have identified shortcomings in Ofcom's current approach, in particular with regards to treating the results of the Austrian auction as First Tier evidence. This is inconsistent with Ofcom's own views about the value of 900 MHz spectrum in the UK not being higher than the value of 800 MHz spectrum. Moreover, there is evidence indicating that the results from the Austrian auction are likely to be a poor indication of relative market value of spectrum in the UK and that these results should be treated as Third Tier evidence.

Taking this into account, we come to a view that a reasonable range for the **relative value of 900 MHz spectrum in the UK is between 62% and 71%**, with the appropriate value likely being closer to the 62% ratio from Ireland, which is a more reliable 900/800 benchmark. Therefore, Ofcom's current proposal of 70% risks overestimating the true market value of 900 MHz spectrum in the UK.

Similarly, we consider that a reasonable range for the **1800 MHz distance ratio in the UK is between 30% and 44%**, with the appropriate value likely being closer to more reliable benchmarks at the lower end of this range, namely Italy (30%) and Ireland (32%). Ofcom's current proposal of distance ratio of 31% is consistent with what the benchmarking evidence indicates is the appropriate relative value of 1800 MHz spectrum in the UK.

These ratios should be applied to a correctly derived estimate of UK 800 MHz value, **absent co-existence cost or coverage obligation**. This is because the relative ratios presented throughout this report have already been adjusted for the presence of co-existence costs or coverage obligations in the valuation of 800 MHz spectrum in benchmark countries (see Annexe 3 for more detail). Relative valuations applicable to an estimate of UK 800 MHz value gross of co-existence cost would be proportionally lower, as shown in Annexe 4.

Annexe 1: Ofcom's revised benchmarking methodology

Table 5. Comparison of Ofcom and Frontier's approach to international benchmarking

	Ofcom August 1 consultation	Frontier reports	Implications
	General approach to benchmarking		
Values used for benchmarking (900 MHz)	Relative valuations of 900 MHz / 800 MHz spectrum.	Relative valuations of 900 MHz / 800 MHz spectrum, and absolute valuations as a sensitivity check.	Ofcom accepts the arguments in favour of relative values. Unlike in the Frontier reports, absolute values are completely ignored in Ofcom's new consultation
Values used for benchmarking (1,800 MHz)	A 'distance method' using valuations of both 800 MHz and 2,600 MHz bands. The UK value is obtained as: $1800_{UK} = \frac{1800_{BC} - 2.6_{BC}}{800_{BC} - 2.6_{BC}} x\,(800_{UK} - 2.6_{UK}) + 2.6_{UK}$ Where BC = Benchmark Country.	Relative valuations of 1,800 MHz / 800 MHz spectrum, and absolute valuations as a sensitivity check.	Ofcom accepts the arguments in favour of relative values. Unlike Frontier, Ofcom uses both 800 MHz and 2,600 MHz valuations in obtaining the 1,800 MHz UK value.
Approach to weighting of benchmark values	Relative values from each country assigned to one of three tiers, from Tier 1 (most informative of UK market values) to Tier 3 (providing little information on UK market values). Then, interpretation of individual benchmarks is driven by an assessment of the risk that they may be understated or overstated estimates of market value in	Relative values considered 'less relevant' for the UK market where the absolute value of the 900 MHz spectrum is outside of the 'appropriate range' – that is, above the UK	Both Ofcom and Frontier categorise individual benchmarks into three categories. However, Ofcom does not consider the UK values of 800 MHz and 2,600 MHz

	the UK.	value of the 800 MHz spectrum, or below the UK value of the 2,600 MHz spectrum. Within the appropriate range, relative values are classified as more or less important based on how informative they are of the UK market.	spectrum as relevant thresholds. Austria considered 'less relevant' by Frontier, but allocated to Tier 1 (most informative values) by Ofcom.
What determines the extent to which benchmarks are informative?	Two criteria: i) do auction outcomes in a benchmark country reflect market value in that country? ii) are these outcomes likely to reflect market value in the UK? Criterion i) is "the main one" for categorising benchmarks into tiers.	Same two criteria, used on equal footing rather than prioritising i).	Ofcom appears to have considered factors that may affect the extent to which benchmarks may not reflect UK market value as less important than Frontier.
Factors affecting the extent to which auction outcomes reflect market value in benchmark countries			
Outcomes from auctions that cleared at or close to reserve prices	Prices from auctions where lots were sold at or close to reserve prices are likely to overestimate market value.	Prices from auctions where lots were sold at or close to reserve prices are likely to overestimate market value.	Both Ofcom and Frontier consider these outcomes as overstating market values.
Unsold spectrum	Prices from auctions where some spectrum remained unsold are likely to overestimate market value.	Prices from auctions where some spectrum remained unsold are likely to overestimate	Both Ofcom and Frontier consider these outcomes as overstating market values. However,

		market value.	different treatment of the Portugal benchmark.
Factors affecting the extent to which auction outcomes reflect market value in the UK			
Demand for 2G spectrum	Ofcom recognise that 900 MHz spectrum may be more valuable in countries with higher demand for 2G services. However: - While some operators may have a higher valuation of 900 MHz spectrum in countries with a high level of 2G traffic, this may not be the case of the marginally excluded bidder. - Auction prices are forward-looking, and the importance of 2G may be decreasing over time. - Prices paid in 900 MHz auctions are not negatively correlated with 3G penetration However, Ofcom does consider Romania as a case where there is "clear evidence" of 2G demand being especially relevant.	We consider 900 MHz and 1800 MHz spectrum to be more valuable in countries with a higher penetration of 2G subscribers.	Unlike Frontier, Ofcom does not consider high demand for 2G services to be necessarily linked to a higher valuation of the 900 MHz spectrum compared to 800 MHz.
Timing of existing licenses / new auctions	Not considered a source of overstatement of absolute or relative values from benchmark auctions. In particular: - Ofcom states explicitly that the development of LTE ecosystems for the 900 MHz band is thought of as having a "limited role". - Ofcom does not consider the high private value that incumbents may attach to existing re-auctioned spectrum to be a source of potential	Prices paid for a re-auctioned band may overstate the market value of that band, reflecting a high private value deriving from past investment specific to that spectrum frequency.	Unlike Frontier, Ofcom does not consider band-specific investments as a potential source of overstatement of the market value of that band when re-auctioned. This is relevant especially for the case of Austria, where

Conclusion

	overstatement.		the 900 MHz and 1,800 MHz frequencies were being re-assigned.
Strategic behaviour	Operators may have some opportunity to engage in strategic behaviour, but this does not necessarily mean they will do so. Factors preventing strategic behaviour include: - Auction design (e.g. the presence of caps) - Necessity of coordination between bidders to take advantage of the opportunity - The behaviour is risky, potentially resulting in overpaying for spectrum. Ofcom does recognise there may be cases where there is 'clear evidence' of strategic bidding behaviour, but does not provide detail on what would constitute 'clear evidence'. Moreover, Ofcom's own summary table of key considerations on the interpretation of benchmarks[38] shows that alleged strategic bidding leads to a tendency to overstate the benchmark.	In the absence of binding spectrum caps, operators may bid for large spectrum lots with the goal of foreclosing competitors. Smaller operators may also bid strategically, in order to drive up the price paid by the auction winner. This would lead auction outcomes to overestimate market value.	Different consideration of the Austrian benchmark. Frontier: outcomes necessarily over-estimate market value. Ofcom: outcomes may be over- or under-estimating market value.

38 August 1, 2014 consultation, Annexe 8, Figure A8.1.

Annexe 2: Ofcom's approach to computing 900 MHz and 1800 MHz estimates

This Annexe provides a detailed explanation of Ofcom's approach in computing its estimates of the value of UK 900 MHz and 1800 MHz spectrum bands, as published in the August 2014 consultation. We rely on the consultation text (main body and Annexe 7), and on the underlying calculations based on DotEcon's database of spectrum prices (the "Benchmarking Model"). Where relevant, we highlight any differences between Ofcom's current approach and previous consultations.

Ofcom's approach consists of three steps:

- Obtain absolute values of 800, 900, and 2600 MHz spectrum from benchmark countries comparable to the UK;
- Compute relative valuations of spectrum from each of the benchmark countries; and
- Apply relative valuations to the relevant UK 800 MHz value to compute estimates of UK 900 MHz and 2.6 GHz values.

Step 1 – Computing absolute values for benchmark countries

Ofcom has revised the inputs used in converting local auction prices into spectrum values comparable with the UK, while maintaining the approach used broadly consistent with previous versions of the consultation:

- First, an absolute value of each spectrum lot is computed in local currency as the Net Present Value (NPV) of payments. The discount rate used here is 2.4%, the real, post-tax cost of debt from the 2011 Mobile Call Termination (MCT) review. Previous proposals used an estimate of Weighted Average Cost of Capital (WACC), at 4.2%.
- The NPV is adjusted for differences in duration of spectrum between benchmark and UK. The discount rate used here is the real, post-tax WACC from the 2011 MCT, 4.7%.
- The NPV is converted from local currency at the time of auction into current GBP. First, applying Purchasing Power Parity (PPP) rates from the World Bank, local currency is converted into GBP at the time of auction. Then, these are converted into current GBP, multiplying by the ratio between the March 2014 Consumer Price Index (CPI) and the CPI at the time of auction.
- A GBP value per MHz and per population is obtained, dividing the NPV by the local population covered and the size of the lot.

Conclusion

- A value comparable to the UK is computed, multiplying the GBP per MHz value by the UK population.
- Where relevant, corrections are applied to account for the deferred availability of spectrum. For example, in the case of Spain, the non-adjusted value of the 800 MHz, £34.5 million, is up-scaled to £40.4 million. The interest rate used is the 4.7% estimate of WACC.

Step 2 – Computing relative valuations for each benchmark

Ofcom now focusses on relative valuations, only using absolute values from benchmark countries as cross-checks:

- For 900 MHz spectrum, the relative valuation used is the ratio between the 900 MHz and 800 MHz spectrum;
- For 1800 MHz spectrum, the relative valuation used is the "distance ratio", computed as $\frac{1800BC-2.6BC}{800BC-2.6BC}$ where BC = Benchmark Country.

Step 3 – Computing 900 and 1800 MHz estimates for each benchmark

Estimating the UK 900 and 1800 MHz values requires applying relative valuations from benchmark countries to UK absolute values:

- For 900 MHz spectrum, the 900/800 ratios are simply multiplied by the relevant UK 800 MHz value;
- For 1800 MHz spectrum, both UK 800 MHz and 2.6 GHz values are used, as follows:

$$1800_{UK} = \frac{1800_{BC} - 2.6_{BC}}{800_{BC} - 2.6_{BC}} x\,(800_{UK} - 2.6_{UK}) + 2.6_{UK}$$

The specific 800 MHz value used can vary by benchmark country. What value is used depends on whether the 800 MHz value from a benchmark country is considered to be inclusive of DTT co-existence costs, and of coverage obligations. For example:

- The 800 MHz value from Austria is considered to be gross of co-existence costs, and not including the cost of coverage obligations. The Austrian 900/800 MHz ratio and 1800 MHz distance ratio are then applied to Ofcom's estimate of the UK 800 MHz value, gross of co-existence costs and not including coverage obligations, £35.63 million.
- The 800 MHz value from Romania is considered to be net of co-existence costs, and including the cost of coverage obligations. The 900/800 MHz ratio and 1800 MHz distance ratio from Romania are

then applied to Ofcom's estimate of the corresponding UK 800 MHz value, £31.08 million.

Table 6 below provides detail on Ofcom's interpretation of benchmark 800 MHz values.

Table 6. Relevant UK comparators for 800 MHz

	Without coverage obligation	With coverage obligation
Net of expected DTT co-existence costs	Czech Republic, Ireland, Portugal, Slovak Republic	Romania
Gross of expected DTT co-existence costs	Austria, Germany, Greece, Italy, Spain, Sweden	Denmark

Source: Ofcom August consultation, Table 3.3.

Annexe 3: Adjusting relative ratios of 900 MHz and 1800 MHz spectrum from international auctions

This Annexe provides further detail on our calculation of adjusted 900/800 MHz ratios and 1800 MHz distance ratios. Our approach is consistent with Ofcom's interpretation of local 800 MHz values, as described in Annexe 2. However, we take a different approach to comparing benchmarking evidence, focussing on (adjusted) relative valuations rather than on point estimates of the UK 900 MHz and 1800 MHz values.

The need for an adjustment arises from the variation across benchmark countries in whether 800 MHz values obtained from local auctions are net or gross of co-existence costs and of coverage obligations. Ofcom accounts for this in generating 900 and 1800 MHz point estimates by using a different UK 800 MHz value for each of the cells in **Table 6**. We choose instead to generate adjusted 900/800 MHz ratios and 1800 MHz distance ratios that are comparable, that is, that can all be applied to the same UK 800 MHz value – in this case net of co-existence costs and coverage obligations.

In order to do this, we multiply 900/800 MHz ratios and 1800 MHz distance ratios as obtained in Ofcom's August consultation by adjustment factors. These are obtained as the ratio between the relevant UK 800 MHz value, and the UK 800 MHz value net of co-existence costs and coverage obligations. Computing adjustment factors therefore requires taking a view on both:

- the appropriate value of the UK 800 MHz spectrum, and
- on the magnitude of the cost of co-existence and of coverage obligations.

In this report, we compute adjustment factors based on Ofcom's 800 MHz estimates, in order to obtain adjusted relative valuations comparable with Ofcom's implied relative valuations of 70% for the 900 MHz spectrum and 31% for the 1800 MHz spectrum. However, this is for illustrative purposes only and it should not be interpreted as considering Ofcom's estimate of UK 800 value to be appropriate. Using a more appropriate estimate of the UK 800 MHz value, for instance as presented in Vodafone's submission on the UK auction, would lead to different adjustment factors.[39] Therefore, Ofcom needs to take this into

[39] However, this would not affect the lower bound of the appropriate ranges presented in the main text of this report.

consideration when deriving the appropriate estimate of 900 MHz and 1800 MHz value.

Table 7 below provides detail on the adjustment factors we used for 900/800 MHz ratios. Where the benchmark 800 MHz value is net of co-existence costs and of coverage obligations (for example, in the case of Ireland, see **Table 6**), no adjustment is required. Where the benchmark 800 MHz value is gross of co-existence costs (for example, in the case of Austria), the 900/800 unadjusted ratio is lower than it would be in the net case. In order to compare the Austria 900/800 ratio with Ireland, then, the Austrian 900/800 ratio needs to be adjusted upwards.

Table 7. Adjustment factors for 900/800 MHz benchmark ratios

	Without coverage obligation	With coverage obligation
Net of expected DTT co-existence costs	1	0.95
Gross of expected DTT co-existence costs	1.09	1.04

Source: Frontier Economics, Ofcom August consultation, Table 3.3.

For 1800 MHz distance ratio, we apply the same approach, but subtracting the UK 2.6 GHz value from the UK 800 MHz value both at the numerator and at the denominator of the adjustment factor. **Table 8** below details the adjustment factors used for 1800 MHz distance ratios.

Table 8. Adjustment factors for 1800 MHz benchmark ratios

	Without coverage obligation	With coverage obligation
Net of expected DTT co-existence costs	1	0.9
Gross of expected DTT co-existence costs	1.1	N/A[40]

Source: Frontier Economics, Ofcom August consultation, Table 3.3.

[40] Denmark is not a benchmark country for the estimation of the UK 1800 MHz value.

Annexe 4: applying the appropriate relative valuations to the UK 800 MHz value gross of co-existence costs

The approach we describe in Annexe 3 may also be used to derive adjusted 900/800 MHz ratios and 1800 MHz distance ratios which could be applied to the UK 800 MHz value **gross of co-existence costs**. These relative valuations would be lower than the ratios we suggest in the main text of this report and in Annexe 3, as shown in **Table 9** below.

Table 9. Summary of appropriate 900 and 1800 MHz relative valuations

Relative value	UK 800 MHz net of co-existence costs	UK 800 MHz gross of co-existence costs
900/800 MHz ratio	62% - 71%	57% - 65%
1800 MHz distance ratio	30% - 44%	27% - 40%

Source: Frontier elaboration based on Ofcom data.

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