

# 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"

### Executive summary

In response to Ofcom's document *Update on European auctions since Ofcom's consultation on Annual licence fees for 900 MHz and 1800 MHz spectrum* (*Update on European auctions* hereinafter), we consider whether the additional auctions may provide relevant evidence for the purposes of estimating the market value of the 900 MHz and 1800 MHz licences in the UK. In particular, we consider auctions in Austria (multiband), Belgium (800 MHz), Czech Republic (multiband), Estonia (800 MHz), Finland (800 MHz), Latvia (800 MHz), Lithuania (800 MHz), Norway (multiband) and Slovenia (multiband).

Ofcom has not made clear what weight, if any, it plans to attach to this evidence and if or how it considers it is relevant to its task of assessing the value of 900 and 1800 MHz spectrum in the UK, which makes the task of responding to its document particularly difficult. Nonetheless, we have attempted to respond as fully as possible under the circumstances and our conclusions are set out below.

The evidence from the auctions where only 800 MHz spectrum was sold (Belgium, Estonia, Finland, Latvia and Lithuania) is **unlikely to provide any relevant information** about the value of 900 MHz and 1800 MHz in the UK:

- No 900 MHz or 1800 MHz was sold in these auctions so the results cannot be used to directly estimate the value of this spectrum.
- The auction outcomes do not provide relevant data on the value of 800 MHz spectrum which could be used in combination with an estimate of the 900/800 or 1800/800 relativities to indirectly estimate the value of 900 MHz or 1800 MHz spectrum:
  - the market value of 800 MHz is unlikely to have been revealed in the majority of these auctions where lots were sold at reserve price; and
  - the differences in key market characteristics further limit any relevance of these 800 MHz auction outcomes for the market value in the UK.

- The prices paid for 800 MHz in these auctions are spread over a wide range from £1.1m to £30m per MHz, which suggests the results need to be treated with caution.

At the same time, the evidence from the multiband auctions in Austria, Czech Republic, Norway, Slovakia and Slovenia, when evaluated carefully using an appropriate benchmarking framework, **can only be considered as less relevant evidence** for deriving 900 MHz and 1800 MHz market value in the UK because:

- The country specific factors driving these auction outcomes imply that the prices paid are unlikely to reflect the market value of 900 MHz and 1800 MHz spectrum in the UK.
- The nature of the auctions means that it is not necessarily clear what the market clearing value of 900 MHz and 1800 MHz spectrum is from the auction:
  - The **Norway** auction was first price sealed bid which provides very limited useful information about market value of spectrum.
  - The **Czech Republic** was an SMRA auction, but as explained below and in our previous report, the results are unlikely to provide any useful information about the market value of spectrum in the UK.
  - The LRP decomposition of the package prices does not provide market clearing prices for individual blocks of spectrum<sup>1</sup>. 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. We also understand that the Austrian auction results are the subject of ongoing legal challenges by a number of the operators there.<sup>2</sup> As a result we do not consider this further analysis to

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<sup>1</sup> Frontier's analysis of the UK auction (Annex 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.

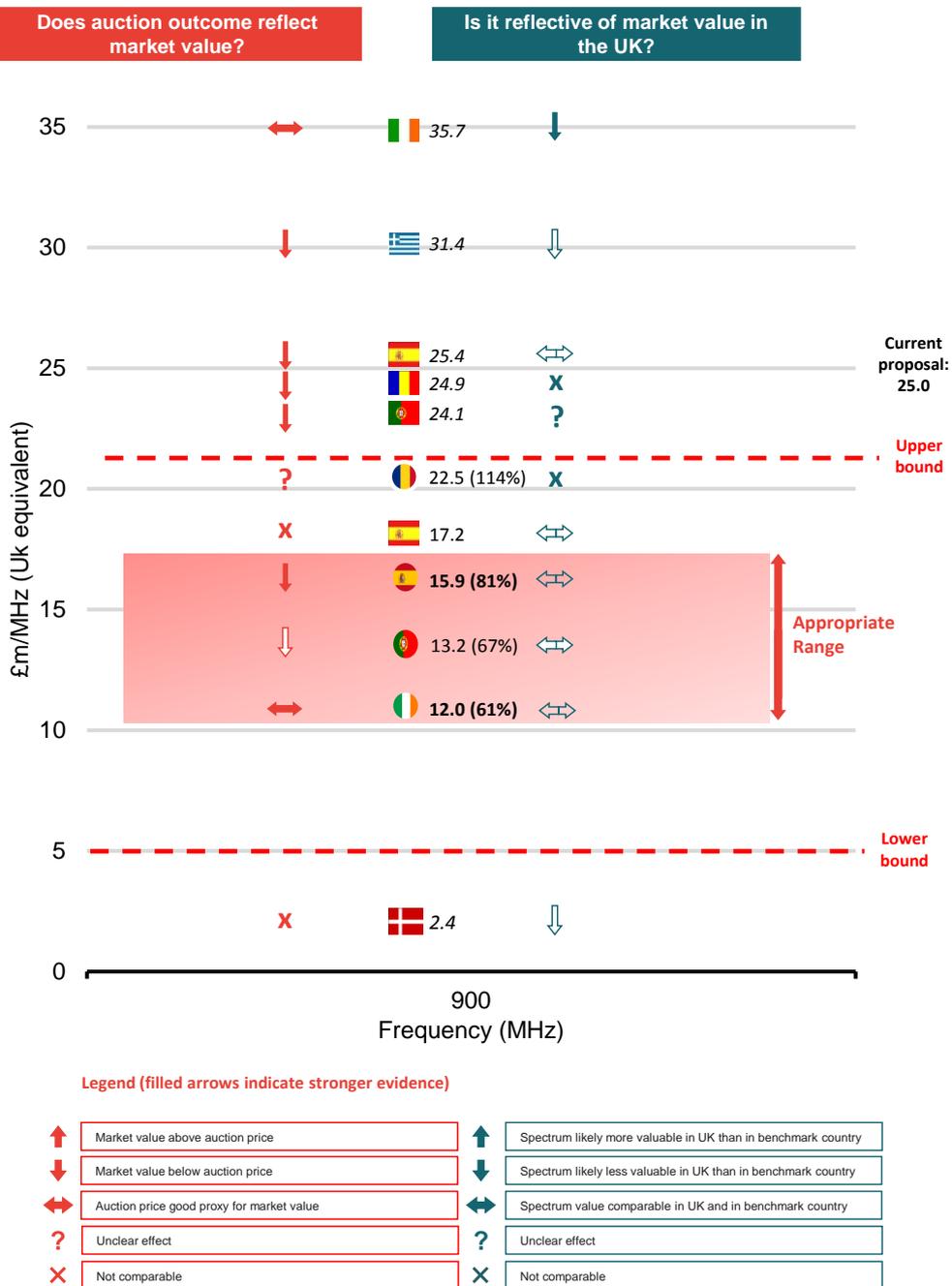
<sup>2</sup> See for instance a Reuters article from 26 November 2013: *H3G joins T-Mobile Austria in telco auction appeal*, available online at <http://uk.reuters.com/article/2013/11/26/us-austria-telecoms-auction-idUKBRE9AP13620131126>

be sufficiently reliable to justify treating the Austrian results as more important evidence.

- The CCA format of the other auctions implies that it is not possible to observe band specific prices paid in these auctions. However, in contrast to Austria, for these auctions Ofcom does not provide any attempt to estimate band specific prices using either LRP methodology (or a more robust alternative relying on detailed bidding data, in line with the approach taken in the UK and Ireland auction). This is relevant not only for new combinatorial auctions in Slovenia, Slovakia and Norway, but also for the auctions in Netherlands and Switzerland that Ofcom already considered in its consultation, without providing any estimate of band specific prices based on LRP methodology.

Overall, our analysis under base case scenario therefore remains unchanged, suggesting that the relative prices in Spain and Ireland are likely to provide the most reliable indicators to inform the appropriate range for the market value of 900 MHz spectrum in the UK, which we find to be between **£12m and £15.9m per MHz**, see **Figure 1** below.

**Figure 1.** Value of 900 MHz spectrum based on international benchmarks (update)



Note: In line with Ofcom’s approach, squared markers refer to absolute (£m per MHz) values, round markers refer to relative value. More important evidence in **bold**, less relevant evidence in *italics*.

Source: Frontier Economics

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We consider the additional evidence from Austria, Slovenia and Norway in our sensitivity analysis for 900 MHz estimates, in which we take into account all available international evidence, after carefully assessing the comparability of such evidence with the UK.<sup>3</sup> The results of our sensitivity analysis are consistent with the estimated ranges for the market value of 900 MHz spectrum in the UK.

**Figure 2.** Results of sensitivity analysis 900 MHz estimates (update)

£m/MHz (UK equivalent)	Price	900MHz	Frontier's more important evidence	Auctions considered by Ofcom	All observations (no outliers)	All observations
Austria (2013)	Absolute	80.0				50%
Netherlands (2012)	Absolute	59.0		50%		50%
Ireland (2012)	Absolute	35.7		50%	50%	50%
Greece (2011)	Absolute	31.4		50%	50%	50%
Spain (2011)	Absolute	25.4		50%	50%	50%
Romania (2012)	Absolute	24.9		50%	50%	50%
Portugal (2011)	Absolute	24.1		50%	50%	50%
Slovenia (2013)	Absolute	24.0			50%	50%
Romania (2012)	Relative (114%)	22.5		75%	75%	75%
Austria (2013)	Relative (110%)	21.5			75%	75%
Spain (May 2011)	Absolute	17.2		75%	75%	75%
<b>Spain (2011)</b>	<b>Relative (81%)</b>	<b>15.9</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Norway (2013)	Absolute	15.1			75%	75%
Switzerland (2012)	Absolute	13.6			75%	75%
Portugal (2011)	Relative (67%)	13.2		75%	75%	75%
<b>Ireland (2012)</b>	<b>Relative (61%)</b>	<b>12.0</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Denmark (2010)	Absolute	2.4		50%		50%
<i>Max</i>			15.9	59.0	35.7	80.0
<i>Min</i>			12.0	2.4	12.0	2.4
<b>Average</b>			<b>14.0</b>	<b>14.1</b>	<b>13.4</b>	<b>15.2</b>

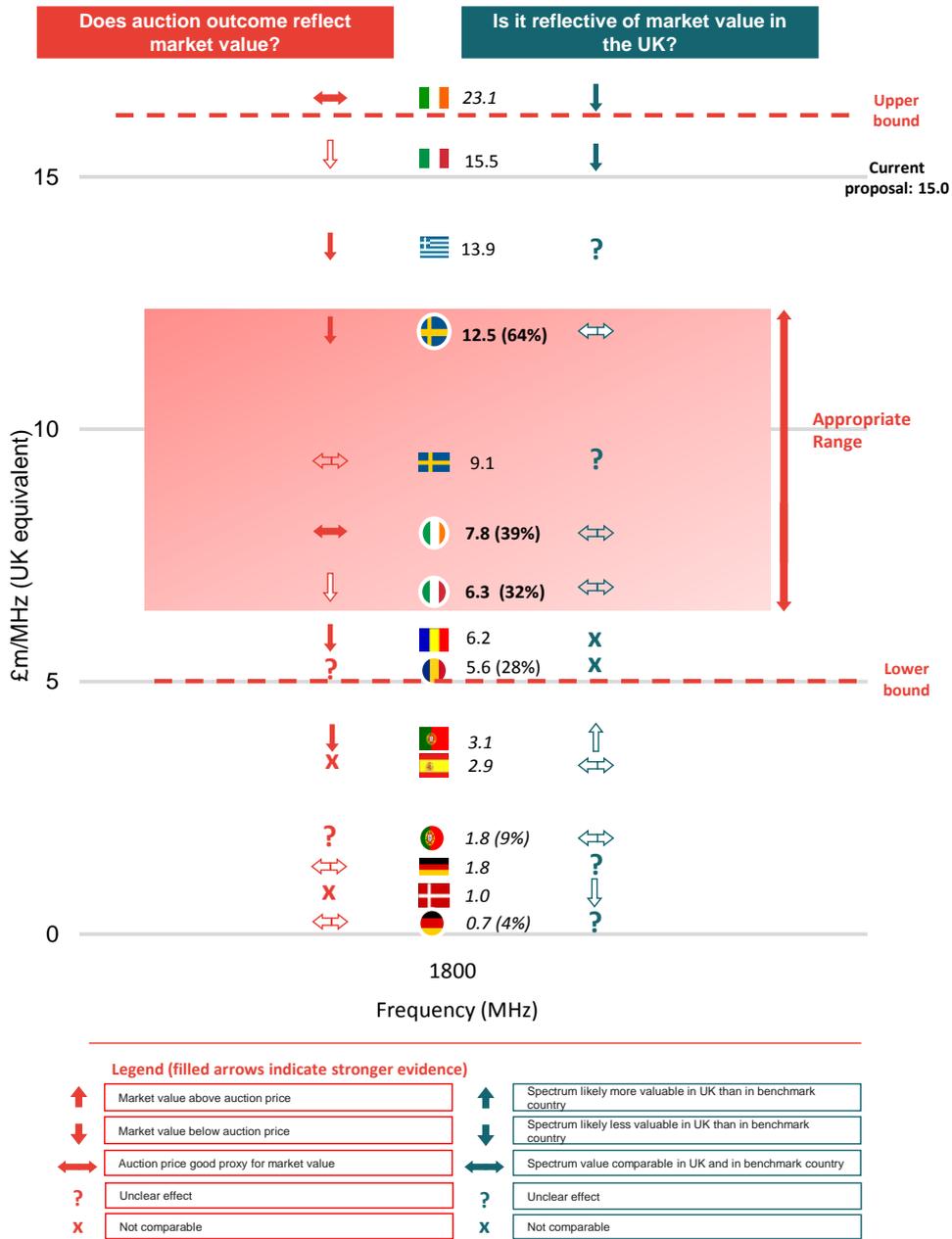
Note: Plausible range highlighted in blue. More important evidence highlighted in **bold**. New evidence highlighted in red.

Source: Frontier Economics

<sup>3</sup> We have already considered the results from the auctions in Norway as a part of 900 MHz sensitivity analysis submitted in response to Ofcom's previous consultation. We therefore only include additional information from the auctions in Slovenia and Austria to update this analysis.

Using a similar approach, we find that the appropriate range for the market value of 1800 MHz spectrum in the UK is between **£6.3m and £12.5m per MHz**. This is based on relative 1800/800 MHz valuations from Sweden and Ireland, see **Figure 3** below.

**Figure 3.** Value of 1800 MHz spectrum based on international benchmarks (update)



Note: In line with Ofcom's approach, squared markers refer to absolute (£m per MHz) values, round markers refer to relative value. More important evidence in **bold**, less relevant evidence in *italics*.

Source: Frontier Economics

We further consider the evidence from Austria, Slovenia, Slovakia and Norway in our sensitivity analysis for 1800 MHz estimates.<sup>4</sup> Again, the results of our sensitivity analysis are again consistent with the estimated ranges for the market value of 1800 MHz spectrum in the UK.

**Figure 4. Results of sensitivity analysis 1800 MHz estimates (update)**

£m/MHz (UK equivalent)	Price	1800MHz	Frontier's more important evidence	Auctions considered by Ofcom	All observations (no outliers)	All observations
Austria (2013)	Absolute	43.9				50%
Netherlands (2012)	Absolute	35.4		50%		50%
Ireland (2012)	Absolute	23.1		50%	50%	50%
Italy (2011)	Absolute	15.5		75%	75%	75%
Slovenia (2013)	Absolute	14.4			75%	75%
Greece (2011)	Absolute	13.9		75%	75%	75%
Slovakia (2013)	Absolute	13.6			75%	75%
Austria (2013)	Relative (66%)	11.8			75%	75%
<b>Sweden (2011)</b>	<b>Relative (64%)</b>	<b>12.5</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Sweden (2011)	Absolute	9.1		75%	75%	75%
Norway (2013)	Absolute	9.1			75%	75%
<b>Ireland (2012)</b>	<b>Relative (39%)</b>	<b>7.8</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Switzerland (2012)	Absolute	8.1			75%	75%
<b>Italy (2011)</b>	<b>Relative (32%)</b>	<b>6.3</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Romania (2012)	Absolute	6.2		75%	75%	75%
Romania (2012)	Relative (28%)	5.6		75%	75%	75%
Portugal (2011)	Absolute	3.1		50%	50%	50%
Spain (May 2011)	Absolute	2.9		50%	50%	50%
Portugal (2011)	Relative (9%)	1.8		50%	50%	50%
Germany (2010)	Absolute	1.8		50%	50%	50%
Denmark (2010)	Absolute	1.0		50%	50%	50%
Germany (2010)	Relative (4%)	0.7		50%	50%	50%
<b>Max</b>			<b>12.5</b>	<b>35.4</b>	<b>23.1</b>	<b>43.9</b>
<b>Min</b>			<b>6.3</b>	<b>0.7</b>	<b>0.7</b>	<b>0.7</b>
<b>Average</b>			<b>8.9</b>	<b>6.2</b>	<b>6.2</b>	<b>7.5</b>

Note: Plausible range highlighted in blue. More important evidence highlighted in **bold**. New evidence highlighted in red.

Source: Frontier Economics

<sup>4</sup> We have already considered the results from the auctions in Norway as a part of 1800 MHz sensitivity analysis submitted in response to Ofcom's previous consultation. We therefore only include additional information from the auctions in Slovenia, Slovakia and Austria auction to update this analysis.

## Introduction

In its proposal for revising 900 MHz and 1800 MHz licence fees<sup>5</sup> Ofcom relies on international benchmarking by using spectrum auction prices from other European countries as a source of estimates for UK market values. Frontier has been asked to consider Ofcom's international benchmarking approach and to assess its appropriateness for deriving reliable estimates of the market value of 900 MHz and 1800 MHz spectrum in the UK.

As explained in our previous report<sup>6</sup> the degree of variation in international benchmarks of auction outcomes means that using the benchmarks to inform the valuation of spectrum in the UK is not a straightforward task. The large variations in prices between different countries means that estimates of UK market values derived from other jurisdictions without an analysis and understanding of such variations are unlikely to be accurate.

Nevertheless, international benchmarking, if appropriately analysed and assessed, can be a useful complement to information about the market value of 900 MHz and 1800 MHz spectrum in the UK derived from the results of the recent UK auction and other sources. After a detailed consideration of the benchmarking evidence that Ofcom has relied on in the country case studies<sup>7</sup>, we identify a number of deficiencies in Ofcom's approach which imply that its estimates of UK market values are inappropriate.

We find that there are major weaknesses in Ofcom's approach to the derivation of market value based on benchmarking which imply that its ALF estimates are unreliable. In particular, we show that i) Ofcom misinterprets information that auction outcomes provide about market value in a number of benchmark countries where auctions cleared at the reserve price and that ii) Ofcom does not appropriately control for country- and auction-specific factors that could make auction outcomes in benchmark countries less comparable to the UK.

Correcting for the main deficiencies in Ofcom's benchmarking approach, and taking into account the appropriate estimates of the market value of 800 MHz spectrum from the UK auction, results in a range of estimates of market values for 900 MHz spectrum of between **£12 and £15.9m per MHz**. This is based

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<sup>5</sup> Annual licence fees for 900 MHz and 1800 MHz spectrum, Ofcom, October 2013 (hereinafter "The Consultation")

<sup>6</sup> Frontier's *Critique of Ofcom's International Benchmarking Analysis* (Annex to Vodafone's response to Ofcom's original consultation on Annual Licence Fees for 900 MHz and 1800 MHz spectrum dated January 2014), hereinafter *Benchmarking report*

<sup>7</sup> Frontier's *Critique of Ofcom's International Benchmarking Analysis – Case Study Annexes* (Annex to Vodafone's response to Ofcom's original consultation on Annual Licence Fees for 900 MHz and 1800 MHz spectrum dated January 2014), hereinafter *Benchmarking case studies*

on the relative prices from the auctions in Spain and Ireland, which are likely to provide the most reliable indicators to inform the appropriate range for the market value of 900 MHz spectrum in the UK. This range of estimates is robust to a number of sensitivities and modifications to the benchmarking sample used.

Using a similar approach, we find that the appropriate range for the market value of 1800 MHz spectrum in the UK is between **£6.3m and £12.5m per MHz**. This is based on relative 1800/800 MHz valuations from Sweden and Ireland and this range is again robust to a number of sensitivities.

## **Additional benchmarking evidence proposed by Ofcom**

In May 2014, Ofcom issued the document *Update on European auctions*, providing an overview of further European spectrum auctions that have concluded since publishing its consultation in October 2013. In particular, Ofcom lists auctions in Austria (multiband), Belgium (800 MHz), Czech Republic (multiband), Estonia (800 MHz), Finland (800 MHz), Latvia (800 MHz), Lithuania (800 MHz), Norway (multiband) and Slovenia (multiband).

Below, we consider whether these auctions may provide additional relevant evidence for the purposes of estimating the market value of the 900 MHz and 1800 MHz licences in the UK. We show that:

- The evidence from the auctions where only 800 MHz spectrum was sold (Belgium, Estonia, Finland, Latvia and Lithuania) is unlikely to provide any useful information about the value of 900 MHz and 1800 MHz in the UK.
- The evidence from the multiband auctions (Austria, Czech Republic, Norway, Slovakia and Slovenia), when evaluated carefully using an appropriate benchmarking framework, can only be considered as less relevant evidence for deriving 900 MHz and 1800 MHz market value in the UK.
- The appropriate range for the market value of 900 MHz and 1800 MHz spectrum in the UK remains unchanged after we consider the additional evidence.

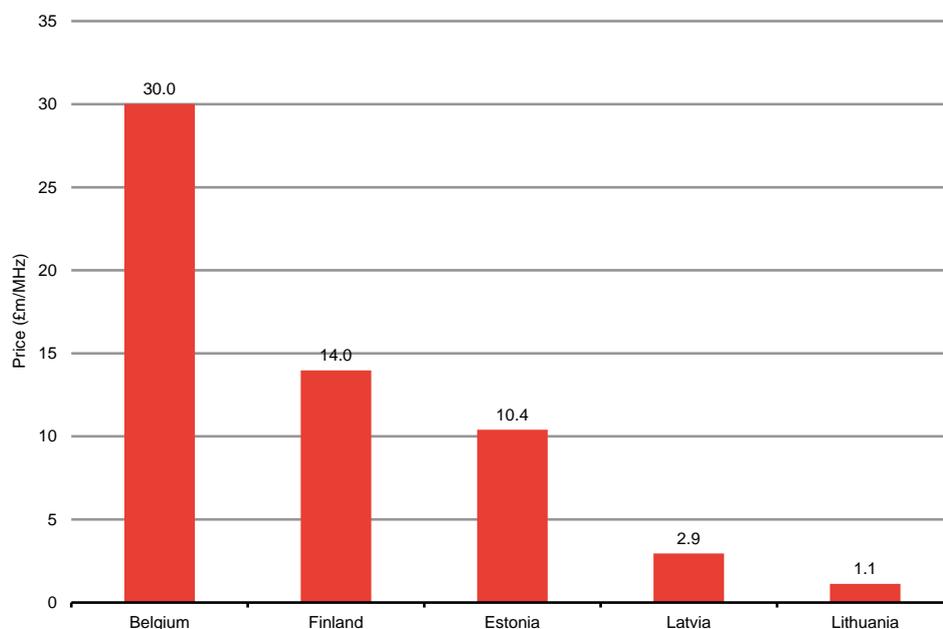
### **The majority of Ofcom's additional evidence is not relevant for the purpose of estimating 900 MHz and 1800 MHz ALF values**

The evidence from the auctions in Belgium, Finland Estonia, Latvia and Lithuania is unlikely to provide any useful information about the value of 900 MHz and 1800 MHz in the UK. This is because:

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- **No 900 MHz or 1800 MHz was sold in these auctions.** The prices paid for 800 MHz spectrum can therefore provide only limited information about the appropriate value of 900 MHz and 1800 MHz in the UK, and should consequently be largely ignored. This is consistent with Ofcom's own approach in the previous consultation from October 2013, where it did not consider outcomes of '800 MHz only' auctions.
- **The 800 MHz prices paid in these auctions range from £1.1m to £30m per MHz, which suggests the results need to be treated with caution.** In particular, the outcome from Lithuania is below what Ofcom considers a plausible lower bound for 800 MHz spectrum in the UK. At the same time, the prices paid in Belgium are above Ofcom's own valuation of 800 MHz spectrum in the UK, see **Figure 5** below.

**Figure 5.** Average prices paid in new European 800 MHz auctions (£m per MHz)



Note: All prices converted in the UK equivalent £m per MHz values

Source: Frontier Economics

- **The market value of 800 MHz is unlikely to have been revealed in the majority of these auctions.** With the exception of Latvia, the evidence suggests none of the 800 MHz auction outcomes reveal the market value of spectrum in a given country, due to shortcomings in the auction design.

- In **Belgium**, spectrum cleared at the reserve price, thus likely overestimating market value of 800 MHz spectrum in the country.
  - In **Finland**, auction rules allowed bidders to effectively re-set their bids to the reserve price. This led to circularity in the auction, which in turn led to the auction being paused for 6 months before finally ending with 3 out of 5 blocks clearing at reserve price. Therefore, it is possible that the outcomes overestimate the market value in Finland.
  - In **Estonia**, the three 2x10 MHz blocks of 800 MHz spectrum were sold in three separate proceedings, one of which was a beauty contest with restricted participation of existing operators. The sequence in which spectrum was auctioned effectively allowed the new entrant to observe marginal valuations of incumbent operators and potentially bid strategically in the last auction in order to inflate the prices paid by the winning incumbent operators.<sup>8</sup> Therefore, it is possible that the auction outcomes overestimate the market value of 800 MHz spectrum in Estonia.
  - In **Lithuania**, the price paid for the same spectrum varied significantly between operators and our understanding is that the spectrum was assigned through ‘first-price sealed-bid’ auction. Therefore, the prices paid are unlikely to reflect the market value of 800 MHz spectrum in Lithuania.
- **The differences in key market characteristics further limit any relevance of these 800 MHz auction outcomes for the market value in the UK.** There are significant differences in market characteristics between the countries where 800 MHz spectrum was auctioned and the UK, which makes any comparison more difficult. For instance, all countries except Lithuania had higher level of margin per user pre-auction, which indicates spectrum might be more valuable than in the UK. At the same time, demand for mobile data services was lower in all countries except Finland, which could lead to lower valuation of 4G spectrum.

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<sup>8</sup> In Estonia, the first block of 2x10 MHz spectrum was sold in a beauty contest. Subsequently, there were two SMRA auctions, with 2x10 MHz sold in each of them, with a restriction on the participation of incumbent operators. In the first auction, two incumbent operators Elisa Eesti and Tele 2 Eesti competed and the spectrum was sold for €5.086m which is likely reflecting the private valuation of unsuccessful bidder Elisa Eesti. In the second auction, the new entrant and the incumbent operator Tele2 Eesti competed for the remaining block, which eventually sold for €5.098m. This might overestimate the true market value of the spectrum. The price paid might not reflect the private value of the unsuccessful bidder if the new entrant has pushed the price up above its own private value. This was possible, as it had information about operator Tele2 Eesti’s willingness to pay for this spectrum from the previous auction.

Overall, the available evidence suggests the 800 MHz auction outcomes in Belgium, Finland, Estonia, Latvia and Lithuania is unlikely to provide any useful information about the value of 900 MHz and 1800 MHz in the UK.

### The relevant new evidence needs to be assessed carefully using an appropriate benchmarking framework

The evidence from the multiband auctions in Austria, Czech Republic, Norway, Slovakia and Slovenia is potentially relevant for estimating market value of 900 MHz and 1800 MHz spectrum in the UK.

It should be noted that **we have already included the results from the auctions in Austria, Czech Republic and Norway as a part of our benchmarking analysis submitted in response to Ofcom's previous consultation.** We have shown that none of these auctions provide useful information about the market value in the UK and our view remains unchanged. In particular, we have shown that:

- **Austria:** the nature of combinatorial auction implies that it is not possible to directly observe band-specific prices from the auction. In addition, these outcomes are less comparable with the UK due to high strategic valuations driven by weak spectrum caps in the auction.
- **Czech Republic:** the specific nature of the Czech 4G auctions implies that the result would provide only limited information about the market value of 1800 MHz spectrum in the UK. The auction included significant measures to promote new entry and was undertaken twice, with 2x15.8 MHz of 1800 MHz spectrum reserved for a new entrant left unsold and remaining 1800 MHz spectrum clearing at the reserve price.<sup>9</sup>
- **Norway:** the nature of combinatorial auction implies that it is not possible to directly observe band-specific prices from the auction and the first-price nature of the auction in Norway led to auction outcomes that are unlikely to reflect the market value in the UK, even if it was possible to reliably decompose the band-specific prices.

Therefore, we treat outcomes of these auctions as less relevant evidence and do not consider them when estimating the appropriate range for 900 MHz and 1800 MHz UK spectrum value under our base case scenario. Nevertheless, we

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<sup>9</sup> As explained in our *Benchmarking report*, the first auction got cancelled in March 2013, on the basis that prices were too high. The second auction in November 2013 cleared at reserve prices. Finally, there was speculation that the new entrant bidder in the first auction was bidding strategically to weaken the largest of the three incumbent mobile operators. This new entrant bidder did eventually acquire the largest incumbent mobile operator during the auction process.

consider the estimated value of spectrum from Austria and Norway in the sensitivity analysis presented in our *Benchmarking report*.

The results from Slovakia and Slovenia were not available when we submitted our benchmarking analysis to Ofcom. Also, we did not have access to LRP estimates of prices for different blocks from the Austrian auction. This new evidence is discussed below. We show that:

- **Austria:** the LRP estimates of block specific prices potentially provide some additional information about the relative value of spectrum in Austria between bands. However, the overall design of the Austrian auction meant that the winning prices, values attached to losing bids, and hence also the LRP estimates, were likely to have been heavily influenced by ‘strategic’ considerations. Strategic supplementary bids may well have been submitted by
  - two largest operators with the intention of excluding a third operator; or
  - they may have been submitted by a weak third operator, with the intention of increasing the prices paid by other bidders.

In addition there is evidence of potential strategic bidding in the primary round, which could have disproportionately increased the prices of existing spectrum in the 900 MHz and 1800 MHz bands (compared to the 800 MHz band), and the resulting price would become closer to the private value attached to these bands by current holder of the spectrum. Therefore, while LRP estimates may provide some indication of relative 900/800 and 1800/800 prices in the Austrian auction, these estimates are unlikely to reflect relative differences in the market clearing prices in the UK. If anything, they would likely overestimate the market value of 900/1800 spectrum in the UK.

- **Slovenia:** the auction had a CCA format, which means that it is not possible to directly observe band-specific prices. Based on the differences in auction design (800 MHz spectrum reserved for a new entrant) and market characteristics, we conclude that it is unclear to what extent auction outcomes in Slovenia might reflect the market value of 900 MHz and 1800 MHz spectrum in the UK. If anything, there is some indication that the auction outcome might potentially overestimate UK market values.
- **Slovakia:** the auction had a CCA format, which again means that it is not possible to directly observe band-specific prices. Based on the differences in auction design (high reserve prices for 800 MHz spectrum) and market characteristics we conclude that it is unclear to what extent the auction outcomes in Slovakia reflect the market value of 1800 MHz spectrum in the UK.

Overall, we consider the results from the auctions in Austria, Slovenia and Slovakia as less relevant evidence for deriving the UK market value of 900 MHz and 1800 MHz spectrum. This is because:

- The CCA format of the auction implies that it is not possible to observe band specific prices paid in these auctions. While LRP estimates from Austria provide some additional information, we do not consider these to be sufficiently reliable to justify treating Austrian results as more important evidence.
- The country specific factors driving the auction outcomes in these countries imply that the prices paid are unlikely to reflect the market value of 900 MHz and 1800 MHz spectrum in the UK.

We discuss auction outcomes in these three countries below. A more detailed analysis is provided in an update to our *Benchmarking case studies*, submitted as a part of this response.

### Austria

The multi-band auction in Austria took place in October 2013 with three existing operators taking part in the auction. **Table 1** summarises our views on the overall quality of different types of benchmarks based on the Austrian auction.

**Table 1.** The quality of benchmark – Austria

	Spectrum	Price (LRP estimates)	Auction outcomes revealing market value?	Relevance for the UK market value?
<b>Absolute value (GBP/MHz)</b>	900 MHz	80m	Unclear	Not comparable / Likely overestimating
	1800 MHz	43m	Unclear	Not comparable / Likely overestimating
<b>Values relative to 800 MHz (%)<sup>10</sup></b>	900 MHz	110%	Unclear	Not comparable / Likely overestimating
	1800 MHz	66%	Unclear	Not comparable / Likely overestimating

Source: Frontier Economics

### *Do auction outcomes reflect market value?*

The Austrian auction had a CCA format, which means it is not possible to directly observe band-specific prices and due to the combinatorial nature of the auction there may be no efficient<sup>11</sup> band specific prices. Looking at the overall revenues from the auction it is possible to gauge the absolute level of prices spectrum was obtained at. The prices paid for the packages are significantly greater than the associated reserve prices for the spectrum, suggesting the outcomes are likely to reflect the operators' valuation of packages of spectrum in Austria under the specific design of the Austrian auction, as explained below. However, as discussed in Annex 1 below, there is evidence that the prices were influenced by 'exclusionary' and/or 'price setting' strategic bids (mainly in the

<sup>10</sup> The 900/800 and 1800/800 relative values are calculated using the LRP estimates derived by the RTR, which provide an estimated price for blocks in each of the 'lot categories' made available in the auction. We used the estimated prices for categories A2, B2, and C1 for 800MHz, 900MHz and 1800MHz spectrum respectively. This is in line with Ofcom's recommendation as stated in paragraph 20 a) of the ALF Update. The A2 lots of 800MHz spectrum are comparable to the 800MHz lots without a coverage obligation in the UK. 900MHz and 1800MHz blocks in the B2 and C1 lot categories are comparable to the equivalent blocks in the UK, given that, unlike the other lot categories, the entirety of the blocks in these categories are available for the whole licence period.

<sup>11</sup> Efficient in the sense that a single set of linear prices would result in the market clearing (all spectrum sold with no excess demand).

supplementary round of the auction), which may indicate that prices do not fully reflect the true market value of the spectrum. They may reflect the 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. Such considerations are far from true market value.

As discussed by in our earlier report analysing the results of the UK auction, it is not straightforward to derive the clearing pricing of individual blocks of spectrum, which is the metric against which efficient licence fees should be set, from the results of CCA auctions. In particular, the LRP algorithm, while providing a decomposition of the prices paid for packages, does not necessarily provide robust estimates of the market clearing prices for individual bands, see Annex 1 below.

These concerns are magnified by a lack of transparency of how the LRP methodology functioned, with no UK stakeholders or even Ofcom itself having access to the individual bid data. The complex nature of the auction means that it is not possible to rely on the results of the LRP decomposition,, in particular in a very 'thin' market with only three bidders. For example, without bid data it is impossible to determine the extent to which the results are influenced by bidders' behaviour in the auction. For instance:

- individual operators' expressed marginal valuations for spectrum at or around the final outcome of the auction;
- any strategic bidding behaviour in either the clock phase or the combinatorial phase of the auction; and
- the impact of the auction rules on bidders' ability to make bids reflecting their full market value of packages in the combinatorial part of the auction.

Therefore, it is unclear to what extent relative valuations, based on unreliable LRP estimates of band specific prices, can provide any useful information about the relative value of 900 MHz and 1800 MHz spectrum in Austria.

### *Are these outcomes reflective of market value in the UK?*

In addition, there are three reasons why the results of the Austrian auction, even if correctly derived, may not be reflective of market prices in the UK:

- significant differences in the market in Austria and the UK which potentially increase the value of spectrum usable for GSM and UMTS.
- the combination of a small number of operators and weak spectrum caps on both low frequency spectrum and overall spectrum leading to

significant strategic value attached to large packages of low frequency (and overall) spectrum; and

- the fact that existing 900 and 1800 MHz spectrum was being re-auctioned with relatively high private value attached to this spectrum.

Pre-auction AMPU in Austria was \$10, higher than the pre-auction value of \$8 in the UK, potentially indicating that auction outcomes overestimate market value in the UK. In addition, 2G penetration was 59% compared to 48% in the UK, emphasising the fact that 2G spectrum is likely to be more valuable in Austria, compared to the UK.

In addition, the evidence suggests that spectrum suitable for delivery of mobile data services is likely to be more valuable in Austria than in the UK. In particular, i) the overall importance of mobile broadband access; and ii) the importance of dedicated mobile broadband devices<sup>12</sup> is higher in Austria than the EU in general, and the UK in particular.

- First, almost 70% of broadband users in Austria used mobile broadband services in 2012, having increased from 58% in 2010<sup>13</sup>. Many of these customers use their mobile broadband connection as a primary connection to the internet, which is why RTR decided in 2009<sup>14</sup> to consider mobile broadband to be a substitute to fixed broadband. We note that Austria is the only EU country where regulator came to such a conclusion and where the European Commission accepted the substitutability between fixed and mobile broadband. In contrast, while mobile broadband penetration in the UK is broadly comparable with the Austrian levels, the European Commission in their report on “*Trends in the European broadband markets 2014*”, found mobile broadband services to be mostly used as a complement to the existing fixed broadband subscriptions, with the exceptions being Austria, Finland and Sweden where mobile broadband is more widely used as a primary connection.<sup>15</sup> This explains the higher penetration of dedicated mobile broadband access in Austria compared to the UK, as seen in **Figure 6** below.

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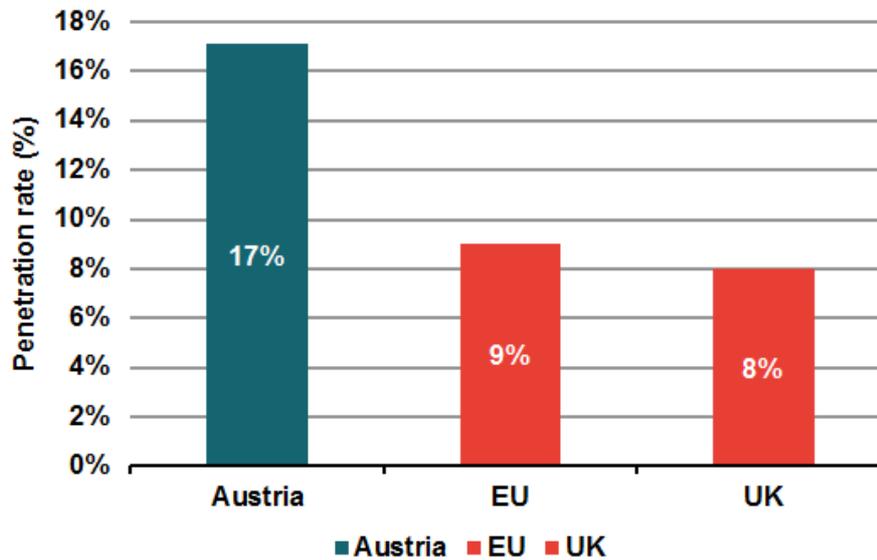
<sup>12</sup> Mobile data cards, modems, key and dongles

<sup>13</sup> Annual Review, 2012, Telekom Monitor, RTR

<sup>14</sup> RTR “Definition for the market for broadband wholesale access” from December 2009 available at [https://www.rtr.at/en/komp/KonsultationTKMVO2003/Marktabgrenzung%20Breitband\\_nat%20Konsultation.pdf](https://www.rtr.at/en/komp/KonsultationTKMVO2003/Marktabgrenzung%20Breitband_nat%20Konsultation.pdf)

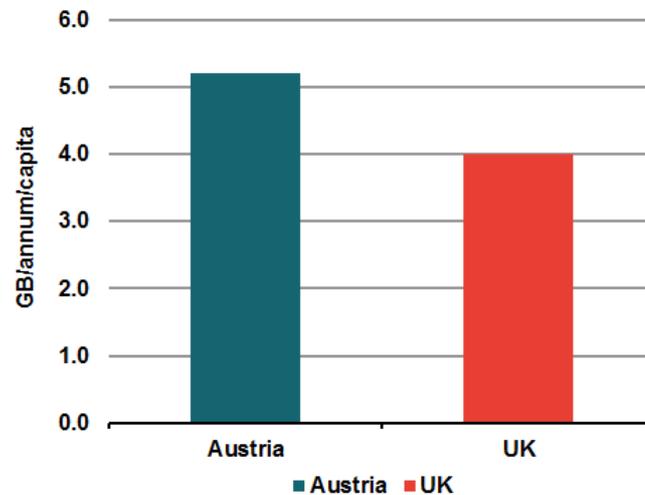
<sup>15</sup> “Scoreboard 2014 - Trends in European broadband markets 2014” Available at <http://ec.europa.eu/digital-agenda/en/news/scoreboard-2014-trends-european-broadband-markets-2014>

**Figure 6.** Mobile penetration (dedicated mobile data access only), January 2013



Source: Digital Agenda Scoreboard 2013

- Second, a large proportion of Austrian mobile broadband users rely on dedicated devices (e.g. dongles) to access the internet. These users would typically have significantly higher consumption of mobile data, compared to customers that use mobile broadband via smartphones. This can be seen in **Figure 7** below, which compares the existing estimates of annual mobile data consumption per capita in Austria and the UK in 2012.

**Figure 7.** Annual mobile data consumption per capita

Source: "EU27 mobile data cost competitiveness report-May 2013", Rewheel

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).

At the same time, the auction design in Austria implies that the results are likely to provide limited information about the value of spectrum in the UK and if anything, they would likely overestimate the market value of spectrum in the UK.

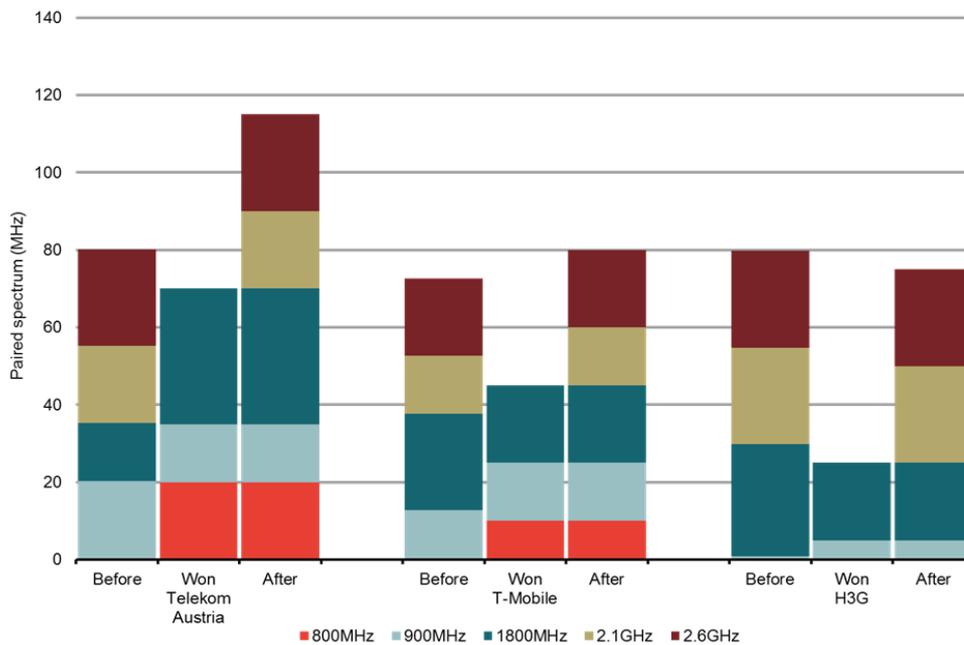
- First, unlike in the UK, spectrum caps in the Austrian auction did not restrict operators from obtaining large amounts of spectrum in any band, which allowed the operators to bid aggressively to obtain spectrum in place of their competitors<sup>16</sup>. This conclusion is supported by the Austrian regulator, which has stated that there was “*highly offensive bidding in the sealed-bid stage*”.<sup>17</sup> The spectrum caps would in principle allow just two operators to acquire all of the spectrum in the auction, effectively excluding the other

<sup>16</sup> Four caps were imposed with bids being ineligible for packages with: total spectrum exceeding 2x70 MHz; spectrum exceeding 2x35 MHz below 1GHz; spectrum exceeding 2x20 MHz in the 800 MHz band; and spectrum exceeding 2x30 MHz in the 900 MHz band.

<sup>17</sup> RTR, <https://www.rtr.at/en/pr/PI28102013TK>

operator. This was particularly true for sub-1 GHz spectrum, where the caps allowed a single operator to obtain over half of the available sub 1-GHz spectrum in the auction (2x35 MHz of the available 2x65 MHz), and the majority of the available 800 MHz spectrum (2x20 MHz of the available 2x30 MHz), see **Figure 8** below. This is in huge contrast with the UK, where Ofcom designed the auction in a way to ensure there are **four** credible wholesale providers (with enough spectrum, including low frequency spectrum) arising from the auction.

**Figure 8.** Spectrum holdings in Austria before and after the auction in 2013 and spectrum won in the auction



Source: RTR

- Second, all sub-1 GHz spectrum in Austria was being auctioned at once, with 800MHz spectrum being made available for the first time, and all existing 900 MHz and 1800 MHz licences being re-allocated<sup>18</sup>. Given sunk costs associated with existing spectrum, operators would have high private values for this spectrum and would be willing to pay up to this private value to prevent being excluded.

<sup>18</sup> Although the spectrum would not be re-assigned until 2016, existing holders (T-Mobile and A1 Telekom) could invest in technology such as LTE-1800 and UMTS-900 in existing holdings prior to any reallocation, increasing the private value of the spectrum to T-Mobile and A1 Telekom, compared to Hutchison.

- Finally one operator, Hutchison, entered the auction with virtually no low frequency spectrum, having disposed of the 900 MHz spectrum acquired as part of the merger with Orange. If H3G continued to have little or no interest in acquiring low frequency spectrum, then it could still strategically bid up the price of this spectrum at little potential risk, with the high private values of 900 MHz spectrum meaning that the other two operators would continue to bid for this spectrum significantly above the market clearing price.

The overall high prices paid in the Austrian auction are therefore likely to reflect the strategic value of potentially excluding competitors from accessing this spectrum and potentially limiting their ability to compete in the future (i.e. a degree of foreclosure). Alternatively, they might reflect some “price setting” objectives by a potentially excluded operator. A combination of strategic bidding and high private values for existing spectrum could therefore lead to the price of 900 and 1800 MHz spectrum being bid up above a market clearing level.

One further factor that could have inflated spectrum prices is 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.

While the 800 MHz spectrum in the auction was available on completion of the auction, the 900 MHz and 1800 MHz spectrum was currently assigned to the three mobile operators, with the use of the spectrum being restricted to GSM. Following the auction the use of the current spectrum would be liberalised, allowing the current users to deploy UMTS equipment in the 900 MHz band and LTE in the 1800 band.<sup>19</sup> The majority of the spectrum would then be re-assigned to the winners of the auction from 1<sup>st</sup> January 2016, with the remaining spectrum being available to the auction winners on 1<sup>st</sup> January 2018 and 1<sup>st</sup> January 2020

The combination of these effects means that the some bidders may have significant private value attached to the 900 and 1800 bands, and certain blocks of spectrum within these bands, due to three effects:

- existing sunk costs at the time of the auction associated with particular bands (900 or 1800) or particular frequencies due to existing investments in GSM equipment;
- the ability to operate the same spectrum before and after 1<sup>st</sup> January 2016 allowing investment in the period up until 2016, for example in LTE in the 1800 band or UMTS in the 900 band without this investment being stranded after 2016; and

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<sup>19</sup> RTR: Results of the consultation procedure and future measures regarding future frequency assignments and the liberalisation of the 900 MHz and 1800 MHz frequency bands

- the potential values associated with being the sole holder of spectrum for the blocks which would otherwise be split between two operators in the period 2016 to 2019.

These effects, which applied to the 900 and 1800 MHz bands in Austria, but which did not apply to the 800 spectrum auctioned, means that the comparisons between 800 and 900/1800 could have been distorted. As a result any results on relative valuations between bands in the Austrian auction to not provide useful information on the relative market values in the UK between 800, 900 and 1800 spectrum.

Based on the above, we conclude that the high demand for mobile data services in Austria, and the specifics of the auction design make results of the Austrian auction less useful for estimating market value in the UK, where Ofcom designed the auction in a way to ensure there are four credible wholesale providers arising from the auction. The evidence suggests that **the absolute values from the Austrian auction (even if derived properly based on bidding data) are likely to overestimate true market value in the UK** where Ofcom is likely to continue to ensure that there is no scope for foreclosure.

With regards to the relative 900/800 and 1800/800 valuations, 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, is likely to inflate the private value of this spectrum compared to the clear 800 spectrum, where no operator will have significant private value. In a situation where one or more operators are bidding strategically, high private values are likely to drive prices for the existing spectrum higher than that for clear spectrum.

In addition there is a question of how reliable the LRP estimates are as an estimate of market clearing prices and how much weight one can put on the relative valuations based on these estimates of band specific prices (discussed in Annex 1).

Finally, while the relative valuations can control to an extent for variation in some of the market characteristics (such as higher AMPU), they are not able to fully control for differences in market characteristics that affect valuation of specific bands differently. For instance, higher GSM usage might lead to higher 900/800 MHz relative valuation in Austria compared to the UK. Therefore, we conclude that **relative values of 900 MHz or 1800 MHz spectrum based on LRP estimates are unlikely to be a good indicator of spectrum value in the UK. If anything, the relative valuations may overestimate the true market value of 900 and 1800 spectrum in the UK.**

## Slovenia

The CCA auction in Slovenia took place in April 2013, with all three incumbent operators taking part. 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz and 2.6 GHz

spectrum was made available in the auction, with spectrum in the 800 MHz band reserved for either a new entrant or the smallest of existing operator.<sup>20</sup> Tusmobil, the third player in the market, subsequently obtained the 2x10MHz that was reserved.

**Table 2** summarises our views on the overall quality of the benchmarks based on the Slovenian auction.

**Table 2.** The quality of benchmark – Slovenia

	Spectrum	Price	Auction outcomes revealing market value?	Relevance for the UK market value?
<b>Absolute value (GBP/MHz)</b>	900MHz	N/A	Potentially a good indicator	Unclear / Potentially overestimating
	1800MHz	N/A	Potentially a good indicator	Unclear / Potentially overestimating

Source: Frontier Economics

### *Do auction outcomes reflect market value?*

The Slovenian auction had a CCA format, which means it is not possible to directly observe band-specific prices. However, looking at the overall revenues from the auction gives an indication of the prices at which spectrum was obtained. It appears that spectrum was sold above reserve price, which suggests that the outcomes are likely to reflect the market value of spectrum in both the 900 MHz and 1800 MHz bands in Slovenia.

### *Are these outcomes reflective of market value in the UK?*

The auction design meant that 2x10 MHz of 800 MHz spectrum was reserved for a new entrant, with another 2x10 MHz block subject to significant coverage obligations.<sup>21</sup> This meant 2x10 MHz of ‘clean’ 800 MHz spectrum remained for

<sup>20</sup> Specifically, an existing operator was able to bid for the ‘reserved’ block if they held no more than a 15% share of mobile subscribers in Slovenia at the time of the auction.

<sup>21</sup> Winners of the 2x10MHz block in the ‘A2’ category were required to provide 95% population coverage within 3 years of the licence term, with at least a 10Mbps outdoor downlink speed in these areas. These obligations could be considered stronger than those imposed on the ‘coverage obligation’ block of 800MHz spectrum in the UK. Although the required population coverage in the UK auction is comparable to that in Slovenia (98% coverage in the UK within three years, as

the three incumbents to compete over, pushing up prices in 800 MHz significantly. This could potentially also drive up prices in other spectrum bands, including 900 MHz and 1800 MHz spectrum.

In addition, the urbanisation rate in Slovenia was 31% lower than that in the UK in the year prior to the auction. This would likely lead to an overestimate of the value of low-frequency 900MHz spectrum in the UK. 2G penetration was significantly higher than the UK which would make 900 MHz and 1800 MHz spectrum more valuable in Slovenia. However, voice usage was higher in the UK, which makes the difference in demand for 2G spectrum unclear. The pre-auction AMPU levels are broadly comparable between the UK and Slovenia.

On balance, we conclude that it is unclear to what extent auction outcomes in Slovenia might reflect market value of spectrum in the UK. If anything, there is some indication that the auction outcome might potentially overestimate UK market values.

### Slovakia

The multi-band CCA auction in Slovakia took place in August 2013, with the three incumbent operators taking part, as well as a new entrant Swan, which obtained spectrum in the 1800 MHz band. As 900 MHz spectrum was not made available in the auction, we only consider the prices paid for 1800 MHz spectrum.

**Table 3** summarises our views on the overall quality of different types of benchmarks based on the Slovak auction.

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well as 95% coverage of England, Scotland and Wales), the associated minimum speed requirement was much lower (2Mbps download speed compared to 10Mbps in Slovenia). The outcomes of the auction suggest that the obligations were seen as a burden by the incumbent operators. Simobil, who obtained the A2 800MHz block, paid €25m less than Telekom Slovenije in total, despite purchasing the same or more spectrum in each of the other frequency bands.

**Table 3.** The quality of benchmark – Slovakia

	Spectrum	Price	Auction outcomes revealing market value?	Relevance for the UK market value?
<b>Absolute value (GBP/MHz)</b>	1800MHz	N/A	Potentially a good indicator	Unclear / Potentially overestimating

Source: Frontier Economics

### *Do auction outcomes reflect market value?*

The auction in Slovakia had a CCA format, meaning that it is not possible to directly observe band-specific prices in the auction. However by looking at the overall revenues from the auction, it is possible to roughly gauge the absolute prices that spectrum was obtained at.<sup>22</sup> It appears that spectrum was sold above reserve price, suggesting that the auction was competitive and thus that auction outcomes may reflect market value in Slovakia.

### *Are these outcomes reflective of market value in the UK?*

It is not clear if the outcome of the Slovak auction would be an accurate reflection of the market value of 1800 MHz spectrum in the UK.

The reserve prices set for 800 MHz spectrum were €19m per 2x5 MHz block, which is approximately £33m per MHz in the UK equivalent terms, which appears very high and might have had increased competition for 1800 MHz spectrum in the auction.<sup>23</sup> The size of the reserve prices is seen when making a comparison with the UK auction. Specifically, in the UK the reserve price for a comparable spectrum block (800 MHz blocks with coverage obligation) was set at £12.5m per MHz, well below that set in Slovakia.<sup>24</sup> In fact, even the reserve

<sup>22</sup> The format of the auction implies we cannot extract information about relative prices paid across different bands, which is why we do not explicitly discuss relative valuations from combinatorial auctions.

<sup>23</sup> This is shown by Telefonica paying very close to reserve prices for its 800MHz and 1800MHz spectrum. The fact that nearly half of the 2x70MHz of 2.6GHz spectrum on offer was left unsold also suggests that competition has likely been most fierce in the 1800MHz band.

<sup>24</sup> All blocks of 800MHz spectrum made available in Slovakia were subject to a coverage obligation. These obligations were broadly comparable to those imposed on the ‘coverage obligation’ block in the UK. Although the population coverage obligations in Slovakia were less imposing than those set in the UK (75% coverage within 3 years, compared to 98% within three years in the UK), national roaming obligations were imposed in Slovakia, unlike in the UK. The minimum speed requirements

prices for 800 MHz spectrum blocks without coverage obligations (set at £22.5m per MHz) were below those in Slovakia. As explained in our *UK auction analysis* the reserve prices for 800 MHz spectrum in the UK were set too high and distorted the auction outcomes. Therefore, it is possible that the prices paid for 1800 MHz in Slovakia were driven by high reserve prices for 800 MHz spectrum, and may therefore overestimate the market value of 1800 MHz spectrum in the UK.

With regards to market characteristics, AMPU prior to the auction was comparable in the two countries. Slovakia's pre-auction 2G penetration rate was 77% which is significantly higher than in the UK, but voice usage was higher in the UK in 2011.

On balance, it is not clear if the price paid for 1800 MHz spectrum is reflective of the market value in the UK. If anything, there is some indication that the auction outcome might potentially overestimate the UK market value.

## Updated ALF estimates including additional relevant evidence

As explained above, the additional auction observations from Austria, Slovenia and Norway are treated as less relevant evidence when deriving the appropriate range for the UK 900 MHz value under our base case scenario.

Our analysis under the base case scenario therefore remains unchanged, see our *Benchmarking report*, suggesting that the relative prices in Spain and Ireland are likely to provide the most reliable indicators to inform the appropriate range for the market value of 900 MHz spectrum in the UK.

**Figure 2** below summarises the benchmarking evidence that we have used for estimating the market value of 900 MHz spectrum. Our sample of relevant evidence consists of 11 observations. Five of these observations are above the upper bound for the market value of 900 MHz spectrum in the UK, based on the results of the UK 4G auction. In addition, one observation, based on the absolute valuation from Denmark, is below the lower-bound for the market value of 2600 MHz spectrum in the UK, as estimated by Ofcom. This also implies that it is below the lower-bound for the market value of 900 MHz spectrum in the UK. Therefore, we treat these six observations as less relevant evidence, and we

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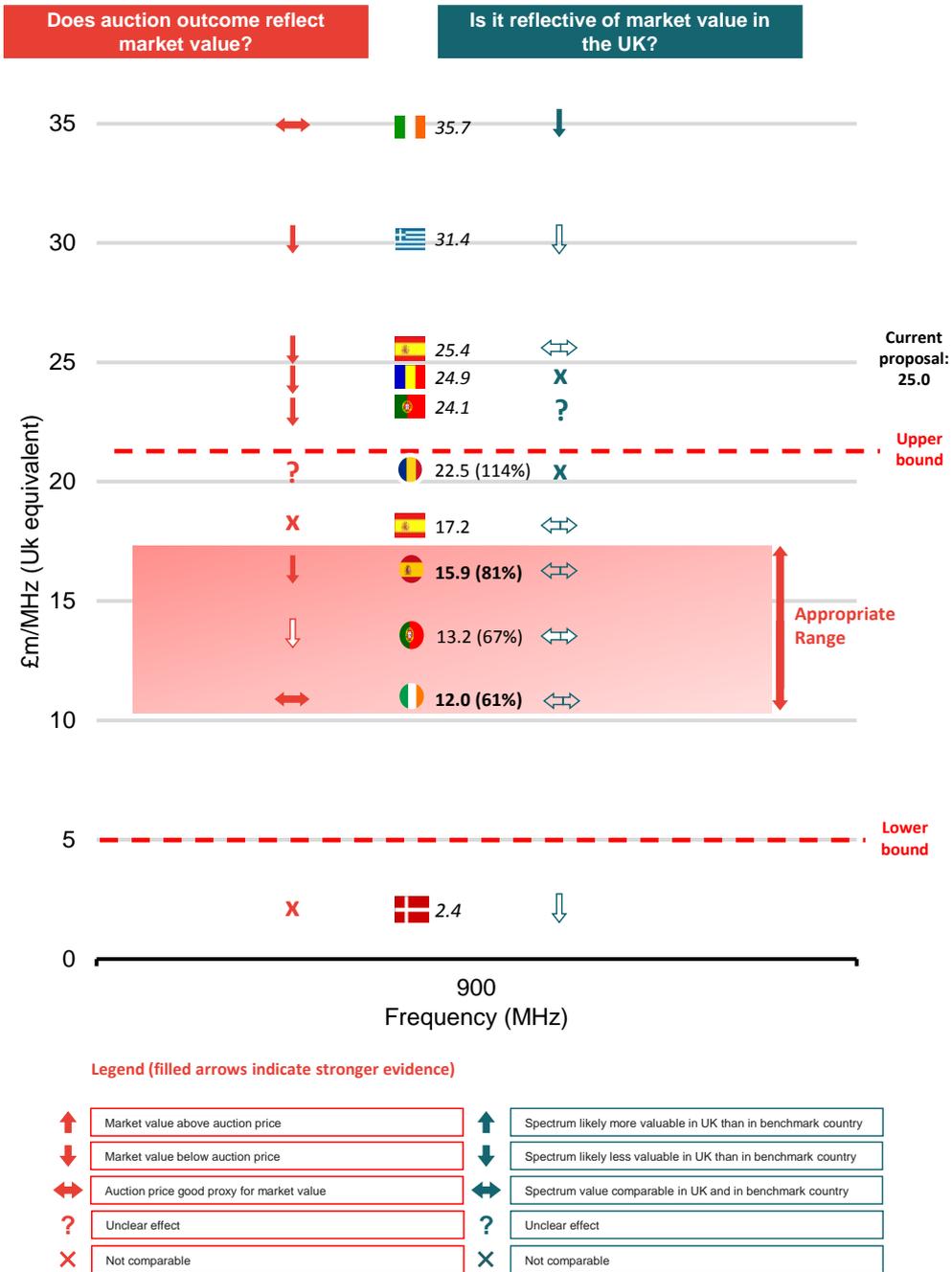
associated with the coverage obligations were also the same across the two countries (2Mbps download speed).

do not consider them when deriving the appropriate range of market values for 900 MHz spectrum in the UK under our base case.<sup>25</sup>

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<sup>25</sup> The 'less relevant' evidence is considered in our sensitivity analysis, where we attach less weight to these observations.

**Figure 9.** Value of 900 MHz spectrum based on international benchmarks



Note: In line with Ofcom’s approach, squared markers refer to absolute (£m per MHz) values, round markers refer to relative value. More important evidence in **bold**, less relevant evidence in *italics*.

Source: Frontier Economics

There are five observations that lie within the plausible range: the absolute valuation from the Spanish beauty contest and the relative valuations based on the auctions in Romania, Spain, Portugal and Ireland.

As explained in the main report, the outcome of the Spanish beauty contest is unlikely to reflect the true market value of 900 MHz spectrum in Spain and we consider this observation to be less important evidence for deriving the value of 900 MHz spectrum in the UK. Similarly, in Portugal and Romania, all sold spectrum went at the reserve price, which implies that the relative valuations could not be expected to be reflective of relative market value<sup>26</sup>. At the same time, in Portugal, operators chose the significantly more expensive 800 MHz over 900 MHz, with some 900 MHz spectrum left unsold, which would suggest that the relative value of 900 MHz to 800 MHz as reflected in the reserve prices can be seen as potentially overestimating the true value of 900 MHz in Portugal. The auction results in Romania are likely to be further distorted by country specific factors and provide only limited information about the true market value of spectrum in the UK. We therefore treat Portugal and Romania as less important evidence and we do not consider these observations when deriving the appropriate range for the UK 900 MHz value under our base case.

Two observations based on **relative values**, derived from the auctions in **Spain** and **Ireland**, lie between the upper- and lower bounds for the market value of 900 MHz spectrum in the UK. Our analysis suggests that the relative prices in these two countries are likely to provide the most reliable indicators to inform the appropriate range for the market value of 900 MHz spectrum in the UK. As 900 MHz spectrum was sold at the reserve price in Spain, this is likely overestimating the market value of 900 MHz spectrum, whereas 800 MHz spectrum sold above the reserve price and could therefore be expected to be reflective of market value of this spectrum. This implies that the application of the relative value of 900/800 MHz from Spain to the UK would overestimate the market value of 900 MHz spectrum in the UK. In Ireland, 800 MHz and 900 MHz spectrum cleared above the reserve price, so the auction outcomes can be expected in general to be reflective of relative market value.<sup>27</sup>

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<sup>26</sup> We note nevertheless that the estimated ratio of 900 MHz to 800 MHz value in Portugal is consistent with the ratios observed in Spain and Portugal, and lies between these ratios: taking therefore Portugal into account in the basic approach to derive the market value of 900 MHz spectrum in the UK would not be expected to affect the results of our analysis.

<sup>27</sup> Our analysis actually suggests that demand for 2G spectrum is likely to be higher in Ireland, which, all else the same, would imply that the ratio of the market value of 900 MHz to 800 MHz in Ireland may be higher than the corresponding ratio in the UK. This could lead to an over-estimation of the value of 900 MHz spectrum in the UK.

Using these relative valuations for 900 MHz spectrum<sup>28</sup>, together with the mid-point of the estimated value of 800 MHz spectrum in the UK, we find that the appropriate range for the market value of 900 MHz spectrum in the UK is between **£12m and £15.9m per MHz**.

We however consider the additional evidence from Austria, Slovenia and Norway in our 900 MHz sensitivity analysis, in which we take into account all available international evidence, after carefully assessing the comparability of such evidence with the UK.

To undertake the sensitivity analysis, we have estimated approximate per MHz prices from the auctions in Switzerland, Norway, Netherlands and Slovenia using a simple decomposition approach<sup>29</sup>, while relying on LRP estimates of band specific prices in Austria. We have attached weights on observations that were considered to be of less relevant evidence, including observations that lie outside the plausible range of 900 MHz market value in the UK. We then calculated a weighted average, attaching 100% weight to the ‘more important’ evidence observations, 75% weight to the observations that are within the plausible range but which are considered to be ‘less important’ evidence, and 50% weight to ‘less relevant’ observations outside the plausible range of 900 MHz market value.

We first undertake this exercise taking into account all auction outcomes from Ofcom’s original benchmarking sample. We then replicate the exercise including additional observations from Austria (relative), Slovenia, Norway and Switzerland<sup>30</sup>, but excluding ‘outlier observations’ from 900 MHz auctions in Netherlands and Austria (absolute)<sup>31</sup>. Finally, we consider the full sample of 17 observations, which includes Switzerland, the only auction in the sample for which Ofcom does not provide any estimate of the spectrum value.

**Figure 10** shows that the estimated weighted average value of 900 MHz spectrum across the alternative samples of observations is broadly similar. Whilst we recognise that international evidence needs to be treated cautiously, because of the limitations in comparability to the UK, the results of our sensitivity analysis are consistent with the estimated range for the market value of 900 MHz spectrum in the UK, as described above.

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<sup>28</sup> These relative valuations are the same as the ones used by Ofcom in its analysis.

<sup>29</sup> See Annex 1 of *Benchmarking report* for more details.

<sup>30</sup> Switzerland is the only auction in Ofcom’s original sample for which Ofcom does not provide any estimate of the spectrum value.

<sup>31</sup> We identify Austria and Netherlands (where the price paid was relatively high) as outlier observations using three different approaches proposed by DotEcon: International benchmarking of 900 MHz and 1800 MHz spectrum value - September 2013, page 11-13. We note that our main conclusions hold even if we consider Denmark (where the price paid was relatively low) as an outlier observation.

**Figure 10.** Results of sensitivity analysis 900 MHz estimates (update)<sup>32</sup>

£m/MHz (UK equivalent)	Price	900MHz	Frontier's more important evidence	Auctions considered by Ofcom	All observations (no outliers)	All observations
Austria (2013)	Absolute	80.0				50%
Netherlands (2012)	Absolute	59.0		50%		50%
Ireland (2012)	Absolute	35.7		50%	50%	50%
Greece (2011)	Absolute	31.4		50%	50%	50%
Spain (2011)	Absolute	25.4		50%	50%	50%
Romania (2012)	Absolute	24.9		50%	50%	50%
Portugal (2011)	Absolute	24.1		50%	50%	50%
Slovenia (2013)	Absolute	24.0			50%	50%
Romania (2012)	Relative (114%)	22.5		75%	75%	75%
Austria (2013)	Relative (110%)	21.5			75%	75%
Spain (May 2011)	Absolute	17.2		75%	75%	75%
<b>Spain (2011)</b>	<b>Relative (81%)</b>	<b>15.9</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Norway (2013)	Absolute	15.1			75%	75%
Switzerland (2012)	Absolute	13.6			75%	75%
Portugal (2011)	Relative (67%)	13.2		75%	75%	75%
<b>Ireland (2012)</b>	<b>Relative (61%)</b>	<b>12.0</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Denmark (2010)	Absolute	2.4		50%		50%
<i>Max</i>			15.9	59.0	35.7	80.0
<i>Min</i>			12.0	2.4	12.0	2.4
<b>Average</b>			<b>14.0</b>	<b>14.1</b>	<b>13.4</b>	<b>15.2</b>

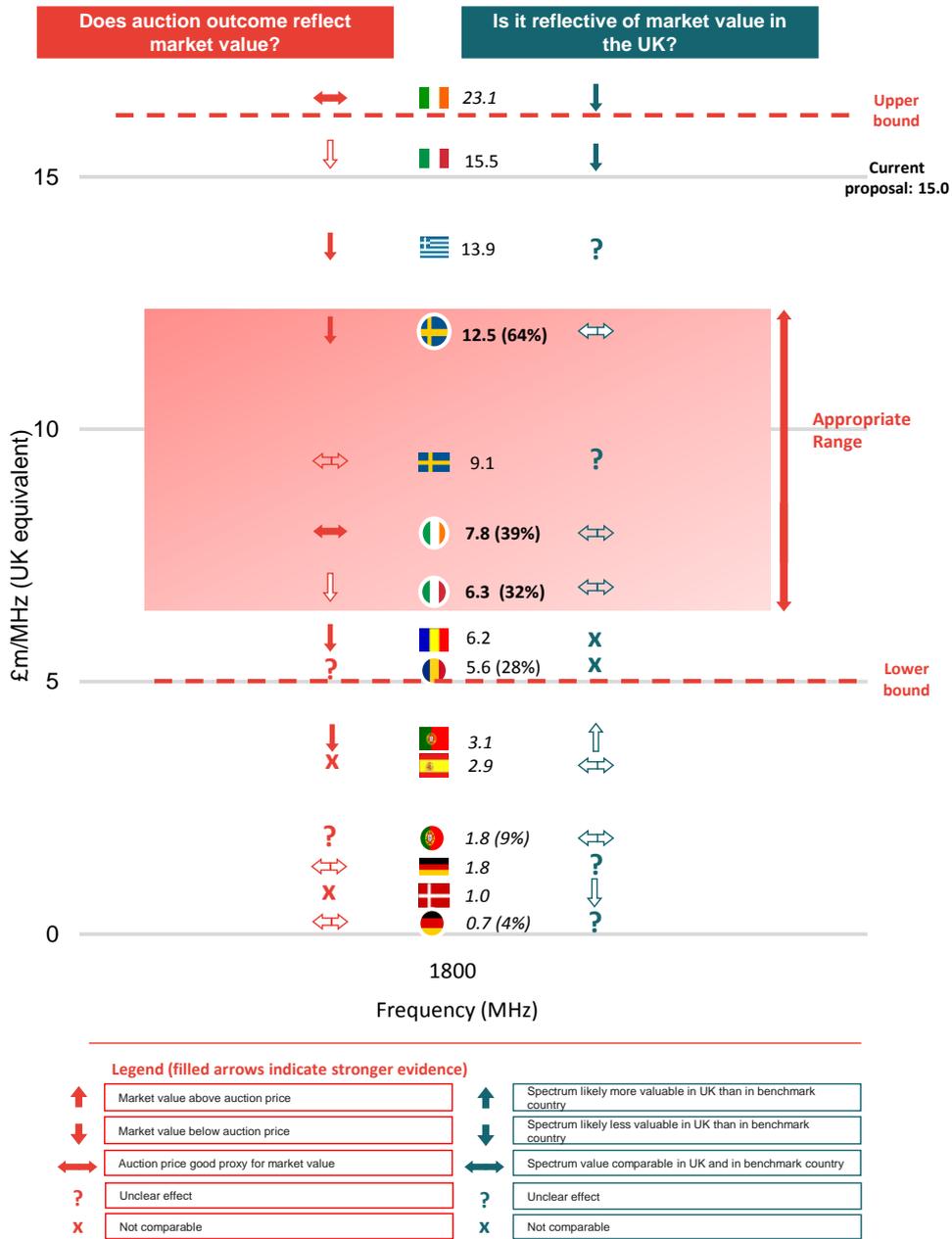
Note: Plausible range highlighted in blue. More important evidence highlighted in **bold**. New evidence highlighted in red.

Source: Frontier Economics

Using a similar approach, we find that the appropriate range for the market value of 1800 MHz spectrum in the UK is still between **£6.3m and £12.5m per MHz**. This is based on relative 1800/800 MHz valuations from Sweden and Ireland, see **Figure 11** below.

<sup>32</sup> We recognise that Netherlands (2012) could be treated as the evidence in the category “*Auctions considered by Ofcom*”, as Ofcom took into account outcomes of the Dutch auction in its original analysis (although only as a less important evidence). We take a conservative approach by including our decomposition estimate of 900 MHz value in Netherlands (£59m per MHz) and not considering the reserve price (£10.2m per MHz) that Ofcom also treat as less important evidence in their original analysis.

**Figure 11.** Value of 1800 MHz spectrum based on international benchmarks (update)



Note: In line with Ofcom’s approach, squared markers refer to absolute (£m per MHz) values, round markers refer to relative value. More important evidence in **bold**, less relevant evidence in *italics*.

Source: Frontier Economics

We further consider the evidence from Austria, Slovenia, Slovakia and Norway in our sensitivity analysis for 1800 MHz estimates. The results of our sensitivity analysis are again consistent with the estimated ranges for the market value of 1800 MHz spectrum in the UK, see **Figure 12.** below.

## CRITIQUE OF OFCOM’S INTERNATIONAL BENCHMARKING ANALYSIS

**Figure 12.** Results of sensitivity analysis 1800 MHz estimates (update)

£m/MHz (UK equivalent)	Price	1800MHz	Frontier's more important evidence	Auctions considered by Ofcom	All observations (no outliers)	All observations
Austria (2013)	Absolute	43.9				50%
Netherlands (2012)	Absolute	35.4		50%		50%
Ireland (2012)	Absolute	23.1		50%	50%	50%
Italy (2011)	Absolute	15.5		75%	75%	75%
Slovenia (2013)	Absolute	14.4			75%	75%
Greece (2011)	Absolute	13.9		75%	75%	75%
Slovakia (2013)	Absolute	13.6			75%	75%
Austria (2013)	Relative (66%)	11.8			75%	75%
<b>Sweden (2011)</b>	<b>Relative (64%)</b>	<b>12.5</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Sweden (2011)	Absolute	9.1		75%	75%	75%
Norway (2013)	Absolute	9.1			75%	75%
<b>Ireland (2012)</b>	<b>Relative (39%)</b>	<b>7.8</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Switzerland (2012)	Absolute	8.1			75%	75%
<b>Italy (2011)</b>	<b>Relative (32%)</b>	<b>6.3</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
Romania (2012)	Absolute	6.2		75%	75%	75%
Romania (2012)	Relative (28%)	5.6		75%	75%	75%
Portugal (2011)	Absolute	3.1		50%	50%	50%
Spain (May 2011)	Absolute	2.9		50%	50%	50%
Portugal (2011)	Relative (9%)	1.8		50%	50%	50%
Germany (2010)	Absolute	1.8		50%	50%	50%
Denmark (2010)	Absolute	1.0		50%	50%	50%
Germany (2010)	Relative (4%)	0.7		50%	50%	50%
<b>Max</b>			<b>12.5</b>	<b>35.4</b>	<b>23.1</b>	<b>43.9</b>
<b>Min</b>			<b>6.3</b>	<b>0.7</b>	<b>0.7</b>	<b>0.7</b>
<b>Average</b>			<b>8.9</b>	<b>6.2</b>	<b>6.2</b>	<b>7.5</b>

## Annex 1: Appropriateness of Austrian LRP results

Ofcom have presented LRP results for the Austrian auction. Due to confidentiality restrictions these have been produced by the Austrian regulator running an executable produced by Ofcom's consultants, with neither Ofcom nor its consultants having access to the underlying bid data.

It is not clear what weight, if any, Ofcom proposes to place on the LRP results. There are a number of reasons why the LRP results may not be robust estimates of the market clearing prices for individual blocks of spectrum in Austria:

- There is the general point that LRP results do not purport to be **market clearing prices for blocks** of spectrum but are a decomposition of the **prices paid for packages** of spectrum in auctions;
- The specific nature of the bids in the Austrian auction, means the winning prices and the the decomposition of these prices into prices per band through the LRP, are reliant on losing bids with a high probability of a strategic element. The critical losing bids which determine the prices, and the excursions (to be minimised by the LRP algorithm) are likely to include attempts to exclude the third operator, or attempts by the third operator to push prices close to the private values of the other bidders (existing 900MHz holders), or some combination of such bids. As such the decomposition of these prices into prices per band, may not reflect bidders' spectrum valuations; and
- Without access to the underlying bid data, it is impossible for Ofcom, its consultants or stakeholders in the UK to properly assess the robustness of the LRP decomposition in the specific circumstances of the Austrian auction.

As noted in the main report, the market situation in Austria differs considerably from the UK market, as does the structure of the auction. The apparent strategic valuations associated with large packages of spectrum are likely to have both distorted the bid data and potentially led to strategic bidding. This may mean that neither the prices paid for winning packages, nor the excursions on those prices, which are input to the LRP calculation, are a true reflection of the market clearing prices for these packages.

## LRP estimates are not estimates of clearing prices for blocks

As set out in *Benchmarking report*, in order to achieve an efficient allocation of spectrum, the prices used to set ALF should reflect a market clearing price for incremental blocks of spectrum.

It is common ground that there may be no decomposition of prices paid for packages paid in combinatorial auctions into individual block prices which result in an efficient allocation. For example Dotecon note<sup>33</sup>:

*“it is possible that there may be no uniform linear price that supports an efficient allocation.”*

Dotecon also note that in all cases a set of linear prices can be determined above which there is no excess demand, but in this case spectrum may be unsold. Similarly in all cases linear prices could be determined below which all spectrum is sold, but there may be excess demand as this point due to combinatorial effects (i.e. more than one operator would seek to acquire a marginal block at this price). As noted in previous Frontier reports, while both of these cases is potentially inefficient there is a clear asymmetry in the impact on welfare of setting prices too high, i.e. such that spectrum is unsold leading to a significant welfare loss, compared to a situation where there is excess demand, where any welfare loss is of second order (a potential mis-allocation between operators).

The rationale behind CCA auctions is that, even in cases where there is no linear set of prices which lead to an efficient outcome, a more efficient non-linear set of package prices can be determined, by allowing operators to express the valuations for packages of spectrum. The outcome is potentially more efficient, in terms of the maximum amount of spectrum being allocated (although there may be a risk of lots remaining unsold) and there being no excess demand.

Taking the results of a CCA auction and applying a linear decomposition cannot, except in special cases, result in linear market clearing prices because such prices will not generally exist. By their nature linear revenue decompositions will effectively average out the incremental value of blocks of spectrum<sup>34</sup> for bidders between the lower bound and upper bounds defined by the point below which all spectrum is allocated and the point above which there is no excess demand. Due to this averaging, for an operator successful in the auction the incremental value of a block of spectrum may be below the associated LRP estimate for the block, i.e. they would give up the incremental block of spectrum at this price.

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<sup>33</sup> 800MHz and 2.6GHz linear reference prices and additional spectrum methodology Report prepared for Ofcom September 2013 page 4

<sup>34</sup> See discussion in 800MHz and 2.6GHz linear reference prices and additional spectrum methodology Report prepared for Ofcom September 2013 page 6

The risk that the LRP methodology could over-estimate the level of prices at which all blocks would be sold (as we have shown it did in UK<sup>35</sup>) is likely to be relatively high in Austria due to a combination of factors:

- The likely relatively high value placed on packages of spectrum relative to incremental value of blocks, due to strategic considerations like foreclosure;
- The relatively small number of bidders;
- The relatively large numbers of different lots available.

Strategic considerations mean that an operator's valuation of a large package of spectrum may be much larger than the sum of incremental spectrum values, as strategic value is associated with the total package of spectrum rather than the individual blocks within the package. This could lead to the marginal value of spectrum increasing at a certain point, due to the increasing possibility of foreclosure. In addition, operators are likely to have high valuations for "core" packages of spectrum which they require to remain viable operators. This structure, with high incremental valuations for initial "core" blocks of spectrum and then relatively high valuations for marginal blocks in large packages, which could increase the chance of foreclosure, could lead to large variations in the marginal cost of spectrum depending on the amount of spectrum acquired. The LRP, by effectively averaging out this variation, could result in a significant loss of information.

The low number of bidders in the Austrian auction (three) and the high spectrum caps facilitates potential foreclosure, as a single bidder can acquire sufficient spectrum to ensure there is not sufficient spectrum for two strong competitors. In auctions, such as the UK auction, with a higher number of bidders and tighter spectrum caps, one operator alone cannot foreclose and co-ordination between more than one operator is difficult. The Austrian regulator introduced measures apparently to dis-incentive collusive bidding, but it is not clear the degree to which these measures were successful or may have introduced further distortions in bidding behaviour and hence the auction outcome<sup>36</sup>.

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<sup>35</sup> Deriving market clearing prices for 800 MHz spectrum from the UK 800 MHz/2600 MHz auction at 5.2

<sup>36</sup> According to a Reuters article from 25 October 2013: "*All three operators have complained about the auction process, which required them to submit blind bids to prevent collusion. This required them to bid without knowledge of the extent of demand for any particular frequency block, thereby pushing up the price.*" Available at <http://www.reuters.com/article/2013/10/25/us-austria-telecoms-auction-idUSBRE99O0NY20131025>

The low number of bidders also means that the prices paid by successful bidders are a function of bids made by the other two bidders in the primary and supplementary rounds.

The Austrian auction was relatively complex with 28 blocks of spectrum divided in 9 categories of spectrum defined across three different bands. The complexity of the auction is indicated by the fact that RTR stated ‘at least 2,000 supplementary bids will be permitted’<sup>37</sup>. Without the underlying bid data it is impossible to examine the potential interactions between such large numbers of bids from a small pool of operators on winning prices or the LRP methodology. What limited information<sup>38</sup> is available on the packages bid shows that operators concentrated their supplementary bids in certain specific categories, presumably for strategic purposes. This again could lead to prices not fully reflecting the marginal costs of bidders.

## **Bids in the auction may not reflect bidders true valuations**

High private values for some bidders, including any strategic value, could facilitate ‘strategic bidding’ by one or more bidders, where they attempt to exclude competitors, drive up the prices paid by competitors and/or reduce the prices they themselves pay. This again could distort the final prices paid and the results of the LRP decomposition.

While CCA auctions attempt to incentivise ‘truthful’ bidding as all bids could potentially be winning bids at the price bid in certain circumstances bidders may submit bids which have very low probability of being winning bids but which may affect the prices paid by others.

The specific structure of the Austrian auction facilitated such strategic bidding, in particular in the supplementary rounds, bidders could submit large numbers of bids for large packages of spectrum. In the event that such a package was significantly bigger than the bidder’s final primary round package, and contained spectrum of high private value to another bidder (such as existing deployed 900MHz or 1800 MHz spectrum), there would be little or no probability of these

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<sup>37</sup> Rules of Procedure under § 55 Par. 9 TKG 2003 Auction Procedure for Frequency Assignments in the 800 MHz, 900 MHz and 1800 MHz Bands (non-binding Web version) paragraph 5.9.3

<sup>38</sup> A limited analysis of the auction process was presented by RTR. See: [https://www.rtr.at/de/pr/PI28102013TK/PK28102013TK\\_Praesentation.pdf](https://www.rtr.at/de/pr/PI28102013TK/PK28102013TK_Praesentation.pdf):

bids being ‘winning bids’ that would affect the amount of spectrum they were allocated. In addition there was a possibility of strategic bidding during the primary ‘clock’ phase of the auction and some evidence that this may have occurred.

### Price setting bidding in the supplementary round

The Austrian auction had several features which facilitated bids in the supplementary round intended to set prices for others but which were unlikely to be winning bids:

- There were only three bidders in the auction;
- Spectrum caps allowed bidders to bid for almost exactly half of the spectrum on offer;
- Bidders had high private value for retaining use of existing spectrum

There were four spectrum caps applied in the auction, three of these applied to the amount of 800, 900 and 800/900 combined spectrum that could be acquired. The remaining overall cap was for the total amount of spectrum that could be acquired, a total of 70 MHz of spectrum.

During the auction demand for spectrum was measured in terms of eligibility points. 2 points were assigned for each 5MHz block of 800 and 900 spectrum and 1 point for each 5 MHz block of 1800 MHz spectrum. In total the spectrum in the action amounted to 41 eligibility points as shown below.

**Figure 13.** Distribution of eligibility points

Kategorie	Band	Blöcke	Bietpunkte
A1	800 MHz	1	2
A2	800 MHz	4	2
A3	800 MHz	1	2
B1	900 MHz	1	2
B2	900 MHz	5	2
B3	900 MHz	1	2
C1	1800 MHz	2	1
C2	1800 MHz	8	1
C3	1800 MHz	5	1

Source: RTR

The overall cap placed on spectrum was equivalent to a cap that no bidder could submit bids for a package comprising of more than 21 eligibility points, or just over half the eligibility points available. Package bids from two bidders could exactly sum to all of the spectrum available, with one bidder bidding for a package of equivalent to 21 eligibility points and the other for a package equivalent to 20 eligibility points<sup>39</sup>.

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<sup>39</sup> However, there are a large number of combinations of bids that sum to 20 or 21 eligibility points so the probability of any random pair of bids of 21 and 20 eligibility points covering all of the available spectrum is small.

## Winner price determination

In a CCA auction format, the winning bids are those package bids which maximise the total amount bid subject to the amount of spectrum bid for in each category being less than or equal to the total amount available in that category.

In CCA auctions, prices paid are second prices, i.e. Vickrey prices<sup>40</sup>. That is the price paid by any winning bidder for a winning package would reflect the opportunity cost of the package acquired. This opportunity cost consists of the difference between:

- The maximum amount bid in total for combinations of bids by other bidders (i.e. not the winning bidder for the package) for the total spectrum available; and
- The total amount bid by other bidders in the winning combination of spectrum.

It can be clearly seen that the amount bid by a winning bidder for a winning package does not have a direct influence on the prices paid, which should in theory incentivise truthful bidding.

Given that the auction had only three bidders, the Vickrey prices, and hence the price paid, for any one bidder reflects bids made by the other two bidders. The total amount bid by the other bidders in the winning combination of spectrum will likely reflect 'truthful' bidding, as all will be seeking to acquire value enhancing spectrum. However it is possible for the bids used to make up the other element of the calculation of the second price, the maximum amount bid excluding one of the bidders, to be based on bids which bidders know with a high degree of certainty will not be part of any winning combination (e.g. the package would be significantly larger than the final primary round package, and would involve a major – or total - loss of existing deployed spectrum by another bidder).

At the end of the primary rounds, in total bidders were bidding on packages with around 35 eligibility points (out of a total of 41 available). However, each of A1 Telekom, T-Mobile and Hutchison bid for packages with 21 eligibility points early in the auction (see **Figure 14** below which showed total demand of 63 eligibility points in the early rounds of the auction) allowing them to submit supplementary bids for packages with 21 points. However, the amount they

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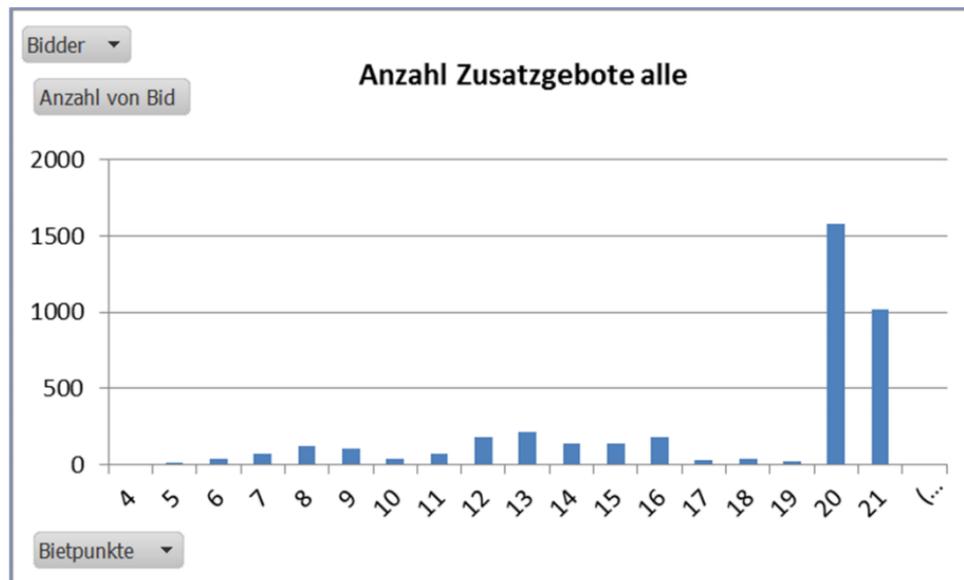
<sup>40</sup> Strictly prices are selected from the set of core prices using rules such as Vickrey nearest, but given the small number of bidders in the Austrian auction and the spectrum caps it appears that Vickrey prices would be the core prices.

could bid for packages with this number of eligibility points was, for each of them, capped by the prices at the point where they reduced demand. Clearly at least one bidder (most likely H3G) was bidding for far fewer than 21 points at the end of the primary rounds, and in the case of such a bidder, any 20/21-point supplementary bids would be unlikely to be winning bids.

The fact that A1 Telekom won a 21 point package suggests that it dropped eligibility the least of all bidders (and perhaps had not dropped at all) and the fact that T-Mobile won a 15 point package suggests that it dropped eligibility far less than H3G: T-Mobile might still have been hoping to exclude Hutchinson completely, or nearly completely. .

However, bids for packages with 20 and 21 activity points by e.g. Hutchison, while having minimal risk of being part of the winning combination, would form part of the price determination. This is because the opportunity cost of spectrum for a winning bidder is dependent on the highest value combination of bids from bidders other than that bidder, i.e. the other two bidders. This is likely to consist of a pair of bids, one with 21 eligibility points and one with 20 eligibility points. Such bids from Hutchison and T-Mobile would be likely to form the price determination for each other (in combination with A1 Telekom's bids) and together for A1 Telekom.

Analysis from RTR shows a disproportionate number of supplementary bids for packages with 20 and 21 bid points (65% of the total bids made). The only plausible explanations for this behaviour are bidders attempting to exclude a competitor, or in the case where an exclusion of another bidder is impossible (the situation most likely faced by H3G), attempting to influence the prices paid by others.

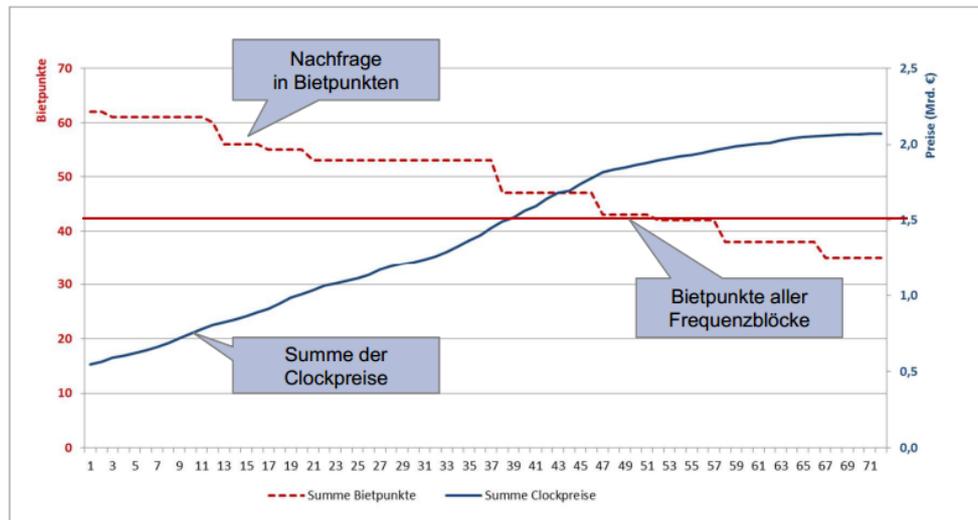
**Figure 14.** Distribution of supplementary bids by eligibility points

Source: RTR

This indicates that the prices paid by winning bidders reflect, at least in part, strategic bidding (either the bids were attempting to reduce competition, or were price setting bids not expected to be winning bids) in the supplementary round.

### Potential strategic bidding in the clock round

The clock phase of Austrian auction was notable in that by the end of the phase, overall demand was very much lower than overall demand as shown below with the red dotted line (demand in each round in eligibility points) at the end of the auction below the solid red line (the total spectrum available).

**Figure 15.** Analysis of the clock phase of the Auction

Source: RTR

Such an apparent lack of demand indicates that demand was reduced by multiple blocks in a round for some categories of spectrum leading to demand for a given category moving from above supply to below supply in a single round (if demand is cut in single blocks then demand for this category would match supply). This can be seen by the sudden drops in demand (the dotted red line) in certain rounds.

This type of behaviour was also observed in the UK auction with Hutchison cutting demand in large increments in the clock round. Such behaviour could be a sign of high combinatorial values associated with large blocks of spectrum (with incomplete parts of a desired package having low value by themselves) or strategic bidding. Analysis of the UK auction suggests that Hutchison's behaviour in that auction was consistent with strategic bidding<sup>41</sup>. Further, note that high combinatorial values – strong complementarities - would tend to lead to a sale price which was significantly below the final round price: the spectrum could not all clear at the final round price, and most likely a significant discount to final round price would be needed to clear the partial package. Instead, the overall sale price (total revenue across bidders) appears very similar to the sum of the final round prices, so this is an indicator against strong complementarities.

<sup>41</sup> Myers, Geoffrey, Spectrum Floors in the UK 4G Auction: An Innovation in Regulatory Design (August 8, 2013).

## **We are unable to assess the robustness of the LRP estimates without the underlying bid data**

The unusual characteristics of the Austrian auction, with three bidders and weak spectrum caps, could have potentially facilitated strategic bidding. The limited analyses publicly available from the auction show evidence consistent with strategic bidding.

With the information available to Ofcom, its consultants or other stakeholders it is impossible to analyse the degree to which potential strategic bidding could have influenced the final package prices and could affect the robustness of the decomposition of these winning prices into linear prices. Without such an analysis, it is impossible to state with any confidence that the linear prices provide any information on relative market clearing prices of bands. To the degree that some of the implicit assumptions underlying the LRP method may not have been met, the LRP method may not be appropriate for the Austrian auction results.

The relatively high 'excursions' reported with the decomposition indicates that the LRP estimates are not a good 'fit' to the prices paid. However without access to the underlying bid data it is impossible to ascertain to what degree this influences the robustness of LRP estimates as the clearing price for any single block.

Access to the underlying bid data could potentially allow direct estimation of the market clearing price for each band by examining the structure of individual operators' bids in the supplementary round. Frontier's analysis of the UK auction shows that this market clearing price for a generic block of spectrum was significantly lower than LRP estimates derived from packages of spectrum.

In order to fully assess the appropriateness of any LRP estimates for the purposes of determining market clearing prices, it is essential to have access to the underlying bid data to assess the extent that results may be affected by a number of issues including:

- High combinatorial value
- 'thin' bidding by participants, with bidders not necessarily bidding on all combinations of spectrum that they could bid on;
- strategic bidding by participants which does not reflect their truthful valuations of packages or is intended to foreclose competitors; and
- combinatorial effects, with values associated with particular packages of spectrum.

Without access to the underlying bid data we cannot ascertain to what extent these effects had an impact on the prices paid in the auction and the LRP

decomposition of these prices. However, the available evidence suggests a relatively large effect.