Annual licence fees for 900 MHz and 1800 MHz spectrum

Provisional decision and further consultation

Annexes 1-7

Contents

Annex 1

Responding to this consultation

How to respond

A1.1 Ofcom invites written views and comments on the issues raised in this document, to be made **by 5pm on Friday 17 April 2015**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://stakeholders.ofcom.org.uk/consultations/annual-licence-fees-further-consultation/howtorespond/form as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response cover sheet (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.

A1.3 For larger consultation responses - particularly those with supporting charts, tables or other data - please email ALF@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

A1.4 Responses may alternatively be posted or faxed to the address below, marked with the title of the consultation.

Robert Emson
3rd Floor
Spectrum Policy Group
Riverside House
2A Southwark Bridge Road
London SE1 9HA

Note that we do not need a hard copy in addition to an electronic version. Ofcom will acknowledge receipt of responses if they are submitted using the online web form but not otherwise.

A1.5 It would be helpful if your response could include direct answers to the questions asked in this document, which are listed together at Annex 4. It would also help if you can explain why you hold your views and how Ofcom's proposals would impact on you.

Further information

A1.6 If you want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Alan McNaboe on 020 7783 4522.

Confidentiality

A1.7 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt. If you think your response should be kept confidential, can you please specify what part or whether

all of your response should be kept confidential, and specify why. Please also place such parts in a separate annex.

A1.8 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and will try to respect this. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.9 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's approach on intellectual property rights is explained further on its website at http://www.ofcom.org.uk/terms-of-use/

Next steps

A1.10 Following the end of the consultation period, and depending on our consideration of the responses to this consultation, we expect to publish our decision around the end of the year.

A1.11 Please note that you can register to receive free mail Updates alerting you to the publications of relevant Ofcom documents. For more details please see: http://www.ofcom.org.uk/email-updates/

Ofcom's consultation processes

A1.12 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.

A1.13 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.

A1.14 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Graham Howell, Secretary to the Corporation, who is Ofcom's consultation champion:

Graham Howell
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA

Tel: 020 7981 3601

Email Graham.Howell@ofcom.org.uk

Annex 2

Ofcom's consultation principles

A2.1 Ofcom has published the following seven principles that it will follow for each public written consultation:

Before the consultation

A2.2 Where possible, we will hold informal talks with people and organisations before announcing a big consultation to find out whether we are thinking in the right direction. If we do not have enough time to do this, we will hold an open meeting to explain our proposals shortly after announcing the consultation.

During the consultation

A2.3 We will be clear about who we are consulting, why, on what questions and for how long.

A2.4 We will make the consultation document as short and simple as possible with a summary of no more than two pages. We will try to make it as easy as possible to give us a written response. If the consultation is complicated, we may provide a shortened Plain English Guide for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A2.5 We will consult for up to 10 weeks depending on the potential impact of our proposals.

A2.6 A person within Ofcom will be in charge of making sure we follow our own guidelines and reach out to the largest number of people and organisations interested in the outcome of our decisions. Ofcom's 'Consultation Champion' will also be the main person to contact with views on the way we run our consultations.

A2.7 If we are not able to follow one of these principles, we will explain why.

After the consultation

A2.8 We think it is important for everyone interested in an issue to see the views of others during a consultation. We would usually publish all the responses we have received on our website. In our statement, we will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 3

Consultation response cover sheet

A3.1 In the interests of transparency and good regulatory practice, we will publish all consultation responses in full on our website, www.ofcom.org.uk.

A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality where appropriate.

A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore Ofcom would encourage respondents to complete their coversheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.

A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' section of our website at http://stakeholders.ofcom.org.uk/consultations/consultation-response-coversheet/.

A3.5 Please put any parts of your response you consider should be kept confidential in a separate annex to your response and include your reasons why this part of your response should not be published. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your cover sheet only, so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

Please tick below what part of your response you consider is confidential, giving your reasons why

Nothing ☐

Whole response ☐

Part of the response ☐

Name/contact details/job title ☐

Organisation ☐

If there is no separate annex, which parts?

If you want part of your response, your name or your organisation not to be published, can Ofcom still publish a reference to the contents of your response (including, for any confidential parts, a general summary that does not disclose the specific information or enable you to be identified)?

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response that Ofcom can publish. However, in supplying this response, I understand that Ofcom may need to publish all responses, including those which are marked as confidential, in order to meet legal obligations. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here. ☐

Name

Signed (if hard copy)

Annex 4

Consultation questions

Question 1: Do you agree with the approach we put forward to assess the impact of the geographic coverage obligation on revising ALF to reflect full market value?

Question 2: Do you agree with our assessment under the approach that we have put forward of the impact of the geographic coverage obligation on the market value of 900 MHz and/or 1800 MHz spectrum for the purpose of revising ALF to reflect full market value (where possible, supported by evidence)?

Question 3: If you think that we should use a different approach to assess the impact of the geographic coverage obligation, what is your alternative approach and why do you consider it more appropriate than the approach we put forward?

Question 4: If you have set out an alternative approach to assess the impact of the geographic coverage obligation, what is your assessment under that approach of the impact of the geographic coverage obligation on the market value of 900 MHz and/or 1800 MHz spectrum for the purpose of revising ALF (where possible, supported by evidence)?

Question 5: Do you have any other comments on whether, and if so how, the geographic coverage obligation, taking account of the associated incremental costs incurred by the MNOs, should impact ALF?

Annex 5

This annex has been left intentionally blank to maintain consistent numbering of the annexes with the corresponding material in the August 2014 consultation.

Annex 6

UK market values of 800 MHz and 2.6 GHz spectrum for the purpose of ALF: supporting material

Introduction

A6.1 This annex provides supporting material for the analysis of UK market value of the 800 MHz and 2.6 GHz spectrum bands for the purpose of ALF, based on the 4G auction data, which is set out in Section 2. For completeness, in some sections of this annex we repeat analysis that was included in Annex 6 of the August 2014 consultation.

A6.2 The annex covers the:

a) Decomposition of 4G auction prices by band;

b) Opportunity costs in the 4G auction by band using the Additional Spectrum Methodology (ASM) and the decomposition method (put forward by Vodafone);

c) Price signals provided by 2x5 MHz and 2x10 MHz increments of 800 MHz spectrum;

d) Linear Reference Prices (LRPs);

e) Marginal bidder analysis for 800 MHz, including the complementarity premium (put forward by EE); and

f) DTT co-existence costs.

Decomposition of 4G auction prices by band

A6.3 The auction prices in the UK 4G auction were determined for each winner on the basis of the higher of the reserve price and the highest losing bids (which could involve bids made by more than one bidder) for constituent elements of that winning package of spectrum. Highest losing bids are the opportunity cost to other bidders based on the bids made in the auction for the particular package of spectrum acquired by that specific winner. An implication of this approach to derive auction prices is that they can be non-linear or non-uniform (as in Section 2, we use these two terms interchangeably in this context). By non-linear or non-uniform we mean that: (a) taking the example of a bidder winning a package of two lots of 800 MHz spectrum, the price for the second lot of 800 MHz may be different from the price for the first lot; and (b) for the same amount of spectrum in the same band, prices can be different between winners.

A6.4 In a combinatorial (or package) auction, such as the UK 4G auction, the identification of the highest losing bids may be complicated, because the removal of winning bidder 1 could lead to a significant rearrangement of the packages of the other bidders that would be highest value in the absence of winning bidder 1 (the price-setting combination of packages). A relatively simple case would be if, in the

absence of bidder 1, the other winning bidders would just obtain more spectrum than in their winning packages (and/or the bidders who failed to win would obtain some spectrum). If so, the auction price for bidder 1 is the sum of the incremental bid values by those bidders for the larger packages compared to their winning packages. A more complex case would be if some aspects of the packages of the other bidders would be smaller as well as others being larger, e.g. in the price-setting combination bidder 2 would win more spectrum in lot category A but less spectrum in lot category C (perhaps because bidder 2 made this bid, but did not make a bid for more spectrum in A and the same amount in C). This means that package rearrangements are involved. As discussed below, in the 4G auction there were instances of both the relatively simple case (Niche) and of more complex cases with package rearrangements (EE, Telefónica and Vodafone).

A6.5 Another source of complication is that three of the five winners of spectrum in the 4G auction acquired packages of spectrum in multiple bands. This raises the question of how to decompose these package prices by band. We set out below a decomposition of the auction prices, based on the nature of the highest losing bids from which they were derived. This decomposition is well-defined for three of the five winning bidders. However, in the case of each of Niche's and Vodafone's auction price we have not identified a unique decomposition by band and instead we present alternatives. Table A6.1 sets out the auction prices for the winning packages in the 4G auction (these are the base prices from the principal stage of the auction and do not include the prices of £15.1m for Niche and £12.1m for Vodafone in the assignment stage).

Table A6.1: 4G auction prices for winning packages

Band Lot category	800 MHz A1	800 MHz A2	2.6 GHz paired C	2.6 GHz unpaired E	Reserve price	Base price
Lot size	2x5 MHz	2x10 MHz	2x5 MHz	5 MHz		
EE	2x5 MHz 1xA1		2x35 MHz 7xC		£330m	£588.876m
H3G	2x5 MHz 1xA1				£225m	£225m
Niche			2x15 MHz 3xC	20 MHz 4xE	£45.4m	£186.476m
Telefónica		2x10 MHz 1xA2			£250m	£550m
Vodafone	2x10 MHz 2xA1		2x20 MHz 4xC	25 MHz 5xE	£510.5m	£790.761m
Total	2x20 MHz 4xA1	2x10 MHz 1xA2	2x70 MHz 14xC	45 MHz 9xE	£1,360.9m	£2,341.113m

Source: Ofcom

A6.6 We now consider the derivation of these auction prices in turn for each of the five winning bidders. We start with the two winning packages that were band-specific, won by H3G and Telefónica, and we then consider the prices for the winning packages of EE, Niche and Vodafone. The analysis set out below is the same as in the August 2014 consultation, with the exception of Niche for which we present below a slightly refined analysis.

H3G

A6.7 H3G's auction price was the reserve price for 2x5 MHz in the 800 MHz band (1xA1). H3G won reserved spectrum and a different pricing rule of less than full opportunity cost applied in the auction to this spectrum compared to unreserved spectrum. Given this different pricing rule and the way H3G bid, it won this reserved 800 MHz spectrum at the reserve price of £225m.[1]

Telefónica

A6.8 Telefónica won 2x10 MHz in the 800 MHz band (with coverage obligation, 1xA2). The entirety of this auction price is therefore attributable to the 800 MHz band. The derivation of this auction price from the highest losing bids is shown in Table A6.2.

Table A6.2: Telefónica's auction price – highest losing bids

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
Vodafone		1	4	4	-2	+1		-1	-£33m
EE	2		6		+1		-1		+£310.5m
Unsold	1				+1				+£225m
Niche			2	5			-1	+1	-£52.5m
H3G	1		2				+2		+£100m
Telefónica's winning package					0	1	0	0	£550m

Source: Ofcom

A6.9 We can see that, even though Telefónica's winning package is only in the 800 MHz band, the set of bids that constitutes the highest losing bids for Telefónica's package includes rearrangements of packages for other bidders in other bands. The reasons are as follows:

a) the highest losing bid for the A2 lot won by Telefónica is Vodafone's bid for a package which, compared to its own winning package, involves substituting the A2 lot for 2xA1 (i.e. an equivalent 2x10 MHz of 800 MHz) but also one fewer lot of E, unpaired 2.6 GHz; and

b) the highest losing bidder for one of the 2xA1 freed up by Vodafone switching from its winning package to the A2 lot is EE, but changing EE's package also involves a reduction of spectrum in EE's package (compared to its winning package) of 1xC (and there are further rearrangements in lot categories C and E involving Niche and H3G).

[1] For further details, see p. 20-21 in Myers (2013), "The innovative use of spectrum floors in the UK 4G auction to promote competition", Centre for the Analysis of Risk and Regulation, London School of Economics, DP 74, November 2013, ISSN 2049-2718, http://www.lse.ac.uk/researchAndExpertise/units/CARR/pdf/DPs/DP74-Geoffrey-Myers.pdf.

EE

A6.10 EE won 2x5 MHz in the 800 MHz band (1xA1) and 2x35 MHz in the 2.6 GHz band (7xC). The derivation of this auction price from the highest losing bids is shown in Table A6.3.

A6.11 The amount of this auction price attributable to 1xA1 is £225m (the reserve price). The remaining amount of the auction price of £363.876m is attributable to 7xC.

Table A6.3: EE's auction price – highest losing bids

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
Unsold	1				+1				+£225m
Telefónica		1	2				+2		+£128m
H3G	1		2				+2		+£100m
Vodafone	2		7	9			+3	+4	+£165.876m
Niche			3					-4	-£30m
EE's winning package					1	0	7	0	£588.876m

Source: Ofcom

Niche

A6.12 Niche won 2x15 MHz in the paired 2.6 GHz band (3xC) and 20 MHz in the unpaired 2.6 GHz band (4xE). The derivation of this auction price from the highest losing bids is shown in Table A6.4.

Table A6.4: Niche's auction price – highest losing bids

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
Telefónica		1	2				+2		+£128m
Vodafone	2		5	9			+1	+4	+£58.476m
Niche's winning package					0	0	3	4	£186.476m

Source: Ofcom

A6.13 The highest losing bid by Telefónica of £128m is attributable to 2xC.

A6.14 We can decompose Vodafone's highest losing bid for 1xC and 4xE more than its winning package at an incremental bid value of £58.476m as follows (using additional package bids by Vodafone):

a) £25.226m for 1xC (as the difference between Vodafone's winning bid and its bid for the package with an additional 1xC, i.e. 2xA1 + 5xC + 5xE);

b) £4.776m for 4xE (as the difference between Vodafone's winning bid and its bid for the package with an additional 4xE, i.e. 2xA1 + 4xC + 9xE); and

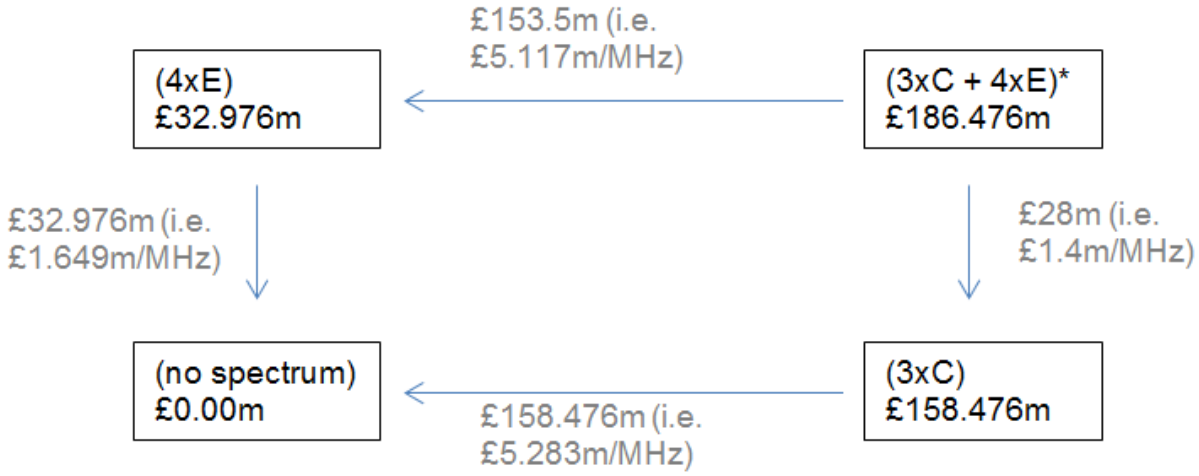
c) residual amount of £28.474m – one interpretation of this is a synergy value for Vodafone to win an additional 1xC and 4xE together (not separately as in the previous calculations).

A6.15 We are not aware of a uniquely correct way to attribute this synergy between 1xC and 4xE. The maximum of Niche's auction price attributable to C would include all of the synergy and the minimum would include none of it (in addition to the £128m from Telefónica's highest losing bid for 2xC). The maximum and minimum attributable to 4xE can similarly be identified by attributing all or none of the synergy to 4xE.

A6.16 However, one way to narrow the range of prices by band for Niche is to apply the decomposition method put forward by Vodafone. The decomposition method identifies what the auction prices would have been for smaller sub-packages of the winning package. The calculation method consists in adding a sufficiently high extra bid for a smaller sub-package of the winning package such that Niche would win that smaller sub-package. Then, we compare the price of winning the smaller sub-package with the price of winning a larger package which includes lots for an additional band. The difference corresponds to the decomposed price of the lots in that additional band. This procedure can result in multiple sets of decomposed prices depending on the order in which the sub-packages are considered.

A6.17 For Niche's winning package of 3xC + 4xE we consider the two sub-packages: 3xC and 4xE. See Figure A6.1.

Figure A6.1: Decompositions of price of Niche's spectrum package



Source: Ofcom

* Niche's winning package

A6.18 Applying this decomposition method we identify two decompositions of Niche's package price of £186.476m by band as follows (assuming unallocated lots at reserve prices):[2]

[2] We show here the decompositions using individual opportunity costs (Vickrey prices), not collective opportunity costs (core prices). See from paragraph A6.68 below for a detailed discussion of this issue.

a) £153.5m for 3xC (or £5.117m per MHz) and £32.976m for 4xE (or £1.649m per MHz); and

b) £158.476m for 3xC (or £5.283m per MHz) and £28m for 4xE (or £1.4m per MHz).

Vodafone

A6.19 Vodafone's winning package included spectrum in all three bands in the 4G auction: 2x10 MHz of 800 MHz (2xA1), 2x20 MHz of paired 2.6 GHz (4xC) and 25 MHz of unpaired 2.6 GHz (5xE). The derivation of this auction price from the highest losing bids is shown in Table A6.5.

Table A6.5: Vodafone's auction price – highest losing bids

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
Unsold A1	1				+1				+£225m
EE	2		6		+1		-1		+£310.5m
Telefónica		1	2				+2		+£128m
H3G	1		2				+2		+£100m
Unsold C			1				+1		+£15m
Niche			3	5				+1	+£1m
HKT				2				+2	+£10.25m
MLL				2				+2	+£1.011m
Vodafone's winning package					2	0	4	5	£790.761m

Source: Ofcom

A6.20 There is a complication in attributing the incremental bid values of EE, Telefónica and H3G (£538.5m in total) between the 800 MHz and paired 2.6 GHz bands. The reason is that, if Vodafone had only won 2xA1 and no C, there would still have been package rearrangements in C for the highest losing bidders – see, for example, the package rearrangements for Telefónica's auction price in Table A6.2.[3] Some of these same bids would also be included in Vodafone's auction price if it had won 4xC and no A1. This means that there is an overlap between the highest losing bids for C shown in Table A6.5 as between the amounts of the auction price attributable to A1 and C.

A6.21 The value of the highest losing bids for 1xA1 in Vodafone's winning package including all package rearrangements is, in effect, the same question as is addressed by ASM for 2x5 MHz of 800 MHz with Vodafone as the excluded bidder - this value is £383.5m (see Table A6.11 below). Adding the reserve price for the unsold 1xA1 gives £608.5m for 2xA1. Under this method, the amount attributable to

[3] Note, however, that the precise package rearrangements would be different as between Vodafone and Telefónica. This is because Telefónica's highest losing bid for 2xC would be included in the package rearrangements for Vodafone's auction price. But it could not be included in the derivation of Telefónica's own price, because that excludes the winner's own bids.

4xC would be the residual of £155m plus the reserve price of the unsold 1xC of £15m, i.e. £170m.

A6.22 Alternatively, we could identify the amount attributable to 4xC by looking at the highest losing bids for 4xC by Telefónica and H3G at £228m. Under this method, the amount attributable to 2xA1 would be the residual of £310.5m plus the reserve price of the unsold 1xC and 1xA1 of £15m and £225m respectively, i.e. £550.5m.

A6.23 The amount of Vodafone's auction price attributable to 5xE is the sum of the incremental bid values in the highest losing bids for E in Table A6.5 by Niche, HKT and MLL at £12.261m.

A6.24 It is also possible to apply the decomposition method to Vodafone's package auction price. This yields the following additional decompositions for (2xA1, 4xC, 5xE):

a) (£608.5m, £152.261m, £30m);

b) (£542.261m, £228m, £20.5m); and

c) (£542.261m, £218.5m, £30m).[4]

Summary of decomposition of auction prices by band

A6.25 The decomposition of the auction prices by band described above (valuing unallocated lots at reserve prices) is summarised in Table A6.6 in £m per MHz.

Table A6.6: Decomposition of auction prices, including alternatives for Niche and Vodafone (in £m per MHz)

	A1	A2	C	E
H3G	£22.5m			
Telefónica		£27.5m		
EE	£22.5m		£5.198m	
Niche (1)			£5.283m	£1.4m
Niche (2)			£5.117m	£1.649m
Vodafone (1)	£27.525m		£5.7m	£0.490m
Vodafone (2)	£30.425m		£4.25m	£0.490m
Vodafone (3)	£30.425m		£3.807m	£1.2m
Vodafone (4)	£27.113m		£5.7m	£0.82m
Vodafone (5)	£27.113m		£5.463m	£1.2m

Source: Ofcom

[4] These decompositions are derived using individual opportunity costs (Vickrey prices), not collective opportunity costs (core prices) – see from paragraph A6.68 below for a detailed discussion of this issue.

A6.26 For Niche the table shows the two sets of figures derived using the decomposition method. For Vodafone the table shows the alternative methods to decompose the prices between A1 and C discussed above.

Opportunity costs in the 4G auction

A6.27 In this section we set out the opportunity costs in the 4G auction of the spectrum won by each of the five winners in the absence of reserve prices (and assuming no change in the auction bids). We derive these opportunity costs by band using two methods: ASM, and the decomposition method. Before discussing in turn each of the winners of spectrum in the 4G auction, we first set out the ASM results, which we use below.

Additional Spectrum Methodology (ASM)

A6.28 In computing the ASM with, for example, Telefónica as the "excluded bidder", we exclude Telefónica's auction bids from the analysis and consider the value of additional 800 MHz to the other bidders. In this way the ASM estimates a value that the other three bidders (but not Telefónica) would place on additional 800 MHz. In other words, the ASM results can be interpreted as the opportunity costs in the 4G auction to other bidders of the spectrum won by Telefónica.

A6.29 In the August 2014 and October 2013 consultations we presented ASM in a slightly different way, as considering hypothetical additional spectrum in the auction. This is an alternative interpretation of the ASM results. However, under this alternative interpretation, we can also consider ASM results for larger amounts of spectrum than won by each excluded bidder. For example, we can interpret the ASM results for 2x15 MHz with Telefónica as the excluded bidder as a proxy for the same amount of 900 MHz from Telefónica's holdings. Below we present results for both interpretations.

A6.30 The ASM method yields different results for each band depending on:

a) the increment of additional spectrum that is added; and

b) the identity of the excluded bidder.

A6.31 The size of the spectrum increment affects the results because the highest losing bids were different for different amounts. They were generally smaller for larger quantities of additional spectrum, but there are exceptions arising from synergies.

A6.32 The identity of the excluded bidder affects the results because the ASM figures are derived as the sum of two components:

a) highest losing bid for the spectrum in question; and

b) package rearrangements.

A6.33 For example, the ASM figure of £38.35m per MHz for 2x5 MHz of 800 MHz with Vodafone as the excluded bidder is composed of:

a) EE's incremental bid value (IBV), compared to its winning package, of £31.05m per MHz for an additional 2x5 MHz of 800 MHz and 2x5 MHz less of 2.6 GHz. This reduction in the amount of 2.6 GHz spectrum was necessary for EE to remain within the overall spectrum cap that applied in the 4G auction; and

b) IBV of that 2x5 MHz of 2.6 GHz to other bidders of £7.3m per MHz, including the effect of package rearrangements, i.e. rearranging 2x5 MHz of 2.6 GHz each from EE and Niche to Telefónica.

A6.34 So the value of the package rearrangements includes Telefónica in working out the highest losing bids when Vodafone is the excluded bidder. But rearrangements involving Telefónica are not included when deriving the ASM value with Telefónica as the excluded bidder (as all of Telefónica's bids are excluded in this case). Hence the ASM results can differ as between different excluded bidders.

A6.35 The value of package rearrangements can be realised in the context of a multi-band (package) auction by shifting bidders from one package to a different package. However, outside of such an auction, realising a similar value would require a co-ordinated set of spectrum trades between, in this example, three operators (EE, Niche and Telefónica).

ASM results for the 800 MHz band

A6.36 The ASM results, interpreted as the opportunity costs in the 4G auction of the 800 MHz spectrum won by each of EE, H3G, Telefónica and Vodafone, are shown in Table 2.3 in Section 2, which is repeated as Table A6.7 below. The results shown are for the incremental value (except in the two rows labelled as averages). So, for example, the ASM results with Telefónica as the excluded bidder are £35.6m per MHz for the first 2x5 MHz and £17.3m for the second 2x5 MHz in the 2x10 MHz block acquired by Telefónica (with an average of these incremental values of £26.45m per MHz).

Table A6.7: ASM results for 800 MHz spectrum interpreted as opportunity costs in the 4G auction (in £m per MHz)

Excluded bidder	2x5 MHz	2x10 MHz
EE	£2.499m	n/a
H3G	£38.4m	n/a
Telefónica - incremental	£35.6m	£17.3m
Telefónica – average (2x10 MHz)	£26.45m	
Vodafone - incremental	£38.35m	£14.5m
Vodafone – average (2x10 MHz)	£26.425m	

Source: Ofcom, Table 2.3 in Section 2 of this Statement

A6.37 The ASM results, interpreted as hypothetical additional spectrum in the auction as a proxy for 900 MHz spectrum, are shown in Table A6.8 for different increments of 800 MHz as a proxy for 900 MHz, and for Telefónica and Vodafone as the excluded bidders, because between them they currently hold all of the 900 MHz spectrum (each with 2x17.4 MHz).

A6.38 The ASM results for 2x10 MHz are lower than for 2x5 MHz. This is affected by the packing issue described in Section 2 involving the absence of a losing bid by EE for an additional 2x10 MHz of 800 MHz. This is also why the ASM results for 2x15 MHz of about £30m per MHz are higher than for 2x10 MHz, by reflecting EE's losing bid

for an additional 2x15 MHz (with a smaller loss in bid value from rearrangement of 2.6 GHz spectrum from EE to other bidders).

Table A6.8: ASM results for additional 800 MHz spectrum as a proxy for 900 MHz (in £m per MHz)

Additional spectrum	2x5 MHz	2x10 MHz	2x15 MHz
ASM results for excluded bidder:			
Telefónica – incremental values	£35.6m	£17.3m	£35.5376m
Telefónica – average of 2x10 MHz	£26.45m		n/a
Telefónica – average of 2x15 MHz	£29.479m		
Vodafone – incremental values	£38.35m	£14.5m	£39.3m
Vodafone – average of 2x10 MHz	£26.425m		n/a
Vodafone – average of 2x15 MHz	£30.717m		

Source: Ofcom

ASM results for the 2.6 GHz band

A6.39 The ASM results, interpreted as the opportunity costs in the 4G auction of the 2.6 GHz spectrum won by each of EE, Niche and Vodafone, are shown in Table A6.9.

Table A6.9: ASM results for 2.6 GHz spectrum interpreted as opportunity costs in the 4G auction (in £m per MHz)

Excluded bidder	2x5 MHz	2x10 MHz	2x15 MHz	2x20 MHz	2x25 MHz	2x30 MHz	2x35 MHz
EE – incremental values	£7.35m	£5.45m	£4.55m	£5.45m	£3.588m	£4.63m	£5.37m
EE – average (2x35 MHz)	£5.198m						
Niche – incremental values	£2.8256m	£9.9744m	£2.5226m				
Niche – average (2x15 MHz)	£5.1075m						
Vodafone – incremental values	£7.3m	£5.5m	£4.5m	£5.5m			
Vodafone – average (2x20 MHz)	£5.7m						

Source: Ofcom

A6.40 The ASM results, interpreted as hypothetical additional spectrum in the auction, are shown in Table A6.10 for different increments of 2.6 GHz as a proxy for 1800 MHz, and for different excluded bidders who are the current holders of spectrum in the 1800 MHz band, reflecting the amount each holds. EE holds 2x45 MHz, H3G 2x15

MHz (in both cases after completion of the spectrum trade between them), and Telefónica and Vodafone each holds 2x5.8 MHz.[5]

Table A6.10: ASM results (incremental values) for additional 2.6 GHz spectrum as a proxy for 1800 MHz (in £m per MHz)

Additional spectrum	2x5 MHz	2x10 MHz	2x15 MHz	2x20 MHz	2x25 MHz	2x30 MHz	2x35 MHz	2x40 MHz	2x45 MHz
ASM results for excluded bidder:									
EE	£7.35m	£5.45m	£4.55m	£5.45m	£3.588m	£4.63m	£5.37m	£2.628m	£0.805m
H3G	£7.35m	£5.45m	£2.848m						
Telefónica	£4.55m								
Vodafone	£7.3m								

Source: Ofcom

H3G

A6.41 H3G won 2x5 MHz in the 800 MHz band (1xA1). The opportunity cost of this spectrum is therefore attributable to the 800 MHz band. The derivation of the opportunity cost of this 1xA1 is shown in Table A6.11.

Table A6.11: Opportunity cost in 4G auction of H3G's 2x5 MHz of 800 MHz

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
EE	2	0	6	0	+1		-1		+310.5
HKT	0	0	0	0					
MLL	0	0	0	0					
Niche	0	0	2	5			-1	+1	-52.5
Telefónica	0	1	2	0			+2		+128
Vodafone	2	0	4	4				-1	-2
Unsold	0	0	0	0					
Opportunity cost of 1xA1 to other bidders									384
Total value excluding H3G *(a)*									4,684
Total value excluding H3G's spectrum + 1xA1 *(b)*									5,068
(b) - (a)									384

Source: Ofcom

A6.42 The opportunity cost of £384m is the same as shown in the ASM results with H3G as the excluded bidder (see Table A6.7).

[5] In the October 2013 consultation we also considered 800 MHz spectrum, and combinations of 800 MHz and 2.6 GHz spectrum, as proxies for 1800 MHz spectrum.

Telefónica

A6.43 Telefónica won 2x10 MHz in the 800 MHz band (with coverage obligation, 1xA2). The opportunity cost of this spectrum is therefore attributable to the 800 MHz band. The derivation of the opportunity cost of the first 2x5 MHz to other bidders is shown in Table A6.12, analysed as if it were without a coverage obligation. Again, this corresponds to the ASM results with Telefónica as the excluded bidder (see Tables A6.7 and A6.8 above)

Table A6.12: Opportunity cost in 4G auction of the first 2x5 MHz to other bidders of Telefónica's 800 MHz spectrum (analysed as if it were without coverage obligation)

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
EE	2	0	6	0	+1		-1		+310.5
HKT	0	0	0	0					
H3G	1	0	2	0			+2		+100
MLL	0	0	0	0					
Niche	0	0	2	5			-1	+1	-52.5
Vodafone	2	0	4	4				-1	-2
Unsold	0	0	0	0					
Opportunity cost of first 1xA1 to other bidders									356
Total value excluding Telefónica *(a)*									4,030.5
Total value excluding Telefónica's spectrum + 1xA1 *(b)*									4,386.5
(b) - (a)									356

Source: Ofcom

A6.44 The derivation of the opportunity cost of 2x10 MHz is shown in Table A6.13.

Table A6.13: Opportunity cost in 4G auction of Telefónica's 2x10 MHz of 800 MHz (analysed as if it were without coverage obligation)

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
EE	4	0	4	0	+3		-3		+748.5
HKT	0	0	0	0					
H3G	0	0	4	0	-1		+4		-165
MLL	0	0	0	0					
Niche	0	0	2	5			-1	+1	-52.5
Vodafone	2	0	4	4				-1	-2
Unsold	0	0	0	0					
Opportunity cost of 2xA1 to other bidders									529
Total value excluding Telefónica *(a)*									4,030.5
Total value excluding Telefónica's spectrum + 1xA1 *(b)*									4,386.5
Total value excluding Telefónica's spectrum + 2xA1 *(c)*									4,559.5
(c) - (b)									173
(c) - (a)									529

Source: Ofcom

EE

A6.45 EE won 2x5 MHz in the 800 MHz band (A1) and 2x35 MHz in the 2.6 GHz band (7xC). The opportunity cost in the 4G auction of this spectrum package is £388.875m – see Table A6.14. This is materially lower than EE's auction price of £588.876m (see Table A6.3 above).

Table A6.14: Opportunity cost in 4G auction of EE's spectrum package

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
Telefónica	2	0	2	0	+2	-1	+2		+127.999
H3G	0	1	2	0	-1	+1	+2		+125
Vodafone	2	0	7	9			+3	+4	+165.876
Niche	0	0	3	0				-4	-30
EE's winning package					1	0	7	0	**388.875**

Source: Ofcom

ASM with a 2x5 MHz increment of 800 MHz

A6.46 The derivation of the opportunity cost of EE's 1xA1 is shown in Table A6.15.

Table A6.15: Opportunity cost in 4G auction of EE's 2x5 MHz of 800 MHz

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
HKT	0	0	0	0					
H3G	0	1	0	0	-1	+1			+25
MLL	0	0	0	0					
Niche	0	0	3	4					
Telefónica	2	0	0	0	+2	-1			-0.001
Vodafone	2	0	4	5					
Unsold	0	0	0	0					
Opportunity cost of 1xA1 to other bidders									24.999
Total value excluding EE *(a)*									4,199.978
Total value excluding EE's spectrum + 1xA1 *(b)*									4,224.977
(b) - (a)									24.999

Source: Ofcom

ASM with a 2x35 MHz increment of 2.6 GHz

A6.47 The derivation of the opportunity cost of the 7xC won by EE is shown in Table A6.16.

A6.48 Note that the sum of the opportunity cost of 1xA1 plus the opportunity cost of 7xC to other bidders is (£24.999m + £363.876m =) £388.875m, which corresponds to the opportunity cost in the 4G auction of EE's spectrum package as set out in Table A6.14 above.

Table A6.16: Opportunity cost in 4G auction of EE's 2x35 MHz of 2.6 GHz

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
HKT	0	0	0	0					
H3G	1	0	2	0			+2		+100
MLL	0	0	0	0					
Niche	0	0	3	0				-4	-30
Telefónica	0	1	2	0			+2		+128
Vodafone	2	0	7	9			+3	+4	+165.876
Unsold	0	0	0	0					
Opportunity cost of 7xC to other bidders									363.876
Total value excluding EE *(a)*									4,199.978
Total value excluding EE's spectrum + 7xC *(b)*									4,563.854
(b) - (a)									363.876

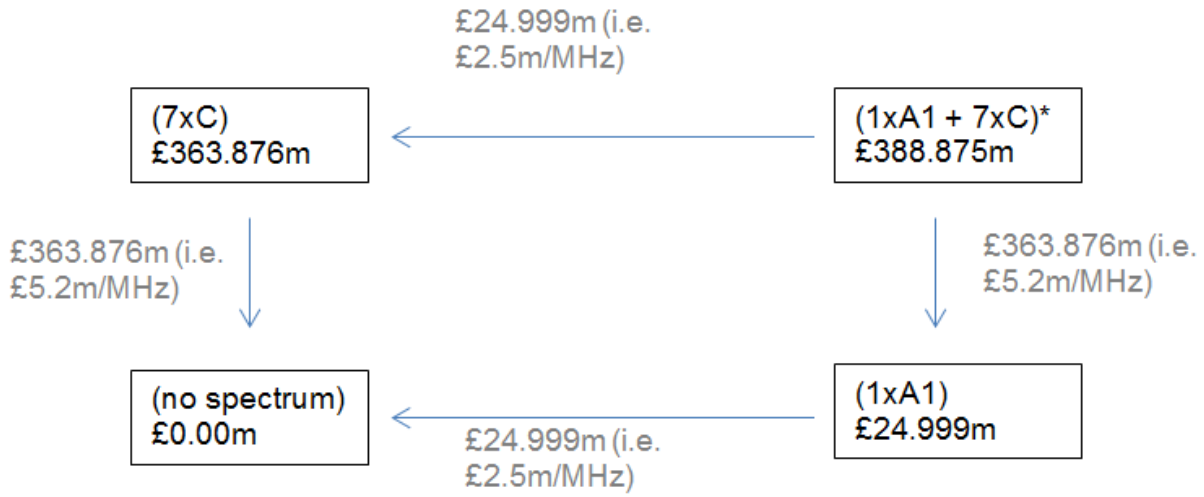
Source: Ofcom

A6.49 In addition, the opportunity cost in the auction attributable to 7xC of £363.876m is the same as the amount of EE's auction price attributable to 7xC – see paragraph A6.11 above.

Decomposition method

A6.50 In Figure A6.2 we apply Vodafone's decomposition approach to the opportunity cost of EE's spectrum to other bidders. The decomposition is the same regardless of the order in which we conduct the analysis; and these are the same figures as in the analysis above using ASM.

Figure A6.2: Decomposition of opportunity cost of EE's spectrum with reserve prices at zero



Source: Ofcom

* EE's winning package

A6.51 For completeness, below we provide the details on how we derived the numbers in Figure A6.2.

A6.52 To apply the decomposition method to the sub-package of **7xC**, we run the Winner Determination and Pricing software (WDP)[6] adding an extra, hypothetical bid for the package 7xC in EE's bid list which would have been guaranteed to win this sub-package.[7]

A6.53 The base price – the core price, reflecting collective opportunity costs – is higher than the Vickrey price, reflecting individual opportunity cost. In fact, we note that the core price for 7xC (£412.279m) is higher than the price for 1xA1 + 7xC (£388.875m). Core prices are above Vickrey prices when the collective opportunity cost of a sub-set of multiple winners is higher than the sum of individual opportunity costs for each of those winners. We discuss further below why, when decomposing package amounts by band, we consider it is more appropriate to use the Vickrey prices than the core prices.

A6.54 Similarly, to apply the decomposition method to the sub-package of **1xA1**, we run the WDP adding an extra bid for the package 1xA1 in EE's bids list. The outcome is a Vickrey price of £24.999m.

Niche

A6.55 Niche won 3 lots of C and 4 lots of E spectrum. The opportunity cost in the 4G auction of this spectrum package is £186.476m – see Table A6.17.

Table A6.17: Opportunity cost in 4G auction of Niche's spectrum package

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
EE	1	0	7	0					
H3G	1	0	0	0					
Telefónica	0	1	2	0			+2		+128
Vodafone	2	0	5	9			+1	+4	+58.476
Niche's winning package							3	4	**186.476**

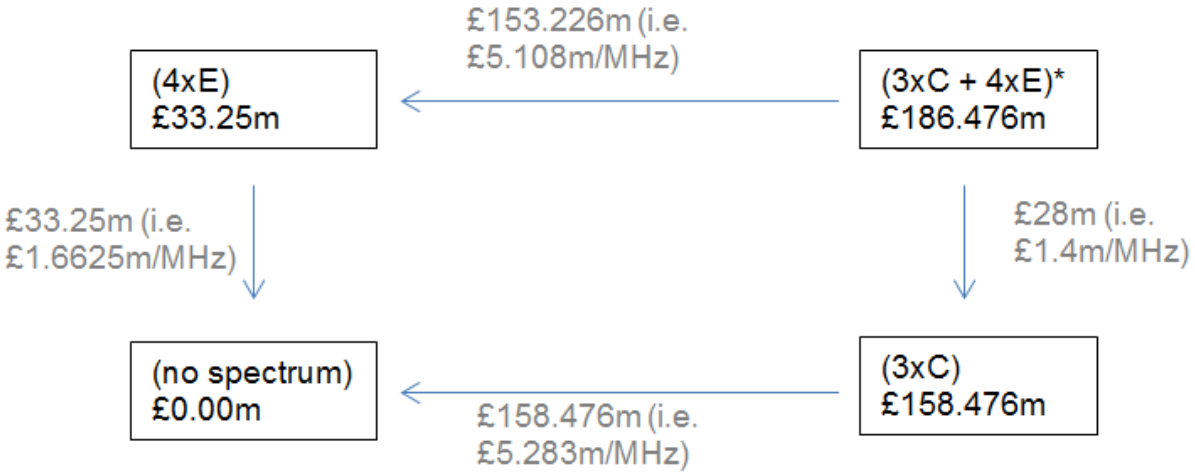
Source: Ofcom

A6.56 This opportunity cost is the same as the auction price for its winning package of £186.476m set out above. The two decompositions by band are set out in Figure A6.3 (these differ slightly from the decompositions of Niche's auction price in Figure A6.1 above).

[6] The WDP software is designed to calculate, from a set of bidders and respective bids, who the winning bidders are, how many lots in each of the available categories they should win, and what the prices are.

[7] We assume a bid value of £1,798m, which is the maximum bid value submitted by EE in the auction. Any other bid value above this would work as well for the purpose of the decomposition.

Figure A6.3: Decompositions of opportunity cost of Niche's spectrum with reserve prices at zero



Source: Ofcom

* Niche's winning package

A6.57 In the absence of reserve prices, the result of the decomposition method is £33.25m for the sub-package of **4xE** and £158.476m for the sub-package of **3xC**. In these cases the core price is the same as the Vickrey price – this applies in most cases and below we only report the core price if it differs from the Vickrey price.

Vodafone

A6.58 Vodafone won 2x10 MHz in the 800 MHz band (2 lots of A1), 4 lots of C and 5 lots of E spectrum. The opportunity cost in the 4G auction of this spectrum package is £770.261m – see Table A6.18. This is lower than Vodafone's auction price of £790.761m (see Table A6.5 above).

Table A6.18: Opportunity cost in 4G auction of Vodafone's spectrum package

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
EE	4	0	4	0	+3		-3		748.5
HKT	0	0	0	2				+2	10.250
H3G	0	0	6	0	-1		+6		-65
MLL	0	0	0	2				+2	1.011
Niche	0	0	2	5			-1	+1	-52.5
Telefónica	0	1	2	0			+2		+128
Vodafone's winning package					2	0	4	5	**770.261**

Source: Ofcom

ASM with a 2x5 MHz increment of 800 MHz

A6.59 The opportunity cost of the first lot of A1 to other bidders in Vodafone's 800 MHz spectrum is calculated as shown in Table A6.19 as £383.5m.

Table A6.19: Opportunity cost in 4G auction of the first 1xA1 to other bidders of Vodafone's 800 MHz spectrum

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
EE	2	0	6	0	+1		-1		+310.5
HKT	0	0	0	0					
H3G	1	0	0	0					
MLL	0	0	0	0					
Niche	0	0	2	4			-1		-55
Telefónica	0	1	2	0			+2		+128
Unsold	0	0	0	0					
Opportunity cost of first 1xA1 to other bidders									383.5
Total value excluding Vodafone *(a)*									3,174.434
Total value excluding Vodafone's spectrum + 1xA1 *(b)*									3,557.934
(b) - (a)									383.5

Source: Ofcom

ASM with a 2x10 MHz increment of 800 MHz

A6.60 The derivation of the opportunity cost of 2x10 MHz is shown in Table A6.20.

Table A6.20: Opportunity cost in 4G auction of Vodafone's 2xA1

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
EE	4	0	4	0	+3		-3		+748.5
HKT	0	0	0	0					
H3G	0	0	4	0	-1		+4		-165
MLL	0	0	0	0					
Niche	0	0	2	4			-1		-55
Telefónica	0	1	0	0					
Unsold	0	0	0	0					
Opportunity cost of 2xA1 to other bidders									528.5
Total value excluding Vodafone *(a)*									3,174.434
Total value excluding Vodafone's spectrum + 1xA1 *(b)*									3,557.934
Total value excluding Vodafone's spectrum + 2xA1 *(c)*									3,702.934
(c) - (b)									145
(c) - (a)									528.5

Source: Ofcom

ASM with a 2x20 MHz increment of 2.6 GHz (C spectrum)

A6.61 The opportunity cost of Vodafone's 4xC spectrum is calculated as shown in Table A6.21.

Table A6.21: Opportunity cost in 4G auction of 4xC to other bidders won by Vodafone

	Packages				Changes from winning packages				
Bidder	A1	A2	C	E	A1	A2	C	E	£m
EE	1	0	7	0					
HKT	0	0	0	0					
H3G	1	0	2	0			+2		+100
MLL	0	0	0	0					
Niche	0	0	3	4					
Telefónica	0	1	2	0			+2		+128
Unsold	0	0	0	0					
Opportunity cost of 4xC to other bidders									228
Total value excluding Vodafone *(a)*									3,174.434
Total value excluding Vodafone's spectrum + 7xC *(b)*									3,402.434
(b) - (a)									228

Source: Ofcom

A6.62 We have not applied ASM to Vodafone's spectrum in category E (unpaired 2.6 GHz band).

Decomposition method

A6.63 For the decomposition method we derive results for each of the sub-packages as follows:

a) 2xA1 + 5xE: £542.261m;

b) 2xA1: £521.761m;

c) 2xA1 + 4xC: £740.261m;

d) 4xC + 5xE: £241.761m;

e) 4xC: £211.761m; and

f) 5xE: £13.761m.

A6.64 For the sub-package of 5xE, using the decomposition method the opportunity cost (Vickrey price) of Vodafone holding 5xE is £13.761m, while the base or core price is much higher at £81.078m. See Table A6.22 for the six decompositions with core prices compared to the decompositions with Vickrey prices. Taking row 1 (core prices) as an example, the decomposition order is (A1, C, E), meaning that the decomposed amounts are derived as follows (where P(i,j,k) refers to the price of the package of i lots of A1, j lots of C and k lots of E):

a) £528.5m for 2xA1 = P(2,4,5) – P(0,4,5);

b) £160.683m for 4xC = P(0,4,5) – P(0,0,5); and

c) £81.078m for 5xE = P(0,0,5).

A6.65 As noted in Section 2, we consider that the possible decomposition suggested by Vodafone in its response to the August 2014 consultation, using a core price of £81.078m for 5xE, is likely to understate market value compared to using the Vickrey price of £13.761m for 5xE – see rows 1 and 2 in Table A6.22.

Table A6.22: Decomposition analysis for Vodafone with core prices and Vickrey prices (in £m)

	Decomposition with core prices				Decomposition with Vickrey prices			
Order	2xA1	4xC	5xE	Total	2xA1	4xC	5xE	Total
1 (A1, C, E)	528.500	**160.683**	**81.078**	770.261	528.500	**228.000**	**13.761**	770.261
2 (C, A1, E)	**461.183**	228.000	**81.078**	770.261	**528.500**	228.000	**13.761**	770.261
3 (E, A1, C)	528.500	211.761	30.000	770.261	528.500	211.761	30.000	770.261
4 (A1, E, C)	528.500	211.761	30.000	770.261	528.500	211.761	30.000	770.261
5 (C, E, A1)	521.761	228.000	20.500	770.261	521.761	228.000	20.500	770.261
6 (E, C, A1)	521.761	218.500	30.000	770.261	521.761	218.500	30.000	770.261
Average per lot	**257.517**	**52.446**	**9.089**	**770.261**	**263.127**	**55.251**	**4.601**	**770.261**

Source: Ofcom

Note: numbers in bold (in boxes) highlight the differences between decompositions with core prices and with Vickrey prices.

A6.66 We noted in Section 2 that we have detailed concerns about the methodological basis on which Vodafone's decomposition using a core price is derived - we now explain these concerns.

A6.67 In the decompositions using core prices (see rows 1 and 2 in Table A6.22) the opportunity cost for five lots of E is much higher at £81.078m (£3.24m per MHz) than for the other decompositions: £20.5m (£0.82m per MHz) and £30m (£1.20m per MHz). It is also much higher than the opportunity cost for the other winner of spectrum in this band, Niche (£1.40m or £1.66m per MHz). The reason for the opportunity cost in these decompositions with core prices being much higher (than in decompositions 3 to 6 in Table A6.22) for the unpaired 2.6 GHz band is that it reflects the collective opportunity cost of Vodafone's unpaired 2.6 GHz spectrum when considered collectively with spectrum won by other operators, not an individual opportunity cost or Vickrey price. In the other decompositions (rows 3 to 6 in Table A6.22) all of the opportunity costs derived are Vickrey prices, which means that they are the individual opportunity costs of Vodafone's spectrum.

A6.68 We consider that it is more appropriate to use individual than collective opportunity costs when decomposing a package amount for the opportunity cost in the auction of spectrum won by a specific winner, in this case Vodafone. This is for three reasons.

A6.69 First, in our view, it is more appropriate in principle for decompositions of package amounts of individual winners in the auction to reflect individual opportunity cost, not collective opportunity cost, which by definition relies on spectrum won by multiple operators - in this case EE, Niche and Vodafone - being considered simultaneously. This is especially so as the auction prices and package opportunity

costs for each winning bidder reflect individual opportunity cost (because Vickrey prices and core prices were the same). It is also the case that the Vickrey price is the minimum amount a bidder would have needed to bid to win the given sub-package.

A6.70 Second, in any case there is no uniquely correct way to attribute the collective opportunity cost between the winners whose spectrum is being considered collectively (in this case EE, Niche and Vodafone). The auction pricing rule in the 4G auction used one specific way to carry out this attribution (nearest to Vickrey prices). But there are many other attribution methods that could be used. In other words, using the collective opportunity cost to decompose an amount for the opportunity cost of a package itself raises a further decomposition problem (i.e. how to decompose the excess in the collective opportunity cost over the sum of the individual opportunity costs for EE, Niche and Vodafone, and attribute it to each of these three bidders). We avoid this further decomposition problem if we use the individual opportunity cost or Vickrey price.

A6.71 An illustration of the problems that can arise when using collective opportunity cost (core prices) in the decomposition of package amounts is the point noted above at paragraph A6.53 when discussing EE. The core price for the smaller sub-package of 7xC at £412.279m (using the attribution rule of nearest to Vickrey prices, as in the 4G auction pricing rules) is higher than the price (without reserve prices) for the larger package won by EE of 1xA1 + 7xC at £388.875m (which reflects the same Vickrey and core price). Applying the decomposition method using core prices, as implemented by Vodafone, would lead in this case to the implication that the decomposed price of 1xA1 is a negative amount (-£23.404m). This is an unrealistic value for 1xA1. This type of result is avoided when using Vickrey prices (individual opportunity costs) in the decomposition method.

A6.72 Third, the specific core pricing constraints in Vodafone's decomposition are from bids by H3G and Telefónica for packages which include D2 lots (low-power concurrent licences for 2.6 GHz spectrum). There was competition in the auction between the lot categories of D and C (standard-power individual licences for 2.6 GHz spectrum). For example, D2 lots were for a bandwidth of 2x20 MHz (whilst D1 lots were for 2x10 MHz). If such bids had won, they would have reduced the amount of the paired 2.6 GHz band allocated to standard-power individual licences by 2x20 MHz. However, in practice, there was limited bidding on the D lots and no winning bids.

A6.73 In the August 2014 consultation we excluded bids for packages including D1 or D2 when computing LRPs. Commenting on this approach, Telefónica stated that:

> "We support this approach, as we do not think any bids containing D lots affected the winner and price determination. Given information available to bidders about participation in the auction, it is clear that such bids must have been placed for strategic purposes and do not reflect market value." [Telefónica's response, p.37]

A6.74 Telefónica was one of the bidders who placed bids for packages including D lots, and one of these bids contributes to the core pricing constraints that drive the low value for 800 MHz spectrum in Vodafone's decomposition (along with a bid from

H3G, also for a package including D2).[8] To the extent that Telefónica's comment applies to its own bids, it provides evidence that we should not rely on such bids for the purpose of determining auction prices or decompositions of package amounts.

A6.75 We can replace the collective opportunity cost in Vodafone's decomposition of £81.078m (£3.24m per MHz) for 5xE, which is dependent on bids for D2 lots, with the individual opportunity cost (Vickrey price) of £13.761m (£0.55m per MHz). When we do so, we derive a revised opportunity cost for Vodafone's 800 MHz spectrum of £528.5m (£26.425m per MHz) - see rows 1 and 2 of the decompositions with Vickrey prices in Table A6.22. This is the same figure for 800 MHz as in the decompositions in rows 3 and 4 of Table A6.22 and as derived using ASM when Vodafone is the excluded bidder.

Summary of decomposition by band of opportunity costs in 4G auction

A6.76 In the absence of reserve prices, the decomposition of the opportunity costs in the auction set out above is summarised in Table A6.23.

Table A6.23: Decomposition of opportunity costs in 4G auction, including alternatives for Niche and Vodafone (in £m per MHz)

	800 MHz	2.6 GHz (paired)	2.6 GHz (unpaired)
H3G	£38.4m		
Telefónica	£26.45m		
EE	£2.499m	£5.198m	
Niche (1)		£5.283m	£1.4m
Niche (2)		£5.108m	£1.663m
Vodafone (1)	£26.425m	£5.7m	£0.550m
Vodafone (2)	£26.425m	£5.294m	£1.2m
Vodafone (3)	£26.088m	£5.7m	£0.82m
Vodafone (4)	£26.088m	£5.4625m	£1.2m

Source: Ofcom

Price signals provided by 2x5 MHz and 2x10 MHz increments of 800 MHz spectrum

A6.77 The question we address in this section is the efficiency properties with price signals based on an increment of 2x5 MHz or 2x10 MHz of spectrum. First, we briefly outline the analysis we included in the August 2014 consultation. Then we summarise responses from stakeholders on the question of the choice of increment for 800 MHz spectrum between 2x5 MHz and 2x10 MHz, and set out our further comments in light of the analysis in Section 2.

[8] The core constraint is provided by the bid by Telefónica for the package of 1xA2 + 1xD2 and the bid by H3G for the package of 3xA1 + 10xC + 1xD2 + 5xE.

Analysis in the August 2014 consultation

A6.78 We noted that the values for 800 MHz and 2.6 GHz of the marginal bidder, or non-holder (NH) of the licences for ALF spectrum, are non-linear. This suggested that, in theory, if the structure of demand of the highest-value NHs for 900 MHz and 1800 MHz followed a similar pattern, the optimal ALF would also be non-linear. However, we did not propose to set a non-linear ALF for practical reasons. First, we did not consider that the evidence available to us would enable us to derive a sufficiently reliable set of non-linear ALFs. This was because we did not have direct evidence on the pattern of NH's values for 900 MHz and the available evidence for the highest-value NH's values for 800 MHz did not provide a robust basis to infer them. Second, it would involve a more complicated implementation than linear ALFs and a departure from past practice for spectrum fees for 900 MHz and 1800 MHz which have always been set at a specified (linear) £ per MHz.

A6.79 We explained that, given that we are setting linear ALFs, the efficiency of the price signals depended not only on the values of the highest-value NH, but also the structure of values of the licence holder (LH). It is the LH that we wish to respond to the ALF price signal, such as by trading or relinquishing spectrum if it is efficient to do so (for simplicity in the discussion below we just refer to relinquishment, not trading). We did not have direct evidence on the values of the LH for 900 MHz. Therefore, instead we worked through a number of illustrative examples to bring out the issues at stake. We considered examples for available supply of 2x20 MHz and 2x15 MHz, with illustrative assumptions about the values of the LH and NH, including variations labelled case (a) and case (b). The assumptions used in these illustrative examples are set out in paragraphs A6.100 to A6.127 in Annex 6 of the August 2014 consultation.

A6.80 Table A6.24 provides a summary of the illustrative examples set out in the August 2014 consultation. If the linear ALF results in the efficient outcome, this is indicated by a relinquishment amount in bold (and if it is inefficient, it is shown in italics).

Table A6.24: Summary of relinquishment incentives on licence holder in illustrative examples compared to efficient outcome

	2x20 MHz supply: Case (a)	2x20 MHz supply: Case (b)	2x15 MHz supply: Case (a)	2x15 MHz supply: Case (b)	2x15 MHz supply: Further example
Efficient relinquishment by LH	2x10 MHz	2x10 MHz	2x5 MHz	None	2x10 MHz
Relinquishment with linear ALF based on the value of NH's increment of:					
2x5 MHz	*None*	*None*	**2x5 MHz**	**None**	*None*
2x10 MHz	**2x10 MHz**	**2x10 MHz**	**2x5 MHz**	*2x5 MHz*	*2x15 MHz*

Source: Ofcom

A6.81 The table shows two examples of a potentially problematic set of circumstances of excessive relinquishment if a linear ALF is based on the value of a 2x10 MHz increment. However, we noted that:

a) There are three other problematic examples of insufficient relinquishment in the illustrative examples above in the alternative of a linear ALF based on the value of a 2x5 MHz increment.

b) The likelihood of excessive relinquishment is mitigated if there is a risk that our estimate of the value of a 2x10 MHz increment may understate market value for the purpose of ALF.

Stakeholder responses and our comments

Responses to the August 2014 consultation

A6.82 Vodafone[9] said that before setting the increment at 2x10 MHz we needed to assess whether it was more likely that:

a) Vodafone/Telefónica between them would relinquish 2x10 MHz which could be used more efficiently by EE; or

b) Vodafone/Telefónica would inefficiently relinquish 2x5 MHz (or less), which could be used more efficiently by EE.

A6.83 Vodafone's response was that the latter, rather than the former, was the more likely outcome when setting ALFs based on a larger marginal increment. Vodafone made the following arguments to support its position:

a) Actual holdings of Vodafone and Telefónica are 2x17.4 MHz (i.e. a total of 2x34.8 MHz) of 900 MHz spectrum, which cannot be divided in contiguous blocks of 2x10 MHz. Thus, by setting a marginal unit of 2x10 MHz including the contiguity premium, we may incentivise the inefficient hand back of a smaller increment (e.g. 2x5 MHz or 2x2.5 MHz) which may have a value below the per MHz value we derive for 2x10 MHz.

b) Neither operator individually is likely to relinquish 2x10 MHz, as that would leave them with 2x7.4 MHz, which is likely to be a sub-optimal residual holding.

c) The likelihood of Telefónica and Vodafone together relinquishing 2x10 MHz of spectrum at the same time is also very small. The two operators are likely to have different private valuations of spectrum such that even if the operator with lower value relinquishes some spectrum, the other operator is unlikely to simultaneously relinquish the necessary remainder of the spectrum.

A6.84 Telefónica[10] said that if 900 MHz spectrum were priced based on the value of 2x10 MHz instead of 2x5 MHz, there is a significant risk that valuable spectrum could go unused because: (i) there is only 2x34.8 MHz in the 900 MHz band, thus it is not possible to allocate all the spectrum in blocks of 2x10 MHz; and (ii) were 2x5 MHz to be offered in the marketplace priced at a level that included a contiguity premium, it would likely go unsold. This corresponds to the cases of excessive relinquishment, explored in our August 2014 consultation, when setting the ALF based on the value of the non-holder's increment of 2x10 MHz.

[9] See Vodafone's response to our August 2014 consultation, p. 13-21, and Annex 1, p. 5-6.
[10] See p. 28-29, paragraph 61 in Telefónica's response to the August 2014 consultation.

A6.85 Stakeholders[11] argued that there is no good technical reason to choose a 2x10 MHz increment:

a) There is nothing in practice stopping the trading or handing back of smaller blocks than 2x10 MHz.

b) 3G and LTE both support a usable unit of spectrum of 2x5 MHz. Aggregation of non-contiguous spectrum could mean that smaller allocations would have value.

c) The appropriate use of 900 MHz is still 2G technology, thus, the incremental unit could be down to 200 KHz.

A6.86 EE argued that the marginal bidder analysis focused on an arbitrary marginal increment, but that choosing a marginal increment of 2x10 MHz was inconsistent with Ofcom's recognition in the August 2014 consultation that in the face of uncertainty it needed to act conservatively.

A6.87 Telefónica[12] said that it did not believe that the value of 900 MHz spectrum would be inflated by the contiguity premium in the same way 800 MHz was in the 4G auction (even if looking at the increment value of 2x10 MHz). It claimed this was because:

a) At the time of the auction, EE's contiguity premium may have been uniquely high relative to other operators, owing to its position as the UK's largest operator by subscribers and one-off option to refocus its networking using low frequency spectrum. Now that the auction outcome has reinforced its focus on high frequency spectrum, there is no reason to believe its value of 900 MHz spectrum (a band that is less important for LTE than 800 MHz) would be inflated in the same way); and

b) Other potential marginal buyers of 900 MHz, such as H3G or Niche, have lower values than EE for marginal 800 MHz and presumably lower contiguity premiums.

Our comments

A6.88 One of the changes we have made in our analysis compared to the August 2014 consultation is that now we do not choose one marginal increment over the other. Instead we consider values for both 2x5 MHz and 2x10 MHz marginal increments – see Section 2 for details.

A6.89 We note that the stakeholder responses generally focus on the supply side, e.g. how much spectrum the current holders might relinquish. This is a relevant part of the picture. However, it is also relevant to consider the demand side.

A6.90 On the demand side, the existence of a contiguity premium means that at any linear price at which the marginal bidder would want to acquire 2x5 MHz it would necessarily prefer to acquire 2x10 MHz. This is because a contiguity premium, by definition, means that the marginal bidder's average per MHz value of 2x10 MHz is

[11] See EE's response to the August 2014 consultation, section 3.2.1, p. 22 ("an operator could purchase a 2x5 MHz holding of 900 MHz spectrum and use this to provide national GSM or LTE services"); and Vodafone's response to the same consultation, p. 13-21, and Annex 1, p. 5-6.
[12] See p. 28-29 in Telefónica's response to the August 2014 consultation.

larger than its average value of 2x5 MHz. Therefore, were we to consider the demand side on its own, 2x10 MHz would be the preferred marginal increment.

A6.91 However, we take account of the supply side as well as the demand side, and so we consider both 2x5 MHz and 2x10 MHz increments in our analysis. We agree that there is nothing in practice stopping the trading or handing back of smaller blocks than 2x10 MHz and our ALF decisions do not impose or attempt to impose any such restrictions. As discussed above, we have acknowledged that there is a risk of inefficient relinquishment in either case of ALF being set on the basis of a 2x5 MHz or a 2x10 MHz increment.

A6.92 As set out in Section 2, we consider that our figures for the market values of the 800 MHz and 2.6 GHz bands are more likely to understate than overstate. This tends to mitigate the risk of excessive relinquishment.

A6.93 We do not consider that the relevance of a 2x10 MHz increment is invalidated because any operator's current holdings or the entire band cannot be divided into an integer number of contiguous 2x10 MHz blocks. This is because we define market value as the *marginal* opportunity cost of the spectrum (see Section 2). We note that both Telefónica's and Vodafone's holdings of 900 MHz exceed 2x10 MHz.

A6.94 As to the claim that the contiguity premium for 900 MHz would be smaller than for 800 MHz, we do not consider that Telefónica has provided a clear, evidence-based rationale. Our analysis in Section 2 takes into account EE's incremental bid values for 800 MHz spectrum additional to its winning package (or packages with at least 2x20 MHz of 2.6 GHz spectrum). Therefore, the values that we use reflect the fact of EE's large holdings of higher frequency spectrum. The values of other potential buyers of 900 MHz, such as H3G or Niche, may be lower than EE's – indeed this is what we in effect assume in our analysis, given the available evidence.

Linear Reference Prices (LRPs)

A6.95 In this section we discuss three methods that yield linear prices as estimates of market-clearing prices based on bids in the 4G auction: revenue-constrained LRPs; LRPs without revenue constraint; and linear prices that avoid excess supply and minimise excess demand.

A6.96 First, we provide an overview description of each method; and we explain why we prefer to omit bids for packages including D1/D2 lots when computing LRPs. Then we discuss for each method the constraints which determine the linear prices and price differentials between bands.

Overview of each LRP method

Revenue-constrained LRPs

A6.97 The LRP methodology is a mathematical algorithm which takes account of both winning and losing bids in an auction to generate linear / uniform prices (i.e. a single price per MHz for each band that is the same for each bidder) that best support the auction outcome. This means that, at these prices, the incentives for bidders to prefer a different outcome are minimised. In this sense the LRP methodology identifies the linear / uniform prices that are closest to market clearing. However, the 4G auction prices were non-linear / non-uniform which means that if those LRPs were implemented, the market would not clear in the sense that not all winning

bidders would have preferred their winning packages to any other packages at those prices.

A6.98 Applying the revenue constraint requires the sum of the LRPs (applied to the winning packages) to be the same as the total auction revenue. The method of revenue-constrained LRPs is thus a revenue attribution approach, i.e. it takes the total auction revenue as given and attributes it to the three different bands taking into account all the bids made, including losing bids as well as the winning bids.

LRPs without revenue constraint

A6.99 The LRPs *without* revenue constraint derive the linear prices that are closest to market clearing, i.e. that minimise the sum of excursions[13] or yield the linear / uniform prices that are as close as possible to separating the winning and losing bids, allowing the sum of the LRPs to differ from the auction revenue. A necessary feature of this method is that it provides a better fit with the bids than when the revenue constraint is imposed (i.e. it involves significantly lower excursions), and there is therefore an argument that it provides a better measure of market-clearing prices.

A6.100 In neither of the LRP methodologies above is there a perfect fit, i.e. there are no LRPs that incentivise all bidders to choose their respective winning packages in the 4G auction. Thus, the aggregate of the excursions across bidders will be strictly positive. This reflects the feature of the 4G auction noted above that auction prices were non-linear / non-uniform (and at those prices, unlike the LRPs, each bidder preferred the package it won amongst the bids it made).

Linear prices that avoid excess supply and minimise excess demand

A6.101 The linear prices that avoid excess supply and minimise excess demand have a number of similarities with the LRPs without revenue constraint. In particular, the linear prices that avoid excess supply:

a) take into account that bidders may prefer a package other their winning package, given a set of linear prices;

b) take cross-band effects into account by looking at all bands simultaneously; and

c) seek to minimise excursions (i.e. same objective compared to the other LRP scenarios), which are the measure of excess demand.

[13] The excursion for a bidder is the maximum amount by which the payoff of any of its bids (difference between amount bid and the price of the bid at the LRP) exceeds the payoff of its winning bid, for the particular set of linear lot prices being considered. Note that the excursion for a bidder will be zero if the payoff for its winning bid is at least as great as the payoff for all of its losing bids. In other words, the excursion for a bidder is the maximum extent to which the proposed linear prices are unable to explain the auction outcome for that bidder. Thus, the lower the excursions, the better the fit.

A6.102 However, a major difference from the other LRP scenarios is the introduction of non-excess supply constraints (one per lot category). This guarantees that, at these linear prices, there is no unused spectrum in any category.[14]

Reasons to exclude the bids for packages with D1 or D2 lots

A6.103 In the LRP determination in the earlier October 2013 consultation, the prices for both D1 and D2 lots were assumed to be zero. Under the LRP methodology bidders are assumed to be payoff-maximisers, so they had an incentive to choose packages with D1 and D2 lots because, by assumption, this spectrum was available free of charge. In the August 2014 consultation we considered that the assumption of free D1/D2 spectrum had the potential to create an undue bias in bidders' choices towards packages with these lot categories in the LRP modelling. We also noted that no D1 or D2 lots were won in the 4G auction.

A6.104 As in the August 2014 consultation, in our view, for the purpose of ALF, it is more appropriate to exclude the bids for packages containing D1 or D2 spectrum when computing the LRPs (including the derivation of linear prices that avoid excess supply and minimise excess demand). This exclusion is equivalent to setting a sufficiently high price (rather than zero) for D1 and D2 spectrum such that it is never preferred by bidders.

Constraints which determine LRPs and price differentials

Revenue-constrained LRPs

A6.105 The LRPs with revenue constraint and excluding bids for D1/D2 are shown in Table A6.25. The excursions are £124.49m in aggregate, with the majority accounted by the excursion for EE of £91.5m. The other excursions by bidder are £28.17m for Telefónica, £4.65m for Vodafone, £0.17m for H3G and zero for Niche, HKT and MLL.

Table A6.25: LRPs with revenue constraint and excluding bids for D1/D2 (£m per lot)

Lot category	Lot size	LRPs
A1	2x5 MHz	£268.9m
A2	2x10 MHz	£506.8m
C	2x5 MHz	£49.9m
E	5 MHz	£6.6m
Revenue		£2,341m
Excursions		£124.49m

Source: Ofcom, Price Point Calculator (PPC) software

[14] For each category, we require that each combination of constraining bids (one from each bidder) yields no excess supply. If, given the linear prices, there are multiple packages among which a bidder is indifferent, then there must be no excess supply for any possible selection of packages.

Constraining bids for LRPs with revenue constraint

A6.106 The allocations at the LRPs are shown in Table A6.26, i.e. the packages that are most profitable for the bidders (based on the bids made). These packages are the constraining bids for this set of LRPs, i.e. the losing bids which impose the relevant constraints.

Table A6.26: Constraining bids for LRPs with revenue constraint (excluding bids for packages including D1 or D2)

Bidder	A1	A2	C	E	Bid value (£m)	Row	Comment
EE (1)	4	0	4	0	1,798	(i)	Constraint on differential in LRPs between A1 and C
EE (2)	2	0	6	0	1,360	(ii)	
H3G (1)	1	0	2	0	665.5	(iii)	Constraint on differential in LRPs between C and E
H3G (2)	1	0	0	9	625.5	(iv)	
HKT	0	0	0	0	0	(v)	Winning bid
MLL	0	0	0	0	0	(vi)	Winning bid
Niche	0	0	3	4	340.4	(vii)	Winning bid
Telefónica	0	1	2	0	1,347.003	(viii)	Highest losing bid for C (but not binding constraint on LRP of C)
Vodafone (1)	2	0	4	4	2,073.044	(ix)	Constraint on differential in LRPs between A1 and A2
Vodafone (2)	0	1	4	4	2,042.044	(x)	

Source: Ofcom

A6.107 We make a distinction between constraining bids and binding bids. The constraining bid is the most profitable package for that bidder – in its absence, the LRPs would change. A binding bid is one which would have an impact on the LRPs if it were changed by a small amount. The binding bids are a subset of the constraining bids, since there can be constraining bids which are not binding (in the specific sense explained above).

A6.108 The binding constraints (based on binding bids) should be construed as conditions in strict equality that characterise the optimal solution to our particular excursion minimisation problem, i.e. the LRPs. For an example, see the conditions in system (1) at paragraph A6.110 below.

A6.109 The constraining bids for HKT, MLL and Niche in rows (v) to (vii) in Table A6.26 are in fact their respective winning bids. This indicates that these bidders do not provide the relevant binding constraints to determine this set of LRPs.

A6.110 Note that from the constraints on price differentials and the revenue constraint we can set out the following system of simultaneous equations:

$$\begin{cases} -2 \times A_1 + 2 \times C = B_{(ii)} - B_{(i)} \\ -2 \times C + 9 \times E = B_{(iv)} - B_{(iii)} \\ -2 \times A_1 + 1 \times A_2 = B_{(x)} - B_{(ix)} \\ 4 \times A_1 + 1 \times A_2 + 14 \times C + 9 \times E = R \end{cases} \quad (1)$$

where R denotes the auction revenue
A_1, A_2, C and E are the LRPs for the respective spectrum bands
$B_{(j)}$ is the bid value for the bid in row *j* of Table A6.26.

A6.111 Solving the system (1) for A_1, A_2, C and E we obtain the LRPs as set out in Table A6.25 above.

Spectrum allocations at LRPs with revenue constraint

A6.112 From Table A6.26 we can see that, at the revenue-constrained LRPs, EE would be indifferent between EE (1) and EE (2), H3G would be indifferent between H3G (1) and H3G (2), while Vodafone would be indifferent between Vodafone (1) and Vodafone (2). Thus, we can construct eight possible scenarios regarding the demand for each band. In particular:

a) scenario 1: EE (1), H3G (1), Vodafone (1);

b) scenario 2: EE (1), H3G (1), Vodafone (2);

c) scenario 3: EE (1), H3G (2), Vodafone (1);

d) scenario 4: EE (1), H3G (2), Vodafone (2);

e) scenario 5: EE (2), H3G (1), Vodafone (1);

f) scenario 6: EE (2), H3G (1), Vodafone (2);

g) scenario 7: EE (2), H3G (2), Vodafone (1); and

h) scenario 8: EE (2), H3G (2), Vodafone (2).

A6.113 Using a conversion that 1 lot of A2 is equivalent to 2 lots of A1, Table A6.27 exhibits the demand in lots for 800 MHz and 2.6 GHz spectrum. Supply of spectrum in each band is: 6 lots of 800 MHz (4xA1 + 1xA2); 14 lots of C; and 9 lots of E. The level of excess demand or supply is shown in brackets. With the exception of scenarios 7 and 8 with excess demand for all bands, each scenario involves at least one band in excess demand and at least one other band in excess supply.

Table A6.27: Demand (and excess demand/supply) in lots for 800 MHz and 2.6 GHz spectrum at LRPs with revenue constraint

Demand (lots)	800 MHz lots	2.6 GHz lots	
		C	E
Scenario 1	9 (+3)	15 (+1)	8 (-1)
Scenario 2	9 (+3)	15 (+1)	8 (-1)
Scenario 3	9 (+3)	13 (-1)	17 (+8)
Scenario 4	9 (+3)	13 (-1)	17 (+8)
Scenario 5	7 (+1)	17 (+3)	8 (-1)
Scenario 6	7 (+1)	17 (+3)	8 (-1)
Scenario 7	7 (+1)	15 (+1)	17 (+8)
Scenario 8	7 (+1)	15 (+1)	17 (+8)

Source: Ofcom

LRPs without revenue constraint

A6.114 The LRPs without revenue constraint and excluding bids for D1/D2 are shown in Table A6.28. The excursions are £77.5m in aggregate, with the majority accounted for by the excursion for EE of £55.5m. The other excursions by bidder are £14m for Telefónica, £6m for Vodafone, £2m for Niche and zero for H3G, HKT and MLL.

Table A6.28: LRPs without revenue constraint excluding bids for packages with D1 or D2 lots (£m per lot)

Lot category	Lot size	LRPs
A1	2x5 MHz	£312m
A2	2x10 MHz	£593m
C	2x5 MHz	£57m
E	5 MHz	£8m
Revenue		£2,711m
Excursions		£77.5m

Source: Ofcom, Price Point Calculator (PPC) software

Constraining bids for LRPs without revenue constraint

A6.115 The constraining bids for LRPs without revenue constraint are set out in Table A6.29.

Table A6.29: Constraining bids for LRPs without revenue constraint (excluding bids for packages including D1 or D2)

Bidder	A1	A2	C	E	Bid value (£m)	Row	Comment
EE (1)	0	0	8	0	850	(i)	Constraint on differential in LRPs between A1 and C
EE (2)	2	0	6	0	1,360	(ii)	
EE (3)	2	0	0	9	1,090	(iii)	Constraint on differential in LRPs between C and E along with (vii) and (viii)
HKT	0	0	0	0	0	(iv)	Winning bid
H3G	1	0	0	0	565.5	(v)	Winning bid
MLL	0	0	0	0	0	(vi)	Winning bid
Niche (1)	0	0	2	4	285.431	(vii)	Constraint on differential in LRPs between C and E
Niche (2)	0	0	3	0	310.431	(viii)	
Telefónica	0	1	2	0	1,347.003	(ix)	Highest losing bid for C (but not binding constraint on LRP of C)
Vodafone (1)	2	0	4	4	2,073.044	(x)	Constraint on differential in LRPs between A1 and A2
Vodafone (2)	0	1	4	4	2,042.044	(xi)	

Source: Ofcom

A6.116 We could derive a system of simultaneous equations (as for the revenue-constrained LRPs above). But instead of such equations, we provide a discussion below of the binding constraints on the price differentials in the LRPs.

A6.117 The price differential in the LRPs **between A1 and A2**, 800 MHz without and with the coverage obligation is determined by Vodafone's constraining bids (and this is also the case in other LRP scenarios). We can see this by comparing the price differential in the LRPs with the incremental bid value between Vodafone's two constraining bids:

a) price differential in LRPs (given difference in lot size) is £312m x 2 - £593m = £31m; and

b) incremental bid value between Vodafone's two constraining bids, rows (x) and (xi) in Table A6.29, is £2,073.044m - £2,042.044m = £31m. This is the discount required by Vodafone (the highest losing bidder for A2) for it to substitute A2 for 2xA1 (which it won[15]).

A6.118 Telefónica's constraining bid in row (ix) is the highest losing bid in the auction for additional C (paired 2.6 GHz). But this is not the binding constraint on the LRP of C – otherwise the LRP would be £64m.

[15] The packages between which this discount is bid by Vodafone are close to Vodafone's winning bid – the only small difference is that they contain 4xE whereas Vodafone's winning package included 5xE.

A6.119 Niche's constraining bids in rows (vii) and (viii) involve substitution between lot categories C and E, 1xC for 4xE. This constrains the price differential in the LRPs **between C and E**:

a) price differential in LRPs between 1xC and 4xE is £57m – (£8m x 4) = £25m; and

b) incremental bid value between Niche's two constraining bids in rows (vii) and (viii) is £310.431m - £285.431m = £25m.

A6.120 EE's constraining bids in rows (i) to (iii) constrain the price differentials in the LRPs between both A1 and C and between C and E.

A6.121 EE's constraining bids in rows (ii) and (iii) involve substitution between C and E, 6xC for 9xE, which constrains the price differential in the LRPs **between C and E** (alongside Niche's constraining bids):

a) price differential in LRPs between 6xC and 9xE is £57m x 6 – £8m x 9 = £270m; and

b) incremental bid value between EE's two constraining bids in rows (ii) and (iii) is £1,360m - £1,090m = £270m.

A6.122 EE's constraining bids in rows (i) and (ii) involve substitution between lot categories A1 and C, 2xA1 for 2xC, which constrains the price differential in the LRPs **between A1 and C**:

a) price differential in LRPs between 2xA1 and 2xC is £312m x 2 - £57m x 2 = £510m; and

b) incremental bid value between EE's two constraining bids in rows (ii) and (i) is £1,360m - £850m = £510m.

A6.123 The discussion above shows that information on the rate of substitution between bands in auction bids is relevant when determining the relative LRPs of those bands. Vodafone's rate of substitution between A1 and A2, noted above, is one example. Niche's rate of substitution between C and E is another example. However, it is less clear that, for the purpose of ALF, EE's rate of substitution between bands is appropriate information to derive forward-looking market-clearing prices. The difference from other bidders is that only for EE was the overall spectrum cap a binding constraint in the auction. For example, this is the case for the two packages in rows (i) and (ii) which constrain the price differential between A1 and C.

A6.124 The binding constraints on the price differential in the LRPs for A1 and C relate to EE's incremental bid values between packages which both include 2xA1 (2x10 MHz of 800 MHz). In contrast, the auction price of A1 is determined by EE's incremental bid value between its winning package of 1xA1 + 7xC and the package of 2xA1 + 6xC (as well as by the value of rearrangements and the reserve price of A1). This involves substitution of 1xA1 for 1xC at an incremental bid value of £310.5m, which is larger than the corresponding differential in the LRPs and the relevant constraining bids of £510m for 2xA1 versus 2xC or an average of £255m per 1xA1 versus 1xC.

Spectrum allocations at LRPs without revenue constraint

A6.125 From Table A6.29 we can see that at LRPs without revenue constraint, EE would be indifferent between EE (1), EE (2) and EE (3), Niche would be indifferent between Niche (1) and Niche (2), while Vodafone would be indifferent between Vodafone (1) and Vodafone (2). Thus, at LRPs without revenue constraint, we can construct twelve possible scenarios regarding the demand for each band. In particular:

a) scenario 1: EE (1), Niche (1), Vodafone (1);

b) scenario 2: EE (1), Niche (1), Vodafone (2);

c) scenario 3: EE (1), Niche (2), Vodafone (1);

d) scenario 4: EE (1), Niche (2), Vodafone (2);

e) scenario 5: EE (2), Niche (1), Vodafone (1);

f) scenario 6: EE (2), Niche (1), Vodafone (2);

g) scenario 7: EE (2), Niche (2), Vodafone (1);

h) scenario 8: EE (2), Niche (2), Vodafone (2);

i) scenario 9: EE (3), Niche (1), Vodafone (1);

j) scenario 10: EE (3), Niche (1), Vodafone (2);

k) scenario 11: EE (3), Niche (2), Vodafone (1); and

l) scenario 12: EE (3), Niche (2), Vodafone (2).

A6.126 Using a conversion that 1 lot of A2 is equivalent to 2 lots of A1, Table A6.30 exhibits the demand (and excess demand/supply) in lots for 800 MHz and 2.6 GHz spectrum. Each scenario involves at least one band in excess demand and at least one other band in excess supply.

Table A6.30: Demand (in lots) for 800 MHz and 2.6 GHz spectrum at LRPs without revenue constraint

Demand (lots)	800 MHz lots	2.6 GHz lots	
		C	E
Scenario 1	5 (-1)	16 (+2)	8 (-1)
Scenario 2	5 (-1)	16 (+2)	8 (-1)
Scenario 3	5 (-1)	17 (+3)	4 (-5)
Scenario 4	5 (-1)	17 (+3)	4 (-5)
Scenario 5	7 (+1)	14 (0)	8 (-1)
Scenario 6	7 (+1)	14 (0)	8 (-1)
Scenario 7	7 (+1)	15 (+1)	4 (-5)
Scenario 8	7 (+1)	15 (+1)	4 (-5)
Scenario 9	7 (+1)	8 (-6)	17 (+8)
Scenario 10	7 (+1)	8 (-6)	17 (+8)
Scenario 11	7 (+1)	9 (-5)	13 (+4)
Scenario 12	7 (+1)	9 (-5)	13 (+4)

Source: Ofcom

Note: Supply is six lots of 800 MHz (4xA1 + 1xA2), fourteen lots of C and nine lots of E.

Linear prices that avoid excess supply and minimise excess demand

A6.127 Linear prices avoiding excess supply, minimising excess demand and excluding bids for D1/D2 are shown in Table A6.31. The excursions are £78.167m in aggregate, with the majority accounted for by the excursion for EE of £55.5m. The other excursions by bidder are £18m for Telefónica, £4.667m for Vodafone, and zero for H3G, Niche, HKT and MLL. The aggregate excursions are slightly higher than for the LRPs without revenue constraint (by 0.9%), but much lower than for the revenue-constrained LRPs (by 37%).[16]

[16] We do not provide a formal demonstration that these LRPs minimise excess demand (measured by excursions) subject to non-excess supply for any lot category. However, we can effectively show that at these linear prices there is no excess supply for any spectrum band, while the total excursions increase by only 0.9% compared to LRPs without revenue constraint. Thus, for clarity, our proposed solution can be described as a feasible solution with excursions that are close to the LRPs without revenue constraint.

Table A6.31: Linear prices that avoid excess supply and minimise excess demand excluding bids for packages with D1 or D2 lots (£m per lot)

Lot category	Lot size	Linear prices
A1	2x5 MHz	£310m
A2	2x10 MHz	£589m[17]
C	2x5 MHz	£55m
E	5 MHz	£6.667m
Revenue		£6,659m
Excursions		£78.167m

Source: Ofcom

Note: An infinitesimal amount or "epsilon" should be subtracted from the linear prices set out in this table in order to ensure that each bidder has a *strict* preference for a package such that there is no excess supply for any band.

A6.128 The linear prices in Table A6.31 above can be derived starting from the LRPs without revenue constraint (at which there is excess supply for at least one lot category – see Table A6.30) and apply sequential price reductions until there is no excess supply for any lot category. In particular, we go through the following steps:

a) We start from the LRPs without revenue constraint in Table A6.28 and reduce the linear price for the E lot category in order to remove its excess supply. Note that the bidder with the highest incremental bid value for E lots is H3G (at 1xA1 + 9xE) with a bid of £6.667m per additional E lot.

b) Reducing the price of E to £6.667m implies that EE now strictly prefers its bid for package 2xA1 + 9xE over all other bids. This is because the relative price of E to C is lower (than in the LRPs without revenue constraint). However, at this set of prices, the demand for C lots is only 8. Thus, there is excess supply for C lots.

c) To remove excess supply for C, we reduce its linear price. Reducing the price of C to £55m makes EE indifferent between the two packages of 2xA1 +6xC and 2xA1 + 9xE. However, at this set of linear prices, EE would strictly prefer a package with 8xC over all other bids. This is because the relative price of C to A1 is lower than previously. Consequently, at this set of linear prices, there is excess supply for A1 lots.

d) To remove excess supply for A1 lots, we have to reduce the linear price of A1 to £310m to make EE indifferent between its three constraining bids.

e) Finally, as discussed further below, we adjust prices by an infinitesimal amount such that: (i) each bidder strictly prefers one constraining bid; and (ii) the aggregate demand, from the preferred bids, is at least as high as the available supply for each lot category.

[17] Given the linear prices for A1, C and E, there is not a unique solution for the linear price of A2. The price of A2 can be anywhere between £589m and £620.001m to achieve the same sum of excursions. We select the price that minimises revenues (provided that the level of excursions is held fixed) and therefore set A2 to the lower bound.

Constraining bids for linear prices that avoid excess supply and minimise excess demand

A6.129 The constraining bids for this set of linear prices are shown in Table A6.32.

Table A6.32: Constraining bids for linear prices that avoid excess supply and minimise excess demand (excluding bids for packages including D1 or D2)

Bidder	A1	A2	C	E	Bid value (£m)	Row	Comment
EE (1)	0	0	8	0	850	(i)	Constraint on differential in linear prices between A1 and C
EE (2)	2	0	6	0	1,360	(ii)	
EE (3)	2	0	0	9	1,090	(iii)	Constraint on differential in linear prices between C and E
HKT	0	0	0	0	0	(iv)	Winning bid
H3G (1)	1	0	0	0	565.5	(v)	Winning bid
H3G (2)	1	0	0	9	625.5	(vi)	Constraint on level of linear price of E
MLL	0	0	0	0	0	(vii)	Winning bid
Niche (1)	0	0	2	4	285.431	(viii)	Constraint on level of linear price of C
Niche (2)	0	0	3	4	340.431	(ix)	Winning bid
Telefónica (1)	0	1	2	0	1,347.003	(x)	Constraint on differential in linear prices between A1 and A2 (upper bound on linear price of A2)[18]
Telefónica (2)	2	0	2	0	1,347.002	(xi)	
Vodafone (1)	2	0	4	4	2,073.044	(xii)	Constraint on differential in linear prices between A1 and A2 (lower bound on linear price of A2)
Vodafone (2)	0	1	4	4	2,042.044	(xiii)	

Source: Ofcom

A6.130 The constraint imposed by Niche is that the linear price of 1 lot of C must be no higher than £55m, so that it prefers its winning package to 2xC + 4xE. This is consistent with the restriction imposed by EE (2) and EE(3) together with the restriction imposed by H3G (1) and H3G (2), which also imply that the price of one lot of C has to be no higher than £55m. It is also consistent with our marginal bidder analysis of the 2.6 GHz band in Section 2.

Spectrum allocations at linear prices that avoid excess supply and minimise excess demand

A6.131 From Table A6.32 we can see that, at the linear prices in Table A6.31, EE would be indifferent between EE (1), EE (2) and EE (3), H3G would be indifferent between

[18] Note that Telefónica (2) is only a constraining bid when the linear price for A2 is at £620.001m (upper bound for A2). Thus, at a price of £589m per additional A2 lot, as proposed in Table A6.31, the bid Telefónica (2) is not a binding constraint.

H3G (1) and H3G (2), while Niche would be indifferent between Niche (1) and Niche (2). Telefónica would be indifferent between Telefónica (1) and Telefónica (2) if the linear price for A2 was at the upper bound of the range £589m - £620.001m, while Vodafone would be indifferent between Vodafone (1) and Vodafone (2) if the linear price for A2 was at the lower bound of the same range (which provides the constraint on the price differential between A1 and A2 in the LRPs with and without revenue constraint, discussed above).[19] Subtracting an infinitesimal amount (or an "epsilon")[20] from the LRPs, each bidder would have a strict preference for a single package. These preferred packages imply the spectrum allocation as exhibited in Table A6.33.

Table A6.33: Spectrum allocation at linear prices avoiding excess supply and minimising excess demand, subtracting an infinitesimal amount (excluding bids for packages including D1 or D2)

Bidder	A1	A2	C	E	Comparison to actual winning packages
EE (2)	2	0	6	0	+1xA1 – 1xC
HKT	0	0	0	0	same
H3G (2)	1	0	0	9	+9xE
MLL	0	0	0	0	same
Niche (2)	0	0	3	4	same
Telefónica (1)	0	1	2	0	+2xC
Vodafone (1)	2	0	4	4	-1xE
Total demand	5	1	15	17	
Total supply	4	1	14	9	
Excess demand	+1	0	+1	+8	+1xA1 + 1xC + 8xE

Source: Ofcom

Marginal bidder analysis for 800 MHz spectrum

A6.132 As in the August 2014 consultation, we note that EE was the marginal bidder for 800 MHz spectrum. Table A6.34 shows EE's demand (or IBVs) for the 800 MHz band. The IBVs in this table are derived from the relevant part of EE's bid map, which is shown in Table A6.38 in the Appendix to this annex.

A6.133 For both 2x5 MHz and 2x10 MHz increments of additional 800 MHz spectrum we cannot directly observe EE's IBV, because EE was not permitted by the overall spectrum cap to bid in the 4G auction for a second lot of A1, or for its second and third lots of A1, in addition to its winning package of 1xA1 + 7xC. These are the highlighted cells in Table A6.34 in bordered cells in the row for packages with 7xC.

[19] At linear prices for A2 between (but not including) £589m and £620.001m, given the linear prices for all other lot categories as in Table A6.31, Telefónica would strictly prefer Telefónica (1), while Vodafone would strictly prefer Vodafone (1).
[20] For example, we considered A1 = £309.9999965m, A2 = £588.999994m, C = £54.9999975m, and E = £6.66666566666667m.

Table A6.34: EE's demand (IBVs) for 800 MHz (lot category A1)

Packages with:	First A1	Second A1	Third A1	Fourth A1
0xC	£230m	£420m	£263.3m[21]	
1xC	dnb	dnb	dnb	Dnb
2xC	£230m	£605m	£290.2m	
3xC	£230m	£555.9m	£266.5m	
4xC	£230m	£505.5m	£326.3m	
5xC	£230m	£491.2m	dnb	Np
6xC	£275m	£461m	np	Np
7xC	£353m*	np	np	Np
Ranking of IBVs in each row	third	first	fourth[22]	Second
Contiguity premium		Likely for 2x10 MHz block		Likely for 2x20 MHz block
Coverage premium / underlying IBVs for sub-1 GHz	Assumed to decline with larger quantities of sub-1 GHz spectrum			
Other relevant drivers of IBVs, e.g. cross-band effects or financial constraints	Unknown impact on IBVs			

Source: Ofcom

dnb EE did not bid for this package
np EE was not permitted to bid for this package by the overall spectrum cap
* EE's winning package

A6.134 Known or expected features of IBVs are shown in the lower rows of Table A6.34. First, we observe the ranking of EE's IBVs for 800 MHz (lot category A1) in packages with a given amount of 2.6 GHz (lot category C), i.e. how the IBVs evolve across the columns in a given row. The highest observed IBV in each row is for EE's second lot of A1. By making a reasonable inference (that EE's IBV for its third lot of A1 is below the reserve price, given that it chose not to make any bids for packages with 3xA1), we infer that the next highest IBV is for its fourth lot of A1. Then its IBV for its first lot of A1 is ranked third and the IBV for its third lot of A1 is ranked fourth.

A6.135 Second, it is likely that an important contributory factor to this ranking of IBVs is the synergies available in larger block sizes. This suggests that the IBVs of EE's second and fourth lots of A1 are likely to include a contiguity premium for acquiring these block sizes with contiguous spectrum.

A6.136 Third, the underlying IBV may decline with larger quantities of spectrum (abstracting from synergies and other factors). For sub-1 GHz spectrum such as 800 MHz this can be characterised as a declining coverage premium. For the first 2x5 MHz of

[21] This is the average value for EE's third and fourth lots of A1 (since EE did not bid separately for a third lot of A1).
[22] This is on the basis that EE chose not to bid for a third lot of A1 (without also bidding for a fourth lot of A1), suggesting that its IBVs were less than the reserve price.

sub-1 GHz acquired by EE, it may have a relatively high value for the coverage advantages associated with such low-frequency spectrum. As it acquires larger quantities of sub-1 GHz spectrum, this premium is likely to reduce in size. However, there is still likely to be a premium present - acquiring sub-1 GHz spectrum still provides advantages over acquiring higher-frequency spectrum, because the signals travel further outdoors and generally deeper into buildings. This means that more customers can be served in locations that are harder to reach, or the customers can be served at higher speeds. For this reason we consider together the coverage premium and the underlying IBV of sub-1 GHz spectrum.

A6.137 Fourth, there may well be a range of other considerations which affect EE's IBVs. For a high-stakes auction such as the 4G auction we expect that bidders would have prepared a detailed spectrum valuation model to inform their bids. The value of spectrum to an operator may involve a large number of different drivers of value, reflecting the range and complexity of the use of different combinations of spectrum in its business and how that might affect its commercial strategy. Examples of possible additional drivers of IBVs include cross-band effects and financial constraints:

a) **Cross-band effects.** The pattern of EE's IBVs suggests cross-band effects are relevant and potentially material. For example, see EE's (generally) increasing IBVs of its third and fourth 2x5 MHz of A1 with larger quantities of C (2.6 GHz), i.e. comparing the rows in Table A6.34. This might suggest the presence of cross-band synergies in EE's bids. However, we note that, in contrast, EE's IBVs of its second 2x5 MHz of A1 are (generally) declining with larger quantities of C, which might indicate some degree of substitutability between the bands.

b) **Financial or budget constraints.** Bidders may have financial constraints which are below their intrinsic values for the spectrum. In a CCA a bidder can respond to such a situation in different ways, as discussed in Section 2.

A6.138 In our view, whilst important insights can be obtained by considering known or likely drivers of spectrum value, it is unrealistic and potentially misleading to believe that the entirety of EE's bids can be explained by considering a small number of such drivers. For this reason in our marginal bidder analysis we focus on the evidence from directly observed IBVs based on bids actually made by EE.

Stakeholder claims about strategic bidding by EE

A6.139 We set out in Section 2 a summary of the claims made by H3G, Telefónica and Vodafone that EE's bids were inflated by strategic bidding due either to price driving or strategic investment. We also set out in Section 2 EE's response to these claims that it did not engage in either type of strategic bidding. Here we provide some further comments on the arguments.

Price driving

A6.140 The key argument put forward by stakeholders about price driving is the claim that EE had little chance of winning its package bid for 4xA1 + 4xC (on which our

proposed market value was based in the August 2014 consultation), and so inflated this bid to drive up the auction prices paid by other bidders.[23]

A6.141 First, we note that EE's bid for 4xA1 + 4xC did not in fact affect the auction prices – see the first section in this annex.

A6.142 Second, under the specific implementation of the 4G auction, any bids placed in the supplementary bids round could potentially be determined as winning bids. This meant that, if a bidder placed a supplementary bid that exceeded its intrinsic value, with the sole intention of raising the price paid by its competitors, it could have ended up winning the spectrum at a loss. This was especially relevant in the 4G auction as the final clock round (at the end of the previous stage of the auction before the supplementary bids round) included two bands in excess supply: 2x10 MHz in the 800 MHz band and 2x5 MHz in the 2.6 GHz band. Therefore, it would have been clear to bidders that the final allocation after the supplementary bids round could be quite different from the final clock round packages. This was indeed the case, including for EE because its final clock round package was 9xE whereas its winning package after the supplementary bids round was entirely different, 1xA1 + 7xC.

A6.143 Third, in its analysis Power Auctions compared an outcome where EE would win the package of 4xA1 + 4xC and all other bidders would be allocated the remaining lots at the final clock round prices, against an allocation where EE would win the package of 2xA1 + 5xC, again with the other bidders winning the remaining lots at final clock round prices. Power Auctions' claim was that, given the bid EE made for the package of 2xA1 + 5xC, it was "very easy for EE to place bids for larger packages without worrying about winning them".[24] In the discussion below we refer to a package that it is alleged EE did not want to win as its "undesired" package.

A6.144 In our view, at the end of the clock stage, when EE was assessing the true likelihood of winning its supplementary bid for the package 4xA1 + 4xC, for this bid to have no chance of winning, it would have needed to compare:

a) highest possible combination of bids that includes EE's supplementary bid for its allegedly undesired package of 4xA1 + 4xC; with

b) lowest possible combination of bids that includes EE's supplementary bid for its allegedly desired package of 2xA1 + 5xC.

A6.145 The highest possible combination of bids that includes EE's bid for the allegedly undesired package was given by EE's bid for 4xA1 + 4xC (£1,798m), plus the maximum bids for all other lots. The latter could be at least as high as at final clock prices. The value of the lots in addition to EE's undesired package at final clock prices is £1,985.6m. Adding the two figures together gives a total of £3,783.6m.

A6.146 The lowest possible combination of bids that includes EE's bid for the allegedly desired package was EE's bid for 2xA1 + 5xC (£1,233.478m), plus the final clock

[23] For example, see p. 30-36 in Annex A, Power Auction's report as part of H3G's response to the August 2014 consultation.
[24] See p. 32 in Annex A, Power Auction's report as part of H3G's response to the August 2014 consultation.

bids from other bidders (£2,520m[25]) plus unsold 9xE at reserve price (£0.9m), i.e. £3,754.378m.

A6.147 The highest combination of bids that includes EE's bid for its allegedly undesired package could have been more than £29m higher than the lowest combination of bids that includes EE's bid for its allegedly desired package. In our view, this shows that EE could not have ruled out the possibility of ending up winning its allegedly undesired package, contrary to the suggestion by Power Auctions in H3G's response.

A6.148 The difference from the calculation by Power Auctions in H3G's response is that Power Auctions assumed in the lowest possible combination that the 9xE package which EE was bidding for in the final clock round would be sold to other bidders at the final clock round price (9 x £24.4m = £219.6m). However, EE could not have guaranteed this would happen and the worst case – lowest possible combination of bids – would have assumed they were unsold and valued them at reserve price.

A6.149 Therefore, in our view EE could not have safely assumed that its bid for 4xA1 + 4xC was riskless – it had some chance of being a winning bid. In these circumstances a price-driving strategy means that a bidder would be risking its primary objective – securing the spectrum it wishes to acquire – to pursue another, secondary objective of raising its competitors' prices. We commented on this when finalising the rules for the 4G auction:[26]

> "In our view a bidding strategy aimed at raising the prices paid by rival bidders, carries significant risks for a bidder pursuing it. Any bid made during the auction can potentially win and the strategy described would involve placing bids that are above the value the bidder places on the package. Unlike in the potential scenarios that led us to remove the Final Price Cap we had proposed in an earlier consultation, the bidder cannot be sure that its inflated bids will not win."

A6.150 Our view above is consistent with the evidence from EE that it did not engage in price driving.

Strategic Investment

A6.151 In the 4G auction, we imposed three competition measures:

a) Spectrum reservation which was aimed at ensuring that at the end of the auction there would be at least four credible national wholesalers;

b) Sub-1 GHz spectrum cap; and

c) Overall spectrum cap.

[25] Excluding the D2 lot in Telefónica's final clock round package (as in Power Auctions' analysis). The amount of spectrum for a D2 lot was equivalent to 4xC, so together with the excess supply in the final clock round of 2xA1 and 1xC, this comprises the assumed desired package for EE for 2xA1 + 5xC.
[26] Paragraph 4.12 in Statement on the making of regulations in connection with the award of the 800 MHz and 2.6 GHz spectrum bands, November 2012, available at http://stakeholders.ofcom.org.uk/binaries/consultations/regs-800mhz/statement/statement.pdf.

A6.152 The spectrum caps prevented a highly asymmetric distribution of spectrum amongst operators.

A6.153 These competition measures substantially reduced the scope or incentive for bidders to engage in strategic investment. Again, this view is consistent with the evidence from EE that it did not engage in strategic investment.

Other responses on the marginal bidder analysis

A6.154 In this section we consider those stakeholder responses on the marginal bidder analysis which we did not discuss in Section 2.

Stakeholder responses

A6.155 Power Auctions on behalf of H3G criticised our implementation of the marginal bidder analysis on the basis that we omitted important information, namely the incremental values revealed by EE's bids on packages including 800 MHz spectrum combined with unpaired 2.6 GHz spectrum (in lot category E). Power Auctions suggested as an "equally plausible" estimate from the marginal bidder analysis a value of £23.68m per MHz for 2x10 MHz of 800 MHz, EE's incremental value on a package containing 2x20 MHz of 800 MHz and 45 MHz of unpaired 2.6 GHz. It argued this bid was less likely to have been inflated by strategic bidding and also had a unique position as EE's final bid in the clock round (and therefore on which it was unconstrained in its bidding in the supplementary round).

A6.156 Power Auctions also argued that we incorrectly focused on the incremental value for 800 MHz spectrum suggested by EE's bid containing 2x20 MHz of 800MHz and 2x20 MHz of paired 2.6 GHz spectrum. It disagreed with the general patterns in EE's bids that we identified as reasons for our proposed market value to be conservative, specifically the relationship between the incremental values of the first block and the third/fourth block of 800MHz (holding the quantity of 2.6 GHz spectrum constant) and the relationship between incremental values of 800 MHz spectrum and the amount of 2.6 GHz in a package. Power Auctions argued that the relationships were unclear, especially once consideration was given to EE's bid on a package containing unpaired 2.6 GHz spectrum, and were not based on fundamental rationales.

A6.157 Telefónica made some specific comments on our marginal bidder analysis and argued that Ofcom should not rely heavily on this methodology. Like Power Auctions it also argued that EE's bid values did not reveal clear complementarities between incremental values of 800 MHz spectrum and the quantity of 2.6 GHz in a package, claiming instead that strategic factors were an influence in EE's bid on the package we used as a proxy. Telefónica also noted that our analysis only relied on two data points.

A6.158 Telefónica further suggested that the value of 900 MHz spectrum would not be inflated by the contiguity premium in the same way 800 MHz was in the 4G auction (even when looking at the value of a 2x10 MHz increment). It also argued that our marginal values for 800 MHz spectrum were not consistent with the relative caps on supplementary bids that would have applied to any bids by EE on 2x15 MHz of 800 MHz spectrum. It suggested this was inconsistent with our view that bidding in the auction was straightforward rather than influenced by strategic considerations.

A6.159 EE argued that a problem with the marginal bidder analysis was that its use by Ofcom to set ALF would provide bidders in future auctions with an incentive not to bid truthfully.

Our comments

A6.160 Regarding Power Auctions' argument that we should consider packages containing unpaired 2.6 GHz spectrum, EE's incremental value for 800 MHz spectrum in addition to its winning package is most relevant to the opportunity cost for the purpose of ALF. This winning package included no unpaired 2.6 GHz spectrum and instead 2x35 MHz of paired 2.6 GHz spectrum. There are material differences between the unpaired 2.6 GHz and the paired 2.6 GHz spectrum bands as reflected in the bids in the auction. It is therefore more relevant to consider bids including varying amounts of paired 2.6 GHz, the spectrum that EE in reality holds, not the unpaired spectrum which it does not in fact have. Therefore, in our view EE's bids for unpaired 2.6 GHz spectrum are a less appropriate guide to its incremental value for 800 MHz for the purpose of ALF, given its current holdings.

A6.161 As to Power Auctions' arguments why the value of £23.68m per MHz should be preferred, we have addressed above and in Section 2 the claim of strategic bidding by EE, and we consider that EE's winning package in the auction is a more relevant reference point than its package in the final clock round which it failed to win.

A6.162 Regarding the comments from Power Auctions and Telefónica about our interpretation of EE's bids, we acknowledge that there are not simple patterns to the bidding. Annex 6 in the August 2014 consultation contained a careful analysis weighing up the risks in the choice of bids to use as proxies, and we have discussed above and in Section 2 the practical difficulties in deriving a quantified estimate from the marginal bidder analysis. Our revised marginal bidder analysis in Section 2 draws on a broader set of incremental values (e.g. see Table 2.6 and paragraph 2.168). In addition, we have derived our candidate market value from a different method, by examining the opportunity costs in the auction (reflecting the clearer separation in our discussion in Section 2, compared to the August 2014 consultation, between opportunity costs in the auction and differences in circumstances from the auction). However, we also note that there are observable features in EE's bid values, in particular the presence of complementarities between 800 MHz and 2.6 GHz spectrum (see the discussion of a complementarity premium below and in Section 2). Furthermore, we have addressed above the argument that EE's bids were distorted by strategic bidding.

A6.163 In response to Telefónica's arguments concerning the relative caps on supplementary bids, as we discussed above, since EE placed no bids on 2x15 MHz of 800 MHz spectrum its incremental value for a third 2x5 MHz lot was likely to have been below the reserve price. We take this into account in our analysis and we do not regard the relative caps on hypothetical bids as adding further important information on EE's underlying values for the spectrum.

A6.164 As to EE's concern about incentives not to bid truthfully in future auctions, we do not consider that in this respect there is a clear difference between the marginal bidder analysis and any of the other methods to assess market value. All of the methods make use of bids in the auction, so there is the potential in any of them for a bidder to seek to affect a subsequent analysis of ALF by Ofcom by modifying its bids (either downwards, e.g. if it may end up paying the ALF, or upwards to seek to raise the ALF to be paid by a competitor).

A6.165 The existence of this potential does not however mean that the bidder necessarily would distort its own bids to this end. For example, which specific bids will affect an analysis of ALF may not be easy for a bidder to identify at the time of an auction. This is especially the case if, as in our analysis in Section 2, we were to make use of a number of different methods and pieces of evidence. Furthermore, by distorting its own bids, a bidder may risk failing to win its preferred spectrum or making a loss due to over-paying, without necessarily achieving its strategic objective. These risks make it less likely that the bidder would choose to distort its bids.

Complementarity premium analysis

A6.166 EE[27] said that the 4G auction was designed to encourage bidders to submit package bids and express complementarities between bands in those bids. In the auction, EE submitted a number of bids that included spectrum in both 800 MHz and 2.6 GHz spectrum bands. It said that "any analysis of EE's bids that include combinations of 800 MHz and 2.6 GHz products must account for these complementarities".

A6.167 In light of this, EE suggested that its bids for a package with Y lots of A1 and Z lots of C can be decomposed into three components. In particular:

> EE Bid for (YxA1 + ZxC) = EE Bid for (YxA1) + EE Bid for (ZxC) + complementarity premium.

In Table A6.38 (EE's bid map) below we set out the complementarity premium for a number of EE's bids, which were computed according to EE's suggestion.

A6.168 In EE's bids in the 4G auction the complementarity premium is increasing in the number of A1 lots for a given number of C lots in the package (i.e. the complementarity premium in any row in the bid map increases across the columns). If this trend also applied to hypothetical EE bids that were not made in the auction, the bid value for 2xA1 + 7xC would be at least £1,469.5m (= Bid for (2xA1) + Bid for (7xC) + complementarity premium = £650m + £696.5m + £123m). This would result in an IBV of at least £420m for an additional A1 lot for EE.

DTT co-existence costs

A6.169 We explained in the August 2014 consultation that we requested information (under Section 32A of the Wireless Telegraphy Act 2006) regarding the assumptions made about DTT co-existence costs in deciding the level of the bids for packages that included 800 MHz lots in the 4G auction. We received the following four responses.

A6.170 EE[28] said that it ✂

A6.171 Vodafone[29] ✂

A6.172 In Telefónica's[30] response ✂

[27] See EE's response to the August 2014 consultation, p. 24, section 3.2.2.
[28] See EE's response (7 May 2014) to our Section 32A letter dated 24 April 2014.
[29] See Vodafone's response (7 May 2014) to our Section 32A letter dated 24 April 2014.
[30] See Telefónica's response (8 May 2014) to our Section 32A letter dated 24 April 2014.

A6.173 H3G[31] said that ✂.

LRPs gross of expected DTT co-existence costs

A6.174 We explained in the August 2014 consultation that, in order to derive the LRPs gross of expected DTT co-existence cost, we took into account adjustments to the bids of all the bidders for 800 MHz (EE, Vodafone, Telefónica and H3G).[32] We considered what the bids gross of DTT co-existence costs would have been, based on stakeholder responses to the information request on DTT co-existence costs.

A6.175 In particular, we:

a) increased ✂ bids for all relevant packages by ✂for 800 MHz;

b) made no change to ✂, which seemed to suggest that its bids gross of DTT co-existence costs would have been the same as its actual bids;

c) calculated first the LRPs without any change to ✂ bids, and then we re-ran the calculation by adding £3m per MHz to all of its bids for 800 MHz to see what difference it made to the resulting LRPs[33]; and

d) calculated first the LRPs without any change to ✂ bids; second, we re-ran the calculations by changing ✂[34]; and third we re-ran the calculations amending ✂.

A6.176 In Table A6.35 we set out the scenarios and results for LRPs without revenue constraint, excluding bids for packages with D1/D2 lots, and gross of expected DTT co-existence cost.[35] As set out above, all scenarios assumed:

a) an increase of ✂ bids for all relevant packages by ✂ for 800 MHz; and

b) no changes to ✂'s bids.

[31] See H3G's response (8 May 2014) to our Section 32A letter dated 24 April 2014.
[32] All calculations were done with the PPC software provided by DotEcon.
[33] We decided to take this approach with ✂ bids given that its response to the information request ✂.
[34] ✂
[35] In all the six scenarios in Table A6.35 the optimal spectrum allocation remained the same as in the actual 4G auction (even if it would have changed the base prices for some bidders).

Table A6.35: LRPs without revenue constraint gross of expected DTT co-existence cost

LRPs	No change to ✂ bids	Changing ✂	Amending ✂
No change to ✂ bids	Scenario 1 A1: £342m A2: £653m C: £57m E: £8m	Scenario 2 A1: £342m A2: £653m C: £57m E: £8m	Scenario 3 A1: £342m A2: £653m C: £57m E: £8m
Add £3m per MHz to all of ✂ bids for 800 MHz	Scenario 4 A1: £342m A2: £653m C: £57m E: £8m	Scenario 5 A1: £342m A2: £653m C: £57m E: £8m	Scenario 6 A1: £342m A2: £653m C: £57m E: £8m

Source: Ofcom

A6.177 We found that the LRPs without revenue constraint gross of expected DTT co-existence cost were identical under all the scenarios reported above. When compared to the LRPs without revenue constraint, excluding the bids for packages with D1/D2 lots and net of DTT co-existence costs reported in Table A6.28, the LRPs were higher by £3m per MHz for 800 MHz spectrum.

Market value of 800 MHz gross of expected DTT co-existence costs

A6.178 As explained in Section 2, we derive our view on the market value of 800 MHz spectrum, net of expected DTT co-existence costs, of £30m per MHz using a range of methods: opportunity costs in the 4G auction, LRPs, and marginal bidder analysis.

Opportunity costs in the auction and marginal bidder analysis

A6.179 It was EE's bids for additional 800 MHz spectrum that set the opportunity costs in the 4G auction for the 800 MHz spectrum won by H3G, Telefónica and Vodafone (in conjunction with the value of rearrangements). For the same reason, in the marginal bidder analysis EE is the relevant marginal bidder for 800 MHz spectrum.

A6.180 EE's response to the information request was that it ✂ because of the expected DTT co-existence costs.

A6.181 In Table A6.36 we set out the opportunity cost of 800 MHz spectrum in the 4G auction relevant to ALF. For comparison, the average of the opportunity costs in the auction of H3G's and Telefónica's 800 MHz spectrum, net of expected DTT co-existence costs, is £30.43m per MHz.

Table A6.36: Opportunity costs of 800 MHz spectrum in 4G auction relevant to ALF (in £m per MHz)

Opportunity cost	No change to ✂ bids	Changing ✂	Amending ✂
No change to ✂ bids	Scenario 1 Telefónica 1st 2x5 MHz: £38.6m 2nd 2x5 MHz: £23.3m Average: £30.95m H3G 2x5 MHz: £41.4m **Average: £34.43m**	Scenario 2 Telefónica 1st 2x5 MHz: £38.6m 2nd 2x5 MHz: £22.05m Average: £30.325m H3G 2x5 MHz: £41.4m **Average: £34.017m**	Scenario 3 Telefónica 1st 2x5 MHz: £38.6m 2nd 2x5 MHz: £20.3m Average: £29.45m H3G 2x5 MHz: £41.4m **Average: £33.43m**
Add £3m per MHz to all of ✂ bids for 800 MHz	Scenario 4 Telefónica 1st 2x5 MHz: £38.6m 2nd 2x5 MHz: £23.3m Average: £30.95m H3G 2x5 MHz: £41.4m **Average: £34.43m**	Scenario 5 Telefónica 1st 2x5 MHz: £38.6m 2nd 2x5 MHz: £22.05m Average: £30.325m H3G 2x5 MHz: £41.4m **Average: £34.017m**	Scenario 6 Telefónica 1st 2x5 MHz: £38.6m 2nd 2x5 MHz: £20.3m Average: £29.45m H3G 2x5 MHz: £41.4m **Average: £33.43m**

Source: Ofcom, Price Point Calculator (PPC) software

A6.182 Table A6.36 suggests that the effect of expected DTT co-existence costs on the average opportunity cost for 800 MHz may be higher than £3m per MHz. This is the case in scenarios 1, 2, 4 and 5. However, we do not think that this analysis should ultimately change the £3m per MHz to add to the value net of expected DTT co-existence costs of 800 MHz to derive the gross value. This is because the larger increase of about £4m per MHz relates to the opportunity cost in the 4G auction which includes the effect of rearrangements. In the absence of rearrangements, as in the marginal bidder analysis, the increase would be £3m per MHz.

A6.183 Therefore, the value of 800 MHz gross of expected DTT co-existence costs is at least £3m per MHz higher than the value net of such costs in both: (i) the opportunity costs in the 4G auction for the 800 MHz spectrum won by H3G, Telefónica and Vodafone; and (ii) the marginal bidder analysis. It is irrelevant that other bidders may have had different expectations about DTT co-existence costs and had a different relationship between their gross and net bids, because these bidders did not make the relevant bids for additional 800 MHz spectrum.

LRPs

A6.184 As set out above, the LRPs without revenue constraint gross of expected DTT co-existence costs are also £3m per MHz higher than the LRPs net of such costs.

Market value of 800 MHz spectrum, gross and net of expected DTT co-existence costs and with and without coverage obligation

A6.185 In Table A6.37 we provide a summary of our market values for the 800 MHz band both gross / net of expected DTT co-existence costs and with / without the coverage obligation.

Table A6.37: Market values for the 800 MHz band, gross/net of expected DTT co-existence costs and with/without coverage obligation (in £m per MHz)

	Without coverage obligation	With coverage obligation
Net of expected DTT co-existence costs	£30m	£28.45m
Gross of expected DTT co-existence costs	£33m	£31.45m

Source: Ofcom

A6.186 The discount for the coverage obligation spectrum is £31m for the 2x10 MHz lot of A2, or £1.55m per MHz. This is the discount of the marginal bidder for A2, Vodafone, and it is also reflected in the LRP results, e.g. see paragraph A6.117 above.

Appendix: EE's bid map

A6.187 The extract from EE's bid map in Table A6.38 shows EE's bid values and the IBVs that can be derived from them. Some of these IBVs are shown, for example, in Table A6.34 as EE's demand for 800 MHz spectrum.

A6.188 EE's bid values for specified packages of spectrum are shown in the grey shaded boxes, with the amount of 800 MHz spectrum in the columns and the amount of 2.6 GHz spectrum in the rows, in both cases in increments of 2x5 MHz. For example, EE's winning bid is £1,049.5m for a package of 1xA1 + 7xC (2x5 MHz of 800 MHz plus 2x35 MHz of 2.6 GHz).

A6.189 The IBVs are the figures between the boxes. For example, EE's IBV for its seventh lot of 2.6 GHz spectrum in packages with no 800 MHz is £72.5m; and IBV for its second lot of 800 MHz in packages including 6xC (2x30 MHz of 2.6 GHz) is £461m.

A6.190 IBVs on a diagonal are shown in italics – they relate to both an increment of additional spectrum in one lot category and a reduction in the other. For example, the IBV for an increment of 1xA1 and a reduction of 1xC compared to EE's winning package is £310.5m.

A6.191 Bold numbers in parenthesis are a calculation of the complementarity premium as suggested by EE – see paragraph A6.167 above.

A6.192 Numbers in unshaded boxes are hypothetical bids for EE assumed by Vodafone (e.g. see Table 2.7 in Section 2).

A6.193 A cell shows as "N/A" if EE did not make a bid for the specific package it represents (and there was no hypothetical bid in Vodafone's assumptions).

Table A6.38: EE's bid map for packages including only lot categories A1 (800 MHz without coverage obligation) and C (paired 2.6 GHz)

2.6 GHz included in packages (C)			800 MHz included in package (A1 only)											
			0 MHz		2x5 MHz			2x10 MHz		2x15 MHz		2x20 MHz		
			0xA1		1xA1			2xA1		3xA1		4xA1		
	0 MHz	0xC	£ -	£ 230.000m	£ 230.000m	£ 420.001m		£ 650.001m	£225m	£875.001m	£301.62m	£ 1,176.622m		
			-		-			-		-		-		
	2x5 MHz	1xC	N/A	-	N/A	-		N/A	-	N/A	-	N/A		
			-		-			-		-		-		
	2x10 MHz	2xC	£ 30.000m	£ 230.000m	£ 260.000m (**£0m**)	£ 605.000m		£ 865.000m (**£185m**)	£225m	£1,090m	£355.48m	£ 1,445.478m (**£239m**)		
			£ 219.558m		£ 219.558m	*£ 385.442m*		£ 170.478m		£170.478m		£ 123.000m		
	2x15 MHz	3xC	£ 249.558m	£ 230.000m	£ 479.558m (**£0m**)	£ 555.920m		£ 1,035.478m (**£136m**)	£225m	£1,260.478m	£308m	£ 1,568.478m (**£142.4m**)		
			£ 160.442m		£ 160.442m	*£ 395.478m*		£ 110.000m		£110.000m		£ 229.522m		
	2x20 MHz	4xC	£ 410.000m	£ 230.000m	£ 640.000m (**£0m**)	£ 505.478m		£ 1,145.478m (**£85.5m**)	£225m	£1,370.478m	£427.52m	£ 1,798.000m (**£211.4m**)		
			£ 102.300m		£ 102.300m	*£ 403.178m*		£ 88.000m		£88.000m		£155.344m		
	2x25 MHz	5xC	£ 512.300m	£ 230.000m	£ 742.300m (**£0m**)	£ 491.178m		£ 1,233.478m (**£71.2m**)	£225m	£1,458.478m	£494.87m	£1,953.344m		
			£ 111.700m		£ 156.700m	*£ 334.478m*		£ 126.522m		£126.522m		£155.344		
	2x30 MHz	6xC	£ 624.000m	£ 275.000m	£ 899.000m (**£45m**)	£ 461.000m		£ 1,360.000m (**£86m**)	£225m	£1,585m	£523.69m	£2,108.688m		
			£ 72.500m		£ 150.500m	*£ 310.500m*		£123.75m		£123.75m		-		
	2x35 MHz	7xC	£ 696.500m	£ 353.000m	£ 1,049.500m (**£123m**)	£434.25m		£1,483.75m	£225m	£1,708.75m	-	N/A		
			£ 153.500m	*£ 199.500m*	£142.485m			£123.75m		-		-		
	2x40 MHz	8xC	£ 850.000m	-	£1,191.985m	£415.515m		£1,607.5m	-	N/A	-	N/A		

Source: Ofcom

Notes: Actual bids are in grey shaded rectangles. Bold numbers in parenthesis are complementarity premia. EE's winning bid is in yellow. All other bids in the map are hypothetical, taken from Vodafone's response to the August 2014 consultation, Annex 1.3, p. 29-30.

Annex 7

Assessment of lump-sum values - supporting material

Introduction

A7.1 This annex provides additional material on the assessment of lump-sum values and supports Section 3.

A7.2 It gives more detail on the sources of information and on the method that we have used in the each of the following areas:

a) Information on European auctions (see paragraphs A7.5 to A7.25).

b) Derivation of UK-equivalent absolute values for these auctions (see paragraphs A7.26 to A7.55).

c) Derivation of relative value benchmarks for lump-sum values from these absolute values (see paragraphs A7.56 to A7.121).

d) Interpretation of benchmarks, including criteria for tiers and assessment of the risks of understatement or overstatement (see paragraphs A7.122 to A7.151).

e) Sensitivity analysis (see paragraphs A7.152-A7.160).

A7.3 These sections address stakeholder comments on the issues where relevant, noting where we have amended our approach in light of these comments and, in other cases, explaining why we do not agree with the points made.

A7.4 In addition, the last sections in this annex cover:

a) Stakeholders' tiering proposals (see paragraphs A7.161 to A7.191).

b) Stakeholders' approach to the derivation of lump-sum values for 900 MHz and 1800 MHz in UK, based on the benchmark data and their tiering proposals (see paragraphs A7.192 to A7.201).

Information on European auctions

A7.5 We use auction prices in European countries from year 2010 onward to inform our estimates of lump-sum values in Section 3. We begin by deriving UK-equivalent absolute spectrum values by band from these prices, and then we use these values to derive relative value benchmarks. In the following discussion we set out the sources and calculation methods we adopt in deriving UK-equivalent absolute values.

Sources of information for deriving spectrum values

A7.6 As in the August 2014 consultation, we use the following sources of information about lot-specific auction prices and licence fees:

a) The main source of information is DotEcon's database of spectrum auctions. This includes award-level information (such as date of the award) as well as lot-specific information. At lot level, the dataset reports both price information (such as reserve price, upfront fee and the future payments, by year, of fees levied on the licence) as well as other non-price information (such as lot size, licence duration, and population covered).

b) For combinatorial clock auctions (CCAs), DotEcon's dataset generally only includes data about lot-specific reserve prices rather than realised lot prices, as the latter are not directly observable.[36] Where total package prices were close to the sum of reserve prices (in Romania and the Slovak Republic) we use reserve prices as an approximation of band-specific prices.

c) LRP information for CCAs where bidding data was available (UK) or we secured the NRA's co-operation to calculate LRPs without disclosure of bid data (Austria).

d) Other evidence submitted by stakeholders about price levels in relevant auctions (e.g. Vodafone's submission about the Irish CCA, which we verified with Comreg).

e) Publicly available information about lot characteristics (such as size, length of the licence term, any applicable coverage obligations or liability to mitigate DTT interference issues), reserve prices, auction prices (at package or lot level) and future fees levied on spectrum licences.

A7.7 Where it is possible to distinguish revenues from assignment stage bids, we exclude these revenues from our calculations of spectrum values.

Identification of auction prices from combinatorial auctions

A7.8 Our benchmarks are, whenever possible, based on information about the market value of specific lots awarded in European auctions. However, some of the awards included in our benchmarking work were CCAs, in which the published prices are for winning packages which often include spectrum in more than one band. Unlike simultaneous multiple-round auctions (SMRAs), prices are not determined on a lot- or band-specific basis in these awards but as prices for the winning packages of spectrum. Where there are winning packages with spectrum in a single band, these provide information on the auction price for that band (for that bidder). Sometimes other information can be used to make inferences about prices by band. In addition, with knowledge of the bids made it is possible to estimate band-specific prices, such as Linear Reference Prices (LRPs).

A7.9 None of the other national regulatory authorities (NRAs) who conducted a combinatorial auction published bid data. However, we approached these NRAs to request information which might allow us to estimate band-specific prices. We described this process and its outcome in the August 2014 consultation. For completeness, we repeat this text in paragraphs A7.10 to A7.14 below.

[36] There are some limited exceptions, for example when a winning package contains only lots from one band.

Approach to other NRAs

A7.10 In January 2013 we contacted the six NRAs which had held CCAs from the beginning of 2010 in the relevant bands (the awards were of 2.6 GHz in Austria; 800 MHz in Denmark and multiple bands in Switzerland, Romania, the Netherlands and Ireland). We requested the disclosure of the full set of bids to us or, if this was not possible, to DotEcon, an independent consultancy which has advised us on this project, on the basis that DotEcon would then calculate LRPs from the bid data, without sharing the bid data with us.

A7.11 None of the NRAs we contacted were willing to disclose their bid data to us or to DotEcon at that time. However, we engaged further with Ireland's Comreg after Vodafone submitted a confidential note to us which included a bar chart showing its best estimate of the price ratios for 800 MHz, 900 MHz and 1800 MHz spectrum in the Irish CCA, based on the prices in the clock rounds of the auction in which supply matched demand for each frequency band. Comreg confirmed that the estimated price ratios (that we put to Comreg on the basis of Vodafone's bar chart) were reasonable indications of the ratios of the different frequency bands in the auction and, respectively, the final clock price for 900 MHz relative to 800 MHz spectrum and the final clock price of 1800 MHz relative to 800 MHz spectrum ("within a couple of percentage points").

A7.12 After the publication of the October 2013 consultation, further combinatorial awards took place in Austria, Norway, the Slovak Republic and Slovenia. In November 2013 we wrote to Austria's NRA, RTR, suggesting alternative approaches through which we might obtain band-specific price information from the 2013 Austrian CCA. RTR agreed to calculate LRPs using software developed by DotEcon. RTR provided us with results in April 2014 and we published this new evidence in our May 2014 update.

A7.13 In May 2014 we wrote to two other NRAs who had concluded a multi-band CCA since our October 2013 consultation (the Slovak Republic and Slovenia), requesting information on similar terms to those we proposed to Austria.[37] Slovenia's NRA, AKOS, told us that it would not be able to do so at the present time. We did not receive a response from the Slovakian NRA.

A7.14 We also re-contacted the Swiss, Netherlands and Irish NRAs asking if they would be willing to calculate LRPs using software to be developed by DotEcon.[38] Each of them replied that this approach raised confidentiality issues, and that they were unable to comply with our request.

[37] We did not request bid data from the Norwegian Post and Telecommunications Authority (NPTA). We considered that its auction was unlikely to be informative of market value, due to the significant risk of bid shading in this first-price sealed bid auction. We asked NPTA to comment on the relative price of different bands, but it declined to do so due to confidentiality.

[38] As regards the three other CCAs which took place before our October 2013 consultation: we derive a 2.6 GHz price for Austria from winning packages which only included paired lots; for Denmark our estimated 800 MHz price is based on the larger package won by TDC; and Romania is discussed in paragraph A7.16.

Available evidence from combinatorial awards

A7.15 As a result of this engagement with other European NRAs our benchmarking sample includes the following[39]:

a) For the 2012 Irish CCA, we estimated band-specific information on the basis of publicly available information and further evidence submitted by Vodafone and confirmed by Comreg (in the manner explained above). This methodology is detailed in Annex 7 (pages 98-99) of the October 2013 consultation.

b) For the 2013 Austrian CCA, we obtained LRPs from RTR, as detailed in the May 2014 Update on European auctions.

A7.16 In addition, we use publicly available information about two further CCAs:

a) For the 2012 Romanian award, we use reserve prices (and the present value of future spectrum fees) as an approximation of band prices, since the total revenue raised by the auction was only slightly above the sum of reserve prices.

b) For the 2014 Slovakian CCA, we use reserve prices as an approximation of band prices, since the total revenue raised by the base prices[40] in the auction was not much higher than the sum of reserve prices (the package price of the new entrant and two incumbents was at reserve price, with only Slovak Telekom paying a price above reserve).

A7.17 Our view remains that we do not have sufficient information from the Netherlands, Swiss, or Slovenian auctions to estimate band-specific prices accurately. This is because we cannot infer prices with sufficient accuracy from publicly available information, and we have been unable to obtain additional information from the relevant NRA to inform the analysis in this document.

Averaging auction lots

A7.18 In the August 2014 consultation, we calculated a UK-equivalent price for each lot sold before deriving a single price for each band by averaging the price of all relevant lots sold (subject to co-existence and coverage obligation considerations, which we discuss below).

A7.19 AM&A said that the approach adopted widely across the industry is to use a weighted average of lot prices, taking account of the population covered and the

[39] AM&A (June 2014 response, p. 11) said that in the absence of information that would allow us to derive band-specific prices for all relevant CCAs, and to avoid the risk of bias, the inputs to the UK 1800 MHz lump-sum value should be restricted to data that is available in the public domain for all countries – i.e. that our data set should not include these prices from CCAs. We consider that it is appropriate to use all relevant information where it is available to us, and we see no reason to exclude potentially useful auction benchmarks on the basis of the unavailability of band-specific prices in other auctions. We do not consider there is any basis for expecting that our approach – which was to contact all relevant NRAs – introduces a risk of bias.

[40] That is, prices before the assignment stage. In the case of Romania, we have not been able to distinguish revenues from assignment stage bids.

size of lots, as this ensures that larger lots and lots that cover larger populations carry more weight in the calculation of the average value.[41]

A7.20 On balance we agree with AM&A that the most appropriate price for spectrum bands in European auctions is based on a weighted average of lots as, for each country, we are calculating a UK-equivalent price per MHz per head of population. We have adjusted our methodology accordingly. This adjustment affects five absolute values (800 MHz in the Czech Republic, 1800 MHz in Portugal and Sweden and 2.6 GHz in Austria and Spain).[42]

Inclusion of additional data point for Denmark

Stakeholder responses

A7.21 Telefónica[43] argued that we should have included an 1800 MHz distance method benchmark for Denmark, based on a different approach to deriving the data points for the relevant auction bands in Denmark. It noted that we had not included this benchmark because the 1800 MHz price was below the 2.6 GHz price. However Telefónica argued that this problem arose because we were not comparing equivalent numbers across bands. It said we used the price of the most expensive licences from Denmark's 800 MHz and 2.6 GHz auctions, which were set by the 2nd/3rd and 4th strongest bidders respectively, whereas we used reserve prices for 900 MHz and 1800 MHz licence, equivalent to a hypothetical 5th strongest bidder. Telefónica said that a better approach for relative values is either: (i) to take the least expensive licences in Denmark's 800 MHz and 2.6 GHz auctions, which were set by the 3rd/4th strongest bidder and reserve price (hypothetical 5th bidder) respectively and which, it said, are more directly comparable to the 900 and 1800 MHz auctions; or (ii) to take the reserve prices for all bands.

A7.22 Telefónica also commented that the omission of the following prices from the data set was odd:

a) France's 800 MHz and 2.6 GHz prices from the 2011 auctions, as well as their paired ratio (in the calculation of the 2.6 GHz proxy).

b) 800 MHz prices for Belgium, Finland, Estonia, Lithuania and Latvia.

Our assessment

A7.23 We do not consider that Telefónica's alternative approach (i) to calculating benchmarks for Denmark should be used:

a) For 800 MHz, we observe two auction prices. The 800 MHz price we use is gross of DTT co-existence costs but with a coverage obligation. Telefónica argued that, under option (a), we should use the (lower) Denmark 800 MHz auction price which is net of DTT co-existence costs and without a coverage obligation. This yields a much higher 900 MHz / 800 MHz paired ratio of £12.6m per MHz, which would, like the benchmark we use of £5.7m per MHz, be subject to a larger risk of

[41] AM&A response to the August 2014 consultation, page 24
[42] The 2.6 GHz price for Spain is used only as part of the average 800 MHz to 2.6 GHz ratio that generates the proxies for 2.6 GHz we use in the distance method.
[43] Telefónica's response to the August 2014 consultation, page 55.

larger understatement. It would also yield a (more) negative 1800 MHz distance method benchmark. The lower Denmark 800 MHz auction price (favoured by Telefónica), which is net of expected DTT co-existence costs, was subject to significant usage restrictions to protect DTT users (which seem more costly than the expected DTT co-existence costs in the UK). On balance, therefore, we consider that it is more appropriate to use the gross 800 MHz price in Denmark.[44]

b) Our 2.6 GHz price is based on TDC's winning package of 2x20 MHz of 2.6 GHz spectrum, for which it paid almost €45m. Hi3G paid less than €1m for its winning package of 2x10 MHz (which also included some unpaired spectrum). The other two bidders won 2x20 MHz and some unpaired spectrum and each paid around €45m. Hi3G's package price reflected reserve price for the 2.6 GHz spectrum because all other bidders were bidding up to their cap, whereas the prices paid by TDC and others reflected the need to outbid Hi3G for 2x20 MHz. In these circumstances, we consider that TFC's price is likely to be a better reflection of market value than Hi3G's.

A7.24 We do not consider that Telefónica's alternative approach (ii), to use reserve prices, is appropriate. There is auction price information In Denmark which reflects bids in the auction and we consider such information, where available, is more appropriate than reserve prices set by the regulator.

A7.25 Regarding Telefónica's other points:

a) We have not derived benchmarks from France because neither ALF band has been auctioned within our timeframe (since the beginning of 2010). In principle we could use the 800 MHz and 2.6 GHz prices in our calculation of the 2.6 GHz proxy. However, these auction prices may not be informative of market value due to the significant risk of bid shading in this sealed bid, first-price auction (for similar reasons as for Norway – see footnote 37). The auction also included a non-financial element in the determination of winning bidders (in relation to commitments for accelerated coverage and offering access to MVNOs).

b) We do not use the 800 MHz price as a benchmark or cross-check in our assessment of international benchmarks, so prices from the countries mentioned by Telefónica would not inform our analysis.

Derivation of UK-equivalent absolute values for European auctions

A7.26 This section sets out the calculation method we adopt in deriving UK-equivalent absolute values by band from the auction prices in the benchmark countries.

A7.27 As in the August 2014 consultation, we use the following information sources to derive UK-equivalent prices:

a) Time series of the "CPI All Items Index" and the UK population from the 2011 Censuses, from the UK Office for National Statistics.[45]

[44] Telefónica commented that: "although 900 MHz data is used, it returns a very low ratio with 800 MHz, so is treated as third tier evidence". To be clear, our assessment of the quality of this evidence is not affected by the level of the ratio.
[45] Available at http://www.ons.gov.uk/

b) Time series of the "PPP conversion factor, GDP (local currency unit per international $)" from the World Bank as our measure of purchasing-power parity.[46]

c) Figures for the post-tax real weighted average cost of capital and cost of debt from the 2011 Review of Mobile Call Termination Charges (respectively equal to 4.6% and 2.2%), as explained in Section 4.

Derivation of spectrum values in benchmark countries

A7.28 The following paragraphs describe the steps for adjusting the value of spectrum bands in the benchmark dataset so that they are placed on a consistent basis.

Future annual fees

A7.29 To calculate the overall value of spectrum, we add upfront auction prices and the present value of future annual fees (both expressed in local currency). The latter is discounted by the cost of debt.

A7.30 Since the August 2014 consultation, we have identified that annual fees are payable on the licences awarded in Portugal and Spain and we have included these in the calculation of absolute values:

a) In Portugal, annual fees were set at Euro 60,000 per MHz for all bands used to provide mobile services.[47]

b) In Spain, the annual fees vary for each licence according to the formula set out in Article 9 of the Royal Decree 20/2011.[48]

Licence duration

A7.31 To account for different lengths in the licence term, we adjust the value to represent a 20-year (240-month) period, comparable to the initial term of UK licences awarded in the 4G auction. We do so by applying the following adjustment factor, assuming the licence has a duration of *T* months and using a post-tax real WACC for each country for reasons explained in Section 4, paragraph 4.79.a:

$$\sum_{t=0}^{239}\left(\frac{1}{(1+WACC)}\right)^{t} \Big/ \sum_{t=0}^{T-1}\left(\frac{1}{(1+WACC}\right)^{t}$$

A7.32 This method assumes the same annual net cash flow in each year to which the adjustment applies (equal to the constant annuity implied by the auction price).

A7.33 Telefónica argued that expected returns from owning a licence are not linear across the licence period, and in particular may be lower at the beginning and end of a 20-

[46] Available at http://data.worldbank.org/indicator/PA.NUS.PPP
[47] See secondary legislation published on 4 November 2011, available at https://dre.pt/application/dir/pdf1s/2011/11/21201/0000200021.pdf . Fee levels have since been revised; we consider that the relevant annual fee is the one at the time of the auction.
[48] See http://www.minetur.gob.es/telecomunicaciones/es-ES/Servicios/Tasas/Paginas/tasaDominio.aspx

year period than in the middle.[49] It said that the linear adjustment methodology could risk overstating benchmark values for licences that were less than 20 years, and that we should recognise this risk. Telefónica argued that there was not a positive correlation between price benchmarks and licence duration.

A7.34 We agree that the limited number of data points available does not show a clear relationship between price and licence duration. However, this is only one of a number of factors affecting licence prices, and other things being equal, we would expect a longer licence to be worth more than a shorter licence. We recognise that annual net cash flows may vary over the duration of a licence, but it is not clear that our licence duration adjustment would necessarily lead to an overstatement as Telefónica suggested. Alternatively, there is a risk that it could lead to an understatement, depending on the profile of cash flows over time, and how this would differ between actual licences and hypothetical 20-year licences in the benchmark country concerned. Telefónica did not provide evidence or reasoning as to why expected net cash flows might be lower at the end of the licence period.

A7.35 We consider that the "constant annuity" adjustment we use is likely to be a reasonable default assumption. We note that the potential for relative values to be affected by this only exists where licence lengths differ between the relevant spectrum bands (which is the case in Austria, Denmark, Slovakia and Sweden).

Delayed availability of spectrum

A7.36 We are aware of two instances where there was a substantial period of time between the auction and the date the spectrum became available to winning bidders:

a) In the case of 800 MHz in Spain, awarded in July 2011, the spectrum could only be used after the completion of the Digital Switchover in 2015.

b) In the case of 900 MHz and 1800 MHz in Austria, awarded in October 2013, the spectrum would become (totally or partially) available to winners only from 2016.

A7.37 For these cases we calculate a "gestation adjustment" to allow for the fact that observed auction prices likely reflect the value of the licence at the date the spectrum becomes available for use, discounted back to the date of the auction. The discount rate used here is a real post-tax WACC for reasons explained in Section 4, paragraph 4.79.a.

Use of country-specific discount rates

A7.38 For the above mentioned adjustments in the August 2014 consultation we used the same discount rate for all countries, based on the WACC and cost of debt in the 2011 MCT market review. Discounting affects our absolute values and relative value benchmarks in up to four ways, that is:

a) the licence duration adjustment (which depends on the WACC);

b) the gestation adjustment (which depends on the WACC);

[49] Telefónica response to the August 2014 consultation, pp.58-59

c) the present value of annual fees (which depends on the cost of debt); and

d) the 2.6 GHz proxy (which we discuss below and which depends on both the WACC and the cost of debt).

A7.39 Telefónica argued that the same discount rate should not be used for every country with licence fees.[50] It said that using the same discount rate severely overstates the value of annual fees in some countries, while slightly understating values in some others, noting that many benchmark country government bonds are rated differently to UK government bonds.

A7.40 Telefónica also commented[51] that the choice of discount rate generally affects absolute values more than relative values. We note that this choice will only have a significant impact on relative values if:

a) annual fees are a significant proportion of the NPV of a spectrum licence and are a significantly greater proportion of the total costs of acquiring a licence band in one band than another (this can occur when a licence in one band has similar annual fees to a licence in another band, but a very different auction price, as in the case of sub-1 GHz spectrum in Ireland);

b) licences in different bands have significantly different durations and start dates (which affect the adjustment factors for licence duration and availability of spectrum);[52] and/or

c) the circumstances in a) and b) above have a significant effect on the 800 MHz and 2.6 GHz benchmarks used in the calculation of the proxy for 2.6 GHz (only with reference to the distance method benchmark of countries where 2.6 GHz was not auctioned in the time period covered by our sample).[53]

A7.41 We have investigated which countries are sensitive to changes in the estimated discount rates. Table A7.1 shows the percentage changes in our relative benchmarks as a result of an illustrative increase of three percentage points in either the WACC or the cost of debt we used in the August 2014 consultation.[54]

a) The Greek 900 MHz / 800 MHz benchmark as well as the Czech, German, Greek, Italian and the Portuguese 1800 MHz distance method benchmarks are unaffected by changes in discount rates. In general, this is because licences for different bands within each country have the same start and end dates and are not subject to annual licence fees.[55]

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[50] Telefónica, pages 56-57.
[51] Telefónica, pages 56 and 60.
[52] This is the case, for example, for Austria 800 MHz licences which have shorter terms and are immediately available, whereas the relevant lot categories in the 900 MHz and 1800 MHz bands have longer terms and delayed availability.
[53] This is the case, for example, for Ireland and Sweden. The ratio of 2.6 GHz and 800 MHz in Austria is affected by changes in discount rates and this affects the ratio used for the 2.6 GHz proxy.
[54] Our illustrative example focuses on increases in the discount rates. A decrease in the discount rates would have an effect on benchmarks in the opposite direction.
[55] There are some exceptions. For example, in Portugal all licences in the bands relevant to the 1800 MHz distance method benchmark are subject to the same annual fee. This means that a change in the cost of debt has the same effect, in absolute terms, on each band-specific absolute value and the

b) The Irish and Portuguese 900 MHz / 800 MHz and the two Romanian benchmarks are only affected by changes in the cost of debt. This is because licences for different bands within each country have the same start and end dates and are subject to annual licence fees.[56]

c) The other relative benchmarks are affected by changes in the WACC and the cost of debt.

Table A7.1: Change in relative value benchmarks with an increase of three percentage points in WACC or cost of debt

	Higher WACC			Higher cost of debt		
Country	900 MHz / 800 MHz ratio	1800 MHz distance method	Source of change	900 MHz / 800 MHz ratio	1800 MHz distance method	Source of change
Austria	9.5%	7.4%	Licence duration, gestation	-0.2%	-0.8%	Annual fees
Czech Republic		0.0%			0.0%	
Denmark	1.6%		Licence duration	-7.7%		Annual fees
Germany		0.0%			0.0%	
Greece	0.0%	0.0%		0.0%	0.0%	
Ireland	0.0%	0.0%		-3.8%	-1.3%	Annual fees, 2.6 GHz proxy
Italy		0.0%			0.0%	
Portugal	0.0%	0.0%		-1.0%	0.0%	Annual fees
Romania	0.0%	0.0%		0.6%	-1.4%	Annual fees
Slovak Republic		-1.6%	Licence duration		0.8%	Annual fees
Spain	-9.2%		Gestation	-1.2%		Annual fees
Sweden		0.2%	Licence duration		0.0%	2.6 GHz proxy

Source: Ofcom

A7.42 Below we focus our analysis of country-specific discount rates on the Tier 1 and Tier 2 countries whose benchmarks are affected by adjustments involving the discount rate (Austria, Ireland, Portugal, Spain and Sweden – which we refer to as the "five discount rate countries"). In all cases the benchmarks are affected by changes to both the WACC and cost of debt.

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effect cancels out. As a result, the Y/X ratio of the distance method benchmark (discussed below in paragraphs A7.58 to A7.64) is invariant to changes in the cost of debt (denoting the effect of annual fees as D): (1800 MHz + D – 2.6 GHz – D) / (800 MHz + D – 2.6 GHz – D) = (1800 MHz – 2.6 GHz) / (800 MHz – 2.6 GHz).

[56] In principle there could be some exceptions. For example, if annual licence fees were exactly proportional to the upfront price of each band, the paired ratio of two bands would be invariant to changes in the cost of debt. There are no such benchmarks in practice.

A7.43 Each of the five discount rate countries has either estimated WACC for the purpose of setting mobile termination rates or, in the case of Ireland, used a previously estimated WACC for the purposes of deriving annual licence fees as described below.

A7.44 For these countries we have now investigated the parameters of these WACC estimates (such as the tax rate, inflation rate, nominal pre-tax cost of debt) and derived country-specific discount rates based on valuations of these parameters. Table A7.2 summarises the value of the parameters relevant to the calculation of the WACC for mobile termination rates in each of the five countries, taking the level of those values at the time of the relevant auction, or at the date of the review of mobile termination rates closest to that auction.

Table A7.2: Information for country-specific discount rates for the five discount rate countries

	Austria	Ireland	Portugal	Spain	Sweden
Year of the auction	2013	2012	2011	2011	2011
Year rates refer to	2013	2012	2012	2011	2011
Real post-tax WACC	**11.37%**	**6.6%**	**6.1%**	**6.2%**	**4.9%**
Tax rate	25%	12.5%	29%	30.1%	26.3%
Relevant inflation rate	1.75%	2.21%	1.7%	1.7%	2%
Pre-tax cost of debt	**7.28% (nominal)**	**4.6% (real)**	**6.1% (nominal)**	**5.5 (nominal)**	**3.84% (nominal)**
Are annual fees index-linked?	No	Yes	No	No	Not applicable
Potential for review of annual fees	Yes*	No	Yes**	Yes	Not applicable
Source	RTR	Comreg	Anacom	CME	PTS

Source: Ofcom from sources set out above.

* Changes to the annual licence fee require an amendment of the relevant legal regulations in the TKGV, the ordinance that regulates the fee. However, this ordinance has not been changed since it was first issued in 1998.

** We are aware that the Government changed the level of annual licence fees in December 2013, http://www.anacom.pt/render.jsp?contentId=1187122&languageId=1

A7.45 For Austria, we refer to RTR's decisions on wholesale markets for voice call termination on individual mobile networks[57] and to information provided to us by RTR about some of the parameters.[58] RTR did not use inflation expectations in the calculation of the WACC, so our estimate is based on forecasts of "harmonised index of consumer prices" for 2014 (1.7%) and 2015 (1.8%) published near the time

[57] RTR decisions M 1.10/12-99-102 of Sept. 30, 2013, available at https://www.rtr.at/en/tk/M_1_10_12

[58] RTR told us that it used a corporate tax rate of 25% and pre-tax nominal cost of debt of 7.28%.

of the auction by the central bank of Austria.[59] The resulting average of 1.75% is consistent with the European Central Bank's objective of an inflation rate below but close to 2%, which can be interpreted as a reference point for long-term inflation expectations.

A7.46 For Ireland, Comreg published a specific methodology for deriving Spectrum Usage Fees (SUF) in the Information Memorandum for the 2012 Multi-band CCA.[60] Comreg previously explained that in its SUF methodology "[t]he discount rate equates to Eircom's Weighted Average Cost of Capital and is used, in this context, as a proxy for the cost of capital of a telecommunications industry operator."[61] We hence use the parameters set out in Comreg's 2008 decision on the WACC for Eircom.[62] Since Ireland's SUF are index-linked to CPI, we have used a real rather than nominal rate for the cost of debt.[63]

A7.47 For Portugal, we refer to Anacom's final decision on the price control obligation for Mobile Termination Rates published in April 2012.[64] We understand that Anacom had not previously estimated the WACC for the purpose of setting MTR.

A7.48 For Spain, we use CME's decisions on the WACC for the financial year 2011-12.[65] CME set MNO-specific WACC. Telefónica (Movistar) had the highest WACC and cost of debt rates of the three Spanish MNOs. In the MCT Market Review 2015-18, in estimating the debt premium for an average efficient operator in the UK, we placed less weight on Telefonica's debt spread because it appeared to be an outlier compared to the debt spread for Vodafone, Orange and Deutsche Telekom.[66] We also comment on the data for Telefónica in our analysis of discount rates for the UK

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[59] See Table 9.1 at: http://www.oenb.at/dms/oenbEN/Monetary-Policy/Downloads/Economic-Outlook-for-Austria/Archive/2013/mop_2013_q2_analyse1_tcm16-256829.pdf

[60] See paragraphs 2.63-2.66 and Annex 6 in Comreg 12/52, *Multiband Spectrum Release Information Memorandum*, 25 May 2012, available at http://www.comreg.ie/_fileupload/publications/ComReg1252.pdf

[61] See footnote 34 at page 36 of Comreg 10/105, *Inclusion of the 1800 MHz Band into the Proposed joint award of 800 MHz and 900 MHz Spectrum*, 15 December 2010, available at http://www.comreg.ie/_fileupload/publications/ComReg10105.pdf

[62] See Table 2 of *Eircom's Cost of Capital*, 22 May 2008, available at http://www.comreg.ie/_fileupload/publications/ComReg0835.pdf

[63] Comreg confirmed that no provision has been made to review annual fees.

[64] See Table 10 at page 117 of Anacom, *Decisão sobre a especificação da obrigação de controlo de preços nos mercados grossistas de terminação de chamadas vocais em redes móveis individuais*, April 2012, available at http://www.anacom.pt/streaming/Decisao_final_obrigacao_controlo_precos.pdf?contentId=1125436&field=ATTACHED_FILE

[65] Movistar,see Table 8 (English translation unavailable) at:
http://telecos.cnmc.es:8080/c/document_library/get_file?uuid=991565eb-f007-46f4-902d-ccf2b3c1ba3d&groupId=10138
Orange, see Table 7 (English translation unavailable) at:
http://telecos.cnmc.es:8080/c/document_library/get_file?uuid=180f48f0-9904-4928-aa95-247b229420a5&groupId=10138
Vodafone, see page 14 (English translation unavailable) at:
http://telecos.cnmc.es:8080/c/document_library/get_file?uuid=7a92a156-fe5d-49fd-a21f-580c75767a4b&groupId=10138

[66] See paragraph A10.176 in Mobile call termination market review 2015-18, Draft Statement, 6 February 2015, http://stakeholders.ofcom.org.uk/consultations/mobile-call-termination-14/draft-statement/

(see paragraph A10.55). For similar reasons, we calculate the Spanish discount rates based on parameters for Orange and Vodafone, i.e. excluding Telefónica. The Spanish regulator did not use inflation expectations in the calculation of the WACC. We referred to forecasts of inflation published near the time of the auction by the central bank of Spain (1.5% in 2012)[67] and the Spanish Government (1.9% expected inflation for the period from 2012 to 2014).[68] The resulting average of 1.7% is consistent with the European Central Bank's objective of an inflation rate below but close to 2%, which can be interpreted as a reference point for long-term inflation expectations.

A7.49 For Sweden, we refer to the WACC established in February 2011, after consultations were conducted during the latter part of 2010.[69] PTS developed "low" and a "high" gearing scenarios. We calculate the WACC and the cost of debt as the simple average of the two.

Conversion to UK equivalents

A7.50 The next step in our calculation relates to the conversion from local currency prices (in most cases, euros) to pounds sterling. This is relevant to deriving absolute value benchmarks, but not to relative values which reflect the ratios of prices in the local currency. For the conversion we use PPP conversion factors from the World Bank,[70] taking the ratio of the PPP factor for the UK and the PPP factor for the benchmark country, both in the year when the auction took place. We now use actual PPP data for 2013, rather than linearly extrapolated figures, as data for this year has become available since we published the August 2014 consultation.

A7.51 When PPP factors are still unavailable (that is, for the year 2014), we use linear extrapolation from the two nearest available data points.

A7.52 Telefónica said that PPP is a very poor proxy for spending on telecoms and is not correlated to any telecom revenue metrics.[71] It did not think that a PPP exchange rate (as opposed to a straight market exchange rate) is necessary when comparing auctions across Western Europe. Telefónica recognised that some adjustment is appropriate for benchmark countries which are much less wealthy than the UK, but doubted that PPP is the right metric to use. However, it did not propose an alternative.

A7.53 We continue to use PPP adjustments because this is is a well-established measure and we have no reason to believe that it would introduce a bias in either direction. In any case, the focus of our approach on relative values means that the issue of currency conversion is only relevant to the extent that it affects the absolute values we use as one of our cross-checks.

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[67] See Bank of Spain's report of March 2011, page 32, available at: http://www.bde.es/f/webbde/SES/Secciones/Publicaciones/InformesBoletinesRevistas/BoletinEconomico/11/Mar/Fich/art1.pdf

[68] See the Spanish Government's report of Spring 2011, Table 3.4, available at: http://serviciosweb.meh.es/APPS/DGPE/TEXTOS/progest/Historicos/Ing/Stability%202011-2014.pdf

[69] See Table 2 in PTS consultation in April 2014 to review the rate set in 2011. PTS report PTS-ER-2014:17, *Consultation on return rates for mobile networks - an update*, 11 April 2014, available at: http://www.pts.se/upload/Rapporter/Tele/2014/consultation-on-return-rates-for-mobile-networks-wacc-pts-er-2014_17.pdf

[70] http://data.worldbank.org/indicator/PA.NUS.PPP

[71] Telefónica response to the August 2014 consultation, page 60

A7.54 We then adjust for inflation between the date of the auction in the benchmark country and the start date of licences awarded in the UK 4G auction (that is, 1 March 2013). The adjustment factor is the ratio between the value of the monthly UK CPI index for March 2013 and the value at the time of the benchmark auction.

A7.55 For comparability, we calculate prices expressed as £ per MHz per head of population.[72] We calculate UK-equivalent values by multiplying prices by the UK population recorded in the 2011 Census, expressed as "£m per MHz".

Derivation of relative value benchmarks

A7.56 Our approach focuses on the use of relative value benchmarks. As in the August 2014 consultation, we base these on:

a) the relative value of 900 MHz to 800 MHz in the benchmark country as the basis for estimating the corresponding 900 MHz benchmark value in UK; and

b) the distance method for estimating the corresponding 1800 MHz benchmark value in UK, as explained further below.

A7.57 After explaining the distance method, and the "Y/X ratio" that it generates, this section then addresses:

a) The way that we treat DTT coexistence and coverage costs when deriving the benchmarks.

b) The use of proxy values for 2.6 GHz spectrum when deriving the benchmark for the 1800 MHz band in Ireland and Sweden where we do not have a relevant auction price.

c) The implications for the 1800 MHz distance method benchmark when one or more of the relevant bands (1800 MHz, 800 MHz, 2.6 GHz) are at risk of understatement or overstatement.

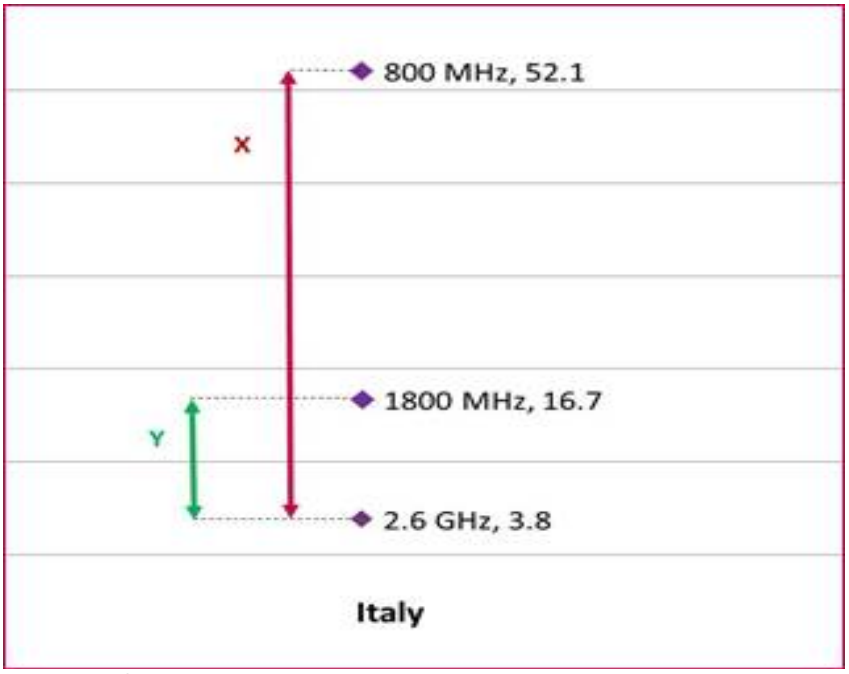
The distance method and "Y/X ratio"

A7.58 As explained in the August 2014 consultation, the distance method focuses on the question of where the value of 1800 MHz lies between the values of 800 MHz and 2.6 GHz. We considered this to be more relevant than the ratios of 1800 MHz to either 800 MHz or to 2.6 GHz on their own. The distance method generates a benchmark for each country using all of the information on spectrum values in these bands to do so, and it produces one (and only one) benchmark for each country.

A7.59 An example of this method is shown in Figure A7.1 below for Italy. In Italy, the price of 1800 MHz spectrum is £12.9m per MHz higher than the price of 2.6 GHz ("Y" in Figure A7.1), and the price of 800 MHz is £48.3m per MHz higher than the price of 2.6 GHz ("X" in Figure A7.1), giving a Y/X ratio of 27%. Given our estimates of values of 800 MHz (£33m per MHz without coverage obligations and gross of expected DTT co-existence costs) and 2.6 GHz (£5.5m per MHz), the Italy distance method benchmark is £12.8m per MHz, because this gives the same ratio of Y to X in the UK as in Italy.

[72] Benchmark country population figures are taken from DotEcon, based on World Bank data.

Figure A7.1: Illustration of the distance method (Italy) (£m per MHz)



Source: Ofcom

A7.60 Benchmark values of 1800 MHz generated by the distance method reflect the values of both 800 MHz and 2.6 GHz spectrum. We consider that, in principle, this is an advantage over the paired ratios of 1800 MHz to either 800 MHz or 2.6 GHz spectrum.

Derivation

A7.61 We explained in the August 2014 consultation that the distance method can be seen as reflecting the proposition that the relative distance of the value of the 1800 MHz band between the values of the 800 MHz and 2.6 GHz bands should be consistent across countries. In particular, it involves the following relationship:

$$\frac{1800_{UK} - 2.6_{UK}}{800_{UK} - 2.6_{UK}} = \frac{1800_{BC} - 2.6_{BC}}{800_{BC} - 2.6_{BC}}$$

where 1800_{UK} is the value of 1800 MHz in the UK, 1800_{BC} is its value in the benchmark country, etc. This implies in turn that an estimate of the value of 1800 MHz in the UK can be calculated as:

$$1800_{UK} = \underbrace{\frac{1800_{BC} - 2.6_{BC}}{800_{BC} - 2.6_{BC}}}_{\text{(a)}} \underbrace{x\ (800_{UK} - 2.6_{UK})}_{\text{(b)}} + \underbrace{2.6_{UK}}_{\text{(c)}}$$

A7.62 This equation can be seen as having three components, labelled (a) to (c) above. Component (a) is the Y/X ratio, described above. Component (b) is the market value premium commanded by 800 MHz over 2.6 GHz spectrum in the UK. Component (c) is the UK value of 2.6 GHz spectrum. Only the first of these components the Y/X ratio, is affected by the values of spectrum in the benchmark country.

A7.63 For example, in a benchmark country for which the corresponding UK 800 MHz value is £33m per MHz (see the countries in the bottom left quadrant of Table A7.4 below), and with the value of 2.6 GHz in the UK as £5.5m per MHz, the distance method value is:

$$1800_{UK} = \frac{1800_{BC} - 2.6_{BC}}{800_{BC} - 2.6_{BC}} \times (£27.5m) + £5.5m$$

A7.64 For example, with a Y/X ratio of 27% (as for Italy in Figure A7.1), the formula above gives a distance method benchmark for the UK of 27% x £27.5m + £5.5m = £12.9m per MHz.

DTT co-existence costs and coverage obligations

A7.65 Where an observed 800 MHz auction price is for a licence which includes liability for DTT co-existence costs, we would expect bidders to reflect the expected costs in their bids, potentially leading to a lower observed price. We refer to the observed 800 MHz auction price in these circumstances as being "net" of expected co-existence costs. Where the price of 800 MHz observed through the auction is for spectrum with little or no expected DTT co-existence costs, we refer to the observed 800 MHz auction price as "gross" of expected DTT co-existence costs.

A7.66 Coverage obligations were included in a significant number of the spectrum licences in the auctions in the benchmark countries. Therefore, observed 800 MHz auction prices may reflect the value with or without a coverage obligation.

A7.67 The values of the 800 MHz band in both the UK and in the benchmark country are used in the formulae for deriving the benchmark values for both 900 MHz and 1800 MHz bands. The values of 800 MHz that are used in the benchmark derivation are therefore expressed on a consistent basis as regards expected DTT co-existence costs and coverage obligations. This section explains our approach for doing this.

A7.68 In the case of 800 MHz licences, we have estimated the UK value net and gross of expected DTT co-existence costs and with or without the 800 MHz coverage obligation, as described in Annex 6 and reported in Table A7.3 (which repeats Table A6.37).

Table A7.3: Implications of expected DTT co-existence costs and coverage obligation on UK 800 MHz value (in £m per MHz)

	Without coverage obligation (lot category A1)	With coverage obligation (lot category A2)
Net of expected DTT co-existence costs	£30m	£28.45m
Gross of expected DTT co-existence costs	£33m	£31.45m

Source: Ofcom

A7.69 In the benchmark countries, where possible, we identify auction prices for 800 MHz spectrum gross of expected DTT co-existence costs and without any discount for a coverage obligation (and use these absolute values, together with the equivalent UK 800 MHz value gross of DTT co-existence costs and without any discount for a

coverage obligation, as the basis for deriving our benchmarks). If such evidence is not available for the benchmark country, we characterise the value of 800 MHz in the benchmark country as to whether it is net or gross of expected DTT co-existence costs and whether or not it has a coverage obligation. We then select the corresponding UK value of the 800 MHz band when computing the UK-equivalent benchmark value.

A7.70 As illustrations of how we use these measures to derive relative value benchmarks:

a) We can identify an auction price for 800 MHz spectrum in Italy that is gross of expected DTT co-existence costs (and without a coverage obligation). Therefore, we generate the UK-equivalent benchmark using the UK figure that is also gross of such costs (and without a coverage obligation) – £33m per MHz in the table above. The formula we use to derive the Italy 1800 MHz distance method benchmark is shown below:

$$\frac{1800_{Italy} - 2.6_{Italy}}{800_{Italy\ \boldsymbol{gross}} - 2.6_{Italy}} \times \left(800_{UK\ \boldsymbol{gross}} - 2.6_{UK}\right) + 2.6_{UK}$$

b) The Ireland 800 MHz auction price is net of expected DTT co-existence costs (and without a coverage obligation). Therefore, we use the UK figure net of such costs (also without coverage obligation) of £30m from the table above. The formula we use to derive the Ireland 900 MHz relative value benchmark is:

$$\frac{900_{Ireland}}{800_{Ireland\ \boldsymbol{net}}} \times 800_{UK\ \boldsymbol{net}}$$

A7.71 Table A7.4 summarises the relevant UK 800 MHz comparators used for the different benchmark countries.

Table A7.4: Relevant UK comparators for 800 MHz

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

Source: Ofcom

A7.72 We note that neither DTT co-existence costs nor band-specific coverage obligations apply to any of the other UK bands used in deriving the benchmarks, namely the 900 MHz, 1800 MHz and 2.6 GHz bands (and we consider separately in Section 6 the impact of the geographic coverage obligation). Similarly, none of these other bands in the benchmark countries were subject to DTT co-existence costs or (onerous[73]) coverage obligations. Accordingly, the equivalent consistency issues do not arise in respect of these bands when deriving the benchmarks.

[73] We noted in the August 2014 consultation that the extent to which a coverage requirement is onerous in a benchmark country depends on the level of coverage an operator would have sought to achieve for commercial reasons in the absence of such an obligation – this is the sense in which we use the term “onerous”.

A7.73 In the rest of this subsection, we first set out how, in the August 2014 consultation, we approached differences in coverage obligations for lots in each band and issues related to DTT co-existence (for 800 MHz only). We then set out stakeholders' submissions. Finally we provide our response to those views.

Our position in the August 2014 consultation

DTT co-existence costs

A7.74 When deriving relative value benchmarks we considered whether some (or all) 800 MHz lots were affected by expected DTT co-existence costs:

a) In some benchmark countries we observed price differentials between different 800 MHz lots that are likely related to expected DTT co-existence costs (this is sometimes the case for one or two lots at the bottom of the 800 MHz band). In these cases, we took the average price of the 800 MHz lots which are less likely to be subject to expected DTT co-existence costs. We then calculated relative value benchmarks (that is, the 900 MHz / 800 MHz paired ratio and the distance method benchmark for 1800 MHz) using the UK market value of 800 MHz gross of expected DTT co-existence costs.

b) In other benchmark countries we did not observe differentials in auction prices across the 800 MHz lots that are likely related to expected DTT co-existence costs. In these cases, we assumed that expected DTT co-existence costs were positive and that all 800 MHz lots were equally affected so that all bids were reduced by the expected amount of DTT co-existence costs. Accordingly, we took the average of all lots to derive the value of 800 MHz in the benchmark country. We then applied the relevant paired ratio or Y/X ratio to the UK market value of 800 MHz net of DTT co-existence costs.[74]

Coverage obligations

A7.75 In calculating the European auction prices of 900 MHz, 1800 MHz and 2.6 GHz we included all available lots of in our dataset, irrespective of their coverage obligations, and we considered the implications of the coverage obligations qualitatively if and when necessary. As part of our analysis of individual awards in Annex 8 of the consultation we set out coverage obligations by band. In principle, if we had considered that such obligations were likely to require deployments significantly in excess of commercial levels then the auction price could risk understating the value of that band (without coverage obligation) in the UK in our assessment. In the event, we did not consider that this was the case in these bands for any of the countries in the dataset.[75]

[74] The level of DTT co-existence cost expected by bidders is not observable and may vary substantially across countries. We do not have a basis for directly adjusting the 800 MHz prices for expected DTT co-existence costs in the benchmark countries. We recognised that our approach to use the corresponding UK 800 MHz value might not be accurate where expected DTT co-existence costs in the benchmark country were significantly different from the UK (as a proportion of the value of 800 MHz). We noted that our approach generates lower benchmarks than using UK market value of 800 MHz gross of co-existence costs.

[75] For example, a coverage obligation applied to 900 MHz in Ireland, Romania, Slovenia and Switzerland; to 1800 MHz in Czech Republic, Ireland, Romania, Slovenia and Switzerland; and in the 2.6 GHz band in Czech Republic, Italy and Romania. We considered that none of these obligations are likely to require coverage substantially in excess of the commercial level.

A7.76 For 800 MHz, we adopted the following approach:

a) When coverage obligations applied which were likely to be over and above commercial levels, and price differentials between 800 MHz lots in the benchmark country could be ascribed to differences in these coverage obligations, we included only blocks without, or with less onerous, coverage obligations in the calculation of an average price of 800 MHz for the benchmark country.[76] We then used the corresponding UK value of 800 MHz (i.e. without coverage obligation) when deriving the relative value benchmark.

b) When there were no differences in coverage obligations across 800 MHz lots in the benchmark country, we calculated the value of 800 MHz as the average of all available lots. We then considered whether or not any coverage obligation (i.e. on all 800 MHz lots) was likely to be onerous. Where there was a basis for believing coverage obligations to be onerous, then we used the UK value of 800 MHz with coverage obligation in the derivation of the relative value benchmark; otherwise we used the UK value without coverage obligation.

Stakeholder responses to the August 2014 consultation

A7.77 Telefónica[77] expressed concern that our adjustments were arbitrary and not supported by evidence, yet were treated as factual (that is, we did not consider the risk of overstatement). Telefónica argued that:

a) The coverage adjustment assumes that the price differential observed in the UK between lots with and without coverage obligation is a good benchmark for coverage obligation costs in the benchmark countries. Telefónica argued that there is no reason to suppose this is the case, as these costs are highly country specific and, even within countries, are bidder-specific.

b) The DTT co-existence cost adjustment assumes that the maximum UK DMSL liability of £3m per MHz is a good benchmark for expectations of DTT co-existence costs in the benchmark countries. Telefónica argued that there is no reason to suppose this is the case, and it said that such estimates likely declined over time as experience from earlier auctions showed lower than expected costs. It cited its own experience as an example, whereby at the time of the UK auction it was aware of the lower-than-expected DTT co-existence costs in Germany.

c) Telefónica said our approach of selecting prices that were likely unaffected by these factors where possible (i.e. without coverage obligations and unlikely to be affected by DTT co-existence costs): (i) disregards valid data (by focusing on lots which result in higher absolute benchmarks); and (ii) prejudices the qualitative assessment. It also considered that we treat our results as factual and we do "not even consider the possibility that [the results of our adjustments] are overstated" as part of our qualitative analysis of benchmarks.

A7.78 Telefónica[78] argued that for each country where coverage obligations and/or DTT costs are relevant we should calculate at least two benchmarks, one with

[76] The only exception to this is Denmark, where we used the larger 2x20 MHz lot which was subject to a coverage obligation. This is because the other 800 MHz lot, which did not include a coverage obligation, was affected by DTT co-existence costs (as we discuss in the next section).
[77] Telefónica response to the August 2014 consultation, pp. 61-62
[78] Telefónica response to the August 2014 consultation, p. 62

adjustment factors and one without, and add a third point (for relevant countries) using local licence prices that were not affected by such adjustments as a cross-check.

Our assessment

A7.79 The starting point for our consideration of Telefónica's arguments is that, where we have the relevant information for the benchmark country (as well as for the UK), we derive the relative benchmark(s) using data points that represent the underlying relevant value of 800 MHz in both the UK and the benchmark country (i.e. without coverage obligation and gross of expected DTT co-existence costs). We consider this to be the most appropriate measure for the reasons explained in Section 2, paragraph 2.184. We only depart from this measure where the only data available in the benchmark country relates to 800 MHz licences that include a coverage obligation and/or are net of expected DTT co-existence costs. In these cases, we select the UK 800 MHz value used to derive the benchmarks on a consistent basis. We now turn to Telefónica's specific points.

A7.80 Telefónica said our approach assumes that the price differential observed in the UK between lots with and without coverage obligation is a good benchmark for coverage obligation costs in the benchmark countries (i.e. that coverage costs are implicitly the same proportion of underlying 800 MHz value in both countries). This does not apply where we are able to use an 800 MHz value without coverage obligation in the benchmark country. There are two countries where we are only able to use an 800 MHz value with coverage obligation, Romania and Denmark.[79] These are both Tier 3 countries; accordingly, this issue is does not have a large impact on our provisional decision. Telefónica itself did not suggest any alternative approach to estimating coverage costs in these cases (and we are not aware of a practical or proportionate alternative approach).

A7.81 Telefónica said that our approach assumes that the maximum UK DMSL liability of £3m per MHz is a good benchmark for expectations of DTT co-existence costs in the benchmark countries. As above, this is only the case where we base the relative benchmarks for a country on values of 800 MHz that are net of DTT co-existence costs (we do this where we are unable to identify a value of 800 MHz which is gross of DTT co-existence costs). This is the case for Ireland, the Czech Republic, Greece, Portugal and the Slovak Republic (the top row in Table A7.4). Telefónica did not suggest any alternative approach to estimating expected DTT co-existence costs in these cases (and we are not aware of a practical or proportionate alternative approach).

A7.82 Telefónica[80] suggested the value of £3m per MHz for the expected DTT co-existence cost in the UK was too high. It argued that, rather than focusing only on prices that are not affected by DTT co-existence and coverage cost, we should have regard to those prices that were affected by such factors, by considering an alternative benchmark derived "without adjustment factors added", as part of a qualitative assessment of the available evidence for the benchmark country

[79] In the case of Romania, this is because we cannot observe an 800 MHz value without coverage obligation. In Denmark one 800 MHz lot did not have a coverage obligation but it sold at a substantial discount because it was subject to usage restrictions to protect DTT users (see paragraph A7.23a) above).
[80] Telefónica response to the August 2014 consultation, pp. 61-62.

(including for countries where we can and do derive benchmarks using gross values for 800 MHz). From the values in Figure 12 and 13 of Telefonica's response, we understand that it has calculated such a benchmark by applying the same ratios we use in our preferred benchmark to the £30m per MHz estimate of the value of 800 MHz in the UK, i.e. net of expected DTT co-existence costs (below, we refer to this as "Telefonica's alternative benchmark"). For countries which we analyse on a "gross" basis, this implies the following formula for the 900 MHz relative value benchmark:

$$\frac{900_{BC}}{800_{BC\,\mathbf{gross}}} \times 800_{UK\,\boldsymbol{net}}$$

A7.83 However, we do not consider Telefónica's alternative benchmark provides useful additional information (especially where we have benchmarks which are not affected by expected DTT co-existence costs).

A7.84 First, we reiterate that our reason for taking £3m per MHz as the difference between 800 MHz UK market value gross and net of DTT co-existence costs is not that it was the maximum liability for these costs. Rather, we adopt this figure based on evidence of the assumptions made by bidders in the UK auction, as set out in detail in Annex 6.

A7.85 Second, for countries where gross 800 MHz values are available, we consider that Telefónica's alternative benchmark treats the prices of 800 MHz in the benchmark country and the value of 800 MHz in the UK in an inconsistent manner. The former is gross of expected DTT co-existence costs, whilst the latter is net of such costs. Therefore, the resulting relative value benchmark systematically understates the value of the ALF band for countries which we analyse on a "gross" basis. For this reason we do not consider this to be an appropriate benchmark.

A7.86 Telefónica also argued that, for relevant countries, we should calculate, as a cross-check, a benchmark using those local licence prices that were not affected by such adjustments. We understand this to be the benchmark calculated on a "net" basis. That is, including only the prices of 800 MHz spectrum affected by DTT co-existence cost in the relativities to other bands in the benchmark countries, and applying these relativities to the £30m per MHz estimate of value of 800 MHz in the UK. This implies the following formula for the 900 MHz relative value benchmark (which we also use in countries where we rely on information net of expected DTT co-existence costs):

$$\frac{900_{BC}}{800_{BC\,\boldsymbol{net}}} \times 800_{UK\,\boldsymbol{net}}$$

A7.87 For completeness, we consider below the effect of deriving additional benchmark values, calculated on a "net" basis even for countries where a price is available which is gross of expected DTT co-existence costs.

A7.88 In countries where we observe different 800 MHz prices, possible alternative benchmarks could be derived, depending on expected DTT co-existence costs and/or coverage obligations:

a) Our preferred relative values in Austria, Spain, Italy and Sweden use an 800 MHz price based on lots which were unaffected by DTT coexistence costs. But we could alternatively derive benchmarks by taking the 800 MHz prices net of expected DTT co-existence costs and comparing them to the corresponding UK

value (i.e. to the 800 MHz value net of expected DTT costs). This is the formula set out at paragraph A7.86 above. Compared to our preferred benchmark, this alternative benchmark uses the same absolute value for 900 MHz or 1800 MHz in the benchmark country, but a lower 800 MHz price in the benchmark country and a lower UK 800 MHz value.

b) Our preferred relative values in Austria and Sweden use an 800 MHz price based on lots which did not include a coverage obligation (that we consider to be onerous). But we could alternatively derive benchmarks by taking the 800 MHz prices for the coverage obligation lots and comparing them to the corresponding UK value (i.e. to the value with coverage obligation, which is £31.45m per MHz, gross of expected DTT co-existence costs). Compared to our preferred benchmark, this alternative benchmark uses the same absolute value for 900 MHz or 1800 MHz in the benchmark country, but a lower 800 MHz price in the benchmark country and a lower UK 800 MHz value.

A7.89 The effect of using these possible alternative benchmarks is set out in Tables A7.5 and A7.6.

A7.90 Table A7.5[81] shows that the alternative benchmarks are actually higher in all cases with the single exception of Italy when its benchmark is based on 800 MHz values net of DTT coexistence costs. The alternative benchmark figure is the same or similar in Austria, slightly higher in Spain, and substantially higher in Sweden. This is because, compared to our preferred benchmark, the 800 MHz value in Sweden in the alternative benchmark is lower by proportionally more than the UK 800 MHz value. These results suggest that expected DTT co-existence costs had a proportionally greater impact on prices in these countries than in the UK. We understand that technical restrictions on use of the bottom two lots in Sweden were particularly stringent.[82]

A7.91 Turning to coverage obligations, all three benchmarks in Table A7.6 are higher under the alternative approach using lot prices which were affected by coverage obligations. Again, this is consistent with our understanding that coverage obligations associated with relevant lots in Austria and Sweden were extensive, and suggests that they had a proportionally greater impact on prices than in the UK.

A7.92 On balance, we do not consider that we should include the above possible alternative benchmarks as additions to the set of benchmarks we have used to inform our view of the lump-sum value of ALF spectrum bands. We remain of the view that, where possible, we should derive benchmarks which do not rely on implicit assumptions about the relative impact of DTT coexistence and coverage obligation costs between benchmark countries and the UK.

[81] In Germany, we only have one Y/X ratio (see the following discussion of the distance method), which was calculated on a "gross" basis using the prices of all six available 800 MHz lots. The lowest 800 MHz lot, which was subject to usage restrictions to protect DTT, did not sell at a lower price (it actually sold at a premium), which suggests that expected DTT co-existence costs were not material. Because of the very small value of the German Y/X ratio, the main driver of the value of the German distance method benchmark (£5.6m per MHz) is the price of 2.6 GHz in the UK.

[82] See http://www.pts.se/upload/Beslut/Radio/2011/10-10534-appendix-a-to-decision-800mhz.pdf for additional restrictions on the bottom two blocks.

Table A7.5: Comparison of relative value benchmarks for 900 MHz and 1800 MHz with different approaches to expected DTT co-existence costs (in £m per MHz)

Country	Our preferred benchmark (based on gross values of 800 MHz)	Possible alternative benchmark (based on net values of 800 MHz)	800 MHz price used for possible alternative benchmark	% difference of alternative to preferred benchmark
Austria (900 MHz)	£37.8m	£38.6m	A1 lot (net of expected DTT coexistence costs; no coverage obligation)	2%
Spain (900 MHz)	£22.2m	£24.6m	A1 lot (net of expected DTT coexistence costs; no coverage obligation)	11%
Austria (1800 MHz)	£23.0m	£23.1m	A1 lot (net of expected DTT coexistence costs; no coverage obligation)	0%
Italy (1800 MHz)	£12.8m	£12.3m	Bottom lot (net of expected DTT coexistence costs; no coverage obligation)	-4%
Sweden (1800 MHz)	£16.0m	£26.0m	Average of the bottom two lots (net of expected DTT coexistence costs; no coverage obligation)	63%

Source: Ofcom

Table A7.6: Comparison of relative value benchmarks for 900 and 1800 MHz with different approaches to coverage obligation (in £m per MHz)

Country	Our preferred benchmark (without coverage obligation)	Possible alternative benchmark (with coverage obligation)	800 MHz price used for possible alternative benchmark	% difference of alternative to preferred benchmark
Austria (900 MHz)	£37.8m	£47.4m	A3 lot (gross of expected DTT coexistence costs; coverage obligation)	25%
Austria (1800 MHz)	£23.0m	£27.5m	A3 lot (gross of expected DTT coexistence costs; coverage obligation)	20%
Sweden (1800 MHz)	£16m	£17.9m	Top lot (gross of expected DTT coexistence costs; coverage obligation)	12%

Source: Ofcom

Proxies for the value of 2.6 GHz spectrum in Ireland and Sweden

A7.93 In its response to our October 2013 consultation where AM&A first proposed the distance method, it suggested that, in countries where 2.6 GHz spectrum had not been auctioned, a value of zero could be used as a proxy for the 2.6 GHz value in order to generate a distance method benchmark. It noted that under the distance method this provides an upper bound for the value of 1800 MHz in the UK implied by that benchmark country as the true value of 2.6 GHz spectrum in that country could not be below zero, and any higher assumed value for 2.6 GHz would reduce the Y/X ratio, generating a lower 1800 MHz value.

A7.94 In the August 2014 consultation we derived a non-zero proxy for 2.6 GHz in countries where it had not been auctioned since 2010 - Ireland and Sweden. Our approach was to take the average (geometric mean) value of the ratio of 2.6 GHz value to 800 MHz value in all countries where this statistic was available, and multiply this ratio by the value of 800 MHz spectrum in Ireland and Sweden respectively.

A7.95 The dataset used to generate the 1800 MHz benchmarks in Section 3 continues to use a proxy measure for 2.6 GHz in Sweden and Ireland. In the discussion below of the proxy for 2.6 GHz:

a) First, we outline stakeholder responses to the August 2014 consultation.

b) Second, we provide our assessment of those responses.

c) Third, we explain our revision to the derivation of the proxy compared to the August 2014 consultation.

d) Fourth, we assess the predictive power of our preferred approach against possible alternative approaches.

e) Finally, we set out our view on the appropriate approach to derive the 2.6 GHz proxy values for Ireland and Sweden.

Stakeholder responses

A7.96 In its response to this consultation,[83] AM&A acknowledged that, despite its limitations, our proxy is likely to be more accurate than a zero proxy. However, it also argued that auction prices should be used wherever possible – even when the spectrum was auctioned prior to 2010, which is the case for Sweden.[84]

A7.97 Some respondents to the August 2014 consultation questioned the informative value of a distance method benchmark where it was necessary to use a proxy for the value of 2.6 GHz. AM&A considered that countries where a proxy 2.6 GHz price is used to calculate the distance method benchmark should be at most Tier 2.[85] H3G argued that, for Sweden, different assumptions produce a wide range of estimates and the use of the 2008 auction price yields a much lower distance method benchmark.

[83] AM&A response to the August 2014 consultation, p. 27
[84] AM&A response to the August 2014 consultation, p. 25
[85] AM&A response to our August 2014 consultation, page 17

A7.98 Telefónica argued that there is no unique way to calculate the 2.6 GHz proxy and we should calculate it as the average of: (i) our August 2014 proxy; (ii) the proxy value implied by the average ratio of 2600 MHz to 1800 MHz (instead of the ratio to 800 MHz); and (iii) the average 2.6 GHz absolute price.

Our assessment of responses

A7.99 We do not agree with AM&A that it would be appropriate to use the 2008 auction of 2.6 GHz in Sweden for the reasons explained in Annex 8 (paragraphs A8.626 to A8.636).

A7.100 We address the significance of using a 2.6 GHz proxy for choice of tier later in this annex (paragraph A7.172d).

A7.101 We agree with Telefónica's argument that there is no uniquely correct methodology to derive a 2.6 GHz proxy. However, we consider that the alternate proxy measures proposed by Telefonica are less appropriate than our preferred method:

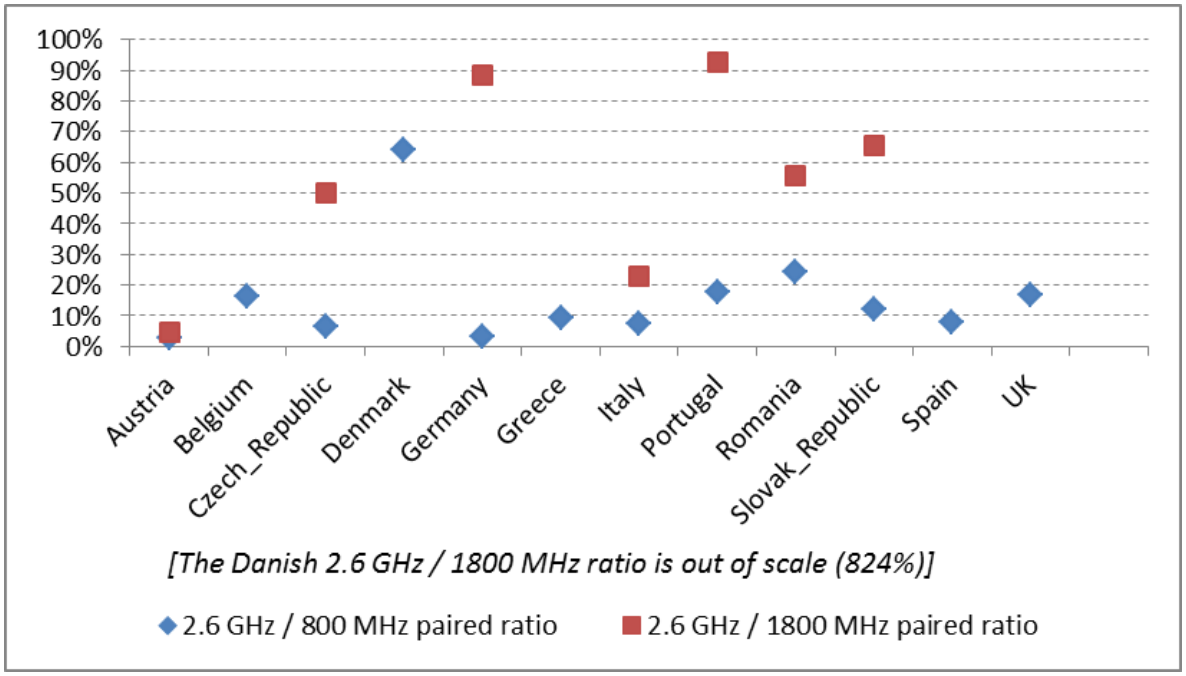
a) Telefónica suggested a proxy based on the ratio of 2.6 GHz values to 1800 MHz values. We note that these ratios appear to be more variable than the ratios of 2.6 GHz to 800 MHz, as shown in Figure A7.2. As discussed below, our revised approach to generating a 2.6 GHz proxy is to focus on countries that provide more useful evidence. If we followed Telefónica's suggestion, it would be appropriate to apply a similar approach to considering 2.6 GHz / 1800 MHz ratios. We have identified four countries where the values of 1800 MHz are sufficiently reliable to serve as the basis for Tier 1 benchmarks. Two of these are the countries for which we are trying to find 2.6 GHz values (Ireland and Sweden), leaving only two observations from which to derive a representative ratio.[86] We do not consider that giving weight to a proxy 2.6 GHz value based on these ratios would improve the robustness of our estimates of the value of 2.6 GHz spectrum in Ireland and Sweden.

b) Telefónica also suggested using the absolute values of 2.6 GHz in the derivation of the proxy values for 2.6 GHz in Ireland and Sweden. The absolute values of 2.6 GHz in different countries are more sensitive to country-specific factors. This is the reason why we focus on relative values in our international benchmarking and not on absolute values. Therefore, we consider that it would be inconsistent to use absolute values in the derivation of the 2.6 GHz proxy.

A7.102 Given that we consider these alternative proxy measures to be less appropriate than our preferred method, we also consider that it would be inappropriate to follow Telefónica's suggestion of taking an average that uses these alternate proxy measures.

[86] The remaining two countries, Austria and Italy, generate somewhat different results for the ratio of 2.6 GHz value to 1800 MHz value, of 4% and 23% respectively. We note that applying the geometric mean of these two ratios (10%) to the values of 1800 MHz in Ireland and Sweden would lead to higher 1800 MHz distance method benchmarks than those which result from our preferred method of deriving 2.6 GHz proxy values, discussed below.

Figure A7.2: Dispersion of paired ratios



Source: Ofcom

Revision to our approach to derive the proxy in the August 2014 consultation

A7.103 As noted above, the 1800 MHz benchmarks for Ireland and Sweden in Section 3 are based on a revision to the derivation of the 2.6 GHz proxy, as compared with the August 2014 consultation. We now explain this revision.

A7.104 In our August 2014 consultation, when calculating the average ratio of 2.6 GHz to 800 MHz for the purpose of developing our proxy 2.6 GHz values in Ireland and Sweden, we included ratios from all countries in our data set where both bands had been auctioned.[87] An update of these ratios is set out in Table A7.7.

A7.105 The approach in the August 2014 consultation made no distinction between the different countries in the Table A7.7 when calculating the average ratios (which, in the August 2014 consultation were 10.7% and 9.6% on a net and gross basis respectively). However, we now consider that it is appropriate to recognise that the evidence from different countries differs in terms of its quality, as we do when using our tiering approach in the categorisation of the benchmarks. Based on our analysis in Annex 8, we consider that the following countries provide more useful evidence of the ratio of 2.6 GHz prices to 800 MHz prices: Austria, Germany, Italy and Spain.[88] We also consider that the ratio in the UK falls into this category. We refer to these countries in the discussion below as the "five ratio countries"; and they are highlighted in bold in Table A7.7.

[87] For the purpose of deriving these ratios, in countries where we do not observe prices for 800 MHz both net and gross of expected DTT co-existence costs, we assume that these costs are the same proportion of the 800 MHz net value as in the UK (i.e 10%), and apply this adjustment to the observed 800 MHz price in the benchmark country.
[88] We set out our assessment of these ratios in Annex 8, respectively at paragraphs A8.136, A8.264, A8.386 and A8.593.

Table A7.7: Ratios of 2.6 GHz to 800 MHz

Ratio of 2.6 GHz value to:	800 MHz value net of expected DTT co-existence costs	800 MHz value gross of expected DTT co-existence costs
Austria	**3%**	**3%**
Belgium	16%	15%
Czech Republic	7%	6%
Denmark	71%	64%
Germany	**3%**	**3%**
Greece	9%	8%
Italy	**8%**	**7%**
Portugal	18%	16%
Romania	24%	22%
Slovak Republic	12%	11%
Spain	**9%**	**8%**
UK	**18%**	**17%**

Source: Ofcom

A7.106 In the five ratio countries, the absolute value of 2.6 GHz ranges from 3% to 18% of the absolute value of 800 MHz. The average ratio (derived as a geometric mean) across the five ratio countries is 6.9% (taking 800 MHz values net of expected DTT co-existence costs) or 6.1% (gross). Applying the relevant ratio[89] to the value of 800 MHz in Ireland and in Sweden generates an implied 2.6 GHz value of £4.1m in Ireland and £1.3m per MHz in Sweden. As shown in the "average" row in Table A7.8 below, using these proxy values as an input to calculating 1800 MHz distance method benchmarks for the UK, along with the observed values of 800 MHz and 1800 MHz in Ireland and Sweden, generates benchmark values for 1800 MHz of £14.0m per MHz for Ireland and £16.6m per MHz for Sweden.

A7.107 We have compared results based on the average value, as described above, with the results based on the lowest and highest ratios across the five ratio countries – i.e. 3% in Austria and in the UK (17% on a "gross" basis, 18% on a "net" basis) – and the results are shown in Table A7.8. We also show the result with a 2.6 GHz value of zero. Although this is unrealistic, it illustrates the highest possible distance method benchmarks for 1800 MHz in the UK, given the observed 800 MHz and 1800 MHz values in these benchmark countries. As Table A7.8 illustrates, a lower 2.6 GHz value in the benchmark country leads to a higher implied 1800 MHz distance method benchmark for the UK and vice versa.

A7.108 For Ireland and Sweden, the 1800 MHz distance method value based on the average ratio is closer to the higher 1800 MHz value (based on the lowest ratio in the five ratio countries, i.e. Austria) than it is to the lower 1800 MHz value (based on the highest ratio in the five ratio countries, i.e. UK). The percentage differences from the 1800 MHz value for the average ratio are shown in the third column of Table

[89] i.e. the benchmark country 800 MHz value is net of expected DTT co-existence costs in Ireland, and gross of such costs in Sweden.

A7.8. For example, taking the case of Ireland, the higher 1800 MHz value is only 4% above the average. But the lower 1800 MHz value is 16% below the average. Indeed the highest possible 1800 MHz value, derived using a zero ratio, is only 8% above the average. This suggests using the average ratio could involve a greater risk of overstatement than understatement of the 1800 MHz value.

Table A7.8: Sensitivity of Ireland and Sweden distance method 1800 MHz benchmarks to 2.6 GHz proxy

Relativity to 800 MHz:	2.6 GHz value in Ireland / Sweden £m per MHz	Implied 1800 MHz distance method value in UK £m per MHz	% difference from average	% difference from midpoint
Ireland:				
Zero ratio	-	£15.1m	8%	14%
Lowest ratio (Austria)	£1.9m	£14.6m	4%	10%
Average ratio	**£4.1m**	**£14.0m**	**0%**	**5%**
Midpoint ratio	**£6.4m**	**£13.3m**	**-5%**	**0%**
Highest ratio (UK)	£10.9m	£11.8m	-16%	-12%
Sweden:				
Zero ratio	-	£17.6m	6%	10%
Lowest ratio (Austria)	£0.6m	£17.2m	3%	8%
Average ratio	**£1.3m**	**£16.6m**	**0%**	**4%**
Midpoint ratio	**£2.1m**	**£16.0m**	**-4%**	**0%**
Highest ratio (UK)	£3.5m	£14.6m	-12%	-9%

Source: Ofcom

A7.109 Therefore, rather than taking the average of the 2.6 GHz ratios from the five ratio countries, our preferred approach, which reflects a more conservative interpretation of the evidence, is to take the midpoint of the range implied by the highest and lowest 2.6 GHz ratios for each country. The corresponding values are also shown in Table A7.8. For Ireland, this midpoint is 10.8%, corresponding to an 1800 MHz benchmark of £13.3m per MHz. For Sweden, the midpoint is 9.8%, corresponding to an 1800 MHz benchmark of £16.0m per MHz. The final column of Table A7.8 shows the differences compared to the distance method benchmarks derived using these midpoint ratios.

A7.110 We note that taking the average of 2.6 GHz to 800 MHz ratios from all the countries in our data set, which was our approach in the August 2014 consultation,[90] generates similar 1800 MHz benchmarks for Ireland and Sweden (£13.2m per MHz and £15.9m per MHz respectively) to the midpoint of the ranges considered above.

[90] The ratio for Greece was not available at the time, but is now included in the average.

Predictive power of our preferred approach compared to possible alternative approaches

A7.111 Our dataset includes absolute values for each of the 800 MHz, 1800 MHz and 2.6 GHz bands in eight countries.[91] This allows us to test the predictive power of our preferred approach, as follows:

a) We derive a proxy value for 2.6 GHz and a corresponding 1800 MHz distance method value in these eight countries using our preferred approach.

b) We then compare the proxy value in each country against the actual 1800 MHz distance method benchmark using the actual 2.6 GHz value in that country.

A7.112 For the purposes of comparison, we also apply this procedure to two possible alternative proxy methods:

a) Zero proxy, i.e. assuming a value of 2.6 GHz spectrum in the benchmark country of zero.

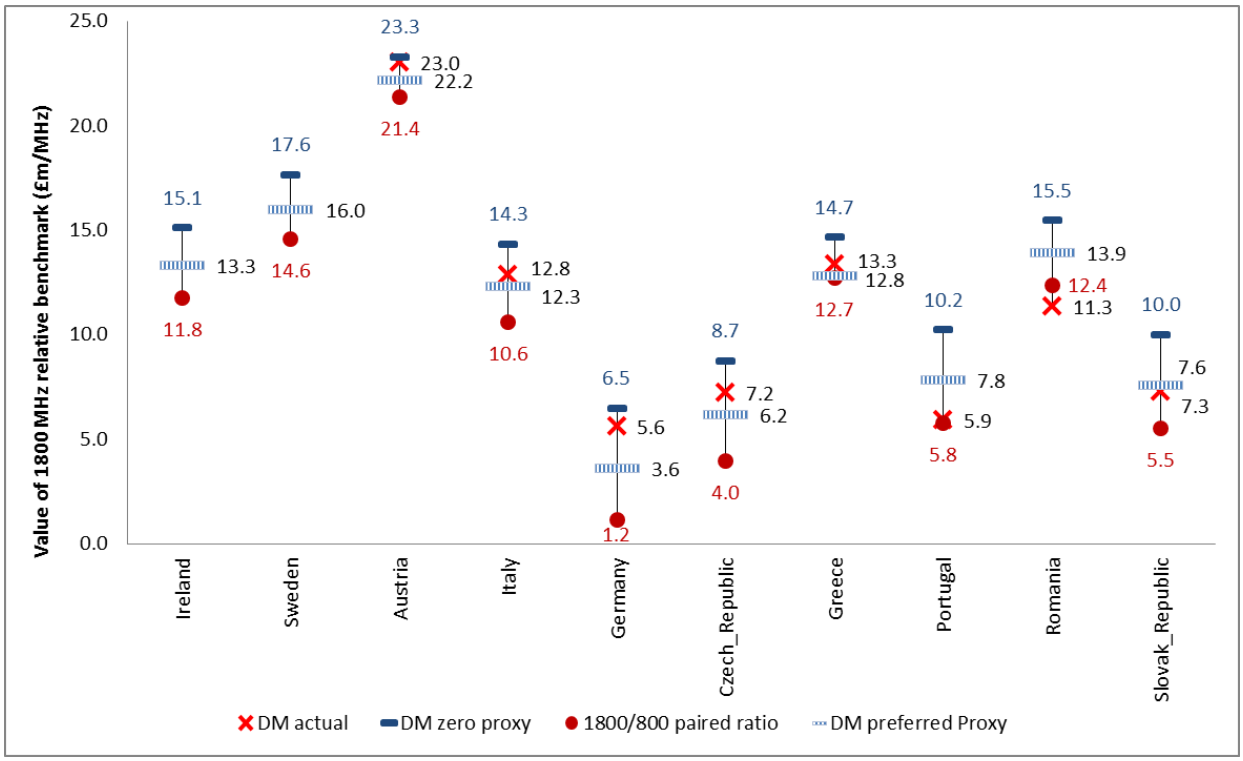
b) 1800 MHz to 800 MHz paired ratio, i.e. deriving the 1800 MHz relative value using this paired ratio instead of the distance method.[92]

A7.113 We have set out above our methodological reasons for favouring our preferred approach over either a zero proxy or the 1800 MHz to 800 MHz paired ratio. Below we set out how each of these three methods performs in predicting the 1800 MHz distance method benchmark value for these eight countries.

A7.114 The comparison is shown in Figure A7.3 and Table A7.9, alongside the available information for Ireland and Sweden (i.e. the countries for which we are developing a proxy method).

[91] We exclude Belgium, Spain and the UK because of the absence of an absolute value for the 1800 MHz band, We exclude Denmark because it generates negative estimates using the distance method.
[92] This is equivalent to the distance method calculated with a 2.6 GHz proxy based on the UK ratio of 2.6 GHz and 800 MHz.

Figure A7.3: Comparison of distance method benchmarks with alternative proxy methods (in £m per MHz)



Source: Ofcom

Table A7.9: Comparison of distance method benchmarks with alternative proxy methods (in £m per MHz)

Country	DM actual	DM zero proxy	Difference from DM actual	1800/800 paired ratio	Difference from DM actual	DM preferred proxy	Difference from DM actual
Ireland		15.1		11.8		13.3	
Sweden		17.6		14.6		16.0	
Austria	23.0	23.3	+0.3	21.4	-1.7	22.2	-0.8
Italy	12.8	14.3	+1.5	10.6	-2.3	12.3	-0.6
Germany	5.6	6.5	+0.8	1.2	-4.5	3.6	-2.0
Czech Republic	7.2	8.7	+1.5	4.0	-3.3	6.2	-1.1
Greece	13.3	14.7	+1.3	12.7	-0.7	12.8	-0.5
Portugal	5.9	10.2	+4.3	5.8	-0.1	7.8	+1.9
Romania	11.3	15.5	+4.1	12.4	+1.0	13.9	+2.6
Slovak Republic	7.3	10.0	+2.7	5.5	-1.8	7.6	+0.3
Range of differences			**+0.3 to +4.3**		**-4.5 to +1.0**		**-2.0 to +2.6**
Average difference			**+2.1**		**-1.6**		**-0.03**

Source: Ofcom

A7.115 For the eight countries, we can see that:

a) The zero proxy for 2.6 GHz leads to an overstatement in the 1800 MHz distance method benchmark in all eight countries. On average, the overstatement is £2.1m per MHz. The zero proxy provides the best prediction in two countries: Austria (Tier 1) and Germany (Tier 2). This is not surprising as in those countries the price of 2.6 GHz was very low relative to other spectrum bands. Our preferred approach is the second best proxy in these two countries, and understates the 1800 MHz distance method benchmark in both cases.

b) The 1800 MHz / 800 MHz paired ratio understates the distance method benchmark in seven of the eight countries. On average, the understatement across all eight countries is £1.6m per MHz. The paired ratio provides the best prediction in three countries: Greece, Portugal and Romania, which are all Tier 3 countries. Our preferred approach is the second best proxy for these three countries.

c) Our preferred method understates the distance method benchmark in five countries (Austria, Italy, Germany, Czech Republic and Greece and overstates in three (Portugal, Romania and Slovak Republic). On average, it provides a small understatement of £0.03m per MHz. Our preferred method provides the best prediction in three countries: Italy (Tier 1), Czech Republic (Tier 3) and Slovak Republic (Tier 3). As noted above, it also provides the second best prediction in the other five countries.

d) In all countries the distance method benchmark with our preferred method falls in the range between the benchmarks with the paired ratio benchmark and the zero proxy.

A7.116 In our view, this comparison suggests that:

a) The zero proxy method is at risk of overstating the 1800 MHz distance method benchmark.

b) The 1800 MHz / 800 MHz paired ratio is at risk of understating the 1800 MHz distance method benchmark.

c) Our preferred approach provides better predictions on average than either the zero proxy method or 1800 MHz / 800 MHz paired ratio. In addition, we do not have clear evidence that it is likely systematically to overstate or understate values.

Our preferred approach to derive 2.6 GHz proxy values for Ireland and Sweden

A7.117 As noted by Telefónica, there is no uniquely correct methodology to derive a 2.6 GHz proxy. However, we have set out above our methodological and empirical reasons for favouring our preferred approach over alternative methods, including those put forward by Telefónica (1800 MHz to 2.6 GHz paired ratio and absolute values of 2.6 GHz).

A7.118 Using our preferred approach of taking the 1800 MHz distance method values implied by the midpoint of the range of ratios in the five ratio countries, we consider that:

a) the 2.6 GHz values associated with this approach (£6.4m for Ireland and £2.1m for Sweden) are the appropriate 2.6 GHz proxy values for these two countries;

b) £13.3m is the appropriate distance method benchmark value of 1800 MHz for Ireland; and

c) £16.0m is the appropriate benchmark value of 1800 MHz for Sweden.

Effect of risk of overstatement or understatement in band-specific values on 1800 MHz benchmark

A7.119 The effect of a risk that a benchmark overstates or understates UK market value in the price of a spectrum band in a benchmark country will be to change the Y/X ratio set out above, which is:

$$\frac{1800_{BC} - 2.6_{BC}}{800_{BC} - 2.6_{BC}}$$

A7.120 The effect on the Y/X ratio depends on the band:

a) An overstated 1800 MHz value will increase the ratio, leading to an overstated distance method benchmark.

b) An overstated 800 MHz value will reduce the ratio, leading to an understated distance method benchmark.

c) If 800 MHz has a higher value than 1800 MHz in the benchmark country, as is the case for all countries from which we derive 1800 MHz distance method benchmarks, an overstated 2.6 GHz value will reduce the ratio, leading to an understated 1800 MHz distance method benchmark, and vice versa.[93]

A7.121 The effect of an understated or overstated Y/X ratio on the distance method benchmark depends on the relative distance between bands in the benchmark country:

a) In countries where the Y/X ratio is low (such as Germany, Portugal and the Czech and Slovak Republics) the distance method benchmark largely reflects the UK value of 2.6 GHz (component (c) in the equation in paragraph A7.61 above), so a moderate absolute understatement or overstatement in the prices of bands in the benchmark country's auctions will tend to have a limited effect.

b) In countries where there is a higher Y/X ratio, such as Austria, Italy and Romania, the potential effect of a moderate absolute understatement or overstatement in band prices on the distance method benchmark will tend to be greater, as the component based on the absolute distance of 800 MHz and 2.6 GHz in the UK (component (b) in the equation in paragraph A7.61) has relatively more weight than component (c) based on the UK 2.6 GHz value.

[93] To take a very simple example, suppose that the true values for 1800 MHz, 800 MHz and 2.6 GHz are 2, 3 and 0 respectively, but the observed 2.6 GHz value is 1. The correct ratio is 2/3 or 67%, but the observed ratio will be ½ or 50%.

Interpretation of benchmarks

Quality of evidence: tiers

A7.122 We categorise the available benchmarks into three tiers which reflect their relative quality according to the extent to which we consider them to be informative of UK market values.

a) Our criteria for placing a benchmark in Tier 1 are that:

i) The auction prices appear likely to have been primarily determined by a **market-driven process** of bidding in the auctions (generally this means the prices were not set by reserve prices); and

ii) Based on the evidence available to us, the relative prices in the auction are at least as likely to be based on bidders' **intrinsic valuations** of spectrum as on strategic bidding; and

iii) The outcome appears likely to be informative of forward-looking relative **spectrum values in the UK**, having regard to country-specific circumstances and auction dates (i.e. (b) (ii) below does not hold).

b) Our criteria for placing a benchmark in Tier 2 are that one or more of the criteria for Tier 1 are not met; however:

i) There is some evidence that the relative auction prices reflect bidders' relative intrinsic valuations of different bands; and

ii) There is a clear, evidence-based reason for considering that the outcome is less informative of forward-looking relative spectrum values in the UK, however the outcome is not obviously *uninformative* of forward-looking relative spectrum values in the UK.

c) Our criterion for placing a benchmark in Tier 3 is that it does not meet the criteria for Tier 1 or Tier 2.

A7.123 We recognise that applying these criteria entails a degree of judgement. However, we consider that this is appropriate in light of the limited number of benchmarks available, and the challenges in interpreting them. A more mechanistic set of criteria, such as those proposed by some stakeholders, risks downgrading benchmarks which are more informative of UK market values, or upgrading benchmarks which are less informative.

Risk of understatement or overstatement

A7.124 In some cases there is a risk that the benchmark is an understated or overstated estimate of the UK value of the relevant band. We characterise the nature of the risks according to the:

a) Likelihood of understatement or overstatement (irrespective of its scale in point b) below): we consider whether this can be categorised as a larger risk or a smaller risk, but in some cases we cannot be sure of the likelihood of possible understatement or overstatement.

b) Scale of the potential understatement or overstatement: we consider whether this can be categorised as larger or a smaller understatement or overstatement, but in some cases we cannot be sure of the scale of possible understatement or overstatement.

c) Direction of potential effect: whether the risk is of an understatement or overstatement, or both. In some cases there may be some reasons for considering the benchmark may be an understatement, and other reasons for considering it may be an overstatement. In these cases, we reach a view as to whether the effects tend to balance out, or one is likely to be stronger than another.

A7.125 In assessing the risks, we consider both whether the auction outcomes are likely to reflect market value in the country concerned, and also whether there are other factors, such as country-specific factors or the date of the award, that might inform our interpretation of what the benchmark says about market value in the UK. In the following paragraphs we consider each of these points in turn.

Whether auction outcomes reflect market value in the country concerned

A7.126 Auction outcomes may not reflect the market value of spectrum in the relevant country for a number of reasons, for example due to:

a) Design of the auction: tight spectrum caps may mean there was limited competition in the auction, so that prices may understate market value. Where NRAs have placed restrictions on their auctions such as spectrum caps, spectrum reservations or exclusions of certain bidders (especially incumbents), these can have the effect of preventing some bidders from genuinely expressing their intrinsic value for incremental spectrum, which may be above the valuation of the lowest winning bidder in the auction.

b) Strategic bidding: bidders may bid above their intrinsic value of spectrum to foreclose other bidders or to raise their costs. Alternatively they may seek to understate their demand for spectrum in order to acquire it at a lower price. Types of strategic bidding are described in paragraph A7.148 below.

A7.127 In some auctions we observe that the auction prices are at, or very close to, reserve prices, either for individual lots or for the sum of reserve prices across lots in winning packages. If all spectrum was sold, this means that winners valued the spectrum above the reserve price, but the valuation of the highest losing bidder may have been below the reserve price, suggesting that the reserve price may be an upper bound on market value. If some spectrum was unsold at reserve price, this is a further reason for thinking that prices risk overstating market value.

A7.128 However, an observation that prices did not exceed reserve, and/or that some spectrum was unsold, does not necessarily mean that the reserve price overstated market value. For example, competition in the auction may have been restricted by binding spectrum caps or other regulatory provisions, or bidders may have strategically understated their demand to keep prices low. The situation is further complicated for relative benchmarks, where one or more of the prices used to calculate the benchmark is a reserve price, and/or where spectrum sold out in one band but not another.

A7.129 In view of these considerations, it is necessary to consider the circumstances of the auction on a case by case basis, and we follow this approach in Annex 8.

Whether country-specific factors influence the interpretation of benchmarks

A7.130 In the August 2014 consultation, we considered whether country-specific factors might lead a benchmark to be at risk of overstating or understating the market value of 900 MHz and 1800 MHz spectrum in the UK. The relevant consideration for our benchmarking framework is whether country-specific factors might affect the relative values of different frequency bands.

A7.131 We said that:

a) There are possible reasons for considering that differences in urbanisation between countries may drive differences in bands, particularly leading to higher relative values for 800 MHz and 900 MHz spectrum in less urbanised countries compared to higher-frequency spectrum. The available empirical evidence provides some support for this view, and we have taken account of this in interpreting evidence from countries which are considerably less urbanised than the UK.

b) There may be reasons for considering that large differences in the proportion of traffic that is 2G drive differences in values, particularly higher values of 900 MHz spectrum relative to other bands. However, the available empirical evidence does not provide clear support for such a relationship, and we have not generally taken such differences as a basis for considering there to be a risk of understatement or overstatement.

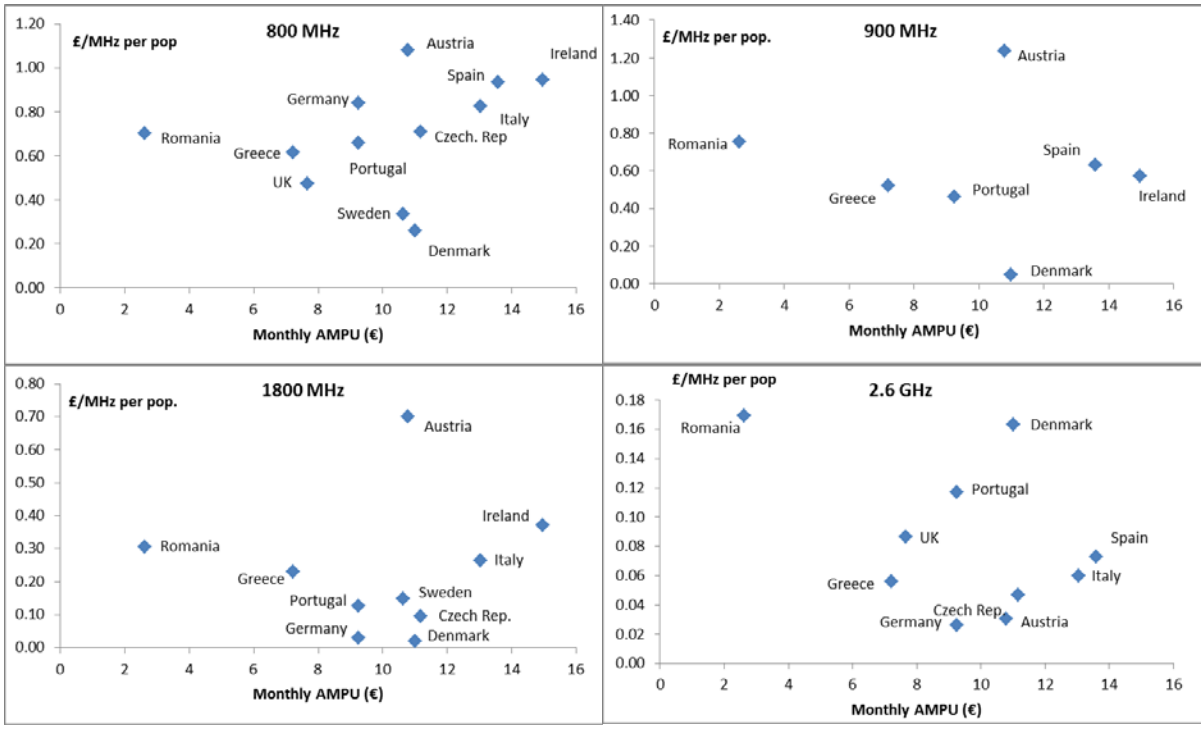
c) The case for other country-specific factors (for example, average margin per user or AMPU) driving differences in relative values is unclear, and does not appear to be supported by the empirical evidence as a systematic driver of auction prices, and we have not taken differences in these other factors as a basis for considering a risk of understatement or overstatement.

A7.132 Stakeholders did not disagree with our interpretation of these country-specific factors. However, for completeness we have repeated the empirical analysis of country-specific factors discussed in paragraphs A7.62-A7.78 of the August 2014 consultation, based on our revised benchmarking dataset, to consider whether or not the available evidence continues to support our interpretations above.

AMPU

A7.133 Updated evidence as to the relationship between average margin per user (AMPU) and auction prices is presented in Figure A7.4. The scatter plots are still based on a small number of evidence points, as we have only added two data points (800 MHz and 2.6 GHz for Greece) since August 2014. Our view remains that these scatter plots do not provide clear evidence of a positive relationship in any of the relevant spectrum bands, or collectively.

Figure A7.4: AMPU scatter plots[94]



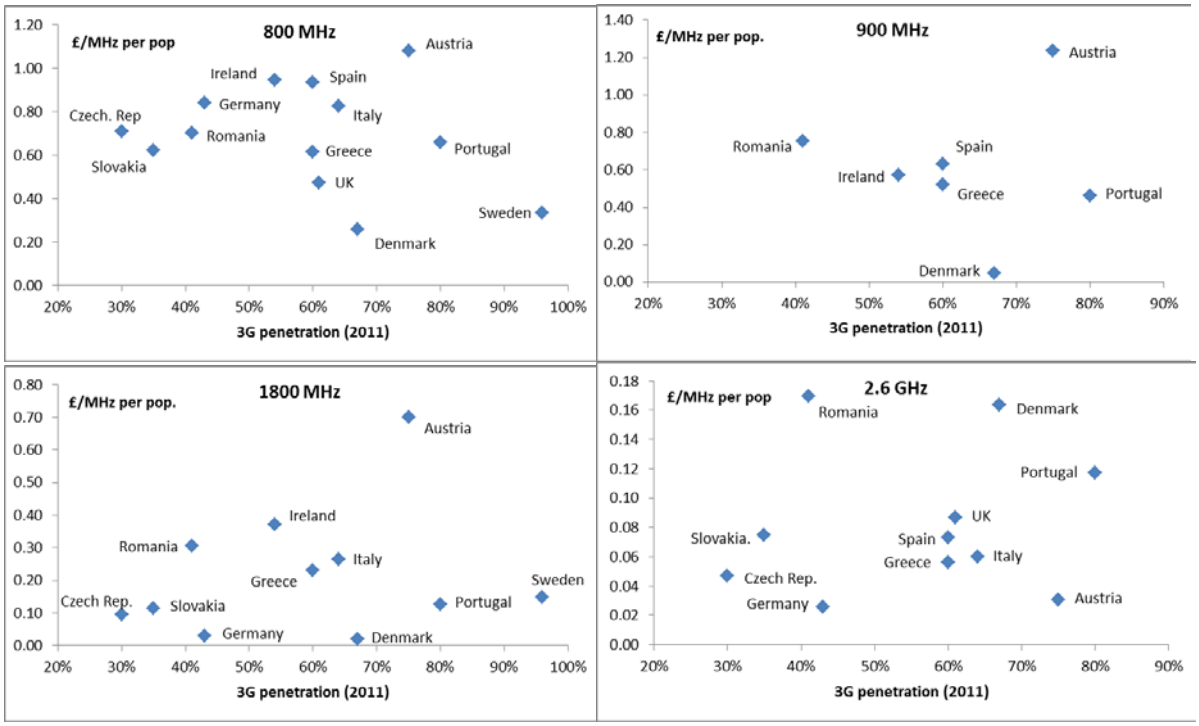
Source: Ofcom

Demand for 2G spectrum

A7.134 In the August 2014 consultation we considered the argument that ALF spectrum should be valued more highly in countries with relatively high 2G traffic than in countries where a majority of customers are using 3G and 4G enabled devices, and we noted this would imply a negative relationship between 3G penetration rates and auction prices for the ALF bands. We present updated scatter plots of 3G penetration and auction prices in Figure A7.5 below. As in the August 2014 consultation, these scatter plots do not indicate that there is a negative correlation between these factors for the 900 MHz and 1800 MHz bands. The evidence does not therefore provide support for the argument that the ALF spectrum bands are valued more highly in countries where there is higher demand for 2G services.

[94] We note that these scatter plots do not include data for the Slovak Republic.

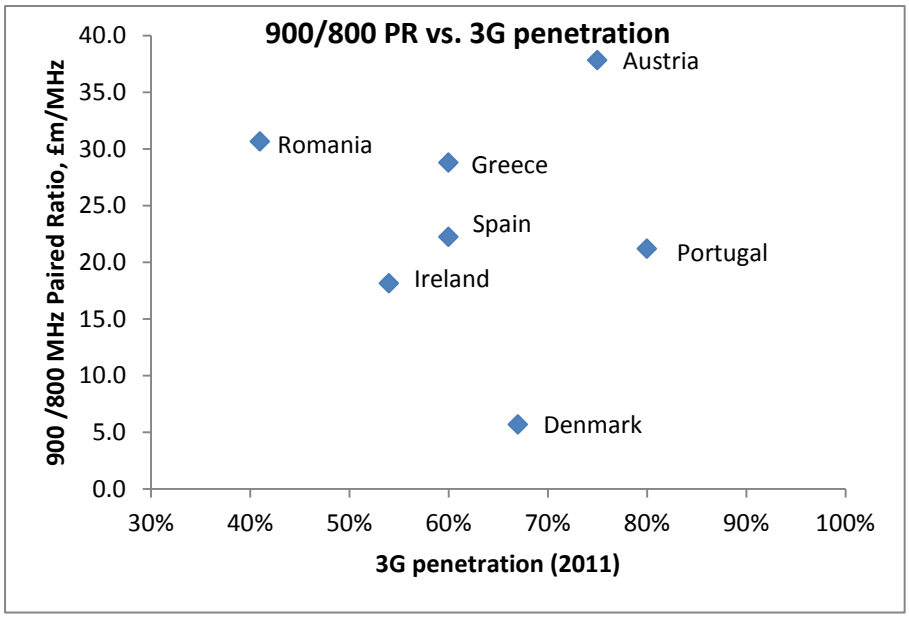
Figure A7.5: 3G penetration scatter plots



Source: Ofcom

A7.135 In addition to looking at the absolute value of auction prices by band, we also considered the relationship between 3G penetration and the 900 MHz / 800 MHz paired ratio, presented in Figure A7.6. Comparing 3G penetration rates against a relative value – the 900 MHz / 800 MHz paired ratio – should in principle control for the presence of other country-specific factors. We now have seven benchmarks to test this proposition (as Greece is now included). As in the August 2014 consultation, the evidence does not provide support for a negative relationship.

Figure A7.6: 900 MHz / 800 MHz paired ratio to 3G penetration



Source: Ofcom

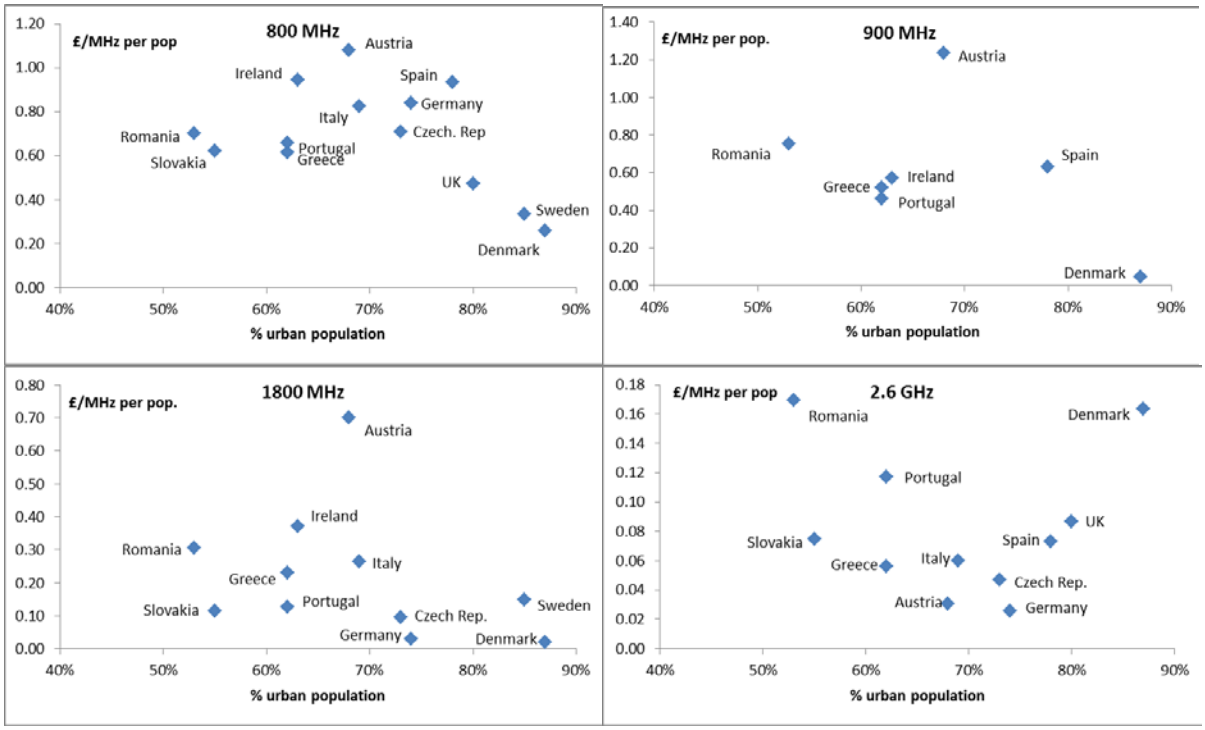
Urbanisation

A7.136 We have considered whether there is an empirical relationship between auction prices and urbanisation. The updated scatter plots are shown in Figure A7.7 below. As in the August 2014 consultation:

a) They are broadly consistent with a negative relationship between urbanisation and auction prices for sub-1 GHz spectrum. This is slightly clearer in the case of 800 MHz than 900 MHz.

b) They do not provide evidence of a relationship between urbanisation and auction prices for 1800 MHz or 2.6 GHz spectrum.

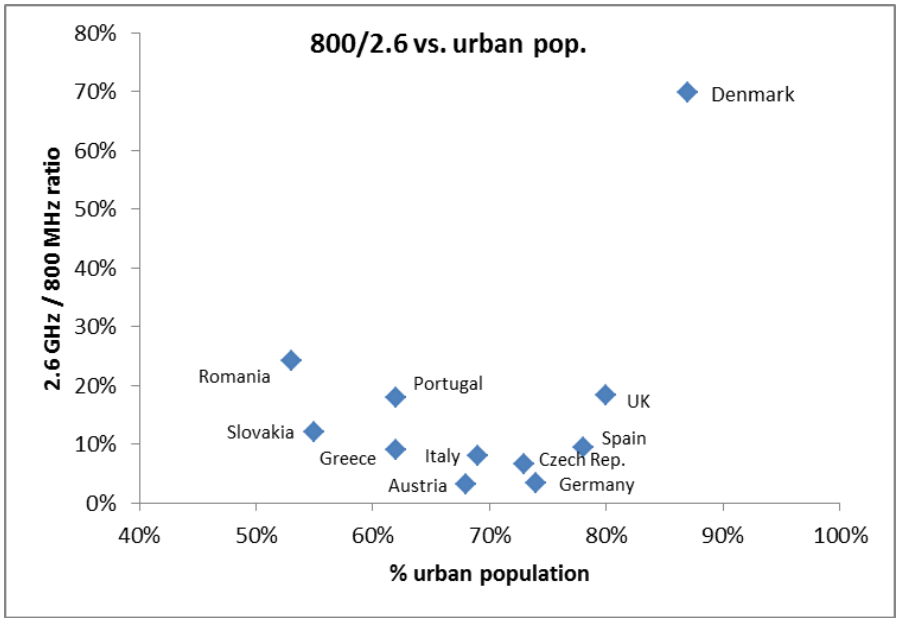
Figure A7.7: Urbanisation scatter plots



Source: Ofcom

A7.137 We also consider the relationship between urbanisation and the ratio of 2.6 GHz and 800 MHz auction prices, presented in Figure A7.8. We would expect this ratio to display a positive correlation with urbanisation levels if more urbanised countries value 2.6 GHz relatively more than sub-1 GHz spectrum. However the updated scatter plot does not provide clear evidence of such a relationship.

Figure A7.8: 2.6 GHz / 800 MHz ratio to urbanisation levels



Source: Ofcom

A7.138 Overall, we consider that the positions outlined above in paragraph A7.131 remain consistent with the available empirical evidence based on our revised benchmarking dataset. Accordingly, we have maintained our views on the impact of these factors on our interpretation of benchmarks.

Summary of conclusions on country-specific factors

A7.139 As in the August 2014 consultation, we still consider that:

a) Values for 800 MHz and 900 MHz spectrum compared to higher-frequency spectrum may be higher in less urbanised countries.

b) Values of 900 MHz spectrum may be higher relative to other bands in countries where there is a larger proportion of 2G traffic, although the available empirical evidence does not provide clear support for such a relationship.

c) The case for other country-specific factors (for example, average margin per user or AMPU) driving differences in relative values is unclear, and does not appear to be supported by the empirical evidence as a systematic driver of auction prices.

Whether date of award influences the interpretation of benchmarks

A7.140 We also consider whether the timing of awards may have affected the value of spectrum. Specifically, the development of LTE ecosystems for the 900 MHz and 1800 MHz bands over recent years may have increased the value of these bands to losing bidders, and hence their auction prices. If so, older auction results may understate the current forward-looking value of these bands in the UK.

900 MHz

A7.141 In the August 2014 consultation we said that there was limited evidence of a change in LTE900 expectations over the period of auctions we are considering, and we did not take this factor into account in our interpretation of benchmarks.

A7.142 H3G said in its response to the August 2014 consultation that 4G is being rapidly deployed across other European markets.[95] In light of this, and of recent developments since August 2014, we have reassessed the prospects for LTE900. We discuss this issue further in paragraphs A9.14-A9.32 of Annex 9. Based on the evidence presented in Annex 9, we now consider that there is some evidence of a recent increase in commercial opportunities for LTE deployment in the 900 MHz band:

a) Some potentially important developments (e.g. the release of popular devices which support LTE900 – see paragraph A9.24) took place before the Austria multiband award in October 2013, and we do not have a basis for considering that this award understated the forward-looking market value of 900 MHz spectrum.

b) Of the other auctions of 900 MHz spectrum in our data set, the most recent was in Ireland in November 2012. A number of the potentially important commercial developments discussed in Annex 9 took place later than this date. On balance, we consider that 900 MHz values observed in Ireland, and in earlier awards in Denmark, Greece, Portugal and Spain,[96] risk understating the forward-looking market value of 900 MHz spectrum in the UK, although we cannot be sure of the scale or likelihood of this risk.

1800 MHz

A7.143 In the August 2014 consultation we considered evidence relating to the development of LTE1800 (which is presented in paragraphs A9.33-A9.34). Based on this evidence we said that:

a) Increased interest in Europe in 1800 MHz for LTE can reasonably be dated between late 2011 and early 2012. Auctions which took place after early 2012 are therefore likely to reflect the emergence of an LTE1800 ecosystem.

b) It is possible that operators would have anticipated in mid-2011 the development of the LTE1800 ecosystem, and factored this into their auction strategies accordingly. However, we do not have clear evidence that this was the case. We considered that uncertainty around the ecosystem may have meant that the value of 1800 MHz was lower (by comparison with 2013 valuations) to some degree in auctions conducted in 2011 (Italy, Sweden and Portugal). We considered there is a risk that the market value of 1800 MHz in these auctions is a smaller understatement of the UK market value of 1800 MHz, though we cannot be sure of the likelihood of this risk.

c) For auctions conducted before 2011 (Germany and Denmark), there was much less certainty about the LTE1800 ecosystem. This may have led 1800 MHz to be considerably undervalued (by comparison with 2013 valuations) in auctions conducted in 2010. We considered there is a larger risk that the market value of 1800 MHz in these auctions understates the UK market value of 1800 MHz, at a larger scale of potential understatement.

[95] H3G response to the August 2014 consultation, page 34

[96] In Romania, we believe that the continuing importance of 2G to incumbent and new entrant operators means that developments in LTE900 prospects are not so relevant.

A7.144 For auctions of 1800 MHz before 2011, we also considered that the likelihood and scale of the risk of understatement are of sufficient importance that we should take it into account in our judgement on the relevant tier for the benchmark.

A7.145 AM&A (p. 13) questioned our view that the timing of awards makes the relative values less reflective of market value today. We discuss AM&A's arguments in more detail in paragraphs A9.35 to A9.37. Based on this assessment, we remain of the view that the timing of awards creates a risk that the market value of 1800 MHz at the time of the awards understates the UK market value of 1800 MHz today, as set out above, and we have continued to take account of this in our interpretation of the relevant 1800 MHz benchmarks, as set out above.

A7.146 The above paragraphs discuss the relevance of the date of an award with respect to the use of 900 MHz and 1800 MHz for LTE (4G). For 3G, our view is that the position of these bands has not changed materially over the period of the awards we consider. The 900 MHz band has been used to provide 3G services for several years. In contrast, it is unlikely that much value has been attached to the prospective use of the 1800 MHz band for 3G, particularly since the recent migrations from 2G in the 1800 MHz band (where they have happened) have been from 2G to LTE.

Strategic behaviour

A7.147 Several respondents argued that operators in some auctions had the incentive and ability to bid strategically and had done so, and that this behaviour caused final auction prices for certain spectrum bands to diverge from market value, with the result that both absolute and relative values overstate or understate respective market values.

A7.148 We characterise these arguments in terms of a number of different types of strategic behaviour, in particular:

a) Strategic investment, where a bidder, with the aim of foreclosing downstream competition, bids above its intrinsic value of spectrum to prevent it being acquired by the bidder's downstream competitors.[97] Such a bidding strategy (whether or not it achieves its aim) by one or more bidders could result in auction prices that overstate market value.

b) Price-driving, where a bidder overstates its true demand to raise the auction prices paid by other bidders. One potential motivation is to force another bidder to spend more for one lot category, so that it has a smaller budget to compete for another category in which the price-driving bidder is interested. Another is to weaken downstream competition (by making it harder for the bidder who is the intended target of a price driving strategy to finance other investments which could otherwise make it more competitive). Price driving could lead to auction prices that overstate market value in some bands, and possibly to prices that understate market value in other bands (if the bidder who is the intended target of a price driving strategy is budget-constrained in the latter).

[97] We distinguish here between intrinsic value and strategic investment value to a bidder. Intrinsic value is the bidder's value of the spectrum in the absence of strategic considerations.

c) Strategic demand reduction, where bidders reduce the auction price they pay for the spectrum they purchase by understating their true demand. A bidder may engage in strategic demand reduction unilaterally or coordinated with other bidders (such as through the use of bids as signals between bidders as to their intentions). Strategic demand reduction will lead to auction prices that understate market value.

d) Signalling, for example where a bidder places a bid for one lot which is intended to send a signal to other bidders of its intentions in other lots in the same or different spectrum bands in the same auction. One example of signalling might be as part of a coordinated strategy of demand reduction.

A7.149 While operators may have some opportunity to engage in strategic behaviour, this does not necessarily mean that they will do so. In some cases they may be constrained by the auction design from making such bids (for example, spectrum caps are a regulatory safeguard aimed at preventing harmful effects on downstream competition from strategic investment). In other cases a successful strategy relies on a degree of coordination with other bidders that is not easy to establish or to maintain while avoiding detection. In addition, strategic bidding can be risky, potentially leading bidders to overpay for spectrum or fail to acquire their preferred spectrum, without necessarily achieving their strategic objectives.

A7.150 Strategic behaviour involves a bidder departing from straightforward bids of its intrinsic value of the spectrum. This value is private to the bidder, and not generally visible. While some patterns of bidding may provide evidence of a strategic motive, allegations of strategic bidding are often difficult to prove or disprove.

A7.151 In the absence of clear evidence, we are not in a position to take the view that alleged cases of strategic bidding behaviour did or did not occur. We take account of arguments relating to strategic behaviour as follows:

a) Quality of evidence (tiers): in deciding the tier to which a benchmark belongs, we consider the extent to which relative prices are likely to reflect intrinsic valuations or strategic behaviour, as described in paragraph A7.148 above. We have not identified any benchmarks where, on the available evidence, we consider the benchmark should be in a lower tier solely in view of the likelihood of strategic behaviour.[98]

b) Risk of understatement or overstatement: in some cases, the possibility of strategic behaviour informs our assessment of whether there is a risk of understatement or overstatement.

Sensitivity analysis

Stakeholder responses

A7.152 Stakeholders commented on the use of sensitivity analysis. In some cases this was in the context of specific critiques of our assessment.

[98] In the case of Germany, we take account of the evidence of strategic bidding (see Annex 8). However, in any case, we would categorise the Germany 1800 MHz benchmark in Tier 2 because it does not satisfy our third criterion for inclusion in Tier 1.

A7.153 AM&A, on behalf of EE and H3G, argued that we had not conducted a rigorous sensitivity analysis, which would have demonstrated that in the case of 1800 MHz our lump-sum value estimates were highly sensitive to the choice of tiers to which benchmarks were allocated. It argued that in light of this we needed to be confident that our tiering criteria produced a robust outcome, but this was not the case (AM&A also proposed its own tiering criteria, listed in paragraph A7.163 (b) below). EE and H3G made similar points in their submissions.

A7.154 Telefónica also noted the sensitivity of our results to the choice of tiers, but said our approach of assessing each benchmark qualitatively had considerable merit, although it disagreed with the weight we had put on the Austria benchmarks for both bands. Vodafone argued that even when using a conservative approach we should supplement this with further checks.

Our assessment

A7.155 We consider a range of criteria and evidence in reaching our view on the most appropriate tier for each benchmark, taking account of points made in stakeholder responses. Similarly, for our assessment of the risks of understatement or overstatement, we consider a range of evidence including stakeholder responses. Our lump-sum value estimates for 900 MHz and 1800 MHz are based on our best view of the most appropriate tier and assessment of risks, given the available evidence.

A7.156 We consider AM&A's tiering analysis in paragraphs A7.171 to A7.184. Clearly, given the relatively small number of benchmarks available for each band, and their range of values, the act of placing a benchmark in one tier rather than another has the potential to make a difference to the analysis.

A7.157 There would be some potential for our analysis of lump-sum values to be different, if we had reached different views on the choice of tiers or assessment of risks for the benchmarks. In some cases moving benchmarks between tiers could imply a higher estimate, such as moving the Ireland 900 MHz or 1800 MHz benchmark to a lower tier. In some cases it could imply a lower estimate, such as moving either of the Austria benchmarks into Tier 2 (which might be more likely to affect 900 MHz, where it is one of only two Tier 1 benchmarks, than 1800 MHz), or moving the Spain 900 MHz benchmark to Tier 1 (although this might have limited effect as it is relatively close to our lump-sum value estimate). Other cases where the changes would be less likely to have an effect include moving the Sweden 1800 MHz benchmark from Tier 1 to Tier 2, or moving the Tier 2 1800 MHz benchmark, Germany, into Tier 1 (while very low, the benchmark is at larger risk of larger overstatement).

A7.158 We explain the reasons for our choice of tier and assessment of risks for each of the benchmarks in this annex and in Annex 8. In addition, we have investigated the sensitivity of benchmarks in relation to a range of considerations including issues discussed in this annex, such as discount rates, treatment of expected DTT co-existence and coverage obligation costs, and methods to derive proxy values for 2.6 GHz in Ireland and Sweden.

A7.159 We do not consider that a revision to either of our lump-sum value estimates for 900 MHz or 1800 MHz spectrum is appropriate in light of this discussion.

A7.160 As regards Vodafone's argument, we note that in addition to the discussion above we have presented cross-checks on our estimates in Section 3.

Stakeholders' tiering proposals

A7.161 A significant focus of stakeholders' comments related to our framework for assigning benchmarks to particular tiers, and to the application of this framework to a number of specific country benchmarks.

A7.162 We discuss stakeholder arguments concerning the tiering of specific benchmarks in the relevant country assessments in Annex 8. In this section we focus on broader comments on our tiering approach, including alternative frameworks proposed by stakeholders.

AM&A (on behalf of H3G and EE)

A7.163 AM&A (on behalf of EE and H3G) argued that our framework to determine the tier for each benchmark was effectively a subjective country-by-country assessment. It presented an alternative framework for deciding the tier and weight to attach to each benchmark:

a) AM&A placed all benchmarks in only two tiers, instead of the three tiers which we used in our August 2014 consultation. AM&A argued that benchmarks in our third tier were effectively excluded from the selection of the lump-sum values and from our weighted average cross-check. It said that removing Tier 3 as a category and placing all non-excluded benchmarks in either Tier 1 or Tier 2 means all of the included benchmarks are given some weighting in the determination of the lump-sum values.[99] H3G said that a three-tier framework produces a much wider range of possible lump-sum values, and that moving to two tiers "reduces the range of possible values, minimising the scope for subjectivity to unduly influence values while still recognising key differences in the quality of individual benchmarks".[100]

b) AM&A used the following criteria for categorising benchmarks as Tier 2 rather than Tier 1. Benchmarks are only classed as Tier 1 under its framework if none of these criteria apply:

   i) Band-specific prices could not directly be inferred (on this basis all combinatorial clock auction (CCA) or other package auction benchmarks are in AM&A's Tier 2);

   ii) some spectrum was unsold;

   iii) significant time had elapsed between auctions for the relevant bands;

   iv) the auction finished at reserve price; or

   v) in the case of 1800 MHz, a proxy was used for 2.6 GHz spectrum.

A7.164 On this basis AM&A categorised all 900 MHz benchmarks in our sample as Tier 2 (except Denmark, which it excluded), and for 1800 MHz it categorised Germany and Italy as Tier 1 and all others as Tier 2.

[99] AM&A's response to the August 2014 consultation, page 12
[100] H3G response to the August 2014 consultation, pages 17 and 20

A7.165 In support of its first criterion in A7.163 b) i) above, AM&A argued that we entirely ignored inaccuracies introduced through the disaggregation of package auction prices.[101] In particular, AM&A questioned how reliable the LRP methodology (used in Austria) or final clock round prices (used for Ireland) could be as measures of band-specific prices.[102] It said that:

a) Even with all relevant data available, there is still a significant uncertainty regarding the magnitude of LRPs. By adopting a marginal bidder approach rather than an LRP approach to determine UK band-specific prices, AM&A said that we acknowledged the inherent error bounds in LRP calculations.

b) Final clock-round prices in the UK were £84.6 million per MHz for 800 MHz and £18.4 million per MHz for 2.6 GHz, which are markedly different from any value in the respective LRP ranges. With respect to Ireland, H3G also noted that the Y/X ratio in the 1800 MHz distance method is very different depending on whether final clock round price ratios or a simple linear fit is used to calculate it.[103]

c) AM&A said that it was inconsistent for Switzerland's band-specific prices to be excluded on the basis that they are unreliable evidence, while no consideration is given to the lack of reliability of band-specific prices in countries such as Austria.[104] AM&A argued that if we exclude entirely certain CCAs, we should classify benchmarks from the CCAs we include as Tier 2 at best.[105]

NERA (on behalf of Telefónica)

A7.166 NERA, on behalf of Telefónica, proposed an econometric approach to screening for potential outliers in our benchmarking sample. Under this approach, NERA pooled our observations from all four spectrum bands (800 MHz, 900 MHz, 1800 MHz and 2.6 GHz) and used this data to construct two models in which either absolute or relative values are explained as a function of population and the frequency band being auctioned. It also included a country-specific error term in addition to the standard error term.

A7.167 Using this model, NERA generated predictions for absolute and relative spectrum prices in each country. NERA then considered a country to be a potential outlier if the observed auction price fell outside of a designated confidence interval (set by NERA at 98%) around the auction prices predicted by its model. NERA argued that this statistical analysis can serve as a starting point for allocating benchmarks to our three tiers of evidence. Specifically, data points that are classed as potential outliers should be assigned little weight unless there are sound qualitative reasons not to dismiss the benchmark.

A7.168 Based on the model outputs, NERA considered that Austria should be downgraded to Tier 3 due to its exceptionally high price, while Ireland should be downgraded to Tier 2 as its value was also significantly above the predicted level, though not outside of the defined confidence intervals. It also said that the qualitative evidence available for the benchmarks supported these tiering revisions, particularly in the

[101] AM&A response to the August 2014 consultation, page 15
[102] AM&A response to the August 2014 consultation, pp. 14-15
[103] H3G response to the August 2014 consultation, page 22
[104] AM&A response to the August 2014 consultation, Annex C1
[105] AM&A response to the August 2014 consultation, page 15

case of Austria (we summarise NERA's qualitative assessment of Austria in paragraphs A8.81-A8.84).

Frontier (on behalf of Vodafone)

A7.169 Frontier (on behalf of Vodafone) did not make substantive comments about the overall tiering framework, but it disagreed with a number of our individual tiering decisions, as summarised below.

Summary of stakeholder tiering proposals

A7.170 We summarise MNOs' tiering proposals for each country benchmark in Tables A7.10 and A7.11 (using the term "lower" in the case of AM&A to reflect its argument that there should be no distinction between Tiers 2 and 3), along with the choice of tier in Ofcom's August 2014 consultation. These tables also highlight those benchmarks where the stakeholder assessment of tier differs from our view in the August 2014 consultation.

Table A7.10: Summary of tiering for 900 MHz benchmarks

	Ofcom August 2014 consultation	Frontier (for Vodafone)	NERA (for Telefónica)	AM&A (for H3G and EE)
Austria	1	3	3	Lower
Denmark	3	3	2	Excluded
Ireland	1	1	1	Lower
Portugal	2	2	2	Lower
Romania	3	3	3	Lower
Spain	2	1	2	Lower

Source: Ofcom from stakeholder responses

Table A7.11: Summary of tiering for 1800 MHz benchmarks

	Ofcom August 2014 consultation	Frontier (for Vodafone)	NERA (for Telefónica)	AM&A (for H3G and EE)
Austria	1	3	3	Lower
Czech Republic	3	3	3	Lower
Germany	2	2	2	1
Ireland	1	1	2	Lower
Italy	1	1	1	1
Portugal	3	3	3	Lower
Romania	3	3	3	Lower
Slovakia	3	3	3	Lower
Sweden	2	1	2	Lower

Source: Ofcom from stakeholder responses

Our assessment

Our view of comments by AM&A (on behalf of H3G and EE)

Criteria for choice of tier

A7.171 We have maintained our three-tier framework for the benchmarking data. We consider that there are material differences in the quality of evidence provided by benchmarks that we place in our second tier of evidence, compared to those that we place in our third tier, and that it is appropriate to recognise this as part of our tiering decisions. We explain our reasons for placing individual benchmarks in these tiers in the relevant country assessments in Annex 8.

A7.172 Turning to AM&A's criteria for not placing benchmarks in Tier 1:

a) AM&A's criterion i) is that benchmarks derived from combinatorial auctions should automatically be excluded from the first tier of evidence. We disagree with this approach (as discussed in further detail below). In the context of 900 MHz, we note that applying this criterion led AM&A to place all benchmarks in the same tier (see Table A7.10). This meant that benchmarks which reflect a market-driven process (Austria and Ireland) were given the same weight as those which largely reflect the ratio of reserve prices set for each band by the NRA (Portugal, Romania and Spain). We do not consider this is an appropriate approach.

b) AM&A's criteria ii) and iv) are not to include in Tier 1 any countries where spectrum in the relevant bands went unsold, or was sold at reserve price. These are broadly similar in effect to the first criterion which we use, i.e. whether auction prices appear likely to have been primarily determined by a market-driven process of bidding in the auctions.

c) AM&A's criterion iii) is a significant time gap between auctions for the relevant bands. The only cases where AM&A applied this criterion in such a way as to arrive at a different decision on choice of tier to us relates to the Austria 1800 MHz benchmark, where there was a three-year gap between the date of the auction for the 2.6 GHz band and the auction for the 800 MHz and 1800 MHz bands.[106] However, this benchmark is not sensitive to the absolute value of 2.6 GHz.[107] As it is unlikely that the benchmark would be materially different if the 2.6 GHz spectrum had been auctioned for a different price at a later date, we do not consider this provides an appropriate basis for putting the benchmark in a lower tier.

d) AM&A's criterion v) is the use of a proxy for 2.6 GHz. We do not consider that the use of a proxy creates a level of uncertainty that justifies an automatic downgrade

[106] The other countries where auctions of the relevant bands did not take place at the same time are Sweden and Greece. In the case of Sweden, there was a seven month gap between the relevant auctions but we note that, in Figure 4.1 of AM&A's response, it did not treat this as a significant time gap for the purposes of this criterion. In the case of Greece, AM&A placed the benchmarks in the lowest tier, as we do.

[107] In Austria, the 800 MHz and 1800 MHz prices were very high relative to 2.6 GHz. This means that a change in the 2.6 GHz price does not affect the Y/X ratio significantly. For example, a doubling of the 2.6 GHz price in Austria only changes the Y/X ratio by 1%, which lowers the distance method benchmark by just £0.3m per MHz (from £23m per MHz to £22.7m per MHz).

of the 1800 MHz benchmarks in countries where we use it (Ireland and Sweden). Instead we consider the use of a proxy in the round along with other factors.

Use of prices from combinatorial auctions

A7.173 We now explain our further views on the use of prices from combinatorial auctions, including our response to stakeholder comments on Austria, Ireland and Switzerland.

A7.174 We recognise that there can be more than one way to estimate a single price for each band in CCAs. However:

a) This issue is not unique to CCAs – in some SMRAs we observe different auction prices for the same band, from which we either select one of the prices or derive a single band price by taking an average.

b) We assess the inclusion and tiering of individual benchmarks on a case-by-case basis, whether they come from an SMRA or a CCA, taking into account in each case the specific circumstances and the price information available.

A7.175 We include in Tier 1 the benchmarks from CCA auctions in both Austria and Ireland and so discuss these in turn.

A7.176 In the case of Austria, we use the LRP methodology to derive band specific prices. AM&A noted that our use of LRP in Austria contrasted with the fact that we did not use it to derive prices in the UK auction – and, in view of its tiering criteria, argued that the Austria benchmarks should automatically be downgraded from Tier 1. AM&A suggested that by departing from LRPs to determine UK band-specific prices we were effectively acknowledging the inherent error bounds in LRP calculations in Austria. We do not agree with AM&A's argument.

A7.177 In Section 2 and Annex 6 we consider four methods in our analysis of bids in the UK 4G auction: (i) decompositions of the auction prices; (ii) decompositions of the opportunity costs in the auction; (iii) LRPs; and (iv) marginal bidder analysis. The following points are relevant to our analysis of the UK auction:

a) In the particular circumstances of the UK auction, we do not take the auction prices as the most appropriate estimates of market value because of various specific complications which we set out in Section 2. For example, decompositions by band of the opportunity costs in the auction generally differ from decompositions of the auction prices, because of the role that reserve prices played in affecting the UK auction prices.

b) In Section 2 we consider LRPs both with and without the revenue constraint. In the circumstances of the UK auction, we identify specific reasons why the revenue-constrained LRPs are too low for the purpose of ALF. We also consider that an advantage of the marginal bidder analysis is that it allows us to examine the implications of specific differences in circumstances from the UK 4G auction which we identify as being relevant to ALF.

A7.178 Our reasons for not preferring LRPs in the case of the UK are not relevant in the case of Austria:

a) The available evidence suggests that reserve prices do not affect the revenue-constrained LRPs in Austria (see paragraphs 14-15 in the May update).

b) We have not identified any corresponding reasons or relevant differences in circumstances why the auction prices or the revenue-constrained LRPs in Austria understate market value.

A7.179 In addition, Table A8.1.6 in Annex 8 shows that there is a significant degree of similarity between the ratios of LRPs (both with and without revenue constraint) and final clock prices in Austria.

A7.180 In the August 2014 consultation we used the LRPs without revenue constraint for Austria benchmarks, and we noted that these provided a better fit with the bids than the revenue-constrained LRPs (as reflected in lower "excursions"). We recognise this argument in favour of using the LRPs without revenue constraint. However, in addition to the reasons set out above, we also note that the revenue-constrained LRPs produce lower benchmarks than the LRPs without revenue constraint. Using the revenue-constrained LRPs is therefore consistent with our approach of being conservative in interpreting the evidence.

A7.181 Turning to Ireland, we derived band-specific price estimates based on the ratios of clock prices in the clock rounds of the auction in which supply matched demand for each frequency band. As noted above, ComReg examined our methodology and estimates, and considered the estimates to be a reasonable indication not just of final clock round prices but also of the relative values of the different frequency bands in the Irish auction. This is more relevant and specific evidence than the relationship between final clock prices and final band values in the UK auction, referred to by AM&A.[108]

A7.182 H3G suggested that a different Y/X ratio in the 1800 MHz distance method can be generated by a simple linear fit. This approach selects a set of band prices for which the implied total of winning packages is as close as possible to observed package prices. However, this method has considerable limitations. In the case of Ireland, it is seeking to explain three variables (the price for each band) using four observations (the winning package prices).[109] It takes no account of losing bids in the auction.

A7.183 We do not use a simple linear fit in our analysis of the UK auction. We note that in the case of the UK this method would indicate a *premium* for spectrum with the 800 MHz coverage obligation.[110] However, such a result is incorrect, given the bids made in the auction. In contrast, all the methods that we consider in Section 2 include a *discount* for the 800 MHz spectrum with coverage obligation.

A7.184 Finally, in relation to Switzerland, the Swiss Regulator (OFCOM) has not provided us with clock prices or bid data on the auction so we have not been able to derive LRP estimates or any other meaningful evidence on band-specific prices for this

[108] For completeness, we note that AM&A did not accurately report the final clock round prices in the UK 4G auction. They were £42.3m per MHz for the 800 MHz band (£423m per 2x5 MHz lot), and £9.2m per MHz for the 2.6 GHz band (£92m per 2x5 MHz lot). The ratio of these clock prices is 21.7%. The ratio of our values for 2.6 GHz and 800 MHz (net of expected DTT co-existence costs) in Section 2 is 18.3%.

[109] Indeed, since three operators won the same amount of 800 MHz and 900 MHz spectrum in this auction, different prices between the two bands can only be inferred from the fact that the fourth won some 900 MHz spectrum (2x5 MHz) and no 800 MHz spectrum.

[110] Page 22, DotEcon, 800 MHz and 2.6 GHz linear reference prices and additional spectrum methodology, September 2013, http://www.dotecon.com/assets/images/linear-reference-prices.pdf

auction. We consider that it is not possible to make reliable inferences about band-specific prices from the publicly available price information in Switzerland. We noted in Annex 8 of the August 2014 consultation that prices were materially non-uniform between bidders (e.g. Swisscom paid 25% less than Sunrise for a package which included significantly more 1800 MHz and 2.1 GHz spectrum and only 2x5 MHz less 2.6 GHz spectrum). We believe that there are significant differences in the quality of evidence from the Swiss auction compared to the Austrian and Irish auctions, and that it remains appropriate to treat them in a different way.

Our view of comments by NERA (on behalf of Telefónica)

A7.185 As we discussed in the August 2014 consultation, there is a range of country-specific factors that can affect the auction prices in any country. We considered that the presence of such country-specific factors tends to increase the uncertainty of absolute values in other countries as benchmarks for the UK. This is the key reason why we conduct our analysis primarily in terms of relative values, which are less likely to be affected by country-specific factors.[111]

A7.186 NERA's model attempted to address this by pooling observations from all four spectrum bands and including band-specific dummies as explanatory variables. NERA said that this approach can control for country-specific effects because the regression uses more than one observation per country.

A7.187 However, it is not clear that this leads to more robust results than considering the bands separately. In particular, we consider that pooling the data does not adequately control for country-specific variation because there are insufficient observations for all countries included in the samples. This means that the explanatory variables may still be reflecting between-country variation rather than the impact of, say, frequency on spectrum value.

A7.188 NERA's regressions based on relative values are potentially more relevant because, as discussed above, focusing on relative values controls for country-specific effects to some extent. However, in this case the sample size is limited to 15 or 16 observations. Robust statistical inference typically requires a minimum of 30 observations, and we consider a substantially larger sample would be needed given the number of factors that are likely to affect relative spectrum value and which we would need to control for in order for results to be meaningful.

A7.189 Both of NERA's models assume that any differences in the drivers of prices in different spectrum bands can be captured by a constant term (e.g. that an increase in any one of the explanatory factors has the same incremental effect on price, regardless of the spectrum band considered). NERA has not provided any justification for this assumption and we see no *a priori* reason to believe this would be the case.

A7.190 Furthermore, our assessment is that a number of the observations in our data set (i.e. those which we place in Tier 3) have relatively little informative value. NERA's

[111] EE, H3G, Telefónica and Vodafone all supported our focus on relative values. Telefónica said in its response to the October 2013 consultation (page 18) that one could attempt an econometric study to identify which factors are significant in determining spectrum values, but it doubted the sample of benchmarks was sufficient to produce reliable results.

econometric analysis does not take this into account and implicitly gives all observations the same weight.

A7.191 Overall, we do not consider that NERA's approach offers a reliable basis for determining that specific data points are outliers. Instead, our view remains that our qualitative approach to assessing the quality of evidence (tiers) and the risks of understatement or overstatement is more appropriate.

Stakeholders' approach to the derivation of lump-sum values for 900 MHz and 1800 MHz in UK

A7.192 The MNOs used the following approaches to derive lump-sum values for 900 MHz and 1800 MHz bands from the benchmark datasets:

a) EE's proposed lump-sum values were based on analysis by AM&A in which the proposed values were set with reference to the simple average of the highest tier benchmarks (which in the case of 900 MHz is Tier 2). AM&A said that it would be appropriate to apply a small discount to this simple average and used its judgement to do this. Its discount to the simple average was 8% in the case of 900 MHz and 11% in the case of 1800 MHz.[112] As a cross-check AM&A also calculated lump-sum values based on a weighted average of benchmarks, where Tier 1 benchmarks were given twice as much weight as Tier 2 benchmarks, and noted that its proposed values also represented a small discount to the corresponding weighted averages. AM&A said that this was consistent with the aim of setting lump-sum values conservatively.[113]

b) H3G calculated its lump-sum values as a weighted average of benchmarks, giving Tier 1 benchmarks twice as much weight as Tier 2 benchmarks (and following the tiering used by AM&A). H3G said that these values should be upper bounds because they include no discount to reflect a conservative approach.[114] However, H3G also said it had "no particular objection" to a "non-mechanistic approach" to deriving lump-sum values, with weighted average values used as cross-checks, "as both approaches should produce similar values if consistently applied".[115]

c) Telefónica derived lump-sum value estimates based on an assessment of benchmarks in the round. In doing so it had regard to four principles intended to reflect a conservative approach to the benchmarking evidence which, it argued, we should adopt.[116] It said that the chosen value should:

   i) not be dependent on specific benchmarks that appear to be "gross outliers", without clear quantitative evidence that they are not distorted;

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[112] AM&A response page 34 (£8m per MHz as against an average of £9.6m per MHz for the 1800 MHz band) and page 34 (£19m per MHz as against an average of £21.3m per MHz for the 900 MHz band)
[113] AM&A response to the August 2014 consultation, page 38
[114] H3G response to the August 2014 consultation, pages 29-30. H3G's values, based on the benchmarking evidence (Table 11, page 32), were weighted averages without such a discount and corresponded to AM&A's weighted average lump-sum values, but H3G.also reported AM&A's set of lump-sum values with a discount.
[115] H3G response to the August 2014 consultation, page 29
[116] Telefónica response to the August 2014 consultation, page 71

ii) not exceed the lowest first tier benchmark without a clear qualitative rationale;

iii) not exceed the average of Tier 1 and Tier 2 benchmarks without a clear qualitative rationale; and

iv) be based on a statistical analysis of all benchmarks and a qualitative analysis of individual benchmarks, and take account of the impact of assumptions underpinning those numbers.

d) Frontier (on behalf of Vodafone) proposed a range of possible relative values for 900 MHz and 1800 MHz spectrum (the 900 MHz / 800 MHz ratio and 1800 MHz distance method Y/X ratios respectively) defined by the highest and lowest benchmarks within (its view of) the first tier of evidence. It said that appropriate relative values are likely to be closer to the more reliable benchmarks which were at the lower end of these ranges.[117] As a sensitivity, it calculated relative values as a weighted average of first and second tier benchmarks (with first tier benchmarks given twice as much weight as second tier benchmarks), and also as a weighted average of all benchmarks (with weights of 100%, 75% and 50% given to each of the three tiers).

A7.193 EE and H3G said that our lump-sum value for 1800 MHz was less conservative than for 900 MHz in the August 2014 consultation:

a) AM&A (on behalf of EE and H3G) said that, with regard to 1800 MHz, our tiering assignment produced a weighted-average lump-sum value that is in the top 2% of all possible weighted-average lump-sum values that can be produced (based on all the possible combinations of placing the nine available benchmarks into three tiers).[118] It said that, in contrast, the corresponding weighted-average lump-sum value for 900 MHz is towards the centre of possible weighted-average lump-sum values.

b) H3G noted that our proposed 1800 MHz lump-sum value was 15% higher than the average of all benchmarks, while for 900 MHz our value was 17% lower than the average.[119]

c) H3G also commented that we had reduced our initial 900 MHz lump-sum value (based on Tier 1 benchmarks) to take account of the lower Tier 2 benchmark values, but did not do so for 1800 MHz on the basis that one of the Tier 2 benchmarks (Sweden) was above the initial 1800 MHz value. H3G said that if the correct 2.6 GHz value was used for Sweden (the 2008 auction price), the Tier 2 benchmarks would imply a reduction in the 1800 MHz value, which would have ensured a consistent application of our conservative approach.[120]

Our assessment

A7.194 The approaches used by the MNOs to go from the benchmark datasets to their proposed lump-sum values, or relative values in the case of Vodafone, have a

[117] Vodafone (August 2014 response, page 4) said that adopting a conservative approach to the evidence entails adopting figures at the lower end of each of these ranges.
[118] AM&A response to the August 2014 consultation, page 9
[119] H3G response to the August 2014 consultation, page 15
[120] H3G response to the August 2014 consultation, page 26-27

number of similarities to the approach that we have used.[121] All of them pay attention to the average of benchmarks in different tiers, paying more attention to the average of the first tier. EE, Telefónica and Vodafone all used an element of judgement to arrive at their proposed values (as opposed to a mechanistic approach). Only H3G used the average number as the precise basis for its proposals (although even H3G said that it has no particular objection to a non-mechanistic approach).

A7.195 Telefónica's proposed criteria i) and iv) are closely related to its argument that statistical analysis can be used to identify benchmarks as "outliers". However, as discussed above in paragraphs A7.185 to A7.191, we disagree that the statistical analysis presented by NERA achieves this. Nor do we consider that we have a sufficient basis to ignore certain benchmarks as outliers, given the very limited number of available data points.

A7.196 We consider that our estimates for both bands are consistent with its criteria ii) and iii). However, we do not consider that it is necessary or appropriate to adopt either of these criteria as general rules.

A7.197 We remain of the view that it is not appropriate to derive lump-sum values mechanistically, using an average of benchmarks (weighted by tier of evidence or otherwise). Such an approach does not take into account our assessment of the risk that particular benchmarks might understate or overstate the UK market value of ALF spectrum. We also do not consider that it is necessarily more objective than the approach we have adopted – in particular the resulting averages will be dependent on the choice of weighting ascribed to each tier, which is in itself subjective.

A7.198 Table A7.12 below shows what the weighted averages would be when the weighting factors used by the MNOs in their responses are applied to our benchmark dataset in Section 3. Column A broadly corresponds to AM&A's proposed weights by giving first-tier evidence twice as much weight as second-tier evidence (although for the purposes of this table we have maintained our three-tier approach), and it gives third-tier benchmarks a weight of 0.5. Column B corresponds to the weights in Frontier's alternative sensitivity check.

A7.199 The illustrative weights in Column A produce lump-sum values for 900 MHz and 1800 MHz which are 9% and 6% higher respectively than the estimated values of £23m per MHz and £13m per MHz in our provisional decision in Section 3.

A7.200 Column B gives more weight to Tier 2 and Tier 3 benchmarks, relative to Tier 1 (e.g. in column B, Tier 3 is given half as much weight as Tier 1, whereas in column A, it is given a quarter as much weight as Tier 1). The resulting value for 900 MHz (£24.2m per MHz) is slightly higher than our lump-sum value, whereas the value for 1800 MHz (£12.7m per MHz) is slightly below our lump-sum value. This largely reflects the fact that Tier 3 benchmarks for 1800 MHz are (with the exception of Greece) lower than the lowest Tier 1 benchmark. However, we consider that column B gives significantly more relative weight to benchmarks in Tier 2 and Tier 3 than can be justified on the basis of our qualitative assessment of the benchmarking

[121] Although, of course, they have a different assessment of the datasets, notably as regards the choice of tier for certain countries, as discussed above.

evidence. In view of the subjective nature of the selection of weights, we have not included weighted averages as a cross-check in Section 3.

Table A7.12: Illustrative weights for 900 MHz and 1800 MHz benchmarks

	A (AM&A weights)	B (Frontier weights)
First-tier weighting	2	1
Second-tier weighting	1	0.75
Third-tier weighting	0.5	0.5
Illustrative weighted average value for 900 MHz (£m per MHz)	£25.1m	£24.2m
Illustrative weighted average value for 1800 MHz (£m per MHz)	£13.8m	£12.7m

Source: Ofcom

A7.201 Finally, we disagree with EE's and H3G's arguments (in paragraph A7.193 above) that we have been more conservative for 900 MHz than for 1800 MHz:

a) We do not consider that a comparison of our lump-sum value against the distribution of lump-sum values based on a random assignment of benchmarks to tiers is meaningful. This is because a random assignment ignores the difference in the quality of evidence represented by these different tiers. The AM&A observation simply reflects the fact that for 1800 MHz the lower-tier benchmarks are relatively low in value (all but one of the Tier 2 and 3 benchmarks for 1800 MHz are below the lowest Tier 1 benchmark), whereas in the case of 900 MHz all but one of the Tier 2 and 3 benchmarks are above the lowest Tier 1 benchmark.

b) For similar reasons, we do not consider it meaningful that, in H3G's observation, our 1800 MHz value is above the simple average of all benchmarks (combining Tiers 1, 2 and 3), whereas the 900 MHz benchmark is below the simple average.

c) H3G's comment about our use of lower Tier 2 values when assessing the lump-sum values for 900 MHz and 1800 MHz is not relevant to the updated assessment in Section 3, because we now categorise Sweden as a Tier 1 benchmark for 1800 MHz. We remain of the view that it is appropriate to use a 2.6 GHz proxy, and not the 2008 auction price, when deriving the Sweden 1800 MHz benchmark, for the reasons explained in Annex 8.