

## **Observations from the UK 800MHz and 2600MHz auction 2013**

### **INTRODUCTION AND EXECUTIVE SUMMARY**

This paper examines the recent UK spectrum auction and considers the nature and quality of the evidence that the auction can provide in the context of setting spectrum fees for 900MHz and 1800MHz.<sup>1</sup> To the extent that the UK auction can be interpreted to reveal the market value for 800 MHz and 2.6 GHz spectrum (without even considering the difficulties involved in translating those values into corresponding values for 900 MHz or 1800 MHz spectrum) we find that:

1. The average prices paid would at first sight appear to be around £258m for 2x5 MHz of 800 spectrum, and £52.5m for 2x5 MHz of 2600 spectrum.
2. However, the reserve prices set by Ofcom significantly and artificially inflated the prices paid for 800 MHz spectrum.
3. Further, Ofcom's "opt-in" mechanism seriously distorted the prices paid, and distorted H3G's bidding in its attempt to take advantage of this mechanism.
4. Without the reserve price and opt-in distortions, the average price for 2x5 MHz of 800 MHz spectrum would have been in the range of £135m- £168m.
5. The Additional Spectrum Methodology leads to entirely inconsistent and irrelevant results, with no bearing on the real value of spectrum.

We consider these points in turn below. Our analysis is based purely on the bid information published by Ofcom<sup>2</sup>, the methodologies described in the auction rules<sup>3</sup> and previous consultations by Ofcom<sup>4</sup>. We concentrate only on the auction principal stage, as assignment stage bids have relevance only to the allocation of specific lots of the auctioned spectrum and have no possible relevance to other bands. We have also excluded the low power lots (D1 and D2) from the analysis because, although there were some bids on them, they were eclipsed by higher bids for C and played no part in any price setting.

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<sup>1</sup> It is entirely without prejudice to other concerns Vodafone has or intends to raise including the relevant marginal increment for 900 and 1800 MHz spectrum, Ofcom's legal duties, network modelling approaches to spectrum value and long-term trends in the availability and fungibility of spectrum.

<sup>2</sup> Auction Data for the 800 MHz and 2.6 GHz Combined Award: <http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/awards-archive/completed-awards/800mhz-2.6ghz/auction-data/>

<sup>3</sup> Statutory Instruments setting out the rules for the 800 MHz and 2.6 GHz award: <http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/awards-archive/completed-awards/800mhz-2.6ghz/notices/statutory-instruments/>

<sup>4</sup> Second Consultation on assessment of future mobile competition and proposals for the award of 800MHz and 2.6GHz spectrum and related issues, 12<sup>th</sup> January 2012  
<http://stakeholders.ofcom.org.uk/consultations/award-800mhz-2.6ghz/>

## ACTUAL AUCTION OUTCOMES

The outcome of the UK auction principal stage was, as is widely known, as follows:

BIDDER	A1	A2	C	E	Price paid (£)
Vodafone	2	0	4	5	790,761,000
Telefonica	0	1	0	0	550,000,000
EE	1	0	7	0	588,876,000
H3G	1	0	0	0	225,000,000
Niche	0	0	3	4	186,476,000
<b>Totals</b>	<b>4</b>	<b>1</b>	<b>14</b>	<b>9</b>	<b>2,341,113,000</b>

Any analysis of a CCA outcome should start with an explanation of the prices paid. Using the published auction rules, we can explain these base prices by considering counterfactual auctions, where in turn each bidder is excluded. The “opportunity cost” column in the tables below takes each remaining bidder’s bid for the package won in the counterfactual auction and subtracts their bid for the package won in the real auction. (Note that these differences may be negative, or may reflect a value assigned to unsold spectrum.) The sum of that column represents the overall opportunity cost for awarding spectrum to each winning bidder. Further, in this CCA the opportunity costs meet all the conditions for base prices laid down in Schedule 5 of the auction rules, so in this auction the base prices are identical to the opportunity costs.

If Vodafone’s bids had been excluded then the outcome would have been as follows:

BIDDER	A1	A2	C	E	Opportunity Cost (£)
Telefonica	0	1	2	0	128,000,000
EE	2	0	6	0	310,500,000
H3G	1	0	2	0	100,000,000
Niche	0	0	3	5	1,000,000
HKT	0	0	0	2	10,250,000
MLL	0	0	0	2	1,011,000
Unsold	1	0	1	0	240,000,000
<b>Totals</b>	<b>4</b>	<b>1</b>	<b>14</b>	<b>9</b>	<b>790,761,000</b>

Thus Vodafone paid £790,761,000 for two lots of A1, four lots of C and five lots of E.

If Telefonica’s bids had been excluded then the outcome would have been as follows:

BIDDER	A1	A2	C	E	Opportunity Cost (£)
Vodafone	0	1	4	4	(33,000,000)
EE	2	0	6	0	310,500,000
H3G	1	0	2	0	100,000,000
Niche	0	0	2	5	(52,500,000)
Unsold	1	0	0	0	225,000,000
<b>Totals</b>	<b>4</b>	<b>1</b>	<b>14</b>	<b>9</b>	<b>550,000,000</b>

Hence Telefonica paid £550m for the A2 lot.

If EE's bids had been excluded then the outcome would have been as follows:

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	7	9	165,876,000
Telefonica	0	1	2	0	128,000,000
H3G	1	0	2	0	100,000,000
Niche	0	0	3	0	(30,000,000)
Unsold	1	0	0	0	225,000,000
<b>Totals</b>	<b>4</b>	<b>1</b>	<b>14</b>	<b>9</b>	<b>588,876,000</b>

Hence EE paid £588,876,000 for one A1 lot and seven C lots.

If H3G's primary and supplementary round bids had been excluded, the outcome would have been unchanged – H3G's opt-in bid for the same A1 package would have won, and all other bidders would have won the same as they did in the real auction. So H3G paid just the reserve price of £225m for one A1 lot.

If Niche's bids had been excluded then the outcome would have been as follows:

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	5	9	58,476,000
Telefonica	0	1	2	0	128,000,000
EE	1	0	7	0	0
H3G	1	0	0	0	0
<b>Totals</b>	<b>4</b>	<b>1</b>	<b>14</b>	<b>9</b>	<b>186,476,000</b>

Thus BT/Niche paid £186,476,000 for three C lots and four E lots. However, given the CCA process, this gives little information as to the underlying prices that were paid by band. To attempt to arrive at this, further analysis is needed.

## HOW DO PRICES PAID BREAK DOWN INTO INDIVIDUAL BANDS?

### *Linear reference prices*

There is no single answer to the question of how prices break down by band, but one approach, described in Ofcom's second consultation referenced above, is to calculate the linear reference prices, as the best attempt to "rationalise" the bidders' winnings in terms of a price per lot in each band (i.e. explain why they won what they did rather than an alternative package).

Ofcom did not release these prices in the auction data, as they played no role in the actual auction result. However, Vodafone have calculated them as follows (rounded to the nearest £1000):

- A1 £268,914,000
- A2 £506,828,000  
Average £263,747,000 per 2x5 MHz of 800
- C £49,914,000
- E £6,648,000

The prices of D1 and D2 are indeterminate, but irrelevant. The implied total revenue at these prices is £2,341,112,000, a total that is just slightly less than the real revenue owing to rounding errors.

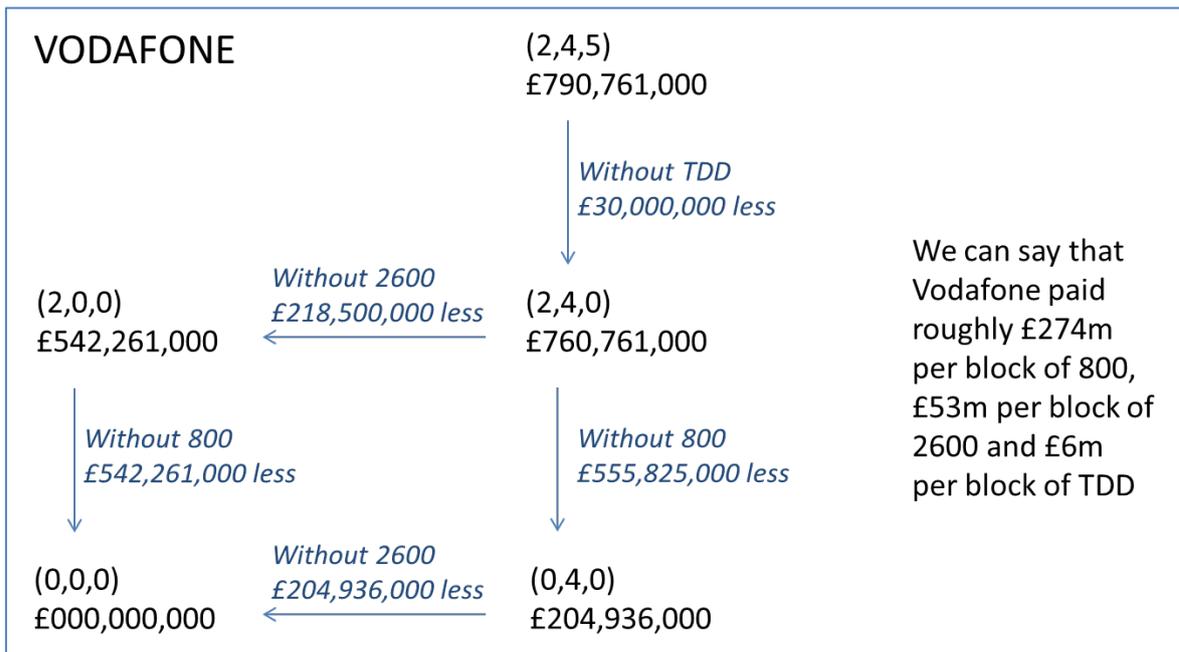
Important to the definition of the linear reference prices is the notion of an “excursion”: this measures how much a bidder would have preferred an alternative package at the proposed prices to the package they actually won. The larger that number is, the worse the fit, and the linear prices are chosen to minimize the sum of bidder excursions while still accounting for the total auction revenue. If the residual excursions are still large, it means that no set of linear prices is a good fit.

In the actual auction the residual excursions are substantial. At the linear reference prices, EE would have a net preference (bid – price) of £1049.5m - £618.312m = £431.188m for their winning package of A1+7C, but a net preference of £1360m - £837.312m = £522.688m for the alternative package of 2A1+6C. This gives them an excursion of £522.688m - £431.188m = £91.5m. Similarly, Telefonica has an excursion of £28.2m on the alternative package of A2+2C, and Vodafone has an excursion of £4.6m on the alternative package of 2A1+4C+4E. We can conclude the auction outcome is simply not well explained by any set of linear prices.

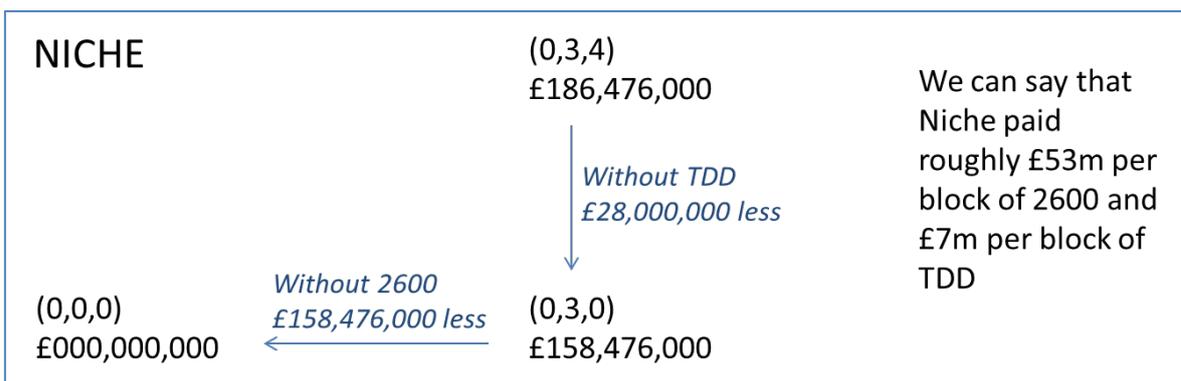
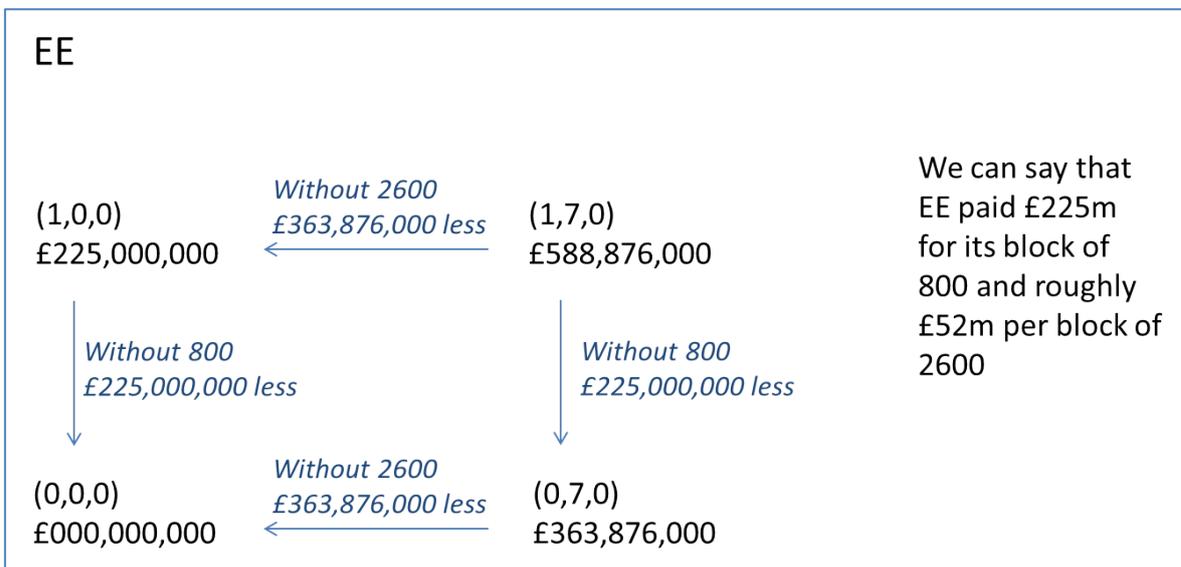
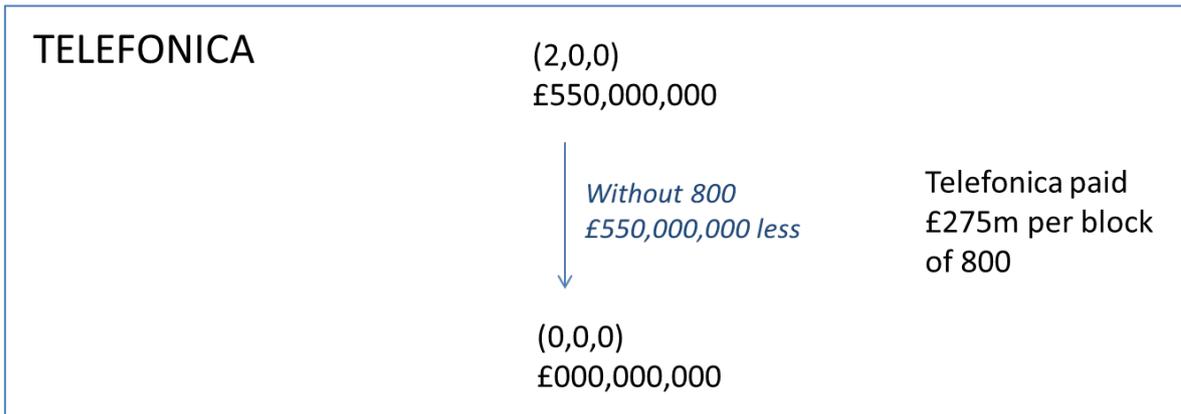
**Decompositional approach**

An alternative approach to assessing prices by band is to determine how much each bidder would have had to pay if they had bid exclusively for smaller packages than they actually won, (i.e. a decompositional approach). The results are shown below. These diagrams make it clear why the linear prices are a poor fit: there is a large difference in the price apparently paid by different bidders for 2x5 MHz of 800 MHz spectrum, varying from £225m for EE and H3G to £275m for Telefonica.

For Vodafone, we can examine the consequences on the sum paid of progressively stripping out bands from the bid package (and varying the order for removal of 2600MHz and 800MHz):



A similar exercise can be conducted for the other winning bidders:



If we also include H3G's 800MHz lot paid for at reserve price, these calculations suggest:

- An average price for 800MHz of around  $(£550m + £548m^5 + £225m + £225m) / 6 = £258$  million per 2x5 MHz block.
- An average price for 2.6GHz paired of around  $(£212m + £364m + £159m) / 14 = £52.5$  million per 2x5 MHz block.
- An average price for 2.6 unpaired of around  $(30 + 28) / 9 = £6.5$  million per 5MHz block.

The implied total auction revenue at £2,341m is similar to the actual outcome. We observe that these average prices are fairly similar to the linear reference prices, but with a shift in the revenue split from 800MHz (which was relatively lightly contested in terms of bid volumes) towards 2.6GHz (which was more heavily contested). As a result, this gives a better reflection of actual auction activity.

It is necessary however to examine the impact of the specific auction conditions such as reserve prices and the opt-in rule on the auction sums paid. It is possible to examine this by calculating what the auction prices would have been in the absence of these distorting conditions.

### THE DISTORTING EFFECT OF AUCTION CONDITIONS - RESERVE PRICES AND THE OPT-IN RULE

Ofcom's own decisions (on reserve price and opt-in) had a very significant impact on the prices actually paid. This means one cannot read off the auction prices as a simple indication of "market prices", or of "market value" for the 800 MHz or 2600 MHz spectrum. Instead we should use the auction payments that would have occurred in the absence of such distortionary conditions.

#### **Reserve Prices**

We have re-run the same winner and price determination algorithm, but with all reserve prices set to a nominal £1000. Under these circumstances the winning bidders and packages are exactly the same, but the prices are significantly lower.

BIDDER	A1	A2	C	E	Price paid (£)
Vodafone	2	0	4	5	770,261,000
Telefonica	0	1	0	0	526,338,000
EE	1	0	7	0	388,875,000
H3G	1	0	0	0	136,666,000
Niche	0	0	3	4	186,476,000
Totals	4	1	14	9	2,008,616,000

Vodafone has calculated the revised linear reference prices arising from this outcome (again to the nearest £1000):

- A1 £224,336,000
- A2 £ 417,671,000
- Average £219,169,000 per 2x5 MHz of 800
- C £45,850,000
- E £5,744,000

<sup>5</sup> The rough average for Vodafone of the two 800MHz outcomes above

Unfortunately, the linear fit is even poorer than before: EE has an excursion of £213m, Telefonica has an excursion of £36.3m, H3G has an excursion of £8.3m and Vodafone has an excursion of £6.2m. This auction outcome simply cannot be explained by any set of linear prices.

Using our “smaller package” approach, as outlined in the previous section, we see that the incremental prices paid by bidders for 2.6GHz spectrum are essentially unchanged. This is understandable, because there was extensive bidding for the 2.6GHz spectrum (there was no unsold spectrum in any counterfactuals) and so the sums paid were unaffected by the reserve prices. However, the outcome for 800MHz is rather different: Telefonica’s price per 2x5 MHz of 800MHz drops to about £263m, Vodafone’s price drops to about £261m, H3G’s price for 800 drops to about £137m, and EE’s price drops to about £25m. This variation explains why it is even harder than before to fit linear prices. The average for 800MHz however is around £202m per 2x5MHz.

From this we conclude the following:

- Without the large reserve prices, the auction would have raised around £332.5m less in total;
- The impact of the reserve prices was simply to inflate the prices paid for 800MHz MHz spectrum (especially by EE and H3G); the reserves did not affect the prices paid for 2.6 GHz spectrum;
- Removing that inflation, the average price paid for 800MHz spectrum drops from £258m to £202 million per 2x5 MHz block (roughly £258m - £332.5m / 6).

***The Opt-in Rule:***

We have further re-run the winner and price determination algorithm but with the exclusion of H3G’s opt-in bids. Again everyone wins exactly the same packages, and everyone apart from H3G pays the same prices – but H3G would have paid £384 million instead of £225 million:

BIDDER	A1	A2	C	E	Price paid (£)
Vodafone	2	0	4	5	790,761,000
Telefonica	0	1	0	0	550,000,000
EE	1	0	7	0	588,876,000
H3G	1	0	0	0	384,000,000
Niche	0	0	3	4	186,476,000
Totals	4	1	14	9	2,500,113,000

Why? If all H3G’s bids (including the opt-in bids) had been excluded then the outcome would have been as follows:

BIDDER	A1	A2	C	E	Opportunity Cost (£)
Vodafone	2	0	4	4	(2,000,000)
Telefonica	0	1	2	0	128,000,000
EE	2	0	6	0	310,500,000
Niche	0	0	2	5	(52,500,000)
Totals	4	1	14	9	384,000,000

Arguably, the effect of the opt-in rule was to give H3G a £159m subsidy for spectrum they would have won anyway. However, the situation is even more distorted by the opt-in rule than that because, as we show below, H3G's bids appear to have been carefully constructed to take advantage of the opt-in that was given to them.

### ANALYSIS OF H3G'S BID PATTERN

H3G's supplementary bids show an interesting pattern. They bid £565.5m for lot A1 and £400.5m for lot 4C which is a difference of £165m. This sum is exactly the difference in reserve prices (£225m – £60m). They also bid £25m more for A2 than for A1 (again, the same as the reserve price difference.)

It seems highly improbable that H3G's valuation difference between packages was exactly the reserve price difference. However, recall that (knowing it was the only opted-in bidder) if H3G had just made their opt-in bids and no others, the auction rules would have guaranteed them to win one of the three opt-in packages at the reserve price. By raising all three opt-in bids by exactly the same amount (£360.5m), they maintained this property: ***Provided the auction software awarded them an opt-in package, as it was almost bound to do, it would have to do so at reserve price.***

But what about H3G's other bids? Was there a risk that one of them might have won instead and therefore at a price potentially much greater than the reserve price? Our conclusion is that H3G deliberately bid in a manner to minimize this risk. All other bids were structured so as to be highly unlikely to be winning bids. Their primary round bids for packages with A1 and A2 lots also included huge amounts of 2.6MHz (10 C lots and the D2 lot). It was virtually impossible for those bids to have won because that would have required preventing anyone else winning paired 2.6MHz spectrum. Notably, H3G made no attempt to increase these bids in the supplementary round: it simply left them at the largest primary round values.

H3G's new supplementary round bids were all marginal extensions to the opt-in packages, with an incremental value well below the final round prices: about £6m-£7m per E block (for packages of 4, 5 and 9 blocks), and about £50m per C block (for up to two additional C blocks). We can assume these were not intended to be winning bids, but were aimed to set prices: indeed these bids did set prices for 2.6GHz. It appears that H3G did not attempt to price-set on extra 800MHz blocks, since at this stage in the auction there was too high a risk of winning such 800MHz spectrum.

This all suggests H3G's objective: ***“Win spectrum at the reserve price and make everyone else pay more”***. If that was indeed the H3G bid team's objective, then they achieved it. However, we must observe that such an objective contains no inherent concept of the underlying value of the spectrum. The CCA format is designed to achieve efficient outcomes at fair market prices by encouraging bidders to express their true value for spectrum: if key bidders do not express their values, it cannot do so.

We cannot infer how H3G would have bid in an auction without the opt-in distortion, so cannot easily determine what the “fair market” prices would have been. What we *can* conclude is that H3G had no particular need or desire for 800MHz spectrum - if other bidders had preferred 800MHz a bit more, then H3G would have been happy to win 2.6GHz instead. Indeed, the inferred bid strategy certainly suggests H3G had no particular need to win *any particular* spectrum in the auction; they just took whatever the opt-in gave them.

### WHAT MIGHT THE MARKET PRICES HAVE BEEN WITHOUT H3G?

We can attempt to correct for the opt-in distortion by just removing all H3G’s bids from the auction. However, doing that would significantly change the winnings of all the other bidders and artificially lower all prices (e.g. there will be only three bidders for six blocks of 2x5 MHz at 800MHz, so the resulting price is likely to be significantly depressed). It is not possible using this method to assess a market price for what the other bidders won in the real auction.

A better market estimate can be obtained by removing both H3G’s bids *and their winnings* (one A1 lot) from the auction, so that only 2x25MHz of 800MHz is considered to have been auctioned (with other bands unchanged). The other bidders will then win the same packages as in the real auction, and set each other’s prices for that remaining spectrum, so creating a reduced market, without any opt-in distortions.

To ensure that only bidders set prices (not Ofcom itself via the reserve price), we will also reduce all reserve prices to a nominal £1000 in the calculation of the price that would have been paid:

BIDDER	A1	A2	C	E	Price paid (£)
Vodafone	2	0	4	5	450,765,000
Telefonica	0	1	0	0	307,977,000
EE	1	0	7	0	298,207,000
Niche	0	0	3	4	186,476,000
Totals	3	1	14	9	1,243,425,000

Again, we can explain these prices by considering counterfactual auctions (in this case, second-order counterfactuals, because the base auction scenario is itself counterfactual).

If Vodafone’s bids had been excluded then the outcome would have been as follows:

BIDDER	A1	A2	C	E	Opportunity cost (£)
Telefonica	0	1	2	0	128,000,000
EE	2	0	6	0	310,500,000
Niche	0	0	3	5	1,000,000
HKT	0	0	0	2	10,250,000
MLL	0	0	0	2	1,011,000
Unsold	1	0	3	0	4,000
Totals	3	1	14	9	450,765,000

If Telefonica's bids had been excluded then the outcome would have been as follows:

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	0	1	5	9	27,476,000
EE	2	0	6	0	310,500,000
Niche	0	0	3	0	(30,000,000)
Unsold	1	0	0	0	1,000
Totals	3	1	14	9	307,977,000

If EE's bids had been excluded then the outcome would have been as follows:

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	8	7	174,956,000
Telefonica	0	1	2	0	128,000,000
Niche	0	0	4	0	(15,000,000)
HKT	0	0	0	2	10,250,000
Unsold	1	0	0	0	1,000
Totals	3	1	14	9	298,207,000

If Niche's bids had been excluded then the outcome would have been as follows:

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	5	9	58,476,000
Telefonica	0	1	2	0	128,000,000
EE	1	0	7	0	0
Totals	3	1	14	9	186,476,000

The linear reference prices are a terrible fit in this case:

- A1 £226,016,000
- A2 £421,032,000
- Average £219,816,000 per 2x5 MHz of 800
- C £7,016,000
- E £513,000

Even at a glance we can see that the fitted 2.6GHz prices are far too low. Also, recalling the concept of an "excursion" (the extent to which a bidder would prefer to have won an alternative package at these prices), all the main bidder excursions are large. EE has an excursion of £92.5m; Telefonica has an excursion of about £114m; Vodafone has an excursion of about £137m.

We can again attempt a better estimate using the "smaller package" approach employed above:

EE pays the reserve price (£1000) for its A1 lot, and about £43m per C lot.

Niche pays about £58m per C lot, and about £3m per E lot.

Telefonica pays about £154m per A block.

Vodafone pays about £183.5m per A1 lot, £18m per C lot and £2.5m per E lot.

These calculations suggest:

- An average price for 800MHz of around  $(£308m + £367m) / 5 = £135$  million per 2x5 MHz block. (Or an average of £168.5m for Vodafone and Telefonica alone.)
- An average price for 2.6GHz paired of around  $(301 + 174 + 72) / 14 = £39$  million per 2x5 MHz block.
- An average price for 2.6GHz unpaired of around  $(12 + 12) / 9 = £3$  million per 5MHz block.

We can see that the reason for EE only having to pay the reserve price is that whilst EE sets 800MHz prices for Vodafone and Telefonica, these two operators are unable to set EE's or each other's prices, owing to the existence of the spectrum caps. Therefore, the extent to which £135m is an underestimate of the fair market price of 800MHz is entirely determined by how much Vodafone and Telefonica would have been prepared to pay for additional sub 1GHz spectrum over their capped amounts, had they been permitted to bid for it. This is obviously indeterminate.

### **ADDITIONAL SPECTRUM METHODOLOGY (ASM)**

A further metric described by Ofcom in the 2012 spectrum consultation referred to above is to consider what might have happened if additional spectrum had been included in the auction (extra 800 MHz spectrum as a proxy for 900MHz; extra 800MHz and/or 2.6GHz spectrum as a proxy for 1800MHz) but with the same bids made as in the real auction.

In our 2012 consultation response, Vodafone has already communicated our concerns about the artificiality of this method. Bidders' bids are based on the actual amounts of spectrum available in a real auction, not a hypothetical world where 900 MHz spectrum is somehow converted into 800MHz. We also pointed out that this methodology could create perverse bidding incentives (inviting non-serious bids which were never intended to be winning and had no chance of winning in the real auction) and could give wildly different results for different bidders.

Our calculations of the ASM using the actual auction bids documented by Ofcom fully support these prior concerns. In particular:

- The ASM results for additional 800MHz spectrum are entirely dominated by a clearly non-serious EE bid for a very large package of 4 A blocks and 4C lots. EE had no chance of winning such a package in the real auction, and are very unlikely to have bid the same package price in the counterfactual auctions.
- The results are also dominated by factors like the reserve prices and spectrum caps, factors which are very unlikely to have been set the same way in the counterfactual auctions.
- The methodology gives wildly different valuations for different bidders, especially when applied to the 1800MHz spectrum.

Accordingly, we would urge Ofcom to simply discard this methodology as giving inconsistent and irrelevant results.

To illustrate these points, we have attempted to apply the methodology in the ways described in the Ofcom 2012 consultation. We will first calculate the winning auction packages if some additional spectrum had been made available, but a particular bidder

was prevented from winning that spectrum. We will then calculate the relevant “opportunity costs” for the bidder i.e. imagine how much the bidder might have had to pay for the relevant additional spectrum if they had actually won it at auction.

*ASM applied to 900 MHz spectrum*

What if there was an additional 2x15 MHz of 800MHz in the auction<sup>6</sup>, but Vodafone could not win it?

It is unclear from the description in the Ofcom consultation whether the additional spectrum should be added as A1 lots, or a mixture of A1 and A2 (arguably a substitute for the 900MHz spectrum should inherit a strong population coverage obligation analogous to A2). The top half of the table below considers increasing the supply of A1 from the actual 4 lots to a presumed 7 lots; the second half considers adding one further 2x10MHz lot of A2 and one further 2x5MHz lot of A1. In either circumstance Vodafone is restricted to its actual auction outcome.

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	4	5	0
Telefonica	0	1	2	0	128,000,000
EE	4	0	4	0	748,500,000
H3G	1	0	2	0	100,000,000
Niche	0	0	2	4	(55,000,000)
Totals	7	1	14	9	921,500,000

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	4	5	0
Telefonica	0	1	2	0	128,000,000
EE	2	1	4	0	602,500,000
H3G	1	0	2	0	100,000,000
Niche	0	0	2	4	(55,000,000)
Totals	5	2	14	9	775,500,000

We can apply the same approach to the other operators. What if there was an additional 2x15 MHz of 800MHz, but Telefonica could not win it?

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	7	9	165,876,000
Telefonica	0	1	0	0	0
EE	4	0	4	0	748,500,000
H3G	1	0	0	0	0
Niche	0	0	3	0	(30,000,000)
Totals	7	1	14	9	884,376,000

<sup>6</sup> This was deemed by the methodology to be a “proxy” for the 2x17.4MHz of 900MHz held by Vodafone and Telefonica

BIDDER	A1	A2	C	E	Opportunity cost (£)
H3G	1	0	0	0	0
EE	4	0	4	0	748,500,000
Niche	0	0	3	0	(30,000,000)
Telefonica	0	1	0	0	0
Vodafone	0	1	7	9	134,876,000
Totals	5	2	14	9	853,376,000

It will be seen that there is considerable variation in outcomes, depending on what sort of 800MHz spectrum is added, and whether the calculation is for Vodafone or Telefonica. Averaging all four outcomes might suggest around £286m per 2x5MHz, i.e. apparently a higher price for the additional spectrum than for the spectrum in the real auction, even though the supply has been increased by 50% and the bidders restricted.

But in each case the outcome is totally dominated by a particular bid which EE made for 4A blocks plus 4C lots. That bid raises many serious concerns:

- In the real auction, EE must have known that they had no chance of winning such a large package of 800MHz. To win it, they would have to exclude two bidders completely from the Digital Dividend (including one of Vodafone or Telefonica), something which was prima facie highly improbable.
- Further, by the time of the supplementary round, **all** other bidders had already expressed a higher value for 800MHz spectrum than EE themselves, so the chance of EE excluding two bidders was now essentially zero. The bid cannot have been a serious attempt to win spectrum.
- The 4A1+4C bid expresses a marginal value for the extra 800MHz of £748.5m / 3 = £249.5m, which is close to a round sum of £250m. Also, it was the largest EE bid by value. The matching bid for 2A1+A2+4C is even more dubious, as it could not possibly have won in the auction, even if there had been no competition from other bidders. (The bid value had too little increment over their bid for A2+6C, well below the reserve price for A1 blocks). Such details support the conclusion that the bid was not a serious attempt to win spectrum. It is far more likely to have been a price-setting bid, or even a deliberate attempt to play the ASM.
- Even if the bid did represent EE's true valuation, much of the value of such a high bid would clearly be from the market impact of excluding players from the Digital Dividend. This factor simply could not have applied if there had been additional 800 MHz spectrum available in the auction (no prospect of excluding anyone). EE could not have had the same values in the counterfactual.

One way of eliminating the dependency on such a large and problematic package is just to exclude it. We have therefore removed EE's bids for the packages containing 2x20 MHz of 800 MHz spectrum and recalculated the ASM results.

Removing just these bids gives a very different set of outcomes. In particular, some of the additional spectrum is now unsold, quite plausibly because of the spectrum caps and reserve prices in the *real* auction. Further, the amount and nature of the unsold spectrum depends heavily on the reserve prices assumed in the *counterfactual* auctions. Since the caps and reserve prices are unlikely to have been set the same way in a counterfactual as in the real auction, these results are very hard to interpret.

We can try to minimize the distortion by setting all reserve prices to a nominal £1000, but cannot allow for bids which might have been made with looser spectrum caps.

For Vodafone:

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	4	5	0
Telefonica	2	0	2	0	127,999,000
EE	2	0	6	0	310,500,000
H3G	0	1	0	0	25,000,000
Niche	0	0	2	4	(55,000,000)
Unsold <sup>7</sup>	1	0	0	0	
Totals	7	1	14	9	408,499,000

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	4	5	0
Telefonica	0	1	2	0	128,000,000
EE	2	0	6	0	310,500,000
H3G	0	1	0	0	25,000,000
Niche	0	0	2	4	(55,000,000)
Unsold	1	0	0	0	
Totals	5	2	14	9	408,500,000

Similarly for Telefonica:

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	4	4	(2,000,000)
Telefonica	0	1	0	0	0
EE	2	0	6	0	310,500,000
H3G	1	0	2	0	100,000,000
Niche	0	0	2	5	(52,500,000)
Unsold	2	0	0	0	
Totals	7	1	14	9	356,000,000

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	4	4	(2,000,000)
Telefonica	0	1	0	0	0
EE	2	0	6	0	310,500,000
H3G	0	1	2	0	125,000,000
Niche	0	0	2	5	(52,500,000)
Unsold	1	0	0	0	
Totals	5	2	14	9	381,000,000

These outcomes are less than half those obtained when the EE 4A+4C bid is included. The average of the four Vodafone and Telefonica outcomes is equivalent to around £130m per 2x5MHz of additional 800MHz spectrum.

<sup>7</sup> The 2012 consultation which described the ASM did not propose to add a reserve price for unsold spectrum, so we have not done so here.

*ASM applied to 1800 MHz spectrum*

In a similar way, we have attempted to apply Ofcom's ASM methodology in valuing different bidders' 1800 MHz spectrum. For example, what if there was an additional 2x5 MHz of 2.6GHz<sup>8</sup>, but Vodafone could not win it?

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	4	5	0
Telefonica	0	1	2	0	128,000,000
EE	1	0	7	0	0
H3G	1	0	0	0	0
Niche	0	0	2	4	(55,000,000)
Totals	4	1	15	9	73,000,000

Or what if there was an additional 2x5 MHz of 2.6GHz, but Telefonica could not win it?

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	4	4	(2,000,000)
Telefonica	0	1	0	0	0
EE	1	0	7	0	0
H3G	1	0	2	0	100,000,000
Niche	0	0	2	5	(52,500,000)
Totals	4	1	15	9	45,500,000

EE: What if there was an additional 2x45 MHz of 2.6GHz<sup>9</sup>, but EE could not win it?

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	8	7	174,956,000
Telefonica	0	1	2	0	128,000,000
EE	1	0	7	0	0
H3G	1	0	2	0	100,000,000
Niche	0	0	4	0	(15,000,000)
HKT	0	0	0	2	10,250,000
Totals	4	1	23	9	398,206,000

Or an extra 2x20 MHz of 800MHz and 2x25 MHz of 2.6GHz<sup>10</sup>, but EE could not win it?

BIDDER	A1	A2	C	E	Opportunity cost (£)
Vodafone	2	0	7	9	165,876,000
Telefonica	2	0	2	0	127,999,000
EE	1	0	7	0	0
H3G	0	1	0	0	25,000,000
Niche	0	0	3	0	(30,000,000)
Unsold	3				
Totals	8	1	19	9	288,875,000

<sup>8</sup> This was deemed a proxy for the 2x5.8MHz of 1800MHz held by Vodafone and Telefonica.

<sup>9</sup> This was deemed a proxy for the 2x45MHz of 1800MHz held by EE.

<sup>10</sup> This was deemed an alternative proxy for the 2x45MHz of 1800MHz held by EE.

Again, we have attempted to minimize unsold spectrum by setting all reserve prices to £1000. It does not make much difference if the additional spectrum includes A2 lots.

Some further observations:

- As we feared, the methodology gives thoroughly inconsistent valuations of existing spectrum. The supposed valuations of Vodafone's 1800 MHz spectrum (£73m), Telefonica's 1800 MHz spectrum (£45.5m) and EE's 1800 spectrum (£44.2m or £32.1m per 2x5 MHz) differ wildly, with a factor of two or more separating the lowest and highest figures.
- The variation for EE arises because much of the additional spectrum remains unsold in one of the counterfactual auctions. This is influenced by the reserve prices and spectrum caps as they affect the other bidders. These reserve prices and caps are unlikely to have been the same in the counterfactual auctions.

Given all these anomalies, we are at a loss to infer anything sensible about the value of 900MHz and 1800MHz spectrum from the Additional Spectrum Methodology. We urge Ofcom to discard this methodology as giving inconsistent and irrelevant results.

## **CONCLUSIONS**

Our analysis concludes that while there are considerable difficulties in interpreting the outcomes of the auction, some usable conclusions may be drawn:

On the face of it, the auction suggests a market value of around £258m for 2x5MHz of 800MHz spectrum and around £52.5m for 2x5MHz of 2600MHz spectrum; but this 800MHz outcome is simply a product of the reserve price that Ofcom set. Without the reserve price, the packages awarded to each operator would have been the same, but the payment for 800MHz would have been approximately £202m per 2x5MHz.

What is more, observation of H3G's bids suggests that their strategy was strongly conditioned by the detailed auction rules, specifically the intersection of the reserve prices and the opt-in rule – in effect H3G's bidding would appear to be designed to ensure that they received whatever spectrum allowed to them by the opt-in rule at the reserve price, whilst at the same time price setting at 2600GHz. As H3G's bidding had little to do with their underlying valuation of the spectrum it should be disregarded in any evaluation of the revealed market values. Excluding both H3G's bids and their winning spectrum package from the auction suggests an underlying 800MHz valuation of £135m-£168m per 2x5MHz, and £39m for 2x5MHz of 2600MHz.

Finally, Ofcom has suggested the possibility of using an Additional Spectrum Methodology (ASM) to derive underlying values from the auction. We have attempted to employ the ASM and have found some difficulties as the method has not been fully specified. However, our analysis does show that the ASM outcomes are entirely dominated by one particular EE bid that had no chance of success in the live auction. Removing this bid halves the 800MHz ASM outcomes. These issues, coupled with our previous criticisms of the logic of the ASM, completely undermine this whole approach.

Vodafone Limited  
4 July 2013