Annex C: Additional explanation of the cost-benefit role of auctions

This annex explains more about the innovative CCA designs set out in Chapter 10, where the auction is used as part of a cost-benefit analysis of policy alternatives. The first section considers H3G's incentives when bidding for spectrum floors in the UK's 2013 auction. Then, the second section shows a worked example of the auction's cost-benefit role when it is designed to sell spectrum and procure coverage obligations simultaneously.

C1 Bids by H3G for spectrum floors in the UK's 2013 auction

In 2013 the difference of £165 million between H3G's bid amounts for alternative spectrum floors provided the benefit side of the cost-benefit analysis conducted within the auction to determine the choice of reserved spectrum, and the cost side was the opportunity cost of £107 million reflected in the bids of all the other operators (see Section 10.1). H3G seemed to design its bid strategy to ensure that whichever spectrum floor it obtained would be at the reserve price, and it won the floor of one lot of 800 MHz spectrum without coverage obligation (1xA1) at a reserve price of £225 million.[1] Did the 2013 auction determine the economically efficient choice of spectrum floors, given H3G's strategic bids?

Section 10.1 suggested that H3G would have been risking a loss in profit by departing in its bids from the difference in its intrinsic values. To analyse this profit loss in more detail, assume, as shown in the final column of the third row in Figure C1.1 that H3G's incremental intrinsic value was only £50 million – the difference between intrinsic values of £250 million for the floor of 1xA1 and £200 million for the other floor of four lots in the 2.6 GHz paired band (4xC). Under this assumption, the economically inefficient choice of spectrum floor would have been made in the 2013 auction, because the assumed incremental *intrinsic* value was less not more than the opportunity cost to other bidders of £107 million. However, such a low incremental intrinsic value and the wrong choice of spectrum floor is not easy to reconcile with H3G's *observed* bids, because it would have made H3G's observed incremental bid value of £165 million significantly less profitable.

The first column in Figure C1.1 shows the outcome for an incremental bid value reflecting *strategic* bids of the difference in reserve prices of £165 million, consistent with H3G's observed bids. At the assumed intrinsic value of £250 million, it would earn an illustrative profit of £25 million. However, if H3G's true values had been similar to these illustrative assumptions for intrinsic values, it would instead have been much more profitable to make straightforward bids, as shown in the second column.

With straightforward bidding of the assumed incremental *intrinsic* value of £50 million, H3G would have won the other spectrum floor, 4xC, because that incremental bid value would have been less not more than the opportunity cost to other bidders. H3G would have paid a price well above the reserve price of £60 million at £118 million (calculated as the £225 million reserve price for the other floor, 1xA1, less the opportunity cost to other bidders of £107 million).[2] However, even with the price

Figure C1.1. Comparison of strategic and straightforward bids for spectrum floors for illustrative assumed intrinsic values in £ million

	Strategic bids reflecting difference in reserve prices	Straightforward bids reflecting assumed intrinsic values
Floor of 1xA1	225	250
Floor of 4xC	60	200
Incremental bid value	165	50
Opportunity cost to other bidders for 1xA1 over 4xC	107	
Winning floor	1xA1	4xC
Price	225	118
Profit	25	82

Source: Author.

above the reserve level, the straightforward bid strategy would have been much more profitable at £82 million (the assumed £200 million intrinsic value for 4xC less the price of £118 million).

The loss of profit from strategic instead of straightforward bidding would have been £57 million (£82 million with straightforward bidding less £25 million with the strategic bids), caused by strategic bidding leading to the inefficient choice of spectrum floor. When that occurred, the loss of profit was equal to the opportunity cost of £107 million less H3G's assumed incremental intrinsic value of £50 million, and it would therefore have increased, the more that the observed incremental *strategic* bid value of £165 million departed from the incremental *intrinsic* value. This loss of profit tends to reduce the likelihood of a low incremental intrinsic value for H3G as in the illustrative assumptions, compared to an amount above the opportunity cost of £107 million and closer to H3G's observed incremental bid value – for which the outcome in the auction of 1xA1 as the winning floor would have been the economically efficient choice.

C2 Unbundled coverage obligations

In 2018 the UK regulator proposed to integrate the procurement of coverage obligations into a CCA design which would also simultaneously sell spectrum by using unbundled coverage obligations offered in the auction at negative prices (see Section 10.2). I provide here a simple worked example of the cost-benefit role of the auction for a single obligation. The same principles would apply to multiple obligations, and to multiple levels of an obligation.

The role given to cost-benefit analysis when determining the auction outcomes means that a bid for a coverage obligation wins only if the level of benefits specified by the regulator is at least as high as the costs indicated by auction bids. In this approach the regulator uses its policy judgement to estimate the benefits – the social and public value of the extended mobile coverage provided by a coverage obligation – and sets the negative reserve price of the unbundled obligation at this level. A negative reserve price provides a maximum subsidy to an operator taking on an obligation or the maximum discount available to offset its spectrum purchases.

The costs of an obligation to the firms bidding are measured in the auction by the loss in total bid value if an obligation is awarded. There are two categories of cost:

Figure C2.1. Illustrative bids for spectrum and a coverage obligation – first scenario where the coverage obligation is awarded

Comparing two sets of bids: (i) and (ii)	700 MHz lots	3.6–3.8 GHz lots	Coverage obligation	Bid amounts
Flamingo, without obligation (i)	3	12	0	1000
Giraffe, without obligation (i)	3	12	0	600
Total bid value without obligation (i)	6	24	0	1600
Flamingo, with obligation (ii)	3	16	1	800
Giraffe, without obligation (ii)	3	8	0	500
Total bid value with obligation: (ii)	6	24	1	1300
		Loss in total bid value (**LTBV**)		300
Maximum discount (MD = 350) versus LTBV (previous row)			Award the obligation: because set (ii) wins	MD > LTBV

Source: Author.

- Network cost – the difference in bids by the coverage bidder for the same spectrum with and without the obligation.
- Opportunity cost of a change in the allocation of spectrum – the difference between the incremental bid values of the coverage bidder gaining, and other firms losing, the additional spectrum whose allocation is changed.

Figure C2.1 illustrates how package bids from the supplementary bids round can lead to the obligation being awarded in a first scenario. Two sets of bids are shown, labelled (i) and (ii), made by two bidders, called Flamingo and Giraffe. For illustration, the spectrum lots are the two main bands in the 2021 auction, 700 MHz and 3.6–3.8 GHz. The first set of bids, (i), in the first two rows is the highest-value combination of package bids from the two bidders for all the spectrum lots but without a bid for the coverage obligation. Both make bids for 3 lots of 700 MHz and 12 lots of 3.6–3.8 GHz at differing bid amounts, 1000 by Flamingo and 600 by Giraffe. Hence, the total value of this set of bids in the third row is 1600.

The second set of bids, (ii), in the fourth and fifth rows is the highest-value combination of package bids from the two bidders for all the spectrum lots, but this time including a bid for the coverage obligation by Flamingo. Flamingo's package now includes more spectrum, 16 instead of 12 lots of 3.6–3.8 GHz, alongside the obligation. Giraffe's package is correspondingly smaller with 8 instead of 12 lots of 3.6–3.8 GHz and no coverage bid. In other words, in this example the spectrum allocation would be changed by the coverage obligation being awarded – Flamingo would win 4 more lots of 3.6–3.8 GHz and Giraffe 4 fewer lots. The bid amounts are also different compared to set (i). Although Flamingo's spectrum package is larger than in set (i) it specifies a lower bid amount by 200 (at 800 instead of 1000), because its cost of the obligation is assumed here to be bigger than its value for the additional spectrum.[3] Giraffe's package is smaller and so its bid amount is lower by 100 (at 500 instead of 600). The total value of the second set of bids in the sixth row is 1300.

To determine whether the bid for the coverage obligation is a winning bid, we look at the difference in total bid value compared to the maximum discount which is assumed to be 350. The loss in bid value in set (ii) compared to set (i) is 300 in the seventh row, reflecting both categories of cost

Figure C2.2. Illustrative bids for spectrum and a coverage obligation – second scenario where the coverage obligation is not awarded

Comparing two sets of bids: (i) and (ii)	700 MHz lots	3.6–3.8 GHz lots	Coverage obligation	Bid amounts
Flamingo, without obligation (i)	3	12	0	1000
Giraffe without obligation (i)	3	12	0	700
Total bid value without obligation (i)	6	24	0	1700
Flamingo, with obligation (ii)	3	16	1	800
Giraffe with obligation (ii)	3	8	0	500
Total bid value with obligation (ii)	6	24	1	1300
			LTBV	400
Maximum discount (MD = 350) versus LTBV (previous row)	Do not award the obligation: because set (i) wins			MD < LTBV

Source: Author.

(network and opportunity cost), which is less than the maximum discount as shown in the bottom row. So the cost-benefit balance is favourable and the obligation is awarded.

Figure C2.2 shows a second scenario, with higher opportunity costs of the change in allocation and where the coverage obligation is not awarded. Giraffe's reduction in bid amount between the first set of bids (700) and the second set (500) is now higher at 200 instead of 100 in the first scenario, reflecting its higher opportunity cost of losing out on the 4 lots of 3.6–3.8 GHz. This means that the total costs of awarding the coverage obligation are also larger by 100, so that in this scenario the costs exceed the benefits given by the maximum discount. Even though Flamingo makes a bid for the coverage obligation, it is not a winning bid because the cost-benefit balance is unfavourable.

Notes

[1] Myers (2013).

[2] See Myers (2013, p.20) for an explanation of the pricing rule for spectrum floors.

[3] The difference of 200 between Flamingo's bid amounts is smaller than its network cost of the obligation by its value for the additional spectrum (4 lots of 3.6–3.8 GHz). Flamingo's network cost would be transparent if it also made a bid for the coverage obligation with the same number of 700 MHz and 3.6–3.8 GHz lots as in the first set of bids. The net opportunity cost of a change in spectrum allocation is the difference between Flamingo's incremental bid value to gain the additional lots and Giraffe's higher loss in incremental bid value by losing out on them, which would be the residual between the loss in total bid value of 300 and that network cost.

Reference

Myers, Geoffrey (2013) 'The innovative use of spectrum floors in the UK 4G auction to promote mobile competition', *CARR Discussion Paper* Number 74: https://perma.cc/4UVQ-K9C2